# Model Curriculum for Postgraduate Degree Courses in Engineering & Technology

## January 2018

## Volume I

ALL INDIA COUNCIL FOR TECHNICAL EDUCATION
Nelson Mandela Marg, Vasant Kunj, New Delhi 110070
www.aicte-india.org

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**Volume-I**

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# Preface

Post Graduate Education and Research in Engineering and Technology has gained distinct importance in context of challenges and opportunities in National development. The ambitious -Making in India Mission has already started showing targeted results in terms of increased manufacturing sector. Numbers of international projects are being setup in India through MoUs considering favourable policies and conditions. The start-ups projects have created a new generation of entrepreneurs in diverse fields of engineering by tapping vast potential of innovative minds. The skill development mission has attracted large number of youths to acquire skills of their liking and to convert skills in to employment and enterprise.

The advances in engineering sciences and their applications in service, manufacturing and agriculture sectors for commercial benefits has made paradigm shift from under graduate to post graduate level education in engineering and technology. The knowledge, skills and competency of engineers required by industry for enhancing their competitiveness in the market need to be developed from post graduate education and research in engineering and technology. The expansion of engineering PG education in the last decade has offered opportunity to bachelor degree holders to enhance their academic excellence and skills. There are number of PG programs in engineering and technology branches in different specializations which are offered at about 4000 colleges. The Post Graduate Education and Research in specialised subject have enhanced academic out comes. The teaching and research facilities created for conducting PG projects have connected institutes with industry for consultancy and research. Realizing of importance of PG education in engineering, orientation of curriculum of PG programmes to make it more relevant and useful is considered need the hour. The All India Board of PG Education and Research in Engineering and Technology of AICTE has decided to review and update curriculum for various courses and programs in technical education. The focus is fixed to design and develop model curricula at PG level in the light of fast changing technological advancement, new emerging areas and also changes in pedagogy and delivery system in teaching and learning process.

The model curriculum was developed for six branches of engineering-Electronics and Communications Engineering, Computer Science, Mechanical Engineering, Civil Engineering, Electrical Engineering and Chemical Engineering and Technology. The subcommittees constituted for the purses included experts of each branch. The philosophy of drafting model curriculum for PG level programmes has been evolved through elaborate deliberation through numbers of meetings. The major specializations in each branch of engineering are selected for making model curriculum. The course objectives and course outcomes are made part of the model curriculum to ensure development of specialized knowledge and relevant skill in integrated manner of learning.

A standard academic format common for all PG programmes describing numbers of credits, weight age for lecture, laboratories work and projects have been fixed considering the scope of study. The position and sequence of study of core courses and elective courses are made to ensure sequential and integral learning. The focus on advance study in core courses through theory and laboratories work supported by study on relevant programme specific electives are incorporated. The selection of unique courses in the basket of elective is a special features of model curricula ensuring flexibility and diversity. The emphasis on understanding advanced concepts of PG course is ensured through elaborate practical work conducted through actual and virtual laboratory experiments. The concept of designing experiments and developing concept application is made part of learning process. The PG course is spread over two years in four semesters and inclusion of mini project, audit courses, open electives and dissertation are the special features of the curriculum. The contents of course are unitised to facilitate its execution. The list of suggested reading is also made part of the curriculum.

The students are asked to learn IPR/ research methodology to understand importance and process of creation of patents through research. The introduction of two Audit courses covering subjects of developing desired attitude among the learners is on the line of initiatives such as Unnat Bharat Abhiyan, Yoga, Value education, Disaster management, Sanskrit, Pedagogy, Constitution of India, Personality development through Indian culture etc. The introduction of mini projects ensures preparedness of students to undertake major projects/ dissertation. The courses included under open electives are of importance in the context of special skill development and they are on Business analytics, industrial safety, operation research and cost management of engineering project. This courses shall make students capable to work in industrial environment. The dissertation/major project work of PG programme of one-year duration is given strong weight age in the curriculum. It is expected to undertake industrially relevant problem to develop an optimal solution through extensive research work. The students and faculty can design the research project in consultant with industry preferably in the region. The planning of laboratory work/ modelling/ computational work with execution schedule is suggested at the being of the programme to ensure expected outcome. This will lead to creation of patents from the result of the programme.

The exercise of drafting model PG curriculum has been undertaken along with feedback from experts from industry, research organizations and alumni to make it relevant, dynamic and updated. The extensive work performed by members of the sub committees to develop model curriculum in various specializations of core branches of engineering and technology through marathon meetings and tire less work is highly appreciated. I extent sincere thanks to all the members of subcommittees for their contributions in developing model PG curriculum. Adopting and implementing the model curriculum by institutions and universities would help create human resource with desired competency. The cooperate sector would be benefited from trained manpower for improvement in quality and productivity leading to competitiveness in the global marketing through technological intervention. The students with advance knowledge and special skills would be able to offer innovative ideas, technology, product and process in national development process and fulfil their career goals. With the specialized curriculum of PG Programmes, the institutes can transform themselves into global institutes. This would not only retain the large number of graduate students going around for higher studies but would also attract international students making country a global place of higher learning and research in engineering and Technology.

November, 2017

New Delhi

**Prof. Vilas S. Sapkal**
Chairman,
All India Board of Post Graduate Education
and Research in Engineering and Technology

**Subcommittees for drafting model curriculum for PG programs in Engineering and Technology**

1) **Electronics & Communication Engineering**

   **Names of Members**
   1. Dr. Priti Rege, Department of Electronics & Telecommunication, Govt. College of Engineering, Pune
   2. Dr. Vineet Sahula, Professor Department of Electronics & Communication Engineering, MNIT, Jaipur
   3. Dr. R.K. Baghel, Department of Electronics and Communication Engineering, MANIT, Bhopal

2) **Computer Science**

   **Names of Members**
   1. Prof Rajesh Bhatia, Dean and Chairman PEC University, Chandigarh
   2. Prof. Atal Chaudhari, Dept. of Computer Science & Engineering, Jadhapur University, Kolkata
   3. Dr. Meenu Chawla, Prof., Computer Science, Maulana Azad National Institute of Technology Bhopal, Link road Number 3 Near Kali Mata Mandir, Bhopal, MP- 462 003.

3) **Mechanical Engineering**

   **Names of Members**
   1. Prof. Sam Sher, Delhi Technological University, Delhi.
   2. Prof. D.W. Pandey Professor, Mechanical Engineering College of Engineering Pune.
   3. Dr. Gajendra Dixit, Prof, Mechanical Engineering, Maulana Azad National Institute of Technology, Bhopal, Link road No 3, Near Kali Mata Mandir, Bhopal, MP 462 034.

4) **Civil Engineering**

   **Names of Members**
   1. Dr. C.S.P. Ojha, Department of Civil Engineering, IIT Roorkee
   2. Prof. G.S. waminatha, Civil Engineering, NIT, Tiruchirapulli
   3. Dr. Rajendra R. Joshi, College of Civil Engineering, Pune

5) **Electrical Engineering**

**Names of Members**

1. Dr. M.K. Khedkar, Prof. Electrical Engineering. Visvesvaraya National Institute fo Technology, South Ambazari Road, Nagpur
2. Dr. Prerana Gour, NSIT, Dwarka, New Delhi
3. Dr. Abhijit Abhyankar, Department of Electrical Engineering, IIT, Delhi

6) **Chemical Engineering & Technology**

**Names of Members**

1. Dr. R.S. Sapkal, Ex-Director BCUD, Professor Department of Chemical Technology, SGB Amravati University, Amravati.
2. Dr. R.W, Gaikwad, Prof. Department of Chemical Engineering, Pravra Rural Engineering College, Loni, Distt Ahamdnagar 413 736
3. Dr. S.H. Sonawane, Department of Chemical Engineering, NIT, Warangal.

**Distinct features of model PG curriculum in Engineering and Technology:**

1. **Standardized academic structure for all PG Programs with uniform credit distribution.**
2. **Advanced study of specialization through core subjects, flexible and diverse program specific electives.**
3. **Open electives to widen skills.**
4. **Enhanced engagement of industry in developing innovations and problem solutions.**
5. **Collaborating and interactive learning to ensure talent development.**
6. **Inbuilt mechanism for regular upgradation of curriculum.**
7. **Focus on development of advanced knowledge and specific skills required for industrial development.**
8. **Ensured competency development of learner.**

**Open Elective**

1. Business Analytics
2. Industrial Safety
3. Operations Research
4. Cost Management of Engineering Projects
5. Composite Materials
6. Waste to Energy

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

| **Research Methodology and IPR** | |
|---|---|
| **Teaching Scheme**<br>Lectures: 1hrs/week | |
| **Course Outcomes:**<br>At the end of this course, students will be able to<br>• Understand research problem formulation.<br>• Analyze research related information<br>• Follow research ethics<br>• Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.<br>• Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.<br>• Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits. | |

## Syllabus Contents:

**Unit 1:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Unit 2:** Effective literature studies approaches, analysis

Plagiarism, Research ethics,

**Unit 3:** Effective technical writing, how to write report, Paper

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**Unit 4:** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Unit 5:** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Unit 6:** New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

## References:


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- Mayall, "Industrial Design", McGraw Hill, 1992.
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- Asimov, "Introduction to Design", Prentice Hall, 1962.
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# Contents

# MODEL CURRICULUM

of

# Engineering & Technology PG Courses

# Computer Science

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## M. Tech. (Computer Science & Engineering) Specialization: Data Science

### Semester I

| Course Number | Subject |
|---|---|
| 1CS01 | Program Core I-<br>Mathematical foundations of Computer Science |
| 1CS02 | Program Core II-<br>Advanced Data Structures |
| 1CSxx | Program Elective I-<br>Data Science/ Distributed Systems/ Data Preparation and Analysis |
| 1CSxx | Program Elective II-<br>Recommender System/ Machine Learning/ Data Storage Technologies and Networks |
| 1Axxx | Research Methodology and IPR |
| 1Axxx | Audit Course |
| 1CS03 | Laboratory 1 (Advanced Data Structures) |
| 1CS04 | Laboratory 2 (Based on Electives) |

### Semester II

| Course Number | Subject |
|---|---|
| 2CS05 | Program Core III –<br>Advance Algorithms |
| 2CS06 | Program Core IV –<br>Soft Computing |
| 2CSxx | Program Elective III –<br>Data Visualization/ Big Data Analytics/ Data Warehouse and Data Mining |
| 2CSxx | Program Elective IV –<br>Data Security and Access Control/ Web Analytics and Development/ Knowledge Discovery |
| 2Axxx | Audit Course |
| 2CS07 | Laboratory 3 (Based on cores) |
| 2CS08 | Laboratory 4 (Based on Electives) |
| 2CS09 | Mini Project with Seminar |

### Semester III

| Course No. | Subject |
|---|---|
| 3CSxx | Program Elective V –<br>GPU Computing/ Cloud Computing/ Distributed Databases |

| | |
|---|---|
| 3CSxx | **Open Elective**<br>1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy |
| 3CS10 | Dissertation-I /Industrial Project |

## Semester IV

| | Subject |
|---|---|
| | Dissertation II |

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

# M. Tech. (Computer Science & Engineering) Specialization: Information Security

## Semester I

| Course Number | Subject |
|---|---|
| 1CS01 | Program Core I-<br>Mathematical foundations of Computer Science |
| 1CS02 | Program Core II-<br>Advanced Data Structures |
| 1CSxx | Program Elective I-<br>Digital Forensics/ Ethical Hacking/<br>Intrusion Detection |
| 1CSxx | Program Elective II-<br>Malware Analysis & Reverse Engineering/ Secure Software Design and Enterprise Computing/ Machine Learning |
| 1Axxx | Research Methodology & IPR |

| | |
|---|---|
| 1Axxx | Audit Course |
| 1CS03 | Laboratory 1 (Advanced Data Structures) |
| 1CS04 | Laboratory 2 (Based on Electives) |

**Semester II**

| Course Number | Subject |
|---|---|
| 2CS05 | Program Core III –<br>Advance Algorithms |
| 2CS06 | Program Core IV –<br>Soft Computing |
| 2CSxx | Program Elective III –<br>Data Encryption & Compression/ Steganography & Digital Watermarking/ Information Theory & Coding |
| 2CSxx | Program Elective IV –<br>Security Assessment and Risk Analysis/ Secure Coding/ Biometrics |
| 2Axxx | Audit Course |
| 2CS07 | Laboratory 3 (Based on cores) |
| 2CS08 | Laboratory 4 (Based on Electives) |
| 2CS09 | Mini Project with Seminar |

**Semester III**

| Course No. | Subject |
|---|---|
| 3CSxx | Program Elective IV –<br>Data Warehousing & Mining/ Web Search & Information Retrieval/ Database Security and Access Control |
| 3CSxx | Open Elective –<br>1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy |
| 3CS10 | Dissertation-I /Industrial Project |

**Semester IV**

| | Subject |
|---|---|
| | Dissertation II |

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

## M. Tech. (Computer Science & Engineering)

### Semester I

| Course Number | Subject |
|---|---|
| 1CS01 | Program Core I- Mathematical foundations of Computer Science |
| 1CS02 | Program Core II-Advanced Data Structures |
| 1CSxx | Program Elective I –<br>Machine Learning/ Wireless Sensor Networks/ Introduction to Intelligent Systems |
| 1CSxx | Program Elective II –<br>Data Science/ Distributed Systems/ Advanced Wireless and Mobile Networks |
| 1Axxx | Research Methodology and IPR |
| 1Axxx | Audit Course |
| 1CS03 | Laboratory 1 (Advanced Data Structures) |
| 1CS04 | Laboratory 2 (Based on Electives) |

### Semester II

| Course Number | Subject |
|---|---|
| 2CS05 | Program Core III - Advance Algorithms |
| 2CS06 | Program Core IV - Soft Computing |
| 2CSxx | Program Elective III –<br>Data Preparation and Analysis/ Secure Software Design & Enterprise Computing/ Computer Vision |
| 2CSxx | Program Elective IV –<br>Human and Computer Interaction/ GPU Computing/ Digital Forensics |
| 2Axxx | Audit Course |
| 2CS07 | Laboratory 3 (Based on cores) |
| 2CS08 | Laboratory 4 (Based on Electives) |
| 2CS09 | Mini Project with Seminar |

**Semester III**

| Course No. | Subject |
|---|---|
| 3CSxx | Program Elective 5 –<br>Mobile Applications and Services/ Compiler for HPC/ Optimization Techniques |
| 3CSxx | Open Elective –<br>1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy |
| 3CS10 | Dissertation-I /Industrial Project |

**Semester IV**

| | Subject |
|---|---|
| | Dissertation II |

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

**M.Tech. (Computer Science & Engineering) Specialization : Advanced Computing**

**Semester I**

| Course Number | Subject |
|---|---|
| 1CS01 | Program Core I –<br>Mathematical foundations of Computer Science |
| 1CS02 | Program Core II –<br>Advanced Data Structures |
| 1CSxx | Program Elective I –<br>Compiler for HPC/ Operating System Design/ Optimization Techniques |
| 1CSxx | Program Elective II –<br>Cluster and Grid Computing/ Parallel Programming Tools and Model/ Big Data Analytics |
| 1Axxx | Research Methodology and IPR |

| | |
|---|---|
| 1Axxx | Audit Course |
| 1CS03 | Laboratory 1 (Advanced Data Structures) |
| 1CS04 | Laboratory 2 (Based on Electives) |

**Semester II**

| Course Number | Subject |
|---|---|
| 2CS05 | Program Core III –<br>Advance Algorithms |
| 2CS06 | Program Core IV –<br>Soft Computing |
| 2CSxx | Program Elective III –<br>Distributed Database/ Concurrence, Parallelism and Distributed System/ HPC Architecture, and Ecosystem |
| 2CSxx | Program Elective IV –<br>Parallel Algorithms/ Threaded and Message-passing Programming/ Human Centered Computing |
| 2Axxx | Audit Course |
| 2CS07 | Laboratory 3 (Based on cores) |
| 2CS08 | Laboratory 4 (Based on Electives) |
| 2CS09 | Mini Project with Seminar |

**Semester III**

| Course No. | Subject |
|---|---|
| 3CSxx | Program Elective V –<br>High Performance Scientific Computing/ Quantum Computing/ DNA Computing |
| 3CSxx | Open Elective –<br>1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy |
| 3CS10 | Dissertation-I /Industrial Project |

**Semester IV**

| | Subject |
|---|---|
| | Dissertation II |

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

**M.Tech. (Computer Science & Engineering) Specialization: Internet of Things**

**Semester I**

| Course Number | Subject |
|---|---|
| 1CS01 | Program Core I-<br>Mathematical foundations of Computer Science |
| 1CS02 | Program Core II-<br>Advanced Data Structures |
| 1CSxx | Program Elective I-<br>Data Science/ Wireless Access Technologies/ Mobile Applications and Services |
| 1CSxx | Program Elective II-<br>Machine Learning/ Smart Sensors and Internet of Things/ Logic and Functional programming |
| 1Axxx | Research Methodology and IPR |
| 1Axxx | Audit Course |
| 1CS03 | Laboratory 1 (Advanced Data Structures) |
| 1CS04 | Laboratory 2 (Based on Electives) |

**Semester II**

| Course Number | Subject |
|---|---|
| 2CS05 | Program Core III –<br>Advance Algorithms |
| 2CS06 | Program Core IV –<br>Soft Computing |
| 2CSxx | Program Elective III –<br>Sensor Networks and Internet of Things/ Data Visualization/ IoT Application and Communication Protocol |
| 2CSxx | Program Elective IV –<br>Big Data Analytics/ Network Security/ Advanced Machine Learning |
| 2Axxx | Audit Course |
| 2CS07 | Laboratory 3 (Based on cores) |
| 2CS08 | Laboratory 4 (Based on Electives) |
| 2CS09 | Mini Project with Seminar |

**Semester III**

| Course No. | Subject |
|---|---|
| 3CSxx | Program Elective V –<br>Cloud Computing/ IOT and Smart Cities/ Emulation and Simulation Methodologies |
| 3CSxx | Open Elective<br><br>1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy |
| 3CS10 | Dissertation-I /Industrial Project |

**Semester IV**

| | Subject |
|---|---|
| | Dissertation II |

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

**Course Scheme for M.Tech. Computer Science and Engineering Specialization: Data Science**

**M.Tech Sem-I.**

| Course Number | Subject | Scheme Of Studies Per Week | | | Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| 1CS01 | Program Core I-<br>Mathematical foundations of Computer Science | 3 | 0 | 0 | 3 |
| 1CS02 | Program Core II-<br>Advanced Data Structures | 3 | 0 | 0 | 3 |
| 1CSxx | Program Elective I-<br>Data Science/ Distributed Systems/ Data Preparation and Analysis | 3 | 0 | 0 | 3 |
| 1CSxx | Program Elective II-<br>Recommender System/ Machine Learning/ Data Storage Technologies and Networks | 3 | 0 | 0 | 3 |
| 1Axxx | Research Methodology and IPR | 2 | 0 | 0 | 2 |
| 1Axxx | Audit Course | 2 | 0 | 0 | 0 |
| 1CS03 | Laboratory 1 (Advanced Data Structures) | 0 | 0 | 4 | 2 |
| 1CS04 | Laboratory 2 (Based on Electives) | 0 | 0 | 4 | 2 |
| Total Credits: 18 | | | | | |

**M.Tech Sem- II**

| Course Number | Subject | Scheme Of Studies Per Week | | | Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| 2CS05 | Program Core III –<br>Advance Algorithms | 3 | 0 | 0 | 3 |
| 2CS06 | Program Core IV –<br>Soft Computing | 3 | 0 | 0 | 3 |
| 2CSxx | Program Elective III –<br>Data Visualization/ Big Data Analytics/ Data Warehouse and Data Mining | 3 | 0 | 0 | 3 |
| 2CSxx | Program Elective IV –<br>Data Security and Access Control/ Web Analytics and Development/ Knowledge Discovery | 3 | 0 | 0 | 3 |
| 2Axxx | Audit Course | 2 | 0 | 0 | 0 |
| 2CS07 | Laboratory 3 (Based on cores) | 0 | 0 | 4 | 2 |
| 2CS08 | Laboratory 4 (Based on Electives) | 0 | 0 | 4 | 2 |
| 2CS09 | Mini Project with Seminar | 2 | 0 | 0 | 2 |
| Total Credits: 18 | | | | | |

***Students be encouraged to go to Industrial Training/Internship for at least 2-3 months during semester break.**

**M.TechIII Sem***

| Course No. | Subject | Scheme of Studies Periods Per Week | | | Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| 3CSxx | Program Elective V –<br>GPU Computing/ Cloud Computing/ Distributed Databases | 3 | 0 | 0 | 03 |
| 3CSxx | **Open Elective**<br>1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy | 3 | 0 | 0 | 03 |
| 3CS10 | Dissertation-I /Industrial Project | 0 | 0 | 20 | 10 |
| Total Credits 16 | | | | | |

***Students going for Industrial Project/Thesis will complete these courses through MOOCs.**
**M.TechSem-IV**

| | Subject | Scheme of Studies Per Week | | | Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| | Dissertation II | 0 | 0 | 32 | 16 |
| Total Credits: 16 | | | | | |

The program offers several elective courses, focusing on different aspects of Data Science. A student can choose to do any course from given program elective set.

**Program Outcomes of CSE (M.Tech.) program:**

The main outcomes of the CSE (M.Tech.) program are given here. At the end of the program a student is expected to have:

1. An understanding of the theoretical foundations and the limits of computing.
2. An ability to adapt existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
3. An ability to design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
4. Understanding and ability to use advanced computing techniques and tools.
5. An ability to undertake original research at the cutting edge of computer science & its related areas.
6. An ability to function effectively individually or as a part of a team to accomplish a stated goal.
7. An understanding of professional and ethical responsibility.
8. An ability to communicate effectively with a wide range of audience.
9. An ability to learn independently and engage in life¬long learning.

10. An understanding of the impact of IT related solutions in an economic, social and environment context.

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

**Syllabus, course objective and course outcomes for various post graduation courses.**

**Core Subjects:**

| | |
|---|---|
| **Course Code** | 1CS01 |
| **Course Name** | Mathematical Foundation of Computer Science |
| **Credits** | 3 |
| **Pre-Requisites** | Discrete Mathematics |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • To understand the mathematical fundamentals that is prerequisites for avariety of courses like Data mining, Network protocols, analysis of Web traffic, Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning. |
| • To developthe understanding ofthe mathematical and logical basis to many modern techniques in information technology like machine learning, programming language design, and concurrency. |
| • To study various sampling and classification problems. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1**<br>Probability mass, density, and cumulative distribution functions, Parametric families of distributions, Expected value, variance, conditional expectation, Applications of the univariate and multivariate Central Limit Theorem, Probabilistic inequalities, Markov chains | 7 |
| **Unit 2**<br>Random samples, sampling distributions of estimators**,** Methods of Moments and Maximum Likelihood**,** | 7 |
| **Unit 3**<br>Statistical inference**,** Introduction to multivariate statistical models: regression and classification problems, principal components analysis**,** The problem of overfitting model assessment. | 8 |
| **Unit 4**<br>Graph Theory: Isomorphism, Planar graphs, graph colouring, hamilton circuits and euler cycles.<br>Permutations and Combinations with and without repetition.<br>Specialized techniques to solve combinatorial enumeration problems | 11 |
| **Unit 5**<br>**Computer science and engineering applications** | 10 |

| | |
|---|---|
| Data mining, Network protocols, analysis of Web traffic, Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning. | |
| **Unit 6**<br>Recent Trands in various distribution functions in mathmatical field of computer science for varying fields like bioinformatic, soft computing, and computer vision. | 5 |

| **COURSE OUTCOMES** |
|---|
| After completion of course, students would be able to: |
| • To understand the basic notions of discrete and continuous probability. |
| • To understand the methods of statistical inference, and the role that sampling distributions play in those methods. |
| • To be able to perform correct and meaningful statistical analyses of simple to moderate complexity. |

**References**

1. John Vince, Foundation Mathematics for Computer Science, Springer.
2. K. Trivedi.Probability and Statistics with Reliability, Queuing, and Computer Science Applications. Wiley.
3. M. Mitzenmacher and E. Upfal.Probability and Computing: Randomized Algorithms and Probabilistic Analysis.
4. Alan Tucker, Applied Combinatorics, Wiley

| | |
|---|---|
| **Course Code** | 1CS02 |
| **Course Name** | Advanced Data Structures |
| **Credits** | 3 |
| **Pre-Requisites** | UG level course in Data Structures |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • The student should be able to choose appropriate data structures, understand the ADT/libraries, and use it to design algorithms for a specific problem. |
| • Students should be able to understand the necessary mathematical abstraction to solve problems. |
| • To familiarize students with advanced paradigms and data structure used to solve algorithmic problems. |
| • Student should be able to come up with analysis of efficiency and proofs of correctness. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1**<br>**Dictionaries:** Definition, Dictionary Abstract Data Type, Implementation of Dictionaries.<br>**Hashing:** Review of Hashing, Hash Function, Collision Resolution Techniques in Hashing, Separate Chaining, Open Addressing, Linear Probing, Quadratic Probing, Double Hashing, Rehashing, Extendible Hashing. | 7 |
| **Unit 2**<br>**Skip Lists:** Need for Randomizing Data Structures and Algorithms, Search and Update Operations on Skip Lists, Probabilistic Analysis of Skip Lists, Deterministic Skip Lists | 5 |
| **Unit 3**<br>**Trees:** Binary Search Trees, AVL Trees, Red Black Trees, 2-3 Trees, B-Trees, Splay Trees | 9 |
| **Unit 4** | 12 |

| | |
|---|---|
| **Text Processing:** Sting Operations, Brute-Force Pattern Matching, The Boyer-Moore Algorithm, The Knuth-Morris-Pratt Algorithm, Standard Tries, Compressed Tries, Suffix Tries, The Huffman Coding Algorithm, The Longest Common Subsequence Problem (LCS), Applying Dynamic Programming to the LCS Problem. | |
| **Unit 5**<br>**Computational Geometry:** One Dimensional Range Searching, Two Dimensional Range Searching, Constructing a Priority Search Tree, Searching a Priority Search Tree, Priority Range Trees, Quadtrees, k-D Trees. | 10 |
| **Unit 6**<br>Recent Trands in Hashing, Trees, and various computational geometry methods for effeciently solving the new evolving problem | 5 |

| **COURSE OUTCOMES** |
|---|
| After completion of course, students would be able to: |
| • Understand the implementation of symbol table using hashing techniques. |
| • Develop and analyze algorithms for red-black trees, B-trees and Splay trees. |
| • Develop algorithms for text processing applications. |
| • Identify suitable data structures and develop algorithms for computational geometry problems. |

**References:**

1. Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, 2nd Edition, Pearson, 2004.
2. M T Goodrich, Roberto Tamassia, Algorithm Design, John Wiley, 2002.

| | |
|---|---|
| **Course Code** | 2CS05 |
| **Course Name** | Advanced Algorithms |
| **Credits** | 3 |
| **Pre-Requisites** | UG level course in Algorithm Design and Analysis |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • Introduce students to the advanced methods of designing and analyzing algorithms. |
| • The student should be able to choose appropriate algorithms and use it for a specific problem. |
| • To familiarize students with basic paradigms and data structures used to solve advanced algorithmic problems. |
| • Students should be able to understand different classes of problems concerning their computation difficulties. |
| • To introduce the students to recent developments in the area of algorithmic design. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit1**<br>**Sorting:** Review of various sorting algorithms, topological sorting<br>**Graph:** Definitions and Elementary Algorithms: Shortest path by BFS, shortest path in edge-weighted case (Dijkasra's), depth-first search and computation of strongly connected components, emphasis on correctness proof of the algorithm and time/space analysis, example of amortized analysis. | 6 |
| **Unit 2**<br>**Matroids:** Introduction to greedy paradigm, algorithm to compute a maximum weight maximal independent set. Application to MST.<br>**Graph Matching:** Algorithm to compute maximum matching. Characterization of maximum matching by augmenting paths, Edmond's Blossom algorithm to compute augmenting path. | 8 |

| | |
|---|---|
| **Unit 3**<br>**Flow-Networks:** Maxflow-mincut theorem, Ford-Fulkerson Method to compute maximum flow, Edmond-Karp maximum-flow algorithm.<br>**Matrix Computations:** Strassen's algorithm and introduction to divide and conquer paradigm, inverse of a triangular matrix, relation between the time complexities of basic matrix operations, LUP-decomposition. | 9 |
| **Unit 4**<br>**Shortest Path in Graphs:** Floyd-Warshall algorithm and introduction to dynamic programming paradigm. More examples of dynamic programming.<br>**Modulo Representation of integers/polynomials:** Chinese Remainder Theorem, Conversion between base-representation and modulo-representation. Extension to polynomials. Application: Interpolation problem.<br>**Discrete Fourier Transform (DFT):** In complex field, DFT in modulo ring. Fast Fourier Transform algorithm. Schonhage-Strassen Integer Multiplication algorithm | 10 |
| **Unit 5**<br>**Linear Programming:** Geometry of the feasibility region and Simplex algorithm<br>**NP-completeness:** Examples, proof of NP-hardness and NP-completeness.<br>**One or more of the following topics based on time and interest**<br>Approximation algorithms, Randomized Algorithms, Interior Point Method, Advanced Number Theoretic Algorithm | 10 |
| **Unit 6**<br>Recent Trands in problem solving paradigms using recent searching and sorting techniques by applying recently proposed data structures. | 5 |

| **COURSE OUTCOMES** |
|---|
| After completion of course, students would be able to: |
| • Analyze the complexity/performance of different algorithms. |
| • Determine the appropriate data structure for solving a particular set of problems. |
| • Categorize the different problems in various classes according to their complexity. |
| • Students should have an insight of recent activities in the field of the advanced data structure. |

**References:**

1. "Introduction to Algorithms" byCormen, Leiserson, Rivest, Stein.
2. "The Design and Analysis of Computer Algorithms" by Aho, Hopcroft, Ullman.
3. "Algorithm Design" by Kleinberg and Tardos.

## Research Methodology and IPR

| **Teaching Scheme**<br><br>Lectures: 1hrs/week | |
|---|---|

**Course Outcomes:**

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about

Intellectual Property Right to be promoted among students in general & engineering in particular.

- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

**Syllabus Contents:**

**Unit 1:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Unit 2:** Effective literature studies approaches, analysis

Plagiarism, Research ethics,

**Unit 3:** Effective technical writing, how to write report, Paper

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**Unit 4:** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Unit 5:** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Unit 6:** New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

**References:**


- Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
- Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
- Ranjit Kumar, 2 ndEdition, "Research Methodology: A Step by Step Guide for beginners"
- Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd,2007.
- Mayall, "Industrial Design", McGraw Hill, 1992.
- Niebel, "Product Design", McGraw Hill, 1974.
- Asimov, "Introduction to Design", Prentice Hall, 1962.

- Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
- T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008


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|---|---|
| **Course Code** | 2CS06 |
| **Course Name** | Soft Computing |
| **Credits** | 3 |
| **Pre-Requisites** | Basic knowledge of mathematics |

Total Number of Lectures:48

| COURSE OBJECTIVE |
|---|
| • To introduce soft computing concepts and techniques and foster their abilities in designing appropriate technique for a given scenario. |
| • To implement soft computing based solutions for real-world problems. |
| • To give students knowledge of non-traditional technologies and fundamentals of artificial neural networks, fuzzy sets, fuzzy logic, genetic algorithms. |
| • To provide studentan hand-on experience on MATLAB to implement various strategies. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1**<br>**INTRODUCTION TO SOFT COMPUTING AND NEURAL NETWORKS:** Evolution of Computing: Soft Computing Constituents, From Conventional AI to Computational Intelligence: Machine Learning Basics | 7 |
| **Unit 2**<br>**FUZZY LOGIC:** Fuzzy Sets, Operations on Fuzzy Sets, Fuzzy Relations, Membership Functions: Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems, Fuzzy Expert Systems, Fuzzy Decision Making. | 8 |
| **Unit 3**<br>**NEURAL NETWORKS:** Machine Learning Using Neural Network, Adaptive Networks, Feed forward Networks, Supervised Learning Neural Networks, Radial Basis Function Networks : Reinforcement Learning, Unsupervised Learning Neural Networks, Adaptive Resonance architectures, Advances in Neural networks | 10 |
| **Unit 4**<br>**GENETIC ALGORITHMS:** Introduction to Genetic Algorithms (GA), Applications of GA in Machine Learning : Machine Learning Approach to Knowledge Acquisition. | 5 |
| **Unit 5**<br>**Matlab/Python Lib:** Introduction to Matlab/Python, Arrays and array operations, Functions and Files, Study of neural network toolbox and fuzzy logic toolbox, Simple implementation of Artificial Neural Network and Fuzzy Logic | 13 |
| **Unit 6**<br>Recent Trands in deep learning, various classifiers, neural networks and genetic algorithm.<br>Implementation of recently proposed soft computing techniques. | 5 |

| COURSE OUTCOMES |
|---|
| After completion of course, students would be able to: |
| • Identify and describe soft computing techniques and their roles in building intelligent machines |
| • Apply fuzzy logic and reasoning to handle uncertainty and solve various engineering |

| |
|---|
| problems. |
| • Apply genetic algorithms to combinatorial optimization problems. |
| • Evaluate and compare solutions by various soft computing approaches for a given problem. |

References


1. Jyh:Shing Roger Jang, Chuen:Tsai Sun, EijiMizutani, Neuro:Fuzzy and Soft Computing, Prentice:Hall of India, 2003.
2. George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic:Theory and Applications, Prentice Hall, 1995.
3. MATLAB Toolkit Manual


**Elective Subjects**

| | |
|---|---|
| **Course Code** | 1CS23 |
| **Course Name** | Big Data Analytics |
| **Credits** | 3 |
| **Pre-Requisites** | Data Structure, Computer Architecture and Organization |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • Understand big data for business intelligence. Learn business case studies for big data analytics. Understand nosql big data management. Perform map-reduce analytics using Hadoop and related tools |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:** What is big data, why big data, convergence of key trends, unstructured data, industry examples of big data, web analytics, big data and marketing, fraud and big data, risk and big data, credit risk management, big data and algorithmic trading, big data and healthcare, big data in medicine, advertising and big data, big data technologies, introduction to Hadoop, open source technologies, cloud and big data, mobile business intelligence, Crowd sourcing analytics, inter and trans firewall analytics. | 8 |
| **Unit 2:** Introduction to NoSQL, aggregate data models, aggregates, key-value and document data models, relationships, graph databases, schemaless databases, materialized views, distribution models, sharding, master-slave replication, peer-peer replication, sharding and replication, consistency, relaxing consistency, version stamps, map-reduce, partitioning and combining, composing map-reduce calculations. | 8 |
| **Unit 3:** Data format, analyzing data with Hadoop, scaling out, Hadoop streaming, Hadoop pipes, design of Hadoop distributed file system (HDFS), HDFS concepts, Java interface, data flow, Hadoop I/O, data integrity, compression, serialization, Avro, file-based data structures | 9 |
| **Unit 4:** MapReduce workflows, unit tests with MRUnit, test data and local tests, anatomy of MapReduce job run, classic Map-reduce, YARN, failures in classic Map-reduce and YARN, job scheduling, shuffle and sort, task execution, MapReduce types, input formats, output formats | 10 |
| **Unit 5:** | 7 |

| | |
|---|---|
| Hbase, data model and implementations, Hbase clients, Hbase examples, praxis.Cassandra, Cassandra data model, Cassandra examples, Cassandra clients, Hadoop integration. | |
| **Unit 6:**<br>Pig, Grunt, pig data model, Pig Latin, developing and testing Pig Latin scripts.<br>Hive, data types and file formats, HiveQL data definition, HiveQL data manipulation, HiveQL queries. | 6 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • Describe big data and use cases from selected business domains<br>• Explain NoSQL big data management<br>• Install, configure, and run Hadoop and HDFS<br>• Perform map-reduce analytics using Hadoop<br>• Use Hadoop related tools such as HBase, Cassandra, Pig, and Hive for big data analytics |

**References:**


1. Michael Minelli, Michelle Chambers, and AmbigaDhiraj, "Big Data, Big Analytics: Emerging
2. Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.
3. P. J. Sadalage and M. Fowler, "NoSQL Distilled: A Brief Guide to the Emerging World of
4. Polyglot Persistence", Addison-Wesley Professional, 2012.
5. Tom White, "Hadoop: The Definitive Guide", Third Edition, O'Reilley, 2012.
6. Eric Sammer, "Hadoop Operations", O'Reilley, 2012.
7. E. Capriolo, D. Wampler, and J. Rutherglen, "Programming Hive", O'Reilley, 2012.
8. Lars George, "HBase: The Definitive Guide", O'Reilley, 2011.
9. Eben Hewitt, "Cassandra: The Definitive Guide", O'Reilley, 2010.
10. Alan Gates, "Programming Pig", O'Reilley, 2011.


| | |
|---|---|
| **Course Code** | 2CS31 |
| **Course Name** | Distributed Database |
| **Credits** | 3 |
| **Pre-Requisites** | |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • The objective of course is to provide insight to distributed database, normalization techniques and integrity rules. It also includes parallel database systems along with object oriented models. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>Introduction: Distributed Data processing, Distributed database system (DDBMS), Promises of DDBMSs, Complicating factors and Problem areas in DDBMSs, Overview Of Relational DBMS Relational Database concepts, Normalization, Integrity rules, Relational Data Languages, Relational DBMS. | 11 |
| **Unit 2:**<br>Distributed DBMS Architecture: DBMS Standardization, Architectural models for Distributed DBMS, Distributed DBMS Architecture. Distributed Database Design: Alternative design Strategies, Distribution design issues, Fragmentation, Allocation. Semantic Data Control: View Management, Data security, Semantic | 8 |

| | |
|---|---|
| Integrity Control. | |
| **Unit 3:**<br>Overview of Query Processing: Query processing problem, Objectives of Query Processing, Complexity of Relational Algebra operations, characterization of Query processors, Layers of Query Processing.<br>Introduction to Transaction Management: Definition of Transaction, Properties of transaction, types of transaction. Distributed Concurrency Control: Serializability theory, Taxonomy of concurrency control mechanisms, locking bases concurrency control algorithms. | 9 |
| **Unit 4:**<br>Parallel Database Systems: Database servers, Parallel architecture, Parallel DBMS techniques, Parallel execution problems, Parallel execution for hierarchical architecture. | 7 |
| **Unit 5:**<br>Distributed Object Database Management systems: Fundamental Object concepts and Object models, Object distribution design. Architectural issues, Object management, Distributed object storage, Object query processing. Transaction management. Database Interoperability: Database Integration, Query processing. | 8 |
| **Unit 6:**<br>Recent approaches, models and current trends in improving the performance of Distributed Database. | 5 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • Abe to understand relational database management systems, normalization to make efficient retrieval from database and query. |

**References:**

1. Principles of Distributed Database Systems, Second Edition, M. Tamer Ozsu Patrick Valduriez
2. Distributed Databases principles and systems, Stefano Ceri, Giuseppe Pelagatti, Tata McGraw Hill.

| | |
|---|---|
| **Course Code** | |
| **Course Name** | Data Science |
| **Credits** | 3 |
| **Pre-Requisites** | |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • Provide you with the knowledge and expertise to become a proficient data scientist. |
| • Demonstrate an understanding of statistics and machine learning concepts that are vital for data science; |
| • Produce Python code to statistically analyse a dataset; |
| • Critically evaluate data visualisations based on their design and use for communicating stories from data; |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>Introduction to core concepts and technologies: Introduction, Terminology, data | 6 |

| | |
|---|---|
| science process, data science toolkit, Types of data, Example applications. | |
| **Unit 2:**<br>Data collection and management: Introduction, Sources of data, Data collection and APIs, Exploring and fixing data, Data storage and management, Using multiple data sources | 7 |
| **Unit 3:**<br>Data analysis: Introduction, Terminology and concepts, Introduction to statistics, Central tendencies and distributions, Variance,Distribution properties and arithmetic, Samples/CLT, Basic machine learning algorithms, Linear regression, SVM, Naive Bayes. | 10 |
| **Unit 4:**<br>Data visualisation:Introduction, Types of data visualisation,Data for visualisation:Data types, Data encodings, Retinal variables, Mapping variables to encodings, Visual encodings. | 11 |
| **Unit 5:**<br>Applications of Data Science,Technologies for visualisation, Bokeh (Python) | 7 |
| **Unit 6:**<br>Recent trends in various data collection and analysis techniques, various visualization techniques, application development methods of used in data science. | 7 |

| **COURSE OUTCOMES** |
|---|
| **On completion of the course the student should be able to** |
| • Explain how data is collected, managed and stored for data science; |
| • Understand the key concepts in data science, including their real-world applications and the toolkit used by data scientists; |
| • Implement data collection and management scripts using MongoDB |

References:


1. Cathy O'Neil and Rachel Schutt. Doing Data Science, Straight Talk From The Frontline. O'Reilly.
2. Jure Leskovek, AnandRajaraman and Jeffrey Ullman. Mining of Massive Datasets. v2.1, Cambridge University Press.


| | |
|---|---|
| **Course Code** | |
| **Course Name** | Machine learning |
| **Credits** | 3 |
| **Pre-Requisites** | |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • To learn the concept of how to learn patterns and concepts from data without being explicitly programmed in various IOT nodes. |
| • To design and analyse various machine learning algorithms and techniques with a modern outlook focusing on recent advances. |
| • Explore supervised and unsupervised learning paradigms of machine learning. |
| • To explore Deep learning technique and various feature extraction strategies. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>**Supervised Learning (Regression/Classification)**<br>• Basic methods: Distance-based methods, Nearest-Neighbours, Decision Trees, Naive Bayes | 10 |

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|---|---|
| • Linear models: Linear Regression, Logistic Regression, Generalized Linear Models<br>• Support Vector Machines, Nonlinearity and Kernel Methods<br>• Beyond Binary Classification: Multi-class/Structured Outputs, Ranking | |
| **Unit 2:**<br>**Unsupervised Learning**<br>• Clustering: K-means/Kernel K-means<br>• Dimensionality Reduction: PCA and kernel PCA<br>• Matrix Factorization and Matrix Completion<br>• Generative Models (mixture models and latent factor models) | 7 |
| **Unit 3**<br>Evaluating Machine Learning algorithms and Model Selection, Introduction to Statistical Learning Theory, Ensemble Methods (Boosting, Bagging, Random Forests) | 6 |
| **Unit 4**<br>Sparse Modeling and Estimation, Modeling Sequence/Time-Series Data, Deep Learning and Feature Representation Learning | 9 |
| **Unit 5**<br>Scalable Machine Learning (Online and Distributed Learning)<br>A selection from some other advanced topics, e.g., Semi-supervised Learning, Active Learning, Reinforcement Learning, Inference in Graphical Models, Introduction to Bayesian Learning and Inference | 9 |
| **Unit 6:**<br>Recent trends in various learning techniques of machine learning and classification methods for IOT applications. Various models for IOT applications. | 5 |

| **COURSE OUTCOMES** |
|---|
| After completion of course, students would be able to: |
| • Extract features that can be used for a particular machine learning approach in various IOT applications. |
| • To compare and contrast pros and cons of various machine learning techniques and to get an insight of when to apply a particular machine learning approach. |
| • To mathematically analyse various machine learning approaches and paradigms. |

**References:**

1. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer 2009 (freely available online)
3. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.

| **Course Code** | |
|---|---|
| **Course Name** | Data Visualisation |
| **Credits** | 3 |
| **Pre-Requisites** | Computer Graphics, Image Processing |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • familiarize students with the basic and advanced techniques of information visualization and scientific visualization, |
| • to learn key techniques of the visualization process |
| • a detailed view of visual perception, the visualized data and the actual visualization, interaction and distorting techniques |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>Introduction of visual perception, visual representation of data, Gestalt principles, information overloads. | 8 |
| **Unit 2:**<br>Creating visual representations, visualization reference model, visual mapping, visual analytics, Design of visualization applications. | 8 |
| **Unit 3**:<br>Classification of visualization systems, Interaction and visualization techniques misleading, Visualization of one, two and multi-dimensional data, text and text documents. | 10 |
| **Unit 4:**<br>Visualization of groups, trees, graphs, clusters, networks, software, Metaphorical visualization | 11 |
| **Unit 5:**<br>Visualization of volumetric data, vector fields, processes and simulations, Visualization of maps, geographic information, GIS systems, collaborative visualizations, Evaluating visualizations | 7 |
| **Unit 6:**<br>Recent trends in various perception techniques, various visualization techniques, data structures used in data visualization. | 4 |

| **COURSE OUTCOMES** |
|---|
| **On completion of the course the student should be able to** |
| • familiar with the design process to develop visualization methods and visualization systems, and methods for their evaluation. |
| • preparation and processing of data, visual mapping and the visualization |
| • have an understanding of large-scale abstract data, |

**References:**

1. WARD, GRINSTEIN, KEIM,.Interactive Data Visualization: Foundations, Techniques, and Applications. Natick : A K Peters, Ltd.
2. E. Tufte, The Visual Display of Quantitative Information, Graphics Press.

| | |
|---|---|
| **Course Code** | 3CS51 |
| **Course Name** | Data Warehousing and Data Mining |
| **Credits** | 3 |
| **Pre-Requisites** | Databases, Probability |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| |
| • The objective of this course is to introduce data warehousing and mining techniques. Application of data mining in web mining, pattern matching and cluster analysis is included to aware students of broad data mining areas. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>Introduction to Data Warehousing; Data Mining: Mining frequent patterns, association and correlations; Sequential Pattern Mining concepts, primitives, scalable methods; | 7 |

| | |
|---|---|
| **Unit 2:**<br>Classification and prediction; Cluster Analysis – Types of Data in Cluster Analysis, Partitioning methods, Hierarchical Methods; Transactional Patterns and other temporal based frequent patterns, | 8 |
| **Unit 3:**<br>Mining Time series Data, Periodicity Analysis for time related sequence data, Trend analysis, Similarity search in Time-series analysis; | 8 |
| **Unit 4:**<br>Mining Data Streams, Methodologies for stream data processing and stream data systems, Frequent pattern mining in stream data, Sequential Pattern Mining in Data Streams, Classification of dynamic data streams, Class Imbalance Problem; Graph Mining; Social Network Analysis; | 11 |
| **Unit 5:**<br>Web Mining, Mining the web page layout structure, mining web link structure, mining multimedia data on the web, Automatic classification of web documents and web usage mining; Distributed Data Mining. | 9 |
| **Unit 6:**<br>Recent trends in Distributed Warehousing and Data Mining, Class Imbalance Problem; Graph Mining; Social Network Analysis | 5 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • Study of different sequential pattern algorithms |
| • Study the technique to extract patterns from time series data and it application in real world. |
| • Can extend the Graph mining algorithms to Web mining |
| • Help in identifying the computing framework for Big Data |

**References:**

1. Jiawei Han and M Kamber, Data Mining Concepts and Techniques,, Second Edition, Elsevier Publication, 2011.
2. Vipin Kumar, Introduction to Data Mining - Pang-Ning Tan, Michael Steinbach, Addison Wesley, 2006.
3. G Dong and J Pei, Sequence Data Mining, Springer, 2007.

| | |
|---|---|
| **Course Code** | |
| **Course Name** | Data Preparation and Analysis |
| **Credits** | 3 |
| **Pre-Requisites** | |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** | |
|---|---|
| • To prepare the data for analysis and develop meaningful Data Visualizations | |
| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
| **Unit1:**<br>**Data Gathering and Preparation:**<br>Data formats, parsing and transformation, Scalability and real-time issues | 9 |

| | |
|---|---|
| **Unit2:**<br>**Data Cleaning:**<br>Consistency checking, Heterogeneous and missing data, Data Transformation and segmentation | 11 |
| **Unit3:**<br>**Exploratory Analysis:**<br>Descriptive and comparative statistics, Clustering and association, Hypothesis generation | 13 |
| **Unit4:**<br>**Visualization:**<br>Designing visualizations, Time series, Geolocated data, Correlations and connections, Hierarchies and networks, interactivity | 15 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • Able to extract the data for performing the Analysis. |

**References:**

1. Making sense of Data : A practical Guide to Exploratory Data Analysis and Data Mining, by Glenn J. Myatt

| | |
|---|---|
| **Course Code** | |
| **Course Name** | Recommender System |
| **Credits**<br>**Prerequisites** | 3 |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • To learn techniques for making recommendations, including non-personalized, content-based, and collaborative filtering<br>• To automate a variety of choice-making strategies with the goal of providing affordable, personal, and high-quality recommendations |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>**Introduction:** Overview of Information Retrieval, Retrieval Models, Search and Filtering Techniques: Relevance Feedback, User Profiles, Recommender system functions, Matrix operations, covariance matrices, Understanding ratings, Applications of recommendation systems, Issues with recommender system. | 9 |
| **Unit 2:**<br>**Content-based Filtering:** High level architecture of content-based systems, Advantages and drawbacks of content based filtering, Item profiles, Discovering features of documents, pre-processing and feature extraction, Obtaining item features from tags, Methods for learning user profiles, Similarity based retrieval, Classification algorithms. | 8 |
| **Unit 3:**<br>**Collaborative Filtering:** User-based recommendation, Item-based recommendation, Model based approaches, Matrix factorization, Attacks on collaborative recommender systems. | 9 |

| | |
|---|---|
| **Unit 4:**<br>**Hybrid approaches:** Opportunities for hybridization, Monolithic hybridization design: Feature combination, Feature augmentation, Parallelized hybridization design: Weighted, Switching, Mixed, Pipelined hybridization design: Cascade Meta-level, Limitations of hybridization strategies | 8 |
| **Unit 5:**<br>**Evaluating Recommender System:** Introduction, General properties of evaluation research, Evaluation designs: Accuracy, Coverage, confidence, novelty, diversity, scalability, serendipity, Evaluation on historical datasets, Offline evaluations. | 6 |
| **Unit 6:**<br>**Types of Recommender Systems:** Recommender systems in personalized web search, knowledge-based recommender system, Social tagging recommender systems, Trust-centric recommendations, Group recommender systems. | 8 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be able to:** |
| • Design recommendation system for a particular application domain.<br>• Evaluate recommender systems on the basis of metrics such as accuracy, rank accuracy, diversity, product coverage, and serendipity |

**References:**


1. Jannach D., Zanker M. and FelFering A., Recommender Systems: An Introduction, Cambridge University Press (2011), 1st ed.
2. Charu C. Aggarwal, Recommender Systems: The Textbook, Springer (2016), 1st ed.
3. Ricci F., Rokach L., Shapira D., Kantor B.P., Recommender Systems Handbook, Springer(2011), 1st ed.
4. Manouselis N., Drachsler H., Verbert K., Duval E., Recommender Systems For Learning, Springer (2013), 1st ed.


| | |
|---|---|
| **Course Code** | |
| **Course Name** | Data Storage Technologies and Networks |
| **Credits** | 3 |
| **Pre-Requisites** | Basic knowledge of Computer Architecture, Operating Systems, and Computer Networking is required. |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • to provide learners with a basic understanding of Enterprise Data Storage and Management Technologies |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>**Storage Media and Technologies** – Magnetic, Optical and Semiconductor Media, Techniques for read/write Operations, Issues and Limitations. | 8 |
| **Unit 2:**<br>**Usage and Access** – Positioning in the Memory Hierarchy, Hardware and Software Design for Access, Performance issues. | 9 |
| **Unit 3:**<br>**Large Storages** – Hard Disks, Networked Attached Storage, Scalability issues, | 7 |

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|---|---|
| Networking issues. | |
| **Unit 4:**<br>**Storage Architecture** - Storage Partitioning, Storage System Design, Caching, Legacy Systems. | 9 |
| **Unit 5:**<br>**Storage Area Networks** – Hardware and Software Components, Storage Clusters/Grids.<br>**Storage QoS**–Performance, Reliability, and Security issues. | 10 |
| **Unit 6**:<br>Recent Trends related to Copy data management, Erasure coding, and Software-defined storage appliances. | 5 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • Learn Storage System Architecture |
| • Overview of Virtualization Technologies, Storage Area Network |

References:

1. The Complete Guide to Data Storage Technologies for Network-centric ComputingPaperback–Import, Mar 1998 by Computer Technology Research Corporation
2. Data Storage Networking: Real World Skills for the CompTIA Storage by Nigel Poulton

| | |
|---|---|
| **Course Code** | |
| **Course Name** | Data Security and Access Control |
| **Credits** | 3 |
| **Pre-Requisites** | Database Management |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • The objective of the course is to provide fundamentals of database security. Various access control techniques mechanisms were introduced along with application areas of access control techniques. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit1:**<br>Introduction to Access Control, Purpose and fundamentals of access control, brief history, Policies of Access Control, Models of Access Control, and Mechanisms, Discretionary Access Control (DAC), Non- Discretionary Access Control, Mandatory Access Control (MAC). Capabilities and Limitations of Access Control Mechanisms: Access Control List (ACL) and Limitations, Capability List and Limitations. | 9 |
| **Unit 2:**<br>Role-Based Access Control (RBAC) and Limitations, Core RBAC, Hierarchical RBAC, Statically Constrained RBAC, Dynamically Constrained RBAC, Limitations of RBAC. Comparing RBAC to DAC and MAC Access control policy. | 8 |
| **Unit 3:**<br>Biba'sintrigity model, Clark-Wilson model, Domain type enforcement model, mapping the enterprise view to the system view, Role hierarchies- inheritance schemes, hierarchy structures and inheritance forms, using SoD in real system Temporal Constraints in RBAC, MAC AND DAC.<br>Integrating RBAC with enterprise IT infrastructures: RBAC for WFMSs, RBAC for UNIX and JAVA environments Case study: Multi line Insurance Company | 10 |
| **Unit 4:**<br>Smart Card based Information Security, Smart card operating system-fundamentals, design and implantation principles, memory organization, smart | 10 |

| | |
|---|---|
| card files, file management, atomic operation, smart card data transmission ATR, PPS Security techniques- user identification, smart card security, quality assurance and testing, smart card life cycle-5 phases, smart card terminals. | |
| **Unit 5:**<br>Recent trends in Database security and access control mechanisms. Case study of Role-Based Access Control (RBAC) systems. | 7 |
| **Unit 6**:<br>Recent Trends related to data security management, vulnerabilities in different DBMS. | 4 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • In this course, the students will be enabled to understand and implement classical models and algorithms |
| • They will learn how to analyse the data, identify the problems, and choose the relevant models and algorithms to apply. |
| • They will further be able to assess the strengths and weaknesses of various access control models and to analyse their behaviour. |

**References:**

1. Role Based Access Control: David F. Ferraiolo, D. Richard Kuhn, RamaswamyChandramouli.
2. http://www.smartcard.co.uk/tutorials/sct-itsc.pdf : Smart Card Tutorial.

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|---|---|
| **Course Code** | |
| **Course Name** | Web Analytics and Development |
| **Credits** | 3 |
| **Pre-Requisites** | |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • The course explores use of social network analysis to understand growing connectivity and complexity in the world ranging from small groups to WWW. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>**Introduction** – Social network and Web data and methods, Graph and Matrices, Basic measures for individuals and networks, Information Visualization | 10 |
| **Unit 2:**<br>**Web Analytics tools:** Click Stream Analysis, A/B testing, Online Surveys | 8 |
| **Unit 3:**<br>**Web Search and Retrieval:** Search Engine Optimization, Web Crawling and indexing, Ranking Algorithms, Web traffic models | 9 |
| **Unit 4:**<br>**Making Connection**: Link Analysis, Random Graphs and Network evolution, Social Connects: Affiliation and identity | 12 |
| **Unit 5:**<br>**Connection:**<br>Connection Search, Collapse, Robustness Social involvements and diffusion of innovation | 9 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be:** |
| • Become familiar with core research communities, publications, focused on web and social media analytics and research questions engaged in |

**References:**


1. Hansen, Derek, Ben Sheiderman, Marc Smith. 2011. Analyzing Social Media Networks with NodeXL: Insights from a Connected World. Morgan Kaufmann, 304.
2. Avinash Kaushik. 2009. Web Analytics 2.0: The Art of Online Accountability.
3. Easley, D. & Kleinberg, J. (2010). Networks, Crowds, and Markets: Reasoning About a Highly Connected World. New York: Cambridge University Press. http://www.cs.cornell.edu/home/kleinber/networks-book/
4. Wasserman, S. & Faust, K. (1994). Social network analysis: Methods and applications. New York: Cambridge University Press. Monge, P. R. & Contractor, N. S. (2003). Theories of communication networks. New York: Oxford University Press.


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|---|---|
| **Course Code** | |
| **Course Name** | GPU Computing |
| **Credits** | 3 |
| **Pre-Requisites** | |

Total Number of Lectures: 48

| COURSE OBJECTIVE |
|---|
| • To learn parallel programming with Graphics Processing Units (GPUs). |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1:**<br>**Introduction**: History, Graphics Processors, Graphics Processing Units, GPGPUs. Clock speeds, CPU / GPU comparisons, Heterogeneity, Accelerators, Parallel programming, CUDA OpenCL / OpenACC,<br>Hello World Computation Kernels, Launch parameters, Thread hierarchy, Warps / Wavefronts, Thread blocks / Workgroups, Streaming multiprocessors, 1D / 2D / 3D thread mapping, Device properties, Simple Programs | 13 |
| **Unit 2:**<br>**Memory**: Memory hierarchy, DRAM / global, local / shared, private / local, textures, Constant Memory, Pointers, Parameter Passing, Arrays and dynamic Memory, Multi-dimensional Arrays, Memory Allocation, Memory copying across devices, Programs with matrices, Performance evaluation with different memories | 7 |
| **Unit 3:**<br>**Synchronization**: Memory Consistency, Barriers (local versus global), Atomics, Memory fence. Prefix sum, Reduction. Programs for concurrent Data Structures such as Worklists, Linked-lists. Synchronization across CPU and GPU<br>**Functions**: Device functions, Host functions, Kernels functions, Using libraries (such as Thrust), and developing libraries. | 10 |
| **Unit 4:**<br>**Support**: Debugging GPU Programs. Profiling, Profile tools, Performance aspects<br>**Streams**: Asynchronous processing, tasks, Task-dependence, Overlapped data transfers, Default Stream, Synchronization with streams. Events, Event-based- | 8 |

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|---|---|
| Synchronization - Overlapping data transfer and kernel execution, pitfalls. | |
| **Unit 5:**<br>**Case Studies**: Image Processing, Graph algorithms, Simulations, Deep Learning | 5 |
| **Unit 6:**<br>**Advanced topics**: Dynamic parallelism, Unified Virtual Memory, Multi-GPU processing, Peer access, Heterogeneous processing | 5 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • Students would learn concepts in parallel programming, implementation of programs on GPUs, debugging and profiling parallel programs. |

References:


1. Programming Massively Parallel Processors: A Hands-on Approach; David Kirk, Wen-meiHwu; Morgan Kaufman; 2010 (ISBN: 978-0123814722)
2. CUDA Programming: A Developer's Guide to Parallel Computing with GPUs; Shane Cook; Morgan Kaufman; 2012 (ISBN: 978-0124159334)


| **Course Code** | |
|---|---|
| **Course Name** | Knowledge Discovery |
| **Credits**<br>**Prerequisites** | 3<br>Data structures, Basic Statistics |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • Conduct case studies on real data mining examples |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>**Introduction KDD and Data Mining -** Data Mining and Machine Learning, Machine Learning and Statistics, Generalization as Search,Data Mining and Ethics | 7 |
| **Unit 2:**<br>**Knowledge Representation** - Decision Tables, Decision Trees, Classification Rules, Association Rules, Rules involving Relations, Trees for Numeric Predictions, Neural Networks, Clusters | 10 |
| **Unit 3:**<br>**Decision Trees** - Divide and Conquer, Calculating Information, Entropy, Pruning, Estimating Error Rates, The C4.5 Algorithm<br>**Evaluation of Learned Results**- Training and Testing, Predicting Performance, Cross-Validation | 9 |
| **Unit 4:**<br>**Classification Rules** - Inferring Rudimentary Rules, Covering Algorithms for Rule Construction, Probability Measure for Rule Evaluation, Association Rules, Item Sets, Rule Efficiency | 8 |
| **Unit 5:**<br>**Numeric Predictions** - Linear Models for Classification and Numeric Predictions, Numeric Predictions with Regression Trees, Evaluating Numeric Predictions | 7 |

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|---|---|
| **Unit 6:**<br>**Artificial Neural Networks** – Perceptrons, Multilayer Networks, The Backpropagation Algorithm<br>**Clustering** - Iterative Distance-based Clustering, Incremental Clustering, The EM Algorithm | 7 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • Able to have knowledge of various knowledge representation methods. |

References:

1. Data mining and knowledge discovery handbook by Maimon, oded(et al.)
2. Data Cleansing : A Prelude to knowledge Discovery

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|---|---|
| **Course Code** | |
| **Course Name** | Distributed Systems |
| **Credits** | 3 |
| **Pre-Requisites** | Database Management Systems |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • To introduce the fundamental concepts and issues of managing large volume of shared data in a parallel and distributed environment, and to provide insight into related research problems. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>**INTRODUCTION**<br>Distributed data processing; What is a DDBS; Advantages and disadvantages of DDBS; Problem areas; Overview of database and computer network concepts<br>**DISTRIBUTED DATABASE MANAGEMENT SYSTEM ARCHITECTURE** Transparencies in a distributed DBMS; Distributed DBMS architecture; Global directory issues | 8 |
| **Unit 2:**<br>**DISTRIBUTED DATABASE DESIGN**<br>Alternative design strategies; Distributed design issues; Fragmentation; Data allocation<br>**SEMANTICS DATA CONTROL**<br>View management; Data security; Semantic Integrity Control<br>**QUERY PROCESSING ISSUES**<br>Objectives of query processing; Characterization of query processors; Layers of query processing; Query decomposition; Localization of distributed data | 11 |
| **Unit 3:**<br>**DISTRIBUTED QUERY OPTIMIZATION**<br>Factors governing query optimization; Centralized query optimization; Ordering of fragment queries; Distributed query optimization algorithms<br>**TRANSACTION MANAGEMENT**<br>The transaction concept; Goals of transaction management; Characteristics of transactions; Taxonomy of transaction models<br>**CONCURRENCY CONTROL**<br>Concurrency control in centralized database systems; Concurrency control in DDBSs; Distributed concurrency control algorithms; Deadlock management | 11 |
| **Unit 4:** | 8 |

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|---|---|
| **RELIABILITY**<br>Reliability issues in DDBSs; Types of failures; Reliability techniques; Commit protocols; Recovery protocols | |
| **Unit 5:**<br>**PARALLEL DATABASE SYSTEMS**<br>Parallel architectures; parallel query processing and optimization; load balancing | 6 |
| **Unit 6:**<br>**ADVANCED TOPICS**<br>Mobile Databases, Distributed Object Management, Multi-databases | 4 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • Design trends in distributed systems. |
| • Apply network virtualization. |
| • Apply remote method invocation and objects. |

**References:**

1. Principles of Distributed Database Systems, M.T. Ozsu and P. Valduriez, Prentice-Hall, 1991.
2. Distributed Database Systems, D. Bell and J. Grimson, Addison-Wesley, 1992.

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|---|---|
| **Course Code** | |
| **Course Name** | Cloud Computing |
| **Credits** | 3 |
| **Pre-Requisites** | |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • The student will also learn how to apply trust-based security model to real-world security problems. |
| • An overview of the concepts, processes, and best practices needed to successfully secure information within Cloud infrastructures. |
| • Students will learn the basic Cloud types and delivery models and develop an understanding of the risk and compliance responsibilities and Challenges for each Cloud type and service delivery model. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>**Introduction to Cloud Computing**<br>Online Social Networks and Applications, Cloud introduction and overview, Different clouds, Risks, Novel applications of cloud computing | 4 |
| **Unit 2:**<br>**Cloud Computing Architecture**<br>Requirements, Introduction Cloud computing architecture, On Demand Computing Virtualization at the infrastructure level, Security in Cloud computing environments, CPU Virtualization, A discussion on Hypervisors Storage Virtualization Cloud Computing Defined, The SPI Framework for Cloud Computing, The Traditional Software Model, The Cloud Services Delivery Model<br>**Cloud Deployment Models**<br>Key Drivers to Adopting the Cloud, The Impact of Cloud Computing on Users, Governance in the Cloud, Barriers to Cloud Computing Adoption in the Enterprise | 11 |

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|---|---|
| **Unit 3:**<br>**Security Issues in Cloud Computing**<br>Infrastructure Security, Infrastructure Security: The Network Level, The Host Level, The Application Level, Data Security and Storage, Aspects of Data Security, Data Security Mitigation Provider Data and Its Security<br>**Identity and Access Management**<br>Trust Boundaries and IAM, IAM Challenges, Relevant IAM Standards and Protocols for Cloud Services, IAM Practices in the Cloud, Cloud Authorization Management | 10 |
| **Unit 4:**<br>**Security Management in the Cloud**<br>Security Management Standards, Security Management in the Cloud, Availability Management: SaaS, PaaS, IaaS<br>**Privacy Issues**<br>Privacy Issues, Data Life Cycle, Key Privacy Concerns in the Cloud, Protecting Privacy, Changes to Privacy Risk Management and Compliance in Relation to Cloud Computing, Legal and Regulatory Implications, U.S. Laws and Regulations, International Laws and Regulations | 11 |
| **Unit 5:**<br>**Audit and Compliance**<br>Internal Policy Compliance, Governance, Risk, and Compliance (GRC), Regulatory/External Compliance, Cloud Security Alliance, Auditing the Cloud for Compliance, Security-as-a-Cloud | 8 |
| **Unit 6:**<br>**ADVANCED TOPICS**<br>Recent devlopments in hybrid cloud and cloud security. | 4 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be able to:** |
| • Identify security aspects of each cloud model |
| • Develop a risk-management strategy for moving to the Cloud |
| • Implement a public cloud instance using a public cloud service provider |
| • Apply trust-based security model to different layer |

**References:**


1. Cloud Computing Explained: Implementation Handbook for Enterprises, John Rhoton, Publication Date: November 2, 2009
2. Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance (Theory in Practice), Tim Mather, ISBN-10: 0596802765,O'Reilly Media, September 2009


| | |
|---|---|
| **Course Code** | |
| **Course Name** | Business Analytics |
| **Credits** | 3 |
| **Prerequisites** | |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • The main objective of this course is to give the student a comprehensive understanding of business analytics methods. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|

| | |
|---|---|
| **Unit 1:**<br>Business Analysis: Overview of Business Analysis, Overview of Requirements, Role of the Business Analyst.<br>Stakeholders: the project team, management, and the front line, Handling Stakeholder Conflicts. | 7 |
| **Unit 2:**<br>Life Cycles: Systems Development Life Cycles, Project Life Cycles, Product Life Cycles, Requirement Life Cycles. | 8 |
| **Unit 3:**<br>Forming Requirements: Overview of Requirements, Attributes of Good Requirements, Types of Requirements, Requirement Sources, Gathering Requirements from Stakeholders, Common Requirements Documents. | 9 |
| **Unit 4:**<br>Transforming Requirements: Stakeholder Needs Analysis, Decomposition Analysis, Additive/Subtractive Analysis, Gap Analysis, Notations (UML & BPMN), Flowcharts, Swim Lane Flowcharts, Entity-Relationship Diagrams, State-Transition Diagrams, Data Flow Diagrams, Use Case Modeling, Business Process Modeling | 10 |
| **Unit 5:**<br>Finalizing Requirements: Presenting Requirements, Socializing Requirements and Gaining Acceptance, Prioritizing Requirements.<br>Managing Requirements Assets: Change Control, Requirements Tools | 10 |
| **Unit 6**<br>Recent Trands in: Embedded and colleborative business intelligence, Visual data recovery, Data Storytelling and Data Journalism. | 4 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • Able to have knowledge of various business analysis techniques. |

**References:**

1. Business Analysis by James Cadle et al.
2. Project Management: The Managerial Process by Erik Larson and, Clifford Gray

**OPEN ELECTIVES**
**Business Analytics**

**Teaching scheme**

**Lecture:-3 h/week**

| | |
|---|---|
| **Course Code** | |
| **Course Name** | **Business Analytics** |
| **Credits**<br>**Prerequisites** | |

Total Number of Lectures: 48

| **Course objective** |
|---|
| |

1. Understand the role of business analytics within an organization.
2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.
4. To become familiar with processes needed to develop, report, and analyze business data.
5. Use decision-making tools/Operations research techniques.
6. Mange business process using analytical and management tools.
7. Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit1:**<br>Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.<br>Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview. | 9 |
| **Unit 2:**<br>Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.<br>Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology. | 8 |
| **Unit 3:**<br>Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.<br>Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization. | 9 |
| **Unit 4:**<br>Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.<br>Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using | 10 |

| | |
|---|---|
| Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model. | |
| **Unit 5:**<br>Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. | 8 |
| **Unit 6:**<br>Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism. | 4 |

| **COURSE OUTCOMES** | |
|---|---|
| | |

1. Students will demonstrate knowledge of data analytics.
2. Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.
3. Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.
4. Students will demonstrate the ability to translate data into clear, actionable insights.

**Reference:**

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

## OPEN ELECTIVES
## Industrial Safety

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**Unit-II:** Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**Unit-III:** Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**Unit-IV:** Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**Unit-V:** Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

**Reference:**


1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.


## OPEN ELECTIVES

## Operations Research

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes: At the end of the course,** the student should be able to

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

**Syllabus Contents:**

**Unit 1:**

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

**Unit 2**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

**Unit 3:**

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

**Unit 4**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

**Unit 5**

Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

**References:**

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

## Open Elective
## Cost Management of Engineering Projects

**Teaching scheme**

**Lecture: - 3 h/week**

Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

**References:**

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

## Open Elective

## Composite Materials

**Teaching scheme**

**Lecture: - 3 h/week**

**UNIT–I**: INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT – II**: REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT – III:** Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT–IV:** Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT – V:** Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

**TEXT BOOKS:**

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

**References:**

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

## Open Elective

## Waste to Energy

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**Unit-II:** Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**Unit-III:** Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**Unit-IV:** Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**Unit-V:** Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

**References:**

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

### AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING

**Course objectives:**

Students will be able to:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title

Ensure the good quality of paper at very first-time submission

**Syllabus**

| Units | CONTENTS | Hours |
|---|---|---|
| 1 | Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness | 4 |
| 2 | Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction | 4 |
| 3 | Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check. | 4 |
| 4 | key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, | 4 |
| 5 | skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions | 4 |
| 6 | useful phrases, how to ensure paper is as good as it could possibly be the first- time submission | 4 |

**Suggested Studies:**

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)

2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook.
4. Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

**AUDIT 1 and 2: DISASTER MANAGEMENT**

**Course Objectives: -**Students will be able to:
1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in

**Syllabus**

| **Units** | **CONTENTS** | **Hours** |
|---|---|---|
| 1 | **Introduction**<br>Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude. | 4 |
| 2 | **Repercussions Of Disasters And Hazards**: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.<br>Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts. | 4 |
| 3 | **Disaster Prone Areas In India**<br>Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics | 4 |
| 4 | **Disaster Preparedness And Management**<br>Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness. | 4 |
| 5 | **Risk Assessment**<br>Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival. | 4 |
| 6 | **Disaster Mitigation**<br>Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India. | 4 |

**SUGGESTED READINGS:**

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.

2. Sahni, PardeepEt.Al. (Eds.),” Disaster Mitigation Experiences And Reflections”, Prentice Hall Of India, New Delhi.
3. Goel S. L., Disaster Administration And Management Text And Case Studies”,Deep &Deep Publication Pvt. Ltd., New Delhi.

## AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE

***Course Objectives***

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects
4. enhancing the memory power
5. The engineering scholars equipped with Sanskrit will be able to explore the
6. huge knowledge from ancient literature

***Syllabus***

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Alphabets in Sanskrit,<br>• Past/Present/Future Tense,<br>• Simple Sentences | 8 |
| 2 | • Order<br>• Introduction of roots<br>• Technical information about Sanskrit Literature | 8 |
| 3 | • Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics | 8 |

***Suggested reading***

1. “Abhyaspustakam” – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. “Teach Yourself Sanskrit” Prathama Deeksha-VempatiKutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. “India’s Glorious Scientific Tradition” Suresh Soni, Ocean books (P) Ltd., New Delhi.

***Course Output***

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

## AUDIT 1 and 2: VALUE EDUCATION

***Course Objectives***

Students will be able to

1. Understand value of education and self- development
2. Imbibe good values in students
3. Let the should know about the importance of character

***Syllabus***

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism. | 4 |

| | | |
|---|---|---|
| | • Moral and non- moral valuation. Standards and principles.<br>• Value judgements | |
| 2 | • Importance of cultivation of values.<br>• Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness.<br>• Honesty, Humanity. Power of faith, National Unity.<br>• Patriotism.Love for nature,Discipline | 6 |
| 3 | • Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline.<br>• Punctuality, Love and Kindness.<br>• Avoid fault Thinking.<br>• Free from anger, Dignity of labour.<br>• Universal brotherhood and religious tolerance.<br>• True friendship.<br>• Happiness Vs suffering, love for truth.<br>• Aware of self-destructive habits.<br>• Association and Cooperation.<br>• Doing best for saving nature | 6 |
| 4 | • Character and Competence –Holy books vs Blind faith.<br>• Self-management and Good health.<br>• Science of reincarnation.<br>• Equality, Nonviolence,Humility, Role of Women.<br>• All religions and same message.<br>• Mind your Mind, Self-control.<br>• Honesty, Studying effectively | 6 |

***Suggested reading***

1. Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

***Course outcomes***

Students will be able to

1. Knowledge of self-development
2. Learn the importance of Human values
3. Developing the overall personality

**AUDIT 1 and 2: CONSTITUTION OF INDIA**

**Course Objectives:**

Students will be able to:

1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

**Syllabus**

| Units | Content | Hours |
|---|---|---|

| | | |
|---|---|---|
| **1** | • **History of Making of the Indian Constitution:**<br>History<br>Drafting Committee, ( Composition & Working) | 4 |
| **2** | • **Philosophy of the Indian Constitution:**<br>Preamble<br>Salient Features | 4 |
| **3** | • **Contours of Constitutional Rights & Duties:**<br>• Fundamental Rights<br>• Right to Equality<br>• Right to Freedom<br>• Right against Exploitation<br>• Right to Freedom of Religion<br>• Cultural and Educational Rights<br>• Right to Constitutional Remedies<br>• Directive Principles of State Policy<br>• Fundamental Duties. | 4 |
| **4** | • **Organs of Governance:**<br>• Parliament<br>• Composition<br>• Qualifications and Disqualifications<br>• Powers and Functions<br>• Executive<br>• President<br>• Governor<br>• Council of Ministers<br>• Judiciary, Appointment and Transfer of Judges, Qualifications<br>• Powers and Functions | 4 |
| **5** | • **Local Administration:**<br>• District's Administration head: Role and Importance,<br>• Municipalities: Introduction, Mayor and role of Elected Representative CEO of Municipal Corporation.<br>• Pachayati raj: Introduction, PRI: ZilaPachayat.<br>• Elected officials and their roles, CEO ZilaPachayat: Position and role.<br>• Block level: Organizational Hierarchy (Different departments),<br>• Village level: Role of Elected and Appointed officials,<br>• Importance of grass root democracy | 4 |
| **6** | • **Election Commission:**<br>• Election Commission: Role and Functioning.<br>• Chief Election Commissioner and Election Commissioners.<br>• State Election Commission: Role and Functioning.<br>• Institute and Bodies for the welfare of SC/ST/OBC and women. | 4 |

**Suggested reading**

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.

4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

**Course Outcomes:**

**Students will be able to:**

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

AUDIT 1 and 2: PEDAGOGY STUDIES

**Course Objectives:**

Students will be able to:

4. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
5. Identify critical evidence gaps to guide the development.

| Syllabus | | |
|---|---|---|
| **Units** | **Content** | **Hours** |
| **1** | • **Introduction and Methodology:**<br>• Aims and rationale, Policy background, Conceptual framework and terminology<br>• Theories of learning, Curriculum, Teacher education.<br>• Conceptual framework, Research questions.<br>• Overview of methodology and Searching. | 4 |
| **2** | • Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.<br>• Curriculum, Teacher education. | 2 |
| **3** | • Evidence on the effectiveness of pedagogical practices<br>• Methodology for the in depth stage: quality assessment of included studies.<br>• How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?<br>• Theory of change.<br>• Strength and nature of the body of evidence for effective pedagogical practices.<br>• Pedagogic theory and pedagogical approaches.<br>• Teachers' attitudes and beliefs and Pedagogic strategies. | 4 |
| **4** | • Professional development: alignment with classroom practices and follow-up support<br>• Peer support<br>• Support from the head teacher and the community.<br>• Curriculum and assessment<br>• Barriers to learning: limited resources and large class sizes | 4 |
| **5** | • **Research gaps and future directions**<br>• Research design<br>• Contexts | 2 |

| | | |
|---|---|---|
| | • Pedagogy<br>• Teacher education<br>• Curriculum and assessment<br>• Dissemination and research impact. | |

**Suggested reading**


1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.


**Course Outcomes**

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

## AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

**Course Objectives**

1. To achieve overall health of body and mind
2. To overcome stress

*Syllabus*

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Definitions of Eight parts of yog. ( Ashtanga ) | 8 |
| 2 | • Yam and Niyam.<br>Do`s and Don't's in life.<br>i) Ahinsa, satya, astheya, bramhacharya and aparigraha<br>ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan | 8 |
| 3 | • Asan and Pranayam<br>i) Various yog poses and their benefits for mind & body<br>ii)Regularization of breathing techniques and its effects-Types of pranayam | 8 |

***Suggested reading***


1. 'Yogic Asanas for Group Tarining-Part-I" :Janardan Swami Yogabhyasi Mandal, Nagpur

2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, AdvaitaAshrama (Publication Department), Kolkata

**Course Outcomes:**

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

**AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS**

***Course Objectives***

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

***Syllabus***

| Unit | Content | Hours |
|---|---|---|
| 1 | Neetisatakam-Holistic development of personality<br>• Verses- 19,20,21,22 (wisdom)<br>• Verses- 29,31,32 (pride & heroism)<br>• Verses- 26,28,63,65 (virtue)<br>• Verses- 52,53,59 (dont's)<br>• Verses- 71,73,75,78 (do's) | 8 |
| 2 | • Approach to day to day work and duties.<br>• Shrimad BhagwadGeeta : Chapter 2-Verses 41, 47,48,<br>• Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,<br>• Chapter 18-Verses 45, 46, 48. | 8 |
| 3 | • Statements of basic knowledge.<br>• Shrimad BhagwadGeeta: Chapter2-Verses 56, 62, 68<br>• Chapter 12 -Verses 13, 14, 15, 16,17, 18<br>• Personality of Role model. Shrimad BhagwadGeeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42,<br>• Chapter 4-Verses 18, 38,39<br>• Chapter18 – Verses 37,38,63 | 8 |

***Suggested reading***

1. "Srimad Bhagavad Gita" by Swami SwarupanandaAdvaita Ashram (Publication
2. Department), Kolkata
3. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath,
4. Rashtriya Sanskrit Sansthanam, New Delhi.

***Course Outcomes***

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

## Course Scheme for M.Tech. Computer Science and Engineering Specialization: Information Security

**M.Tech Sem-I.**

| Course Number | Subject | Scheme Of Studies Per Week | | | Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| 1CS01 | Program Core I-<br>Mathematical foundations of Computer Science | 3 | 0 | 0 | 3 |
| 1CS02 | Program Core II-<br>Advanced Data Structures | 3 | 0 | 0 | 3 |
| 1CSxx | Program Elective I-<br>Digital Forensics/ Ethical Hacking/ Intrusion Detection | 3 | 0 | 0 | 3 |
| 1CSxx | Program Elective II-<br>Malware Analysis & Reverse Engineering/ Secure Software Design and Enterprise Computing/ Machine Learning | 3 | 0 | 0 | 3 |
| 1Axxx | Research Methodology & IPR | 2 | 0 | 0 | 2 |
| 1Axxx | Audit Course | 2 | 0 | 0 | 0 |
| 1CS03 | Laboratory 1 (Advanced Data Structures) | 0 | 0 | 4 | 2 |
| 1CS04 | Laboratory 2 (Based on Electives) | 0 | 0 | 4 | 2 |
| | Total Credits: | 18 | | | |

**M.Tech Sem- II**

| Course Number | Subject | Scheme Of Studies Per Week | | | Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| 2CS05 | Program Core III –<br>Advance Algorithms | 3 | 0 | 0 | 3 |
| 2CS06 | Program Core IV –<br>Soft Computing | 3 | 0 | 0 | 3 |
| 2CSxx | Program Elective III –<br>Data Encryption & Compression/ Steganography & Digital Watermarking/ Information Theory & Coding | 3 | 0 | 0 | 3 |
| 2CSxx | Program Elective IV –<br>Security Assessment and Risk Analysis/ Secure Coding/ Biometrics | 3 | 0 | 0 | 3 |
| 2Axxx | Audit Course | 2 | 0 | 0 | 0 |

| | | | | | |
|---|---|---|---|---|---|
| 2CS07 | Laboratory 3 (Based on cores) | 0 | 0 | 4 | 2 |
| 2CS08 | Laboratory 4 (Based on Electives) | 0 | 0 | 4 | 2 |
| 2CS09 | Mini Project with Seminar | 2 | 0 | 0 | 2 |
| Total Credits: 18 | | | | | |

***Students be encouraged to go to Industrial Training/Internship for at least 2-3 months during semester break.**

**M.Tech III Sem***

| Course No. | Subject | Scheme of Studies Periods Per Week | | | Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| 3CSxx | Program Elective IV –<br>Data Warehousing & Mining/ Web Search & Information Retrieval/ Database Security and Access Control | 3 | 0 | 0 | 03 |
| 3CSxx | Open Elective –<br>1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy | 3 | 0 | 0 | 03 |
| 3CS10 | Dissertation-I /Industrial Project | 0 | 0 | 20 | 10 |
| Total Credits 16 | | | | | |

*Students going for Industrial Project/Thesis will complete these courses through MOOCs.

**M.Tech Sem-IV**

| | Subject | Scheme of Studies Per Week | | | Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| | Dissertation II | 0 | 0 | 32 | 16 |
| Total Credits: 16 | | | | | |

The program offers several elective courses, focusing on different aspects of Information Security. A student can choose to do any course from given program elective set.

**Program Outcomes of CSE (M.Tech.) program:**

The main outcomes of the CSE (M.Tech.) program are given here. At the end of the program a student is expected to have:

1. An understanding of the theoretical foundations and the limits of computing.
2. An ability to adapt existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.

3. An ability to design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
4. Understanding and ability to use advanced computing techniques and tools.
5. An ability to undertake original research at the cutting edge of computer science & its related areas.
6. An ability to function effectively individually or as a part of a team to accomplish a stated goal.
7. An understanding of professional and ethical responsibility.
8. An ability to communicate effectively with a wide range of audience.
9. An ability to learn independently and engage in life¬long learning.
10. An understanding of the impact of IT related solutions in an economic, social and environment context

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

**Syllabus, course objective and course outcomes for various post graduation courses.**

**Core Subjects:**

| | |
|---|---|
| **Course Code** | 1CS01 |
| **Course Name** | Mathematical Foundation of Computer Science |
| **Credits** | 3 |
| **Pre-Requisites** | Discrete Mathematics |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • To understand the mathematical fundamentals that is prerequisites for avariety of courses like Data mining, Network protocols, analysis of Web traffic, Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning. |
| • To developthe understanding ofthe mathematical and logical basis to many modern techniques in information technology like machine learning, programming language design, and concurrency. |
| • To study various sampling and classification problems. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1**<br>Probability mass, density, and cumulative distribution functions, Parametric families of distributions, Expected value, variance, conditional expectation, Applications of the univariate and multivariate Central Limit Theorem, Probabilistic inequalities, Markov chains | 7 |

| | |
|---|---|
| **Unit 2**<br>Random samples, sampling distributions of estimators**,** Methods of Moments and Maximum Likelihood**,** | 7 |
| **Unit 3**<br>Statistical inference**,** Introduction to multivariate statistical models: regression and classification problems, principal components analysis**,** The problem of overfitting model assessment. | 8 |
| **Unit 4**<br>Graph Theory: Isomorphism, Planar graphs, graph colouring, hamilton circuits and euler cycles.<br>Permutations and Combinations with and without repetition.<br>Specialized techniques to solve combinatorial enumeration problems | 11 |
| **Unit 5**<br>**Computer science and engineering applications**<br>Data mining, Network protocols, analysis of Web traffic, Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning. | 10 |
| **Unit 6**<br>Recent Trands in various distribution functions in mathmatical field of computer science for varying fields like bioinformatic, soft computing, and computer vision. | 5 |

| **COURSE OUTCOMES** |
|---|
| After completion of course, students would be able to: |
| • To understand the basic notions of discrete and continuous probability. |
| • To understand the methods of statistical inference, and the role that sampling distributions play in those methods. |
| • To be able to perform correct and meaningful statistical analyses of simple to moderate complexity. |

**References:**

1. John Vince, Foundation Mathematics for Computer Science, Springer.
2. K. Trivedi.Probability and Statistics with Reliability, Queuing, and Computer Science Applications. Wiley.
3. M. Mitzenmacher and E. Upfal.Probability and Computing: Randomized Algorithms and Probabilistic Analysis.
4. Alan Tucker, Applied Combinatorics, Wiley

| | |
|---|---|
| **Course Code** | 1CS02 |
| **Course Name** | Advanced Data Structures |
| **Credits** | 3 |
| **Pre-Requisites** | UG level course in Data Structures |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • The student should be able to choose appropriate data structures, understand the ADT/libraries, and use it to design algorithms for a specific problem. |
| • Students should be able to understand the necessary mathematical abstraction to solve problems. |
| • To familiarize students with advanced paradigms and data structure used to solve algorithmic problems. |
| • Student should be able to come up with analysis of efficiency and proofs of correctness. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1**<br>**Dictionaries:** Definition, Dictionary Abstract Data Type, Implementation of Dictionaries.<br>**Hashing:** Review of Hashing, Hash Function, Collision Resolution Techniques in Hashing, Separate Chaining, Open Addressing, Linear Probing, Quadratic Probing, Double Hashing, Rehashing, Extendible Hashing. | 7 |
| **Unit 2**<br>**Skip Lists:** Need for Randomizing Data Structures and Algorithms, Search and Update Operations on Skip Lists, Probabilistic Analysis of Skip Lists, Deterministic Skip Lists | 5 |
| **Unit 3**<br>**Trees:** Binary Search Trees, AVL Trees, Red Black Trees, 2-3 Trees, B-Trees, Splay Trees | 9 |
| **Unit 4**<br>**Text Processing:** Sting Operations, Brute-Force Pattern Matching, The Boyer-Moore Algorithm, The Knuth-Morris-Pratt Algorithm, Standard Tries, Compressed Tries, Suffix Tries, The Huffman Coding Algorithm, The Longest Common Subsequence Problem (LCS), Applying Dynamic Programming to the LCS Problem. | 12 |
| **Unit 5**<br>**Computational Geometry:** One Dimensional Range Searching, Two Dimensional Range Searching, Constructing a Priority Search Tree, Searching a Priority Search Tree, Priority Range Trees, Quadtrees, k-D Trees. | 10 |
| **Unit 6**<br>Recent Trands in Hashing, Trees, and various computational geometry methods for effeciently solving the new evolving problem | 5 |

| COURSE OUTCOMES |
|---|
| After completion of course, students would be able to: |
| • Understand the implementation of symbol table using hashing techniques. |
| • Develop and analyze algorithms for red-black trees, B-trees and Splay trees. |
| • Develop algorithms for text processing applications. |
| • Identify suitable data structures and develop algorithms for computational geometry problems. |

**References:**


1. Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, 2nd Edition, Pearson, 2004.
2. M T Goodrich, Roberto Tamassia, Algorithm Design, John Wiley, 2002.


| | |
|---|---|
| **Course Code** | 2CS05 |
| **Course Name** | Advanced Algorithms |
| **Credits** | 3 |
| **Pre-Requisites** | UG level course in Algorithm Design and Analysis |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • Introduce students to the advanced methods of designing and analyzing algorithms. |
| • The student should be able to choose appropriate algorithms and use it for a specific problem. |
| • To familiarize students with basic paradigms and data structures used to solve advanced algorithmic problems. |
| • Students should be able to understand different classes of problems concerning their computation difficulties. |
| • To introduce the students to recent developments in the area of algorithmic design. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit1**<br>**Sorting:** Review of various sorting algorithms, topological sorting<br>**Graph:** Definitions and Elementary Algorithms: Shortest path by BFS, shortest path in edge-weighted case (Dijkasra's), depth-first search and computation of strongly connected components, emphasis on correctness proof of the algorithm and time/space analysis, example of amortized analysis. | 6 |
| **Unit 2**<br>**Matroids:** Introduction to greedy paradigm, algorithm to compute a maximum weight maximal independent set. Application to MST.<br>**Graph Matching:** Algorithm to compute maximum matching. Characterization of maximum matching by augmenting paths, Edmond's Blossom algorithm to compute augmenting path. | 8 |
| **Unit 3**<br>**Flow-Networks:** Maxflow-mincut theorem, Ford-Fulkerson Method to compute maximum flow, Edmond-Karp maximum-flow algorithm.<br>**Matrix Computations:** Strassen's algorithm and introduction to divide and conquer paradigm, inverse of a triangular matrix, relation between the time complexities of basic matrix operations, LUP-decomposition. | 9 |
| **Unit 4**<br>**Shortest Path in Graphs:** Floyd-Warshall algorithm and introduction to dynamic programming paradigm. More examples of dynamic programming.<br>**Modulo Representation of integers/polynomials:** Chinese Remainder Theorem, Conversion between base-representation and modulo-representation. Extension to polynomials. Application: Interpolation problem.<br>**Discrete Fourier Transform (DFT):** In complex field, DFT in modulo ring. Fast Fourier Transform algorithm. Schonhage-Strassen Integer Multiplication algorithm | 10 |
| **Unit 5**<br>**Linear Programming:** Geometry of the feasibility region and Simplex algorithm<br>**NP-completeness:** Examples, proof of NP-hardness and NP-completeness.<br>**One or more of the following topics based on time and interest**<br>Approximation algorithms, Randomized Algorithms, Interior Point Method, Advanced Number Theoretic Algorithm | 10 |
| **Unit 6**<br>Recent Trands in problem solving paradigms using recent searching and sorting techniques by applying recently proposed data structures. | 5 |

| COURSE OUTCOMES |
| --- |
| After completion of course, students would be able to: |
| • Analyze the complexity/performance of different algorithms. |
| • Determine the appropriate data structure for solving a particular set of problems. |
| • Categorize the different problems in various classes according to their complexity. |
| • Students should have an insight of recent activities in the field of the advanced data structure. |

**References:**

1. "Introduction to Algorithms" by Cormen, Leiserson, Rivest, Stein.
2. "The Design and Analysis of Computer Algorithms" by Aho, Hopcroft, Ullman.
3. "Algorithm Design" by Kleinberg and Tardos.

## Research Methodology and IPR

| **Teaching Scheme**<br>Lectures: 1hrs/week | |
| --- | --- |

**Course Outcomes:**

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

**Syllabus Contents:**

**Unit 1:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Unit 2:** Effective literature studies approaches, analysis

Plagiarism, Research ethics,

**Unit 3:** Effective technical writing, how to write report, Paper

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**Unit 4:** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Unit 5:** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

| |
|---|
| **Unit 6:** New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs. |

**References:**


1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2 nd Edition , "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
5. Mayall , "Industrial Design", McGraw Hill, 1992.
6. Niebel , "Product Design", McGraw Hill, 1974.
7. Asimov , "Introduction to Design", Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008


| | |
|---|---|
| **Course Code** | 2CS06 |
| **Course Name** | Soft Computing |
| **Credits** | 3 |
| **Pre-Requisites** | Basic knowledge of mathematics |

Total Number of Lectures:48

| COURSE OBJECTIVE |
|---|
| • To introduce soft computing concepts and techniques and foster their abilities in designing appropriate technique for a given scenario. |
| • To implement soft computing based solutions for real-world problems. |
| • To give students knowledge of non-traditional technologies and fundamentals of artificial neural networks, fuzzy sets, fuzzy logic, genetic algorithms. |
| • To provide studentan hand-on experience on MATLAB to implement various strategies. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1**<br>**Introduction to Soft Computing and Neural Networks:** Evolution of Computing: Soft Computing Constituents, From Conventional AI to Computational Intelligence: Machine Learning Basics | 7 |
| **Unit 2**<br>**Fuzzy Logic:** Fuzzy Sets, Operations on Fuzzy Sets, Fuzzy Relations, Membership Functions: Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems, Fuzzy Expert Systems, Fuzzy Decision Making. | 8 |
| **Unit 3**<br>**Neural Networks:** Machine Learning Using Neural Network, Adaptive Networks, Feed forward Networks, Supervised Learning Neural Networks, Radial Basis Function Networks : Reinforcement Learning, Unsupervised Learning Neural Networks, Adaptive Resonance architectures, Advances in Neural networks | 10 |

| | |
|---|---|
| **Unit 4**<br>**Genetic Algorithms:** Introduction to Genetic Algorithms (GA), Applications of GA in Machine Learning : Machine Learning Approach to Knowledge Acquisition. | 5 |
| **Unit 5**<br>**Matlab/Python Lib:** Introduction to Matlab/Python, Arrays and array operations, Functions and Files, Study of neural network toolbox and fuzzy logic toolbox, Simple implementation of Artificial Neural Network and Fuzzy Logic | 13 |
| **Unit 6**<br>Recent Trands in deep learning, various classifiers, neural networks and genetic algorithm.<br>Implementation of recently proposed soft computing techniques. | 5 |

| **COURSE OUTCOMES** |
|---|
| After completion of course, students would be able to: |
| • Identify and describe soft computing techniques and their roles in building intelligent machines |
| • Apply fuzzy logic and reasoning to handle uncertainty and solve various engineering problems. |
| • Apply genetic algorithms to combinatorial optimization problems. |
| • Evaluate and compare solutions by various soft computing approaches for a given problem. |

**References:**


1. Jyh:Shing Roger Jang, Chuen:Tsai Sun, EijiMizutani, Neuro:Fuzzy and Soft Computing, Prentice:Hall of India, 2003.
2. George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic:Theory and Applications, Prentice Hall, 1995.
3. MATLAB Toolkit Manual


**Elective Subjects**

| | |
|---|---|
| **Course Code** | |
| **Course Name** | Machine learning |
| **Credits** | 3 |
| **Pre-Requisites** | |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • To learn the concept of how to learn patterns and concepts from data without being explicitly programmed in various IOT nodes. |
| • To design and analyse various machine learning algorithms and techniques with a modern outlook focusing on recent advances. |
| • Explore supervised and unsupervised learning paradigms of machine learning. |
| • To explore Deep learning technique and various feature extraction strategies. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>**Supervised Learning (Regression/Classification)**<br>• Basic methods: Distance-based methods, Nearest-Neighbours, Decision Trees, Nave Bayes<br>• Linear models: Linear Regression, Logistic Regression, Generalized | 10 |

| | |
|---|---|
| Linear Models<br>• Support Vector Machines, Nonlinearity and Kernel Methods<br>• Beyond Binary Classification: Multi-class/Structured Outputs, Ranking | |
| **Unit 2:**<br>**Unsupervised Learning**<br>• Clustering: K-means/Kernel K-means<br>• Dimensionality Reduction: PCA and kernel PCA<br>• Matrix Factorization and Matrix Completion<br>• Generative Models (mixture models and latent factor models) | 7 |
| **Unit 3**<br>Evaluating Machine Learning algorithms and Model Selection, Introduction to Statistical Learning Theory, Ensemble Methods (Boosting, Bagging, Random Forests) | 6 |
| **Unit 4**<br>Sparse Modeling and Estimation, Modeling Sequence/Time-Series Data, Deep Learning and Feature Representation Learning | 9 |
| **Unit 5**<br>Scalable Machine Learning (Online and Distributed Learning)<br>A selection from some other advanced topics, e.g., Semi-supervised Learning, Active Learning, Reinforcement Learning, Inference in Graphical Models, Introduction to Bayesian Learning and Inference | 9 |
| **Unit 6:**<br>Recent trends in various learning techniques of machine learning and classification methods for IOT applications. Various models for IOT applications. | 5 |

| **COURSE OUTCOMES** |
|---|
| After completion of course, students would be able to: |
| • Extract features that can be used for a particular machine learning approach in various IOT applications. |
| • To compare and contrast pros and cons of various machine learning techniques and to get an insight of when to apply a particular machine learning approach. |
| • To mathematically analyse various machine learning approaches and paradigms. |

**References:**


1. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer 2009 (freely available online)
3. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.


| | |
|---|---|
| **Course Code** | 1CS11 |
| **Course Name** | Digital Forensics |
| **Credits** | 3 |
| **Pre-Requisites** | Cybercrime and Information Warfare, Computer Networks |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • Provides an in-depth study of the rapidly changing and fascinating field of computer forensics. |

| |
|---|
| • Combines both the technical expertise and the knowledge required to investigate, detect and prevent digital crimes. |
| • Knowledge on digital forensics legislations, digital crime, forensics processes and procedures, data acquisition and validation, e-discovery tools |
| • E-evidence collection and preservation, investigating operating systems and file systems, network forensics, art of steganography and mobile device forensics |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1:**<br>**Digital Forensics Science:** Forensics science, computer forensics, and digital forensics.<br>**Computer Crime:** Criminalistics as it relates to the investigative process, analysis of cyber-criminalistics area, holistic approach to cyber-forensics | 9 |
| **Unit 2:**<br>**Cyber Crime Scene Analysis:** Discuss the various court orders etc., methods to search and seizure electronic evidence, retrieved and un-retrieved communications, Discuss the importance of understanding what court documents would be required for a criminal investigation. | 8 |
| **Unit 3:**<br>**Evidence Management & Presentation:** Create and manage shared folders using operating system, importance of the forensic mindset, define the workload of law enforcement, Explain what the normal case would look like, Define who should be notified of a crime, parts of gathering evidence, Define and apply probable cause. | 9 |
| **Unit 4:**<br>**Computer Forensics:** Prepare a case, Begin an investigation, Understand computer forensics workstations and software, Conduct an investigation, Complete a case, Critique a case,<br>**Network Forensics:** open-source security tools for network forensic analysis, requirements for preservation of network data. | 10 |
| **Unit 5:**<br>**Mobile Forensics:** mobile forensics techniques, mobile forensics tools.<br>**Legal Aspects of Digital Forensics:** IT Act 2000, amendment of IT Act 2008. | 8 |
| **Unit 6:**<br>Recent trends in mobile forensic technique and methods to search and seizure electronic evidence | 4 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be able to:** |
| • Understand relevant legislation and codes of ethics |
| • Computer forensics and digital detective and various processes, policies and procedures |
| • E-discovery, guidelines and standards, E-evidence, tools and environment. |
| • Email and web forensics and network forensics |

**References:**

1. John Sammons, The Basics of Digital Forensics, Elsevier
2. John Vacca, Computer Forensics: Computer Crime Scene Investigation, Laxmi Publications

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|---|---|
| **Course Code** | 1CS12 |
| **Course Name** | Ethical Hacking |
| **Credits** | 3 |
| **Pre-Requisites** | Computer Programming, Web Programming, Computer Networks |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • Introduces the concepts of Ethical Hacking and gives the students the opportunity to learn about different tools and techniques in Ethical hacking and security and practically apply some of the tools. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**Introduction to Ethical Disclosure: Ethics of Ethical Hacking, Ethical Hacking and the legal system, Proper and Ethical Disclosure | 9 |
| **Unit 2:**<br>Penetration Testing and Tools: Using Metasploit, Using BackTrackLiveCD Linux Distribution | 8 |
| **Unit 3:**<br>Vulnerability Analysis: Passive Analysis, Advanced Static Analysis with IDA Pro, Advanced Reverse Engineering | 9 |
| **Unit 4:**<br>Client-side browser exploits, Exploiting Windows Access Control Model for Local Elevation Privilege, Intelligent Fuzzing with Sulley, From Vulnerability to Exploit | 10 |
| **Unit 5:**<br>Malware Analysis: Collecting Malware and Initial Analysis, Hacking Malware | 8 |
| **Unit 6:**<br>Case study of vulnerability of cloud platforms and mobile platforms & devices. | 4 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be able to:** |
| • Understand the core concepts related to malware, hardware and software vulnerabilities and their causes |
| • Understand ethics behind hacking and vulnerability disclosure |
| • Appreciate the Cyber Laws and impact of hacking |
| • Exploit the vulnerabilities related to computer system and networks using state of the art tools and technologies |

**References:**

1. Shon Harris, Allen Harper, Chris Eagle and Jonathan Ness, Gray Hat Hacking: The Ethical Hackers' Handbook, TMH Edition
2. Jon Erickson, Hacking: The Art of Exploitation, SPD

| | |
|---|---|
| **Course Code** | 1CS13 |
| **Course Name** | Intrusion Detection |
| **Credits** | 3 |
| **Pre-Requisites** | Computer Networks, Computer Programming |

Total Number of Lectures: 48

| COURSE OBJECTIVE |
| --- |
| • Compare alternative tools and approaches for Intrusion Detection through quantitative analysis to determine the best tool or approach to reduce risk from intrusion |
| • Identify and describe the parts of all intrusion detection systems and characterize new and emerging IDS technologies according to the basic capabilities all intrusion detection systems share. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
| --- | --- |
| **Unit 1:**<br>The state of threats against computers, and networked systems-Overview of computer security solutions and why they fail-Vulnerability assessment, firewalls, VPN's -Overview of Intrusion Detection and Intrusion Prevention-Network and Host-based IDS | 10 |
| **Unit 2:**<br>Classes of attacks - Network layer: scans, denial of service, penetration-Application layer: software exploits, code injection-Human layer: identity theft, root access-Classes of attackers-Kids/hackers/sop<br>Hesitated groups-Automated: Drones, Worms, Viruses | 8 |
| **Unit 3:**<br>A General IDS model and taxonomy, Signature-based Solutions, Snort, Snort rules, Evaluation of IDS, Cost sensitive IDS | 8 |
| **Unit 4:**<br>Anomaly Detection Systems and Algorithms-Network Behavior Based Anomaly Detectors (rate based)-Host-based Anomaly Detectors-Software Vulnerabilities-State transition, Immunology, Payload Anomaly Detection | 10 |
| **Unit 5:**<br>Attack trees and Correlation of alerts-Autopsy of Worms and Botnets-Malware detection-Obfuscation, polymorphism-Document vectors | 8 |
| **Unit 6:**<br>Email/IM security issues-Viruses/Spam-From signatures to thumbprints to zero-day detection-Insider Threat issues-Taxonomy-Masquerade and Impersonation-Traitors, Decoys and Deception-Future: Collaborative Security | 4 |

| COURSE OUTCOMES |
| --- |
| **After completion of course, students would be able to:** |
| • Apply knowledge of the fundamentals and history of Intrusion Detection in order to avoid common pitfalls in the creation and evaluation of new Intrusion Detection Systems. Evaluate the security an enterprise and appropriately apply Intrusion Detection tools and techniques in order to improve their security posture |

**References:**


1. The Art of Computer Virus Research and Defense, Peter Szor, Symantec Press ISBN 0-321-30545-3
2. Crimeware, Understanding New Attacks and Defenses, Markus Jakobsson and Zulfikar Ramzan, Symantec Press, ISBN: 978-0-321-50195-0 2008


| | |
| --- | --- |
| **Course Code** | 1CS21 |
| **Course Name** | Malware Analysis and Reverse Engineering |

| | |
|---|---|
| **Credits** | 3 |
| **Pre-Requisites** | Computer Programming, Compiler Design |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • The objective of this course is to provide an insight to fundamentals of malware analysis which includes analysis of JIT compilers for malware detection in legitimate code. DNS filtering and reverse engineering is included. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>Fundamentals of Malware Analysis (MA), Reverse Engineering Malware (REM) Methodology, Brief Overview of Malware analysis lab setup and configuration, Introduction to key MA tools and techniques, Behavioral Analysis vs. Code Analysis, Resources for Reverse-Engineering Malware (REM) Understanding Malware Threats, Malware indicators, Malware Classification, Examining ClamAVSignatures, Creating Custom ClamAV Databases, Using YARA to Detect Malware Capabilities, Creating a Controlled and Isolated Laboratory, Introduction to MA Sandboxes, Ubuntu, Zeltser'sREMnux, SANS SIFT, Sandbox Setup and Configuration New Course Form, Routing TCP/IP Connections, Capturing and Analyzing Network Traffic, Internet simulation using INetSim, Using Deep Freeze to Preserve Physical Systems, Using FOG for Cloning and Imaging Disks, Using MySQL Database to Automate FOG Tasks, Introduction to Python ,Introduction to x86 Intel assembly language, Scanners: Virus Total, Jotti, and NoVirus Thanks, Analyzers: Threat Expert, CWSandbox, Anubis, Joebox, Dynamic Analysis Tools: Process Monitor, Regshot, HandleDiff, Analysis Automation Tools: Virtual Box, VM Ware, Python , Other Analysis Tools | 12 |
| **Unit 2:Malware Forensics**<br>Using TSK for Network and Host Discoveries, Using Microsoft Offline API to Registry Discoveries , Identifying Packers using PEiD, Registry Forensics with Reg Ripper Plu-gins:, Bypassing Poison Ivy's Locked Files, Bypassing Conficker's File System ACL Restrictions, Detecting Rogue PKI Certificates. | 7 |
| **Unit 3:Malware and Kernel Debugging**<br>Opening and Attaching to Processes, Configuration of JIT Debugger for Shellcode Analysis, Controlling Program Execution, Setting and Catching Breakpoints, Debugging with Python Scripts and Py Commands, DLL Export Enumeration, Execution, and Debugging, Debugging a VMware Workstation Guest (on Windows), Debugging a Parallels Guest (on Mac OS X). Introduction to WinDbg Commands and Controls, Detecting Rootkits with WinDbgScripts, Kernel Debugging with IDA Pro. | 9 |
| **Unit 4:Memory Forensics and Volatility**<br>Memory Dumping with MoonSols Windows Memory Toolkit, Accessing VM Memory Files Overview of Volatility, Investigating Processes in Memory Dumps, Code Injection and Extraction, Detecting and Capturing Suspicious Loaded DLLs, Finding Artifacts in Process Memory, Identifying Injected Code with Malfind and YARA. | 8 |

| | |
|---|---|
| **Unit 5:Researching and Mapping Source Domains/IPs**<br>Using WHOIS to Research Domains, DNS Hostname Resolution, Querying Passive DNS, Checking DNS Records, Reverse IP Search New Course Form, Creating Static Maps, Creating Interactive Maps. | 7 |
| **Unit 6:**<br>Case study of Finding Artifacts in Process Memory, Identifying Injected Code with Malfind and YARA | 5 |

| **COURSE OUTCOMES** |
|---|
| **On completion of the course the student should be able to** |
| • To understand the concept of malware and reverse engineering. |
| • Implement tools and techniques of malware analysis. |

**References:**

1. Michael Sikorski, Andrew Honig "Practical Malware Analysis: The Hands-On Guide to Dissecting Malicious Software" publisher Williampollock

| | |
|---|---|
| **Course Code** | 1CS22 |
| **Course Name** | Secure Software Design and Enterprise Computing |
| **Credits** | 3 |
| **Pre-Requisites** | Computer Programming, Software Engineering |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • To fix software flaws and bugs in various software. |
| • To make students aware of various issues like weak random number generation, information leakage, poor usability, and weak or no encryption on data traffic |
| • Techniques for successfully implementing and supporting network services on an enterprise scale and heterogeneous systems environment. |
| • Methodologies and tools to design and develop secure software containing minimum vulnerabilities and flaws. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>**Secure Software Design**<br>Identify software vulnerabilities and perform software security analysis, Master security programming practices, Master fundamental software security design concepts, Perform security testing and quality assurance. | 8 |
| **Unit 2:**<br>**Enterprise Application Development**<br>Describe the nature and scope of enterprise software applications, Design distributed N-tier software application, Research technologies available for the presentation, business and data tiers of an enterprise software application, Design and build a database using an enterprise database system, Develop components at the different tiers in an enterprise system, Design and develop a multi-tier solution to a problem using technologies used in enterprise system, Present software solution. | 11 |
| **Unit 3:** | 8 |

| | |
|---|---|
| **Enterprise Systems Administration**<br>Design, implement and maintain a directory-based server infrastructure in a heterogeneous systems environment, Monitor server resource utilization for system reliability and availability, Install and administer network services (DNS/DHCP/Terminal Services/Clustering/Web/Email). | |
| **Unit 4:**<br>Obtain the ability to manage and troubleshoot a network running multiple services, Understand the requirements of an enterprise network and how to go about managing them. | 8 |
| **Unit 5:**<br>Handle insecure exceptions and command/SQL injection, Defend web and mobile applications against attackers, software containing minimum vulnerabilities and flaws. | 9 |
| **Unit 6:**<br>Case study of DNS server, DHCP configuration and SQL injection attack. | 4 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be able to:** |
| • Differentiate between various software vulnerabilities. |
| • Software process vulnerabilities for an organization. |
| • Monitor resources consumption in a software. |
| • Interrelate security and software development process. |

**References:**

1. Theodor Richardson, Charles N Thies, Secure Software Design, Jones & Bartlett
2. Kenneth R. van Wyk, Mark G. Graff, Dan S. Peters, Diana L. Burley, Enterprise Software Security, Addison Wesley.

| | |
|---|---|
| **Course Code** | 1CS23 |
| **Course Name** | Secure Coding |
| **Credits** | 3 |
| **Pre-Requisites** | Computer Programming, Compiler Design, Web programming |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • Understand the basics of secure programming. |
| • Understand the most frequent programming errors leading to software vulnerabilities. |
| • Identify and analyze security problems in software. |
| • Understand and protect against security threats and software vulnerabilities. |
| • Effectively apply their knowledge to the construction of secure software systems |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>Introduction to software security, Managing software security risk, Selecting software development technologies, An open source and closed source, Guiding | 10 |

| | |
|---|---|
| principles for software security, Auditing software, Buffet overflows, Access control, Race conditions, Input validation, Password authentication | |
| **Unit 2:**<br>Anti-tampering, Protecting against denial of service attack, Copy protection schemes, Client-side security, Database security, Applied cryptography, Randomness and determinism | **7** |
| **Unit 3:**<br>Buffer Overrun, Format String Problems, Integer Overflow, and Software Security Fundamentals<br>SQL Injection, Command Injection, Failure to Handle Errors, and Security Touchpoints | 9 |
| **Unit 4:**<br>Cross Site Scripting, Magic URLs, Weak Passwords, Failing to Protect Data, Weak random numbers, improper use of cryptography | 8 |
| **Unit 5:**<br>Information Leakage, Race Conditions, Poor usability, Failing to protect network traffic, improper use of PKI, trusting network name resolution | 8 |
| **Unit 6:**<br>Case study of Cross Site Scripting, Magic URLs, Weak Passwords Buffet overflows, Access control, Race conditions. | 5 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be able to:** |
| • Write secure programs and various risk in the softwares. |
| • Eliminate security problems in the open source software. |
| • Real time software and vulnerabilities associated with them. |
| • Interrelate security and software engineering. |

**References:**


1. J. Viega, M. Messier. Secure Programming Cookbook, O'Reilly.
2. M. Howard, D. LeBlanc. Writing Secure Code, Microsoft
3. J. Viega, G. McGraw. Building Secure Software, Addison Wesley


| | |
|---|---|
| **Course Code** | 2CS31 |
| **Course Name** | Data Encryption & Compression |
| **Credits** | 3 |
| **Pre-Requisites** | Image Processing, Linear Algebra, Cryptography |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| |
| • This course will cover the concept of security , types of attack experienced, encryption and authentication for deal with attacks, what is data compression, need and techniques of data compression |

| **LECTURE WITH BREAKUP** | **NO. OF** |
|---|---|

| | LECTURES |
|---|---|
| **Unit 1:** **Introduction to Security:** Need for security, Security approaches, Principles of security, Types of attacks. **Encryption Techniques:** Plaintext, Cipher text, Substitution & Transposition techniques, Encryption & Decryption, Types of attacks, Key range & Size. | 8 |
| **Unit 2:** **Symmetric & Asymmetric Key Cryptography:** Algorithm types & Modes, DES, IDEA, Differential & Linear Cryptanalysis, RSA, Symmetric & Asymmetric key together, Digital signature, Knapsack algorithm. **User Authentication Mechanism:** Authentication basics, Passwords, Authentication tokens, Certificate based & Biometric authentication, Firewall. | 10 |
| **Unit 3:** **Case Studies Of Cryptography:** Denial of service attacks, IP spoofing attacks, Secure inter branch payment transactions, Conventional Encryption and Message Confidentiality, Conventional Encryption Principles, Conventional Encryption Algorithms, Location of Encryption Devices, Key Distribution. **Public Key Cryptography and Message Authentication:** Approaches to Message Authentication, SHA-1, MD5, Public-Key Cryptography Principles, RSA, Digital, Signatures, Key Management. | 9 |
| **Unit 4:** **Introduction:** Need for data compression, Fundamental concept of data compression & coding, Communication model, Compression ratio, Requirements of data compression, Classification. **Methods of Data Compression:** Data compression-- Loss less &Lossy | 7 |
| **Unit 5:** Entropy encoding-- Repetitive character encoding, Run length encoding, Zero/Blank encoding; Statistical encoding-- Huffman, Arithmetic & Lempel-Ziv coding; Source encoding-- Vector quantization (Simple vector quantization & with error term); Differential encoding—Predictive coding, Differential pulse code modulation, Delta modulation, Adaptive differential pulse code modulation; Transform based coding : Discrete cosine transform & JPEG standards; Fractal compression | 10 |
| **Unit 6:** Recent trends in encryption and data compression techniques. | 4 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • At the end of this course the student will have the knowledge of plaintext, cipher text, RSA and other cryptographic algorithm, Key Distribution, Communication Model, Various models for data compression |

**References:**


1. Cryptography and Network Security by B. Forouzan, McGraw-Hill.
2. The Data Compression Book by Nelson, BPB.
3. Cryptography & Network Security by AtulKahate, TMH.


| **Course Code** | 2CS32 |
|---|---|
| **Course Name** | Steganography and Digital Watermarking |
| **Credits** | 3 |

| **Pre-Requisites** | Image and Video Processing, Linear Algebra |
|---|---|

Total Number of Lectures: 48

| **COURSE OBJECTIVE** | |
|---|---|
| | |
| • The objective of course is to provide a insight to steganography techniques. Watermarking techniques along with attacks on data hiding and integrity of data is included in this course. | |
| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
| **Unit 1:**<br>**Steganography:** Overview, History, Methods for hiding (text, images, audio, video, speech etc.), Issues: Security, Capacity and Imperceptibility,<br>Steganalysis: Active and Malicious Attackers, Active and passive steganalysis, | 8 |
| **Unit 2:**<br>Frameworks for secret communication (pure Steganography, secret key, public key steganography), Steganography algorithms (adaptive and non-adaptive), | 8 |
| **Unit 3:**<br>Steganography techniques: Substitution systems, Spatial Domain, Transform domain techniques, Spread spectrum, Statistical steganography, Cover Generation and cover selection, Tools: EzStego, FFEncode, Hide 4 PGP, Hide and Seek, S Tools etc.) | 9 |
| **Unit 4:**<br>Detection, Distortion, Techniques: LSB Embedding, LSB Steganalysis using primary sets, Texture based | 6 |
| **Unit 5:**<br>**Digital Watermarking**: Introduction, Difference between Watermarking and Steganography, History, Classification (Characteristics and Applications),<br>Types and techniques (Spatial-domain, Frequency-domain, and Vector quantization based watermarking), Attacks and Tools (Attacks by Filtering, Remodulation, Distortion, Geometric Compression, Linear Compression etc.), Watermark security & authentication. | 12 |
| **Unit 6:**<br>Recent trends in Steganography and digital watermarking techniques. Case study of LSB Embedding, LSB Steganalysis using primary sets. | 5 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • Learn the concept of information hiding. |
| • Survey of current techniques of steganography and learn how to detect and extract hidden information. |
| • Learn watermarking techniques and through examples understand the concept. |

**References:**

1. Peter Wayner, “Disappearing Cryptography–Information Hiding: Steganography & Watermarking”, Morgan Kaufmann Publishers, New York, 2002.
2. Ingemar J. Cox, Matthew L. Miller, Jeffrey A. Bloom, Jessica Fridrich, TonKalker, “Digital Watermarking and Steganography”, Margan Kaufmann Publishers, New York, 2008.
3. Information Hiding: Steganography and Watermarking-Attacks and Countermeasures by Neil F. Johnson, ZoranDuric, SushilJajodia

4. Information Hiding Techniques for Steganography and Digital Watermarking by Stefan Katzenbeisser, Fabien A. P. Petitcolas

| | |
|---|---|
| **Course Code** | 2CS33 |
| **Course Name** | Information Theory and Coding |
| **Credits** | 3 |
| **Pre-Requisites** | Probability Theory, Computer Networks |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| |
| • The objective of this course is to provide an insight to information coding techniques, error correction mechanism. Various compression techniques for text, video and image are covered for thorough knowledge of efficient information conveying systems. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>Information and entropy information measures, Shannon's concept of Information. Channel coding, channel mutual information capacity (BW), | 8 |
| **Unit 2:**<br>Theorem for discrete memory less channel, information capacity theorem, Error detecting and error correcting codes, | 9 |
| **Unit 3:**<br>Types of codes: block codes, Hamming and Lee metrics, description of linear block codes, parity check Codes, cyclic code, Masking techniques, | 8 |
| **Unit 4:**<br>Compression: loss less and lossy, Huffman codes, LZW algorithm, Binary Image compression schemes, run length encoding, CCITT group 3 1-DCompression, CCITT group 3 2D compression, CCITT group 4 2DCompression. | 10 |
| **Unit 5:**<br>Convolutional codes, sequential decoding. Video image Compression: CITT H 261 Video coding algorithm, audio (speech) Compression. Cryptography and cipher. | 9 |
| **Unit 6:**<br>Case study of CCITT group 3 1-DCompression, CCITT group 3 2D compression. | 4 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • The aim of this course is to introduce the principles and applications of information theory. |
| • The course will study how information is measured in terms of probability and entropy. |
| • The students learn coding schemes, including error correcting codes, The Fourier perspective; and extensions to wavelets, complexity, compression, and efficient coding of audio-visual information. |

**References:**

1. Fundamentals in information theory and coding, Monica Borda,Springer.
2. Communication Systems: Analog and digital, Singh and Sapre, TataMcGraw Hill.

3. Multimedia Communications Fred Halsall.
4. Information Theory, Coding and Cryptography R Bose.
5. Multimedia system Design Prabhat K Andleigh and Kiran Thakrar.

| | |
|---|---|
| **Course Code** | 2CS41 |
| **Course Name** | Security Assessment and Risk Analysis |
| **Credits** | 3 |
| **Pre-Requisites** | Computer and Network Security |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • Describe the concepts of risk management |
| • Define and differentiate various Contingency Planning components |
| • Integrate the IRP, DRP, and BCP plans into a coherent strategy to support sustained organizational operations. |
| • Define and be able to discuss incident response options, and design an Incident Response Plan for sustained organizational operations. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>**SECURITY BASICS**: Information Security (INFOSEC) Overview: critical information characteristics – availability information states – processing security countermeasureseducation, training and awareness, critical information characteristics – confidentiality critical information characteristics – integrity, information states – storage, information states – transmission, security countermeasurespolicy, procedures and practices, threats, vulnerabilities. | 8 |
| **Unit 2:**<br>Threats to and Vulnerabilities of Systems: definition of terms (e.g., threats, vulnerabilities, risk), major categories of threats (e.g., fraud, Hostile Intelligence Service (HOIS), malicious logic, hackers, environmental and technological hazards, disgruntled employees, careless employees, HUMINT, and monitoring), threat impact areas, Countermeasures: assessments (e.g., surveys, inspections), Concepts of Risk Management: consequences (e.g., corrective action, risk assessment), cost/benefit analysis of controls, implementation of costeffective controls, monitoring the efficiency and effectiveness of controls (e.g., unauthorized or inadvertent disclosure of information), threat and vulnerability assessment | 11 |
| **Unit 3:**<br>Security Planning: directives and procedures for policy mechanism, Risk Management: acceptance of risk (accreditation), corrective actions information identification, risk analysis and/or vulnerability assessment components, risk analysis results evaluation, roles and responsibilities of all the players in the risk analysis process, Contingency Planning/Disaster Recovery: agency response procedures and continuity of operations, contingency plan components, determination of backup requirements, development of plans for recovery actions after a disruptive event, development of procedures for offsite processing, emergency destruction procedures, guidelines for determining critical and essential workload, team member responsibilities in responding to an | 9 |

| | |
|---|---|
| emergency situation | |
| **Unit 4:**<br>**POLICIES AND PROCEDURES**<br>Physical Security Measures: alarms, building construction, cabling, communications centre, environmental controls (humidity and air conditioning), filtered power, physical access control systems (key cards, locks and alarms) Personnel Security Practices and Procedures: access authorization/verification (need to know), contractors, employee clearances, position sensitivity, security training and awareness, systems maintenance personnel, Administrative Security Procedural Controls: attribution, copyright protection and licensing , Auditing and Monitoring: conducting security reviews, effectiveness of security programs, investigation of security breaches, privacy review of accountability controls, review of audit trails and logs | 8 |
| **Unit 5:**<br>Operations Security (OPSEC): OPSEC surveys/OPSEC planning INFOSEC: computer security – audit, cryptography encryption (e.g., point to point, network, link), cryptography key management (to include electronic key), cryptography strength (e.g., complexity, secrecy, characteristics of the key) | 9 |
| **Unit 6:**<br>Case study of threat and vulnerability assessment | 3 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • Capable of recommending contingency strategies including data backup and recovery and alternate site selection for business resumption planning |
| • Skilled to be able to describe the escalation process from incident to disaster in case of security disaster. |
| • Capable of Designing a Disaster Recovery Plan for sustained organizational operations. |
| • Capable of Designing a Business Continuity Plan for sustained organizational operations. |

**References:**


1. Principles of Incident Response and Disaster Recovery, Whitman & Mattord, Course Technology ISBN: 141883663X
2. (Web Link) http://www.cnss.gov/Assets/pdf/nstissi_4011.pdf


| | |
|---|---|
| **Course Code** | 2CS43 |
| **Course Name** | Biometrics |
| **Credits** | 3 |
| **Pre-Requisites** | Image Processing |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| |
| • The objective of this course is to introduce Bio-metric and traditional authentication methods. Application of bio-metric systems in government sector and various face recognition and finger print recognition methods are included. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:** | 7 |

| | |
|---|---|
| Introduction and Definitions of bio-metrics, Traditional authenticated methods and technologies. | |
| **Unit 2:**<br>Bio-metric technologies: Fingerprint, Face, Iris, Hand Geometry, Gait Recognition, Ear, Voice, Palm print, On-Line Signature Verification, 3D Face Recognition, Dental Identification and DNA. | 10 |
| **Unit 3:**<br>The Law and the use of multi bio-metrics systems. | 6 |
| **Unit 4:**<br>Statistical measurement of Bio-metric. Bio-metrics in Government Sector and Commercial Sector. | 11 |
| **Unit 5:**<br>Case Studies of bio-metric system, Bio-metric Transaction. Bio-metric System Vulnerabilities. | 9 |
| **Unit 6:**<br>Recent trends in Bio-metric technologies and applications in various domains. Case study of 3D face recognition and DNA matching. | 5 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • Perform R&D on bio-metrics methods and systems. |
| • A good understanding of the various modules constituting a bio-metric system. |
| • Familiarity with different bio-metric traits and to appreciate their relative significance. |
| • A good knowledge of the feature sets used to represent some of the popular bio-metric traits. |
| • Evaluate and design security systems incorporating bio-metrics. |
| • Recognize the challenges and limitations associated with bio-metrics. |

**References:**

1. Biometrics for network security, Paul Reid, Hand book of Pearson
2. D. Maltoni, D. Maio, A. K. Jain, and S. Prabhakar, Handbook of Fingerprint Recognition, Springer Verlag, 2003.
3. A. K. Jain, R. Bolle, S. Pankanti (Eds.), BIOMETRICS: Personal Identification in Networked Society, Kluwer Academic Publishers, 1999.
4. J. Wayman, A.K. Jain, D. Maltoni, and D. Maio (Eds.), Biometric Systems: Technology, Design and Performance Evaluation, Springer, 2004.
5. Anil Jain, Arun A. Ross, Karthik Nanda kumar, Introduction to biometric, Springer, 2011.
6. Biometric Systems: Technology, Design and Performance Evaluation, J. Wayman, A.K. Jain, D. Maltoni, and D. Maio

| | |
|---|---|
| **Course Code** | 3CS51 |
| **Course Name** | Data Warehousing & Mining |
| **Credits** | 3 |
| **Pre-Requisites** | Databases, Probability |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| |
| • The objective of this course is to introduce data warehousing and mining techniques. Application of data mining in web mining, pattern matching and cluster analysis is included to aware students of broad data mining areas. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1:** Introduction to Data Warehousing; Data Mining: Mining frequent patterns, association and correlations; Sequential Pattern Mining concepts, primitives, scalable methods; | 7 |
| **Unit 2:** Classification and prediction; Cluster Analysis – Types of Data in Cluster Analysis, Partitioning methods, Hierarchical Methods; Transactional Patterns and other temporal based frequent patterns, | 8 |
| **Unit 3:** Mining Time series Data, Periodicity Analysis for time related sequence data, Trend analysis, Similarity search in Time-series analysis; | 8 |
| **Unit 4:** Mining Data Streams, Methodologies for stream data processing and stream data systems, Frequent pattern mining in stream data, Sequential Pattern Mining in Data Streams, Classification of dynamic data streams, Class Imbalance Problem; Graph Mining; Social Network Analysis; | 11 |
| **Unit 5:** Web Mining, Mining the web page layout structure, mining web link structure, mining multimedia data on the web, Automatic classification of web documents and web usage mining; Distributed Data Mining. | 9 |
| **Unit 6:** Recent trends in Distributed Warehousing and Data Mining, Class Imbalance Problem; Graph Mining; Social Network Analysis | 5 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be:** |
| • Study of different sequential pattern algorithms |
| • Study the technique to extract patterns from time series data and it application in real world. |
| • Can extend the Graph mining algorithms to Web mining |
| • Help in identifying the computing framework for Big Data |

**References:**


1. Jiawei Han and M Kamber , Data Mining Concepts and Techniques, , Second Edition, Elsevier Publication, 2011.
2. Vipin Kumar, Introduction to Data Mining - Pang-Ning Tan, Michael Steinbach, Addison Wesley, 2006.
3. G Dong and J Pei, Sequence Data Mining, Springer, 2007.


| | |
|---|---|
| **Course Code** | 3CS52 |
| **Course Name** | Web Search and Information Retrieval |
| **Credits** | 3 |
| **Pre-Requisites** | Probability Theory, Database Management, Web Programming |

Total Number of Lectures: 48

| COURSE OBJECTIVE |
|---|
| |
| • The objective of the course is to introduce information retrieval models and query languages. Application of web search and information retrieval in social networks is also included. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1:**<br>Information retrieval model, Information retrieval evaluation, Searching the Web | 7 |
| **Unit 2:**<br>Document Representation, Query languages and query operation, Meta-data search, | 9 |
| **Unit 3:**<br>Indexing and searching, Scoring and ranking feature vectors, | 9 |
| **Unit 4:**<br>Ontology, domain specific search, parallel and distributed information retrieval, | 11 |
| **Unit 5:**<br>Text and multimedia languages, Social networks. | 7 |
| **Unit 6:**<br>Recent trends in Web search and Information retrieval techniques. | 5 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be:** |
| • To identify basic theories and analysis tools as they apply to information retrieval. |
| • To develop understanding of problems and potentials of current IR systems. |
| • To learn and appreciate different retrieval algorithms and systems. |
| • To apply various indexing, matching, organizing, and evaluating methods to IR problem. |
| • To become aware of current experimental and theoretical IR research. |

**References:**


1. C. D. Manning, P. Raghavan and H. Schütze, Introduction to Information Retrieval, Cambridge University Press, 2008 (available at http://nlp.stanford.edu/IR-book).
2. Chakrabarti, S. (2002). Mining the web: Mining the Web: Discovering knowledge from hypertext data. Morgan-kaufman.
3. B. Croft, D. Metzler, T. Strohman, Search Engines: Information Retrieval in Practice, Addison-Wesley, 2009 (available at http://ciir.cs.umass.edu/irbook/).
4. R. Baeza-Yates, B. Ribeiro-Neto, Modern Information Retrieval, Addison-Wesley, 2011 (2nd Edition).


| | |
|---|---|
| **Course Code** | 3CS53 |
| **Course Name** | Database Security and Access Control |
| **Credits** | 3 |
| **Pre-Requisites** | Database Management |

Total Number of Lectures: 48

| COURSE OBJECTIVE |
|---|
| |
| • The objective of the course is to provide fundamentals of database security. Various access control techniques mechanisms were introduced along with application areas of access control techniques. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1:**<br>Introduction to Access Control, Purpose and fundamentals of access control, brief history, | 5 |
| **Unit 2:**<br>Policies of Access Control, Models of Access Control, and Mechanisms, Discretionary Access Control (DAC), Non- Discretionary Access Control , Mandatory Access Control (MAC). Capabilities and Limitations of Access Control Mechanisms: Access Control List (ACL) and Limitations, Capability List and Limitations, | 9 |
| **Unit 3:**<br>Role-Based Access Control (RBAC) and Limitations, Core RBAC, Hierarchical RBAC, Statically Constrained RBAC, Dynamically Constrained RBAC, Limitations of RBAC. Comparing RBAC to DAC and MAC Access control policy, | 8 |
| **Unit 4:**<br>Biba'sintrigity model, Clark-Wilson model, Domain type enforcement model , mapping the enterprise view to the system view, Role hierarchies- inheritance schemes, hierarchy structures and inheritance forms, using SoD in real system, Temporal Constraints in RBAC, MAC AND DAC.<br>Integrating RBAC with enterprise IT infrastructures: RBAC for WFMSs, RBAC for UNIX and JAVA environments Case study: Multi line Insurance Company. | 11 |
| **Unit 5:**<br>Smart Card based Information Security, Smart card operating system-fundamentals, design and implantation principles, memory organization, smart card files, file management, atomic operation, smart card data transmission ATR,PPS Security techniques- user identification , smart card security, quality assurance and testing , smart card life cycle-5 phases, smart card terminals. | 11 |
| **Unit 6:**<br>Recent trends in Database security and access control mechanisms. Case study of Role-Based Access Control (RBAC) systems. | 4 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be:** |
| • In this course, the students will be enabled to understand and implement classical models and algorithms. |
| • They will learn how to analyze the data, identify the problems, and choose the relevant models and algorithms to apply. |
| • They will further be able to assess the strengths and weaknesses of various access control models and to analyze their behaviour. |

**References:**


1. Role Based Access Control: David F. Ferraiolo, D. Richard Kuhn, RamaswamyChandramouli.
2. http://www.smartcard.co.uk/tutorials/sct-itsc.pdf : Smart Card Tutorial.

**OPEN ELECTIVES**
**Business Analytics**

**Teaching scheme**

**Lecture: - 3 h/week**

| | |
|---|---|
| **Course Code** | |
| **Course Name** | **Business Analytics** |
| **Credits**<br>**Prerequisites** | |

Total Number of Lectures: 48

| **Course objective** |
|---|
| 1. Understand the role of business analytics within an organization.<br>2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.<br>3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.<br>4. To become familiar with processes needed to develop, report, and analyze business data.<br>5. Use decision-making tools/Operations research techniques.<br>6. Mange business process using analytical and management tools.<br>**7.** Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit1:**<br>Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.<br>Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview. | 9 |
| **Unit 2:**<br>Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.<br>Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology. | 8 |
| **Unit 3:**<br>Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.<br>Descriptive Analytics, predictive analytics, predicative Modelling, Predictive | 9 |

| | |
|---|---|
| analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization. | |
| **Unit 4:**<br>Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.<br>Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model. | 10 |
| **Unit 5:**<br>Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. | 8 |
| **Unit 6:**<br>Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism. | 4 |

| COURSE OUTCOMES | |
|---|---|
| 1. Students will demonstrate knowledge of data analytics.<br>2. Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.<br>3. Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.<br>**4.** Students will demonstrate the ability to translate data into clear, actionable insights. | |

**Reference:**

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

## OPEN ELECTIVES
## Industrial Safety

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**Unit-II:** Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**Unit-III:** Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**Unit-IV:** Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**Unit-V:** Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

**Reference:**


1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.


## OPEN ELECTIVES

## Operations Research

**Teaching Scheme**

**Lectures: 3 hrs/week**

**Course Outcomes: At the end of the course,** the student should be able to

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

**Syllabus Contents:**

**Unit 1**:

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

**Unit 2**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

**Unit 3**:

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

**Unit 4**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

**Unit 5**

Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

**References:**

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

## Open Elective

## Cost Management of Engineering Projects

**Teaching scheme**

**Lecture: - 3 h/week**

Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

**References:**

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

## Open Elective
## Composite Materials

**Teaching scheme**

**Lecture: - 3 h/week**

**UNIT–I**: INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT – II**: REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT – III:** Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT–IV:** Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT – V:** Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

**TEXT BOOKS**:

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

**References:**

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

## Open Elective
## Waste to Energy

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**Unit-II:** Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**Unit-III:** Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**Unit-IV:** Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**Unit-V:** Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

**References:**

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

## AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING

**Course objectives:**
Students will be able to:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title

Ensure the good quality of paper at very first-time submission

**Syllabus**

| Units | CONTENTS | Hours |
|---|---|---|
| 1 | Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness | 4 |
| 2 | Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction | 4 |
| 3 | Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check. | 4 |
| 4 | key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, | 4 |
| 5 | skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions | 4 |
| 6 | useful phrases, how to ensure paper is as good as it could possibly be the first- time submission | 4 |

**Suggested Studies:**

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)

2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

## AUDIT 1 and 2: DISASTER MANAGEMENT

**Course Objectives: -**Students will be able to:

1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in

**Syllabus**

| Units | CONTENTS | Hours |
|---|---|---|
| 1 | **Introduction**<br>Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude. | 4 |
| 2 | **Repercussions Of Disasters And Hazards**: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.<br>Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts. | 4 |
| 3 | **Disaster Prone Areas In India**<br>Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics | 4 |
| 4 | **Disaster Preparedness And Management**<br>Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness. | 4 |
| 5 | **Risk Assessment**<br>Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival. | 4 |
| 6 | **Disaster Mitigation**<br>Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India. | 4 |

**SUGGESTED READINGS:**


1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.


## AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE

***Course Objectives***

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects
4. enhancing the memory power
5. The engineering scholars equipped with Sanskrit will be able to explore the
6. huge knowledge from ancient literature

***Syllabus***

| Unit | *Content* | *Hours* |
|---|---|---|
| 1 | • Alphabets in Sanskrit,<br>• Past/Present/Future Tense,<br>• Simple Sentences | 8 |
| 2 | • Order<br>• Introduction of roots<br>• Technical information about Sanskrit Literature | 8 |
| 3 | • Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics | 8 |

***Suggested reading***


1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.


***Course Output***

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

## AUDIT 1 and 2: VALUE EDUCATION

***Course Objectives***

Students will be able to

1. Understand value of education and self- development
2. Imbibe good values in students

3. Let the should know about the importance of character

***Syllabus***

| Unit | *Content* | *Hours* |
|---|---|---|
| 1 | • Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism.<br>• Moral and non- moral valuation. Standards and principles.<br>• Value judgements | 4 |
| 2 | • Importance of cultivation of values.<br>• Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness.<br>• Honesty, Humanity. Power of faith, National Unity.<br>• Patriotism.Love for nature ,Discipline | 6 |
| 3 | • Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline.<br>• Punctuality, Love and Kindness.<br>• Avoid fault Thinking.<br>• Free from anger, Dignity of labour.<br>• Universal brotherhood and religious tolerance.<br>• True friendship.<br>• Happiness Vs suffering, love for truth.<br>• Aware of self-destructive habits.<br>• Association and Cooperation.<br>• Doing best for saving nature | 6 |
| 4 | • Character and Competence –Holy books vs Blind faith.<br>• Self-management and Good health.<br>• Science of reincarnation.<br>• Equality, Nonviolence ,Humility, Role of Women.<br>• All religions and same message.<br>• Mind your Mind, Self-control.<br>• Honesty, Studying effectively | 6 |

***Suggested reading***

1. Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

***Course outcomes***

Students will be able to

1. .Knowledge of self-development
2. Learn the importance of Human values
3. Developing the overall personality

**AUDIT 1 and 2: CONSTITUTION OF INDIA**

| **Course Objectives:** |
|---|

Students will be able to:

1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| **1** | • **History of Making of the Indian Constitution:**<br>History<br>Drafting Committee, ( Composition & Working) | 4 |
| **2** | • **Philosophy of the Indian Constitution:**<br>Preamble<br>Salient Features | 4 |
| **3** | • **Contours of Constitutional Rights & Duties:**<br>• Fundamental Rights<br>• Right to Equality<br>• Right to Freedom<br>• Right against Exploitation<br>• Right to Freedom of Religion<br>• Cultural and Educational Rights<br>• Right to Constitutional Remedies<br>• Directive Principles of State Policy<br>• Fundamental Duties. | 4 |
| **4** | • **Organs of Governance:**<br>• Parliament<br>• Composition<br>• Qualifications and Disqualifications<br>• Powers and Functions<br>• Executive<br>• President<br>• Governor<br>• Council of Ministers<br>• Judiciary, Appointment and Transfer of Judges, Qualifications<br>• Powers and Functions | 4 |
| **5** | • **Local Administration:**<br>• District's Administration head: Role and Importance,<br>• Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.<br>• Pachayati raj: Introduction, PRI: Zila Pachayat.<br>• Elected officials and their roles, CEO Zila Pachayat: Position and role.<br>• Block level: Organizational Hierarchy (Different departments),<br>• Village level: Role of Elected and Appointed officials,<br>• Importance of grass root democracy | 4 |
| **6** | • **Election Commission:**<br>• Election Commission: Role and Functioning. | 4 |

| | | |
|---|---|---|
| | • Chief Election Commissioner and Election Commissioners.<br>• State Election Commission: Role and Functioning.<br>• Institute and Bodies for the welfare of SC/ST/OBC and women. | |

**Suggested reading**

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

**Course Outcomes:**

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

**AUDIT 1 and 2: PEDAGOGY STUDIES**

| **Course Objectives:**<br>Students will be able to:<br>4. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.<br>5. Identify critical evidence gaps to guide the development. | | |
|---|---|---|
| **Syllabus** | | |
| **Units** | **Content** | **Hours** |
| **1** | • **Introduction and Methodology:**<br>• Aims and rationale, Policy background, Conceptual framework and terminology<br>• Theories of learning, Curriculum, Teacher education.<br>• Conceptual framework, Research questions.<br>• Overview of methodology and Searching. | 4 |
| **2** | • Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.<br>• Curriculum, Teacher education. | 2 |
| **3** | • Evidence on the effectiveness of pedagogical practices<br>• Methodology for the in depth stage: quality assessment of included studies.<br>• How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?<br>• Theory of change.<br>• Strength and nature of the body of evidence for effective pedagogical practices.<br>• Pedagogic theory and pedagogical approaches.<br>• Teachers' attitudes and beliefs and Pedagogic strategies. | 4 |
| **4** | • Professional development: alignment with classroom practices and follow- | 4 |

| | | |
|---|---|---|
| | up support<br>• Peer support<br>• Support from the head teacher and the community.<br>• Curriculum and assessment<br>• Barriers to learning: limited resources and large class sizes | |
| **5** | • **Research gaps and future directions**<br>• Research design<br>• Contexts<br>• Pedagogy<br>• Teacher education<br>• Curriculum and assessment<br>• Dissemination and research impact. | 2 |

**Suggested reading**


1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.


**Course Outcomes:**

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

## AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

***Course Objectives***

1. To achieve overall health of body and mind
2. To overcome stress

***Syllabus***

| Unit | *Content* | *Hours* |
|---|---|---|

| | | |
|---|---|---|
| 1 | • Definitions of Eight parts of yog. ( Ashtanga ) | 8 |
| 2 | • Yam and Niyam.<br>Do`s and Don't's in life.<br>i) Ahinsa, satya, astheya, bramhacharya and aparigraha<br>ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan | 8 |
| 3 | • Asan and Pranayam<br>i) Various yog poses and their benefits for mind & body<br>ii)Regularization of breathing techniques and its effects-Types of pranayam | 8 |

***Suggested reading***

1. 'Yogic Asanas for Group Tarining-Part-I" : Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

**Course Outcomes:**

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

**AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS**

***Course Objectives***

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

***Syllabus***

| Unit | Content | Hours |
|---|---|---|
| 1 | Neetisatakam-Holistic development of personality<br>• Verses- 19,20,21,22 (wisdom)<br>• Verses- 29,31,32 (pride & heroism)<br>• Verses- 26,28,63,65 (virtue)<br>• Verses- 52,53,59 (dont's)<br>• Verses- 71,73,75,78 (do's) | 8 |
| 2 | • Approach to day to day work and duties.<br>• Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48,<br>• Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,<br>• Chapter 18-Verses 45, 46, 48. | 8 |

| | | |
|---|---|---|
| 3 | • Statements of basic knowledge.<br>• Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68<br>• Chapter 12 -Verses 13, 14, 15, 16,17, 18<br>• Personality of Role model. Shrimad Bhagwad Geeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42,<br>• Chapter 4-Verses 18, 38,39<br>• Chapter18 – Verses 37,38,63 | 8 |

***Suggested reading***

1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication
2. Department), Kolkata
3. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath,
4. Rashtriya Sanskrit Sansthanam, New Delhi.

***Course Outcomes***

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

## Course Scheme for M.Tech. Computer Science and Engineering

### M.Tech Sem-I

| Course Number | Subject | Scheme Of Studies Per Week | | | Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| 1CS01 | Program Core I- Mathematical foundations of Computer Science | 3 | 0 | 0 | 3 |
| 1CS02 | Program Core II-Advanced Data Structures | 3 | 0 | 0 | 3 |
| 1CSxx | Program Elective I – Machine Learning/ Wireless Sensor Networks/ Introduction to Intelligent Systems | 3 | 0 | 0 | 3 |
| 1CSxx | Program Elective II – Data Science/ Distributed Systems/ Advanced Wireless and Mobile Networks | 3 | 0 | 0 | 3 |
| 1Axxx | Research Methodology and IPR | 2 | 0 | 0 | 2 |
| 1Axxx | Audit Course | 2 | 0 | 0 | 0 |
| 1CS03 | Laboratory 1 (Advanced Data Structures) | 0 | 0 | 4 | 2 |
| 1CS04 | Laboratory 2 (Based on Electives) | 0 | 0 | 4 | 2 |
| | Total Credits: | 18 | | | |

### M.Tech Sem- II

| Course Number | Subject | Scheme Of Studies Per Week | | | Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| 2CS05 | Program Core III - Advance Algorithms | 3 | 0 | 0 | 3 |
| 2CS06 | Program Core IV - Soft Computing | 3 | 0 | 0 | 3 |
| 2CSxx | Program Elective III – Data Preparation and Analysis/ Secure Software Design & Enterprise Computing/ Computer Vision | 3 | 0 | 0 | 3 |
| 2CSxx | Program Elective IV – Human and Computer Interaction/ GPU Computing/ Digital Forensics | 3 | 0 | 0 | 3 |
| 2Axxx | Audit Course | 2 | 0 | 0 | 0 |
| 2CS07 | Laboratory 3 (Based on cores) | 0 | 0 | 4 | 2 |
| 2CS08 | Laboratory 4 (Based on Electives) | 0 | 0 | 4 | 2 |
| 2CS09 | Mini Project with Seminar | 2 | 0 | 0 | 2 |
| | Total Credits: | 18 | | | |

*Students be encouraged to go to Industrial Training/Internship for at least 2-3 months during semester break.

**M.Tech III Sem***

| Course No. | Subject | Scheme of Studies Periods Per Week | | | Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| 3CSxx | Program Elective 5 –<br>Mobile Applications and Services/ Compiler for HPC/ Optimization Techniques | 3 | 0 | 0 | 03 |
| 3CSxx | Open Elective–<br>1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy | 3 | 0 | 0 | 03 |
| 3CS10 | Dissertation-I /Industrial Project | 0 | 0 | 20 | 10 |
| | Total Credits 16 | | | | |

*Students going for Industrial Project/Thesis will complete these courses through MOOCs.

**M.Tech Sem-IV**

| | Subject | Scheme of Studies Per Week | | | Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| | Dissertation II | 0 | 0 | 32 | 16 |
| | Total Credits: 16 | | | | |

The program offers several elective courses, focusing on different aspects of Computer Science and Engineering. A student can choose to do any course from given program elective set.

**Program Outcomes of CSE (M.Tech.) program:**

The main outcomes of the CSE (M.Tech.) program are given here. At the end of the program a student is expected to have:

1. An understanding of the theoretical foundations and the limits of computing.
2. An ability to adapt existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
3. An ability to design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
4. Understanding and ability to use advanced computing techniques and tools.
5. An ability to undertake original research at the cutting edge of computer science & its related areas.
6. An ability to function effectively individually or as a part of a team to accomplish a stated goal.
7. An understanding of professional and ethical responsibility.
8. An ability to communicate effectively with a wide range of audience.
9. An ability to learn independently and engage in life¬long learning.

10. An understanding of the impact of IT related solutions in an economic, social and environment context.

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

**Syllabus, course objective and course outcomes for various post graduation courses**

**Core Subjects:**

| | |
|---|---|
| **Course Code** | 1CS01 |
| **Course Name** | Mathematical Foundation of Computer Science |
| **Credits** | 3 |
| **Pre-Requisites** | Discrete Mathematics |

Total Number of Lectures:48

| COURSE OBJECTIVE |
|---|
| • To understand the mathematical fundamentals that is prerequisites for avariety of courses like Data mining, Network protocols, analysis of Web traffic, Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning. |
| • To developthe understanding ofthe mathematical and logical basis to many modern techniques in information technology like machine learning, programming language design, and concurrency. |
| • To study various sampling and classification problems. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1**<br>Probability mass, density, and cumulative distribution functions, Parametric families of distributions, Expected value, variance, conditional expectation, Applications of the univariate and multivariate Central Limit Theorem, Probabilistic inequalities, Markov chains | 7 |
| **Unit 2**<br>Random samples, sampling distributions of estimators, Methods of Moments and Maximum Likelihood, | 7 |
| **Unit 3**<br>Statistical inference, Introduction to multivariate statistical models: regression and classification problems, principal components analysis, The problem of overfitting model assessment. | 8 |
| **Unit 4**<br>Graph Theory: Isomorphism, Planar graphs, graph colouring, hamilton circuits and euler cycles. | 11 |

| | |
|---|---|
| Permutations and Combinations with and without repetition.<br>Specialized techniques to solve combinatorial enumeration problems | |
| **Unit 5**<br>**Computer science and engineering applications**<br>Data mining, Network protocols, analysis of Web traffic, Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning. | 10 |
| **Unit 6**<br>Recent Trands in various distribution functions in mathmatical field of computer science for varying fields like bioinformatic, soft computing, and computer vision. | 5 |

| **COURSE OUTCOMES** |
|---|
| After completion of course, students would be able to: |
| • To understand the basic notions of discrete and continuous probability. |
| • To understand the methods of statistical inference, and the role that sampling distributions play in those methods. |
| • To be able to perform correct and meaningful statistical analyses of simple to moderate complexity. |

**References:**


1. John Vince, Foundation Mathematics for Computer Science, Springer.
2. K. Trivedi.Probability and Statistics with Reliability, Queuing, and Computer Science Applications. Wiley.
3. M. Mitzenmacher and E. Upfal.Probability and Computing: Randomized Algorithms and Probabilistic Analysis.
4. Alan Tucker, Applied Combinatorics, Wiley


| | |
|---|---|
| **Course Code** | 1CS02 |
| **Course Name** | Advanced Data Structures |
| **Credits** | 3 |
| **Pre-Requisites** | UG level course in Data Structures |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • The student should be able to choose appropriate data structures, understand the ADT/libraries, and use it to design algorithms for a specific problem. |
| • Students should be able to understand the necessary mathematical abstraction to solve problems. |
| • To familiarize students with advanced paradigms and data structure used to solve algorithmic problems. |
| • Student should be able to come up with analysis of efficiency and proofs of correctness. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1**<br>**Dictionaries:** Definition, Dictionary Abstract Data Type, Implementation of Dictionaries.<br>**Hashing:** Review of Hashing, Hash Function, Collision Resolution Techniques in Hashing, Separate Chaining, Open Addressing, Linear Probing, Quadratic | 7 |

| | |
|---|---|
| Probing, Double Hashing, Rehashing, Extendible Hashing. | |
| **Unit 2**<br>**Skip Lists:** Need for Randomizing Data Structures and Algorithms, Search and Update Operations on Skip Lists, Probabilistic Analysis of Skip Lists, Deterministic Skip Lists | 5 |
| **Unit 3**<br>**Trees:** Binary Search Trees, AVL Trees, Red Black Trees, 2-3 Trees, B-Trees, Splay Trees | 9 |
| **Unit 4**<br>**Text Processing:** Sting Operations, Brute-Force Pattern Matching, The Boyer-Moore Algorithm, The Knuth-Morris-Pratt Algorithm, Standard Tries, Compressed Tries, Suffix Tries, The Huffman Coding Algorithm, The Longest Common Subsequence Problem (LCS), Applying Dynamic Programming to the LCS Problem. | 12 |
| **Unit 5**<br>**Computational Geometry:** One Dimensional Range Searching, Two Dimensional Range Searching, Constructing a Priority Search Tree, Searching a Priority Search Tree, Priority Range Trees, Quadtrees, k-D Trees. | 10 |
| **Unit 6**<br>Recent Trands in Hashing, Trees, and various computational geometry methods for effeciently solving the new evolving problem | 5 |

| **COURSE OUTCOMES** |
|---|
| After completion of course, students would be able to: |
| • Understand the implementation of symbol table using hashing techniques. |
| • Develop and analyze algorithms for red-black trees, B-trees and Splay trees. |
| • Develop algorithms for text processing applications. |
| • Identify suitable data structures and develop algorithms for computational geometry problems. |

**References:**

1. Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, 2nd Edition, Pearson, 2004.
2. M T Goodrich, Roberto Tamassia, Algorithm Design, John Wiley, 2002.

| | |
|---|---|
| **Course Code** | 2CS05 |
| **Course Name** | Advanced Algorithms |
| **Credits** | 3 |
| **Pre-Requisites** | UG level course in Algorithm Design and Analysis |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • Introduce students to the advanced methods of designing and analyzing algorithms. |
| • The student should be able to choose appropriate algorithms and use it for a specific problem. |
| • To familiarize students with basic paradigms and data structures used to solve advanced algorithmic problems. |
| • Students should be able to understand different classes of problems concerning their computation difficulties. |
| • To introduce the students to recent developments in the area of algorithmic design. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit1**<br>**Sorting:** Review of various sorting algorithms, topological sorting<br>**Graph:** Definitions and Elementary Algorithms: Shortest path by BFS, shortest path in edge-weighted case (Dijkasra's), depth-first search and computation of strongly connected components, emphasis on correctness proof of the algorithm and time/space analysis, example of amortized analysis. | 6 |
| **Unit 2**<br>**Matroids:** Introduction to greedy paradigm, algorithm to compute a maximum weight maximal independent set. Application to MST.<br>**Graph Matching:** Algorithm to compute maximum matching. Characterization of maximum matching by augmenting paths, Edmond's Blossom algorithm to compute augmenting path. | 8 |
| **Unit 3**<br>**Flow-Networks:** Maxflow-mincut theorem, Ford-Fulkerson Method to compute maximum flow, Edmond-Karp maximum-flow algorithm.<br>**Matrix Computations:** Strassen's algorithm and introduction to divide and conquer paradigm, inverse of a triangular matrix, relation between the time complexities of basic matrix operations, LUP-decomposition. | 9 |
| **Unit 4**<br>**Shortest Path in Graphs:** Floyd-Warshall algorithm and introduction to dynamic programming paradigm. More examples of dynamic programming.<br>**Modulo Representation of integers/polynomials:** Chinese Remainder Theorem, Conversion between base-representation and modulo-representation. Extension to polynomials. Application: Interpolation problem.<br>**Discrete Fourier Transform (DFT):** In complex field, DFT in modulo ring. Fast Fourier Transform algorithm. Schonhage-Strassen Integer Multiplication algorithm | 10 |
| **Unit 5**<br>**Linear Programming:** Geometry of the feasibility region and Simplex algorithm<br>**NP-completeness:** Examples, proof of NP-hardness and NP-completeness.<br>**One or more of the following topics based on time and interest**<br>Approximation algorithms, Randomized Algorithms, Interior Point Method, Advanced Number Theoretic Algorithm | 10 |
| **Unit 6**<br>Recent Trands in problem solving paradigms using recent searching and sorting techniques by applying recently proposed data structures. | 5 |

| **COURSE OUTCOMES** |
|---|
| After completion of course, students would be able to: |
| • Analyze the complexity/performance of different algorithms. |
| • Determine the appropriate data structure for solving a particular set of problems. |
| • Categorize the different problems in various classes according to their complexity. |
| • Students should have an insight of recent activities in the field of the advanced data structure. |

**References:**


1. "Introduction to Algorithms" by Cormen, Leiserson, Rivest, Stein.
2. "The Design and Analysis of Computer Algorithms" by Aho, Hopcroft, Ullman.
3. "Algorithm Design" by Kleinberg and Tardos.

## Research Methodology and IPR

| **Teaching Scheme**<br>Lectures: 1hrs/week | |
|---|---|

**Course Outcomes:**

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

**Syllabus Contents:**

**Unit 1:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Unit 2:** Effective literature studies approaches, analysis

Plagiarism, Research ethics,

**Unit 3:** Effective technical writing, how to write report, Paper

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**Unit 4:** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Unit 5:** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Unit 6:** New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

**References:**

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2 nd Edition , "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.

5. Mayall , “Industrial Design”, McGraw Hill, 1992.
6. Niebel , “Product Design”, McGraw Hill, 1974.
7. Asimov , “Introduction to Design”, Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.
9. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

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|---|---|
| **Course Code** | 2CS06 |
| **Course Name** | Soft Computing |
| **Credits** | 3 |
| **Pre-Requisites** | Basic knowledge of mathematics |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • To introduce soft computing concepts and techniques and foster their abilities in designing appropriate technique for a given scenario. |
| • To implement soft computing based solutions for real-world problems. |
| • To give students knowledge of non-traditional technologies and fundamentals of artificial neural networks, fuzzy sets, fuzzy logic, genetic algorithms. |
| • To provide studentan hand-on experience on MATLAB to implement various strategies. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1**<br>**INTRODUCTION TO SOFT COMPUTING AND NEURAL NETWORKS:** Evolution of Computing: Soft Computing Constituents, From Conventional AI to Computational Intelligence: Machine Learning Basics | 7 |
| **Unit 2**<br>**FUZZY LOGIC:** Fuzzy Sets, Operations on Fuzzy Sets, Fuzzy Relations, Membership Functions: Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems, Fuzzy Expert Systems, Fuzzy Decision Making. | 8 |
| **Unit 3**<br>**NEURAL NETWORKS:** Machine Learning Using Neural Network, Adaptive Networks, Feed forward Networks, Supervised Learning Neural Networks, Radial Basis Function Networks : Reinforcement Learning, Unsupervised Learning Neural Networks, Adaptive Resonance architectures, Advances in Neural networks | 10 |
| **Unit 4**<br>**GENETIC ALGORITHMS:** Introduction to Genetic Algorithms (GA), Applications of GA in Machine Learning : Machine Learning Approach to Knowledge Acquisition. | 5 |
| **Unit 5**<br>**Matlab/Python Lib:** Introduction to Matlab/Python, Arrays and array operations, Functions and Files, Study of neural network toolbox and fuzzy logic toolbox, Simple implementation of Artificial Neural Network and Fuzzy Logic | 13 |
| **Unit 6**<br>Recent Trands in deep learning, various classifiers, neural networks and genetic algorithm. | 5 |

| | |
|---|---|
| Implementation of recently proposed soft computing techniques. | |
| **COURSE OUTCOMES** | |
| After completion of course, students would be able to: | |
| • Identify and describe soft computing techniques and their roles in building intelligent machines | |
| • Apply fuzzy logic and reasoning to handle uncertainty and solve various engineering problems. | |
| • Apply genetic algorithms to combinatorial optimization problems. | |
| • Evaluate and compare solutions by various soft computing approaches for a given problem. | |

**References:**

1. Jyh:Shing Roger Jang, Chuen:Tsai Sun, EijiMizutani, Neuro:Fuzzy and Soft Computing, Prentice:Hall of India, 2003.
2. George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic:Theory and Applications, Prentice Hall, 1995.
3. MATLAB Toolkit Manual

**Elective Subjects**

| | |
|---|---|
| **Course Code** | |
| **Course Name** | Machine learning |
| **Credits** | 3 |
| **Pre-Requisites** | |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • To learn the concept of how to learn patterns and concepts from data without being explicitly programmed in various IOT nodes. |
| • To design and analyse various machine learning algorithms and techniques with a modern outlook focusing on recent advances. |
| • Explore supervised and unsupervised learning paradigms of machine learning. |
| • To explore Deep learning technique and various feature extraction strategies. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>**Supervised Learning (Regression/Classification)**<br>• Basic methods: Distance-based methods, Nearest-Neighbours, Decision Trees, Naive Bayes<br>• Linear models: Linear Regression, Logistic Regression, Generalized Linear Models<br>• Support Vector Machines, Nonlinearity and Kernel Methods<br>• Beyond Binary Classification: Multi-class/Structured Outputs, Ranking | 10 |
| **Unit 2:**<br>**Unsupervised Learning**<br>• Clustering: K-means/Kernel K-means<br>• Dimensionality Reduction: PCA and kernel PCA<br>• Matrix Factorization and Matrix Completion<br>• Generative Models (mixture models and latent factor models) | 7 |
| **Unit 3**<br>Evaluating Machine Learning algorithms and Model Selection, Introduction to Statistical Learning Theory, Ensemble Methods (Boosting, Bagging, Random | 6 |

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| Forests) | |
| **Unit 4**<br>Sparse Modeling and Estimation, Modeling Sequence/Time-Series Data, Deep Learning and Feature Representation Learning | 9 |
| **Unit 5**<br>Scalable Machine Learning (Online and Distributed Learning)<br>A selection from some other advanced topics, e.g., Semi-supervised Learning, Active Learning, Reinforcement Learning, Inference in Graphical Models, Introduction to Bayesian Learning and Inference | 9 |
| **Unit 6:**<br>Recent trends in various learning techniques of machine learning and classification methods for IOT applications. Various models for IOT applications. | 5 |

| **COURSE OUTCOMES** |
|---|
| After completion of course, students would be able to: |
| • Extract features that can be used for a particular machine learning approach in various IOT applications. |
| • To compare and contrast pros and cons of various machine learning techniques and to get an insight of when to apply a particular machine learning approach. |
| • To mathematically analyse various machine learning approaches and paradigms. |

**References:**


1. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer 2009 (freely available online)
3. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.


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|---|---|
| **Course Code** | |
| **Course Name** | Wireless Sensor Networks |
| **Credits** | 3 |
| **Pre-Requisites** | Wireless Communication |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • Architect sensor networks for various application setups. |
| • Devise appropriate data dissemination protocols and model links cost. |
| • Understanding of the fundamental concepts of wireless sensor networks and have a basic knowledge of the various protocols at various layers. |
| • Evaluate the performance of sensor networks and identify bottlenecks. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>**Introduction to Wireless Sensor Networks:** Course Information, Introduction to Wireless Sensor Networks: Motivations, Applications, Performance metrics, History and Design factors<br>**Network Architecture:** Traditional layered stack, Cross-layer designs, Sensor Network Architecture<br>**Hardware Platforms:** Motes, Hardware parameters | 9 |
| **Unit 2:**<br>**Introduction to ns-3: I**ntroduction to Network Simulator 3 (ns-3), Description | 9 |

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|---|---|
| of the ns-3 core module and simulation example. | |
| **Unit 3:**<br>**Medium Access Control Protocol design:** Fixed Access, Random Access, WSN protocols: synchronized, duty-cycled<br>**Introduction to Markov Chain:** Discrete time Markov Chain definition, properties, classification and analysis<br>**MAC Protocol Analysis:** Asynchronous duty-cycled. X-MAC Analysis (Markov Chain) | 8 |
| **Unit 4:**<br>**Security**: Possible attacks, countermeasures, SPINS, Static and dynamic key distribution | 8 |
| **Unit 5:**<br>**Routing protocols:** Introduction, MANET protocols<br>**Routing protocols for WSN**: Resource-aware routing, Data-centric, Geographic Routing, Broadcast, Multicast<br>**Opportunistic Routing Analysis**: Analysis of opportunistic routing (Markov Chain)<br>Advanced topics in wireless sensor networks. | 10 |
| **Unit 6:**<br>**ADVANCED TOPICS**<br>Recent development in WSN standards, software applications. | 4 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be able to:** |
| • Describe and explain radio standards and communication protocols for wireless sensor networks. |
| • Explain the function of the node architecture and use of sensors for various applications. |
| • Be familiar with architectures, functions and performance of wireless sensor networks systems and platforms. |

**References:**


1. W. Dargie and C. Poellabauer, "Fundamentals of Wireless Sensor Networks –Theory and Practice", Wiley 2010
2. KazemSohraby, Daniel Minoli and TaiebZnati, "wireless sensor networks -Technology, Protocols, and Applications", Wiley Interscience 2007
3. Takahiro Hara,Vladimir I. Zadorozhny, and Erik Buchmann, "Wireless Sensor Network Technologies for the Information Explosion Era", springer 2010


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| **Course Code** | |
| **Course Name** | Introduction to Intelligent Systems |
| **Credits** | 3 |
| **Pre-Requisites** | Data Structures and Data Management or Data Structures |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • The aim of the course is to introduce to the field of Artificial Intelligence (AI) with emphasis on its use to solve real world problems for which solutions are difficult to express using the traditional algorithmic approach. It explores the essential theory behind methodologies for developing systems that demonstrate intelligent behaviour including dealing with uncertainty, |

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|---|---|
| learning from experience and following problem solving strategies found in nature. | |
| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
| **Unit 1:** Biological foundations to intelligent systems I: Artificial neural networks, Back-propagation networks, Radial basis function networks, and recurrent networks. | 9 |
| **Unit 2:** Biological foundations to intelligent systems II: Fuzzy logic, knowledge Representation and inference mechanism, genetic algorithm, and fuzzy neural networks. | 6 |
| **Unit 3:** Search Methods Basic concepts of graph and tree search. Three simple search methods: breadth-first search, depth-first search, iterative deepening search. Heuristic search methods: best-first search, admissible evaluation functions, hill-climbing search. Optimisation and search such as stochastic annealing and genetic algorithm. | 7 |
| **Unit 4:** Knowledge representation and logical inference Issues in knowledge representation. Structured representation, such as frames, and scripts, semantic networks and conceptual graphs. Formal logic and logical inference. Knowledge-based systems structures, its basic components. Ideas of Blackboard architectures. | 9 |
| **Unit 5:** Reasoning under uncertainty and Learning Techniques on uncertainty reasoning such as Bayesian reasoning, Certainty factors and Dempster-Shafer Theory of Evidential reasoning, A study of different learning and evolutionary algorithms, such as statistical learning and induction learning. | 7 |
| **Unit 6:** Recent trends in Fuzzy logic, Knowledge Representation | 5 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • Able to Demonstrate knowledge of the fundamental principles of intelligent systems and would be able to analyse and compare the relative merits of a variety of AI problem solving techniques. |

**References:**


1. Luger G.F. and Stubblefield W.A. (2008). Artificial Intelligence: Structures and strategies for Complex Problem Solving. Addison Wesley, 6th edition.
2. Russell S. and Norvig P. (2009). Artificial Intelligence: A Modern Approach. Prentice-Hall, 3rd edition.


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|---|---|
| **Course Code** | |
| **Course Name** | Data Science |
| **Credits** | 3 |
| **Pre-Requisites** | |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
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|---|
| • Provide you with the knowledge and expertise to become a proficient data scientist. |
| • Demonstrate an understanding of statistics and machine learning concepts that are vital for data science; |
| • Produce Python code to statistically analyse a dataset; |
| • Critically evaluate data visualisations based on their design and use for communicating stories from data; |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1:**<br>Introduction to core concepts and technologies: Introduction, Terminology, data science process, data science toolkit, Types of data, Example applications. | 6 |
| **Unit 2:**<br>Data collection and management: Introduction, Sources of data, Data collection and APIs, Exploring and fixing data, Data storage and management, Using multiple data sources | 7 |
| **Unit 3:**<br>Data analysis: Introduction, Terminology and concepts, Introduction to statistics, Central tendencies and distributions, Variance,Distribution properties and arithmetic, Samples/CLT, Basic machine learning algorithms, Linear regression, SVM, Naive Bayes. | 10 |
| **Unit 4:**<br>Data visualisation:Introduction, Types of data visualisation,Data for visualisation:Data types, Data encodings, Retinal variables, Mapping variables to encodings, Visual encodings. | 11 |
| **Unit 5:**<br>Applications of Data Science,Technologies for visualisation, Bokeh (Python) | 7 |
| **Unit 6:**<br>Recent trends in various data collection and analysis techniques, various visualization techniques, application development methods of used in data science. | 7 |

| COURSE OUTCOMES |
|---|
| **On completion of the course the student should be able to** |
| • Explain how data is collected, managed and stored for data science; |
| • Understand the key concepts in data science, including their real-world applications and the toolkit used by data scientists; |
| • Implement data collection and management scripts using MongoDB |

References:

1. Cathy O'Neil and Rachel Schutt. Doing Data Science, Straight Talk From The Frontline. O'Reilly.
2. Jure Leskovek, Anand Rajaraman and Jeffrey Ullman. Mining of Massive Datasets. v2.1, Cambridge University Press.

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|---|---|
| **Course Code** | |
| **Course Name** | Distributed Systems |

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|---|---|
| **Credits** | 3 |
| **Pre-Requisites** | Database Management Systems |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • To introduce the fundamental concepts and issues of managing large volume of shared data in a parallel and distributed environment, and to provide insight into related research problems. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>**INTRODUCTION**<br>Distributed data processing; What is a DDBS; Advantages and disadvantages of DDBS; Problem areas; Overview of database and computer network concepts<br>**DISTRIBUTED DATABASE MANAGEMENT SYSTEM ARCHITECTURE**<br>Transparencies in a distributed DBMS; Distributed DBMS architecture; Global directory issues | 8 |
| **Unit 2:**<br>**DISTRIBUTED DATABASE DESIGN**<br>Alternative design strategies; Distributed design issues; Fragmentation; Data allocation<br>**SEMANTICS DATA CONTROL**<br>View management; Data security; Semantic Integrity Control<br>**QUERY PROCESSING ISSUES**<br>Objectives of query processing; Characterization of query processors; Layers of query processing; Query decomposition; Localization of distributed data | 11 |
| **Unit 3:**<br>**DISTRIBUTED QUERY OPTIMIZATION**<br>Factors governing query optimization; Centralized query optimization; Ordering of fragment queries; Distributed query optimization algorithms<br>**TRANSACTION MANAGEMENT**<br>The transaction concept; Goals of transaction management; Characteristics of transactions; Taxonomy of transaction models<br>**CONCURRENCY CONTROL**<br>Concurrency control in centralized database systems; Concurrency control in DDBSs; Distributed concurrency control algorithms; Deadlock management | 11 |
| **Unit 4:**<br>**RELIABILITY**<br>Reliability issues in DDBSs; Types of failures; Reliability techniques; Commit protocols; Recovery protocols | 8 |
| **Unit 5:**<br>**PARALLEL DATABASE SYSTEMS**<br>Parallel architectures; parallel query processing and optimization; load balancing | 6 |
| **Unit 6:** | 4 |

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|---|---|
| **ADVANCED TOPICS**<br>Mobile Databases, Distributed Object Management, Multi-databases | |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • Design trends in distributed systems. |
| • Apply network virtualization. |
| • Apply remote method invocation and objects. |

**References:**

1. Principles of Distributed Database Systems, M.T. Ozsu and P. Valduriez, Prentice-Hall, 1991.
2. Distributed Database Systems, D. Bell and J. Grimson, Addison-Wesley, 1992.

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|---|---|
| **Course Code** | |
| **Course Name** | Advanced Wireless and Mobile Networks |
| **Credits** | 3 |
| **Pre-Requisites** | Computer Networks |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • The students should get familiar with the wireless/mobile market and the future needs and challenges. |
| • To get familiar with key concepts of wireless networks, standards, technologies and their basic operations |
| • To learn how to design and analyse various medium access |
| • To learn how to evaluate MAC and network protocols using network simulation software tools. |
| • The students should get familiar with the wireless/mobile market and the future needs and challenges. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>**INTRODUCTION:**<br>Wireless Networking Trends, Key Wireless Physical Layer Concepts, Multiple Access Technologies -CDMA, FDMA, TDMA, Spread Spectrum technologies, Frequency reuse, Radio Propagation and Modelling, Challenges in Mobile Computing: Resource poorness, Bandwidth, energy etc.<br>**WIRELESS LOCAL AREA NETWORKS:**<br>IEEE 802.11 Wireless LANs Physical & MAC layer, 802.11 MAC Modes (DCF & PCF) IEEE 802.11 standards, Architecture & protocols, Infrastructure vs. Adhoc Modes, Hidden Node & Exposed Terminal Problem, Problems, Fading Effects in Indoor and outdoor WLANs, WLAN Deployment issues | 11 |
| **Unit 2:**<br>**WIRELESS CELLULAR NETWORKS:**<br>1G and 2G, 2.5G, 3G, and 4G, Mobile IPv4, Mobile IPv6, TCP over Wireless Networks, Cellular architecture, Frequency reuse, Channel assignment strategies, Handoff strategies, Interference and system capacity, Improving coverage and capacity in cellular systems, Spread spectrum Technologies. | 10 |

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|---|---|
| **Unit 3:**<br>WiMAX (Physical layer, Media access control, Mobility and Networking), IEEE 802.22<br>Wireless Regional Area Networks, IEEE 802.21 Media Independent Handover Overview<br>**WIRELESS SENSOR NETWORKS**<br>Introduction, Application, Physical, MAC layer and Network Layer, Power Management, Tiny OS Overview. | 8 |
| **Unit 4:**<br>**WIRELESS PANs**<br>Bluetooth AND Zigbee, Introduction to Wireless Sensors,. | 4 |
| **Unit 5:**<br>**SECURITY**<br>Security in wireless Networks Vulnerabilities, Security techniques, Wi-Fi Security, DoS in wireless communication. | 10 |
| **Unit 6:**<br>**ADVANCED TOPICS**<br>IEEE 802.11x and IEEE 802.11i standards, Introduction to Vehicular Adhoc Networks | 5 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be:** |
| • Demonstrate advanced knowledge of networking and wireless networking and understand various types of wireless networks, standards, operations and use cases. |
| • Be able to design WLAN, WPAN, WWAN, Cellular based upon underlying propagation and performance analysis. |
| • Demonstrate knowledge of protocols used in wireless networks and learn simulating wireless networks. |
| • Design wireless networks exploring trade-offs between wire line and wireless links. |
| • Develop mobile applications to solve some of the real world problems. |

**References:**


1. Schiller J., Mobile Communications, Addison Wesley 2000
2. Stallings W., Wireless Communications and Networks, Pearson Education 2005
3. Stojmenic Ivan, Handbook of Wireless Networks and Mobile Computing, John Wiley and Sons Inc 2002
4. Yi Bing Lin and Imrich Chlamtac, Wireless and Mobile Network Architectures, John Wiley and Sons Inc 2000
5. Pandya Raj, Mobile and Personal Communications Systems and Services, PHI 200


| | |
|---|---|
| **Course Code** | |
| **Course Name** | Data Preparation and Analysis |
| **Credits** | 3 |
| **Pre-Requisites** | |

Total Number of Lectures: 48

| COURSE OBJECTIVE |
|---|
| • To prepare the data for analysis and develop meaningful Data Visualizations |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit1:**<br>**Data Gathering and Preparation:**<br>Data formats, parsing and transformation, Scalability and real-time issues | 9 |
| **Unit2:**<br>**Data Cleaning:**<br>Consistency checking, Heterogeneous and missing data, Data Transformation and segmentation | 11 |
| **Unit3:**<br>**Exploratory Analysis:**<br>Descriptive and comparative statistics, Clustering and association, Hypothesis generation | 13 |
| **Unit4:**<br>**Visualization:**<br>Designing visualizations, Time series, Geolocated data, Correlations and connections, Hierarchies and networks, interactivity | 15 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be:** |
| • Able to extract the data for performing the Analysis. |

**References:**

1. Making sense of Data : A practical Guide to Exploratory Data Analysis and Data Mining, by Glenn J. Myatt

| | |
|---|---|
| **Course Code** | |
| **Course Name** | Secure Software Design and Enterprise Computing |
| **Credits** | 3 |
| **Pre-Requisites** | Computer Programming, Software Engineering |

Total Number of Lectures:48

| COURSE OBJECTIVE |
|---|
| • To fix software flaws and bugs in various software. |
| • To make students aware of various issues like weak random number generation, information leakage, poor usability, and weak or no encryption on data traffic |
| • Techniques for successfully implementing and supporting network services on an enterprise scale and heterogeneous systems environment. |
| • Methodologies and tools to design and develop secure software containing minimum vulnerabilities and flaws. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1:**<br>**Secure Software Design**<br>Identify software vulnerabilities and perform software security analysis, Master | 8 |

| | |
|---|---|
| security programming practices, Master fundamental software security design concepts, Perform security testing and quality assurance. | |
| **Unit 2:**<br>**Enterprise Application Development**<br>Describe the nature and scope of enterprise software applications, Design distributed N-tier software application, Research technologies available for the presentation, business and data tiers of an enterprise software application, Design and build a database using an enterprise database system, Develop components at the different tiers in an enterprise system, Design and develop a multi-tier solution to a problem using technologies used in enterprise system, Present software solution. | 11 |
| **Unit 3:**<br>**Enterprise Systems Administration**<br>Design, implement and maintain a directory-based server infrastructure in a heterogeneous systems environment, Monitor server resource utilization for system reliability and availability, Install and administer network services (DNS/DHCP/Terminal Services/Clustering/Web/Email). | 8 |
| **Unit 4:**<br>Obtain the ability to manage and troubleshoot a network running multiple services, Understand the requirements of an enterprise network and how to go about managing them. | 8 |
| **Unit 5:**<br>Handle insecure exceptions and command/SQL injection, Defend web and mobile applications against attackers, software containing minimum vulnerabilities and flaws. | 9 |
| **Unit 6:**<br>Case study of DNS server, DHCP configuration and SQL injection attack. | 4 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be able to:** |
| • Differentiate between various software vulnerabilities. |
| • Software process vulnerabilities for an organization. |
| • Monitor resources consumption in a software. |
| • Interrelate security and software development process. |

**References:**


1. Theodor Richardson, Charles N Thies, Secure Software Design, Jones & Bartlett
2. Kenneth R. van Wyk, Mark G. Graff, Dan S. Peters, Diana L. Burley, Enterprise Software Security, Addison Wesley.


| **Course Code** | |
|---|---|
| **Course Name** | Computer Vision |
| **Credits** | 3 |
| **Pre-Requisites** | Linear algebra, vector calculus, Data structures and Programming. |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • Be familiar with both the theoretical and practical aspects of computing with images. |
| • Have described the foundation of image formation, measurement, and analysis. |

| |
|---|
| • Understand the geometric relationships between 2D images and the 3D world. |
| • Grasp the principles of state-of-the-art deep neural networks. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1:**<br>Overview, computer imaging systems, lenses, Image formation and sensing, Image analysis, pre-processing and Binary image analysis | 8 |
| **Unit 2:**<br>Edge detection, Edge detection performance, Hough transform, corner detection | 9 |
| **Unit 3:**<br>Segmentation, Morphological filtering, Fourier transform | 9 |
| **Unit 4:**<br>Feature extraction, shape, histogram, color, spectral, texture, using CVIPtools, Feature analysis, feature vectors, distance /similarity measures, data pre-processing | 9 |
| **Unit 5:**<br>Pattern Analysis:<br>Clustering: K-Means, K-Medoids, Mixture of Gaussians<br>Classification: Discriminant Function, Supervised, Un-supervised, Semi-supervised<br>Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA, ICA, and Non-parametric methods. | 9 |
| **Unit 6:**<br>Recent trends inActivity Recognition, computational photography, Biometrics. | 4 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be able to:** |
| • Developed the practical skills necessary to build computer vision applications. |
| • To have gained exposure to object and scene recognition and categorization from images. |

**References:**

1. Computer Vision: Algorithms and Applications by Richard Szeliski.
2. Deep Learning, by Goodfellow, Bengio, and Courville.
3. Dictionary of Computer Vision and Image Processing, by Fisher et al.

| | |
|---|---|
| **Course Code** | |
| **Course Name** | Human and Computer Interection |
| **Credits** | 3 |
| **Pre-Requisites** | |

Total Number of Lectures: 48

| COURSE OBJECTIVE |
|---|
| • Learn the foundations of Human Computer Interaction<br>• Be familiar with the design technologies for individuals and persons with disabilities<br>• Be aware of mobile Human Computer interaction. |

- Learn the guidelines for user interface.

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1:**<br>Human: I/O channels – Memory – Reasoning and problem solving; The computer: Devices – Memory – processing and networks; Interaction: Models – frameworks – Ergonomics – styles – elements – interactivity- Paradigms. | 9 |
| **Unit 2:**<br>Interactive Design basics – process – scenarios – navigation – screen design – Iteration and prototyping. HCI in software process – software life cycle – usability engineering – Prototyping in practice – design rationale. Design rules – principles, standards, guidelines, rules. Evaluation Techniques – Universal Design. | 12 |
| **Unit 3:**<br>Cognitive models –Socio-Organizational issues and stake holder requirements –Communication and collaboration models-Hypertext, Multimedia and WWW. | 8 |
| **Unit 4:**<br>Mobile Ecosystem: Platforms, Application frameworks- Types of Mobile Applications: Widgets, Applications, Games- Mobile Information Architecture, Mobile 2.0, Mobile Design: Elements of Mobile Design, Tools. | 8 |
| **Unit 5:**<br>Designing Web Interfaces – Drag & Drop, Direct Selection, Contextual Tools, Overlays, Inlays and Virtual Pages, Process Flow. Case Studies. | 8 |
| **Unit 6:**<br>Recent Trends: Speech Recognition and Translation, Multimodal System | 3 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be:** |
| • Understand the structure of models and theries of human computer interaction and vision.\ <br>• Design an interactive web interface on the basis of models studied. |

**References:**

1. Alan Dix, Janet Finlay, Gregory Abowd, Russell Beale, “Human Computer Interaction”, 3rd Edition, Pearson Education, 2004 (UNIT I , II & III)
2. Brian Fling, “Mobile Design and Development”, First Edition , O�Reilly Media Inc., 2009 (UNIT – IV)
3. Bill Scott and Theresa Neil, “Designing Web Interfaces”, First Edition, O�Reilly, 2009.(UNIT-V)

| | |
|---|---|
| **Course Code** | |
| **Course Name** | GPU Computing |
| **Credits** | 3 |
| **Pre-Requisites** | |

Total Number of Lectures: 48

| COURSE OBJECTIVE | |
|---|---|
| • To learn parallel programming with Graphics Processing Units (GPUs). | |
| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |

| | |
|---|---|
| **Unit 1:**<br>**Introduction**: History, Graphics Processors, Graphics Processing Units, GPGPUs. Clock speeds, CPU / GPU comparisons, Heterogeneity, Accelerators, Parallel programming, CUDA OpenCL / OpenACC,<br>Hello World Computation Kernels, Launch parameters, Thread hierarchy, Warps / Wavefronts, Thread blocks / Workgroups, Streaming multiprocessors, 1D / 2D / 3D thread mapping, Device properties, Simple Programs | 13 |
| **Unit 2:**<br>**Memory**: Memory hierarchy, DRAM / global, local / shared, private / local, textures, Constant Memory, Pointers, Parameter Passing, Arrays and dynamic Memory, Multi-dimensional Arrays, Memory Allocation, Memory copying across devices, Programs with matrices, Performance evaluation with different memories | 7 |
| **Unit 3:**<br>**Synchronization**: Memory Consistency, Barriers (local versus global), Atomics, Memory fence. Prefix sum, Reduction. Programs for concurrent Data Structures such as Worklists, Linked-lists. Synchronization across CPU and GPU<br>**Functions**: Device functions, Host functions, Kernels functions, Using libraries (such as Thrust), and developing libraries. | 10 |
| **Unit 4:**<br>**Support**: Debugging GPU Programs. Profiling, Profile tools, Performance aspects<br>**Streams**: Asynchronous processing, tasks, Task-dependence, Overlapped data transfers, Default Stream, Synchronization with streams. Events, Event-based-Synchronization - Overlapping data transfer and kernel execution, pitfalls. | 8 |
| **Unit 5:**<br>**Case Studies**: Image Processing, Graph algorithms, Simulations, Deep Learning | 5 |
| **Unit 6:**<br>**Advanced topics**: Dynamic parallelism, Unified Virtual Memory, Multi-GPU processing, Peer access, Heterogeneous processing | 5 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • Students would learn concepts in parallel programming, implementation of programs on GPUs, debugging and profiling parallel programs. |

**References:**

1. Programming Massively Parallel Processors: A Hands-on Approach; David Kirk, Wen-mei Hwu; Morgan Kaufman; 2010 (ISBN: 978-0123814722)
2. CUDA Programming: A Developer's Guide to Parallel Computing with GPUs; Shane Cook; Morgan Kaufman; 2012 (ISBN: 978-0124159334)

| | |
|---|---|
| **Course Code** | |
| **Course Name** | Digital Forensics |
| **Credits** | 3 |
| **Pre-Requisites** | Cybercrime and Information Warfare, Computer Networks |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • Provides an in-depth study of the rapidly changing and fascinating field of computer |

| |
|---|
| forensics. |
| • Combines both the technical expertise and the knowledge required to investigate, detect and prevent digital crimes. |
| • Knowledge on digital forensics legislations, digital crime, forensics processes and procedures, data acquisition and validation, e-discovery tools |
| • E-evidence collection and preservation, investigating operating systems and file systems, network forensics, art of steganography and mobile device forensics |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1:**<br>**Digital Forensics Science:** Forensics science, computer forensics, and digital forensics.<br>**Computer Crime:** Criminalistics as it relates to the investigative process, analysis of cyber-criminalistics area, holistic approach to cyber-forensics | 9 |
| **Unit 2:**<br>**Cyber Crime Scene Analysis:** Discuss the various court orders etc., methods to search and seizure electronic evidence, retrieved and un-retrieved communications, Discuss the importance of understanding what court documents would be required for a criminal investigation. | 8 |
| **Unit 3:**<br>**Evidence Management & Presentation:** Create and manage shared folders using operating system, importance of the forensic mindset, define the workload of law enforcement, Explain what the normal case would look like, Define who should be notified of a crime, parts of gathering evidence, Define and apply probable cause. | 9 |
| **Unit 4:**<br>**Computer Forensics:** Prepare a case, Begin an investigation, Understand computer forensics workstations and software, Conduct an investigation, Complete a case, Critique a case,<br>**Network Forensics:** open-source security tools for network forensic analysis, requirements for preservation of network data. | 10 |
| **Unit 5:**<br>**Mobile Forensics:** mobile forensics techniques, mobile forensics tools.<br>**Legal Aspects of Digital Forensics:** IT Act 2000, amendment of IT Act 2008. | 8 |
| **Unit 6:**<br>Recent trends in mobile forensic technique and methods to search and seizure electronic evidence | 4 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be able to:** |
| • Understand relevant legislation and codes of ethics |
| • Computer forensics and digital detective and various processes, policies and procedures |
| • E-discovery, guidelines and standards, E-evidence, tools and environment. |
| • Email and web forensics and network forensics |

**References:**


1. John Sammons, The Basics of Digital Forensics, Elsevier

2. John Vacca, Computer Forensics: Computer Crime Scene Investigation, Laxmi Publications

| | |
|---|---|
| **Course Code** | |
| **Course Name** | Mobile Applications and Services |
| **Credits** | 3 |
| **Pre-Requisites** | Wireless Communication and Mobile Computing |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • This course presents the three main mobile platforms and their ecosystems, namely Android, iOS, and PhoneGap/WebOS. |
| • .It explores emerging technologies and tools used to design and implement feature-rich mobile applications for smartphones and tablets |
| • It also take into account both the technical constraints relative to storage capacity, processing capacity, display screen, communication interfaces, and the user interface, context and profile |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:** Introduction:Introduction to Mobile Computing, Introduction to Android Development Environment, Factors in Developing Mobile Applications, Mobile Software Engineering, Frameworks and Tools, Generic UI Development Android User | 8 |
| **Unit 2:** More on Uis: VUIs and Mobile Apps, Text-to-Speech Techniques, Designing the Right UI, Multichannel and Multimodal Uis, . Storing and Retrieving Data, Synchronization and Replication of Mobile Data, Getting the Model Right, Android Storing and Retrieving Data, Working with a Content Provider | 8 |
| **Unit 3:** Communications via Network and the Web:State Machine, Correct Communications Model, Android Networking and Web, Telephony Deciding Scope of an App, Wireless Connectivity and Mobile Apps, Android Telephony<br><br>Notifications and Alarms:Performance, Performance and Memory Management, Android Notifications and Alarms, Graphics, Performance and Multithreading, Graphics and UI Performance, Android Graphics | 10 |
| **Unit 4:** Putting It All Together : Packaging and Deploying, Performance Best Practices, Android Field Service App, Location Mobility and Location Based Services Android<br>Multimedia: Mobile Agents and Peer-to-Peer Architecture, Android Multimedia | 9 |
| **Unit 5:** Platforms and Additional Issues : Development Process, Architecture, Design, Technology Selection, Mobile App Development Hurdles, Testing, Security and Hacking , Active Transactions, More on Security, Hacking Android | 8 |
| **Unit 6:** Recent trends inCommunication protocols for IOT nodes, mobile computimng techniques in IOT, agents based communications in IOT | 5 |

| **COURSE OUTCOMES** |
|---|
| On completion of the course the student should be able to |

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|---|
| • identify the target platform and users and be able to define and sketch a mobile application |
| • understand the fundamentals, frameworks, and development lifecycle of mobile application platforms including iOS, Android, and PhoneGap |
| • Design and develop a mobile application prototype in one of the platform (challenge project) |

**References:**

1. Wei-Meng Lee, Beginning Android™ 4 Application Development, 2012 by John Wiley & Sons

| | |
|---|---|
| **Course Code** | |
| **Course Name** | Compiler for HPC |
| **Credits** | 3 |
| **Pre-Requisites** | Data Structure, Compiler Design, Theory of Computation |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • The objective of this course is to introduce structure of compilers and high performance compiler design for students. Concepts of cache coherence and parallel loops in compilers are included. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit1:**<br>**High Performance Systems,** Structure of a Compiler, Programming Language Features, Languages for High Performance. | 7 |
| **Unit2:**<br>**Data Dependence:** Data Dependence in Loops, Data Dependence in Conditionals, Data Dependence in Parallel Loops, Program Dependence Graph.<br>**Scalar Analysis with Factored Use-Def Chains:** Constructing Factored Use-Def Chains, FUD Chains for Arrays, Induction Variables Using FUD Chains, Constant Propagation with FUD Chains, Data Dependence for Scalars. Data Dependence Analysis for Arrays. | 7 |
| **Unit3:**<br>Array Region Analysis, Pointer Analysis, I/O Dependence, Procedure Calls, Inter-procedural Analysis.<br>**Loop Restructuring:** Simple Transformations, Loop Fusion, Loop Fission, Loop Reversal, Loop Interchanging, Loop Skewing, Linear Loop Transformations, Strip-Mining, Loop Tiling, Other Loop Transformations, and Inter-procedural Transformations.<br>**Optimizing for Locality:** Single Reference to Each Array, Multiple References, General Tiling, Fission and Fusion for Locality. | 10 |
| **Unit4:**<br>**Concurrency Analysis:** Concurrency from Sequential Loops, Concurrency from Parallel Loops, Nested Loops, Round off Error, Exceptions and Debuggers.<br>**Vector Analysis:** Vector Code, Vector Code from Sequential Loops, Vector Code from For all Loops, Nested Loops, Round off Error, Exceptions, and Debuggers, Multi-vector Computers. | 10 |
| **Unit5:**<br>**Message-Passing Machines:** SIMD Machines, MIMD Machines, Data Layout, Parallel Code for Array Assignment, Remote Data Access, Automatic Data Layout, Multiple Array Assignments, Other Topics. | 10 |

| | |
|---|---|
| **Scalable Shared-Memory Machines:** Global Cache Coherence, Local Cache Coherence, Latency Tolerant Machines. | |
| **Unit 6:**<br>Recent trends in compiler design for high performance computing and message passing machines and scalable shared memory machine. | 4 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be:** |
| • Familiar with the structure of compiler.<br>• Parallel loops, data dependency and exception handling and debugging in compiler. |

**References:**

1. Michael Wolfe, High-Performance Compilers for Parallel Computing, Pearson

| **Course Code** | |
|---|---|
| **Course Name** | Optimization Techniques |
| **Credits** | 3 |
| **Pre-Requisites** | Linear Algebra and Numerical Methods |

Total Number of Lectures: 48

| COURSE OBJECTIVE |
|---|
| The objective of this course is to provide insight to the mathematical formulation of real world problems.<br>To optimize these mathematical problems using nature based algorithms. And the solution is useful specially for NP-Hard problems. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1:**<br>Engineering application of Optimization, Formulation of design problems as mathematical programming problems. | 7 |
| **Unit 2:**<br>General Structure of Optimization Algorithms, Constraints, The Feasible Region. | 7 |
| **Unit 3:**<br>Branches of Mathematical Programming: Optimization using calculus, Graphical Optimization, Linear Programming, Quadratic Programming, Integer Programming, Semi Definite Programming. | 11 |
| **Unit 4:**<br>Optimization Algorithms like Genetic Optimization, Particle Swarm Optimization, Ant Colony Optimization etc. | 12 |
| **Unit 5:**<br>Real life Problems and their mathematical formulation as standard programming problems. | 6 |
| **Unit 6:**<br>Recent trends: Applications of ant colony optimization, genetics and linear and quadratic programming in real world applications. | 5 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be:** |
| • Formulate optimization problems. |
| • Understand and apply the concept of optimality criteria for various types of optimization problems. |
| • Solve various constrained and unconstrained problems in Single variable as well as multivariable. |
| • Apply the methods of optimization in real life situation. |

**References:**

1. Laurence A. Wolsey (1998). Integer programming. Wiley. ISBN 978-0-471-28366-9.
2. Practical Optimization Algorithms and Engineering Applications Andreas Antoniou.
3. An Introduction to Optimization Edwin K., P. Chong & Stanislaw h. Zak.
4. Dimitris Bertsimas; Robert Weismantel (2005). Optimization over integers. Dynamic Ideas. ISBN 978-0-9759146-2-5.
5. John K. Karlof (2006). Integer programming: theory and practice.CRC Press. ISBN 978-0-8493-1914-3.
6. H. Paul Williams (2009). Logic and Integer Programming. Springer. ISBN 978-0-387-92279-9.
7. Michael Jünger; Thomas M. Liebling; Denis Naddef; George Nemhauser; William R. Pulleyblank; Gerhard Reinelt; Giovanni Rinaldi; Laurence A. Wolsey, eds. (2009). 50 Years of Integer Programming 1958-2008: From the Early Years to the State-of-the- Art. Springer. ISBN 978-3-540-68274-5.
8. Der-San Chen; Robert G. Batson; Yu Dang (2010). Applied Integer Programming: Modeling and Solution. John Wiley and Sons. ISBN 978-0-470-37306-4.

## OPEN ELECTIVES
## Business Analytics

**Teaching scheme**

**Lecture: - 3 h/week**

| | |
|---|---|
| **Course Code** | |
| **Course Name** | **Business Analytics** |
| **Credits**<br>**Prerequisites** | |

Total Number of Lectures: 48

| Course objective |
|---|
| 1. Understand the role of business analytics within an organization.<br>2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.<br>3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.<br>4. To become familiar with processes needed to develop, report, and analyze business data.<br>5. Use decision-making tools/Operations research techniques. |

| | |
|---|---|
| 6. | Mange business process using analytical and management tools. |
| **7.** | Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit1:**<br><br>Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.<br><br>Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview. | 9 |
| **Unit 2:**<br><br>Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.<br><br>Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology. | 8 |
| **Unit 3:**<br><br>Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.<br><br>Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization. | 9 |
| **Unit 4:**<br><br>Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.<br><br>Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using | 10 |

| | |
|---|---|
| Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model. | |
| **Unit 5:**<br>Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. | 8 |
| **Unit 6:**<br>Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism. | 4 |

| **COURSE OUTCOMES** | |
|---|---|
| 1. Students will demonstrate knowledge of data analytics.<br>2. Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.<br>3. Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.<br>**4.** Students will demonstrate the ability to translate data into clear, actionable insights. | |

**Reference:**

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

## OPEN ELECTIVES
## Industrial Safety

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**Unit-II:** Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**Unit-III:** Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**Unit-IV:** Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**Unit-V:** Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

**Reference:**

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

## OPEN ELECTIVES

## Operations Research

**Teaching Scheme**

**Lectures: 3 hrs/week**

**Course Outcomes: At the end of the course,** the student should be able to

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

**Syllabus Contents:**

**Unit 1**:

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

**Unit 2**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

**Unit 3**:

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

**Unit 4**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

**Unit 5**

Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

**References:**

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008

2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

## Open Elective
## Cost Management of Engineering Projects

**Teaching scheme**

Lecture: - 3 h/week

Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

**References:**

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

## Open Elective
## Composite Materials

**Teaching scheme**

**Lecture: - 3 h/week**

**UNIT–I**: INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT – II**: REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT – III:** Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT–IV:** Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT – V:** Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TEXT BOOKS:

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

**References:**

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

## Open Elective

## Waste to Energy

### Teaching scheme

Lecture: - 3 h/week

**Unit-I:** Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**Unit-II:** Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**Unit-III:** Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**Unit-IV:** Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**Unit-V:** Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

**References:**

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

## AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING

**Course objectives:**

Students will be able to:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title

Ensure the good quality of paper at very first-time submission

**Syllabus**

| Units | CONTENTS | Hours |
|---|---|---|
| 1 | Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness | 4 |
| 2 | Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction | 4 |
| 3 | Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check. | 4 |
| 4 | key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, | 4 |
| 5 | skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions | 4 |
| 6 | useful phrases, how to ensure paper is as good as it could possibly be the first- time submission | 4 |

**Suggested Studies:**

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .

4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

**AUDIT 1 and 2: DISASTER MANAGEMENT**

**Course Objectives: -**Students will be able to:

1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in

**Syllabus**

| Units | CONTENTS | Hours |
|---|---|---|
| 1 | **Introduction**<br>Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude. | 4 |
| 2 | **Repercussions Of Disasters And Hazards**: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.<br>Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts. | 4 |
| 3 | **Disaster Prone Areas In India**<br>Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics | 4 |
| 4 | **Disaster Preparedness And Management**<br>Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness. | 4 |
| 5 | **Risk Assessment**<br>Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People’s Participation In Risk Assessment. Strategies for Survival. | 4 |
| 6 | **Disaster Mitigation**<br>Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India. | 4 |

**SUGGESTED READINGS:**

1. R. Nishith, Singh AK, “Disaster Management in India: Perspectives, issues and strategies “’New Royal book Company.

2. Sahni, Pardeep Et.Al. (Eds.),” Disaster Mitigation Experiences And Reflections”, Prentice Hall Of India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies” ,Deep &Deep Publication Pvt. Ltd., New Delhi.

AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE

***Course Objectives***

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects
4. enhancing the memory power
5. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

***Syllabus***

| Unit | *Content* | *Hours* |
|---|---|---|
| 1 | • Alphabets in Sanskrit,<br>• Past/Present/Future Tense,<br>• Simple Sentences | 8 |
| 2 | • Order<br>• Introduction of roots<br>• Technical information about Sanskrit Literature | 8 |
| 3 | • Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics | 8 |

***Suggested reading***

1. “Abhyaspustakam” – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. “Teach Yourself Sanskrit” Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. “India’s Glorious Scientific Tradition” Suresh Soni, Ocean books (P) Ltd., New Delhi.

***Course Output***

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

**AUDIT 1 and 2: VALUE EDUCATION**

***Course Objectives***

Students will be able to

1. Understand value of education and self- development
2. Imbibe good values in students
3. Let the should know about the importance of character

***Syllabus***

| Unit | *Content* | *Hours* |
|---|---|---|

| | | |
|---|---|---|
| 1 | • Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism.<br>• Moral and non- moral valuation. Standards and principles.<br>• Value judgements | 4 |
| 2 | • Importance of cultivation of values.<br>• Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness.<br>• Honesty, Humanity. Power of faith, National Unity.<br>• Patriotism.Love for nature ,Discipline | 6 |
| 3 | • Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline.<br>• Punctuality, Love and Kindness.<br>• Avoid fault Thinking.<br>• Free from anger, Dignity of labour.<br>• Universal brotherhood and religious tolerance.<br>• True friendship.<br>• Happiness Vs suffering, love for truth.<br>• Aware of self-destructive habits.<br>• Association and Cooperation.<br>• Doing best for saving nature | 6 |
| 4 | • Character and Competence –Holy books vs Blind faith.<br>• Self-management and Good health.<br>• Science of reincarnation.<br>• Equality, Nonviolence ,Humility, Role of Women.<br>• All religions and same message.<br>• Mind your Mind, Self-control.<br>• Honesty, Studying effectively | 6 |

***Suggested reading***

1. Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

***Course outcomes***

Students will be able to

1. Knowledge of self-development
2. Learn the importance of Human values
3. Developing the overall personality

**AUDIT 1 and 2: CONSTITUTION OF INDIA**

**Course Objectives:**

Students will be able to:

1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional

role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.

3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| **1** | • **History of Making of the Indian Constitution:**<br>History<br>Drafting Committee, ( Composition & Working) | 4 |
| **2** | • **Philosophy of the Indian Constitution:**<br>Preamble<br>Salient Features | 4 |
| **3** | • **Contours of Constitutional Rights & Duties:**<br>• Fundamental Rights<br>• Right to Equality<br>• Right to Freedom<br>• Right against Exploitation<br>• Right to Freedom of Religion<br>• Cultural and Educational Rights<br>• Right to Constitutional Remedies<br>• Directive Principles of State Policy<br>• Fundamental Duties. | 4 |
| **4** | • **Organs of Governance:**<br>• Parliament<br>• Composition<br>• Qualifications and Disqualifications<br>• Powers and Functions<br>• Executive<br>• President<br>• Governor<br>• Council of Ministers<br>• Judiciary, Appointment and Transfer of Judges, Qualifications<br>• Powers and Functions | 4 |
| **5** | • **Local Administration:**<br>• District's Administration head: Role and Importance,<br>• Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.<br>• Pachayati raj: Introduction, PRI: Zila Pachayat.<br>• Elected officials and their roles, CEO Zila Pachayat: Position and role.<br>• Block level: Organizational Hierarchy (Different departments),<br>• Village level: Role of Elected and Appointed officials, | 4 |

| | | |
|---|---|---|
| | • Importance of grass root democracy | |
| **6** | • **Election Commission:**<br>• Election Commission: Role and Functioning.<br>• Chief Election Commissioner and Election Commissioners.<br>• State Election Commission: Role and Functioning.<br>• Institute and Bodies for the welfare of SC/ST/OBC and women. | 4 |

***Suggested reading***

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

***Course Outcomes:***

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

**AUDIT 1 and 2: PEDAGOGY STUDIES**

**Course Objectives:**

Students will be able to:

4. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
5. Identify critical evidence gaps to guide the development.

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| **1** | • **Introduction and Methodology:**<br>• Aims and rationale, Policy background, Conceptual framework and terminology<br>• Theories of learning, Curriculum, Teacher education.<br>• Conceptual framework, Research questions.<br>• Overview of methodology and Searching. | 4 |
| **2** | • Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.<br>• Curriculum, Teacher education. | 2 |
| **3** | • Evidence on the effectiveness of pedagogical practices | 4 |

| | | |
|---|---|---|
| | • Methodology for the in depth stage: quality assessment of included studies.<br>• How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?<br>• Theory of change.<br>• Strength and nature of the body of evidence for effective pedagogical practices.<br>• Pedagogic theory and pedagogical approaches.<br>• Teachers' attitudes and beliefs and Pedagogic strategies. | |
| **4** | • Professional development: alignment with classroom practices and follow-up support<br>• Peer support<br>• Support from the head teacher and the community.<br>• Curriculum and assessment<br>• Barriers to learning: limited resources and large class sizes | 4 |
| **5** | • **Research gaps and future directions**<br>• Research design<br>• Contexts<br>• Pedagogy<br>• Teacher education<br>• Curriculum and assessment<br>• Dissemination and research impact. | 2 |

**Suggested reading**


1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.


**Course Outcomes:**

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

## AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

***Course Objectives***

1. To achieve overall health of body and mind
2. To overcome stress

***Syllabus***

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Definitions of Eight parts of yog. ( Ashtanga ) | 8 |
| 2 | • Yam and Niyam.<br>Do`s and Don't's in life.<br>i) Ahinsa, satya, astheya, bramhacharya and aparigraha<br>ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan | 8 |
| 3 | • Asan and Pranayam<br>i) Various yog poses and their benefits for mind & body<br>ii)Regularization of breathing techniques and its effects-Types of pranayam | 8 |

***Suggested reading***

1. 'Yogic Asanas for Group Tarining-Part-I" : Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

**Course Outcomes:**

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

**AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS**

***Course Objectives***

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

***Syllabus***

| **Unit** | **Content** | **Hours** |
|---|---|---|
| 1 | Neetisatakam-Holistic development of personality<br>• Verses- 19,20,21,22 (wisdom)<br>• Verses- 29,31,32 (pride & heroism)<br>• Verses- 26,28,63,65 (virtue)<br>• Verses- 52,53,59 (dont's)<br>• Verses- 71,73,75,78 (do's) | 8 |
| 2 | • Approach to day to day work and duties.<br>• Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48,<br>• Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,<br>• Chapter 18-Verses 45, 46, 48. | 8 |

| | | |
|---|---|---|
| 3 | • Statements of basic knowledge.<br>• Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68<br>• Chapter 12 -Verses 13, 14, 15, 16,17, 18<br>• Personality of Role model. Shrimad Bhagwad Geeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42,<br>• Chapter 4-Verses 18, 38,39<br>• Chapter18 – Verses 37,38,63 | 8 |

***Suggested reading***

1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

***Course Outcomes***

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

## Course Scheme for M.Tech. Computer Science and Engineering Specialization : Advanced Computing

### M.Tech Semister-I.

| Course Number | Subject | Scheme Of Studies Per Week | | | Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| 1CS01 | Program Core I–<br>Mathematical foundations of Computer Science | 3 | 0 | 0 | 3 |
| 1CS02 | Program Core II –<br>Advanced Data Structures | 3 | 0 | 0 | 3 |
| 1CSxx | Program Elective I –<br>Compiler for HPC/ Operating System Design/ Optimization Techniques | 3 | 0 | 0 | 3 |
| 1CSxx | Program Elective II –<br>Cluster and Grid Computing/ Parallel Programming Tools and Model/ Big Data Analytics | 3 | 0 | 0 | 3 |
| 1Axxx | Research Methodology and IPR | 2 | 0 | 0 | 2 |
| 1Axxx | Audit Course | 2 | 0 | 0 | 0 |
| 1CS03 | Laboratory 1 (Advanced Data Structures) | 0 | 0 | 4 | 2 |
| 1CS04 | Laboratory 2 (Based on Electives) | 0 | 0 | 4 | 2 |
| | Total Credits: | 18 | | | |

**M.Tech Semister- II**

| Course Number | Subject | Scheme Of Studies Per Week | | | Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| 2CS05 | Program Core III –<br>Advance Algorithms | 3 | 0 | 0 | 3 |
| 2CS06 | Program Core IV –<br>Soft Computing | 3 | 0 | 0 | 3 |
| 2CSxx | Program Elective III –<br>Distributed Database/ Concurrence, Parallelism and Distributed System/ HPC Architecture, and Ecosystem | 3 | 0 | 0 | 3 |
| 2CSxx | Program Elective IV –<br>Parallel Algorithms/ Threaded and Message-passing Programming/ Human Centered Computing | 3 | 0 | 0 | 3 |
| 2Axxx | Audit Course | 2 | 0 | 0 | 0 |
| 2CS07 | Laboratory 3 (Based on cores) | 0 | 0 | 4 | 2 |
| 2CS08 | Laboratory 4 (Based on Electives) | 0 | 0 | 4 | 2 |
| 2CS09 | Mini Project with Seminar | 2 | 0 | 0 | 2 |
| | Total Credits: | 18 | | | |

***Students be encouraged to go to Industrial Training/Internship for at least 2-3 months during semester break.**

**M.Tech III Semister***

| Course No. | Subject | Scheme of Studies Periods Per Week | | | Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| 3CSxx | Program Elective V –<br>High Performance Scientific Computing/ Quantum Computing/ DNA Computing | 3 | 0 | 0 | 03 |
| 3CSxx | Open Elective –<br>1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy | 3 | 0 | 0 | 03 |
| 3CS10 | Dissertation-I /Industrial Project | 0 | 0 | 20 | 10 |
| Total Credits 16 | | | | | |

***Students going for Industrial Project/Thesis will complete these courses through MOOCs.**

**M.Tech Sem-IV**

| | Subject | Scheme of Studies Per Week | | | Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| | Dissertation II | 0 | 0 | 32 | 16 |
| Total Credits: 16 | | | | | |

The program offers several elective courses, focusing on different aspects of Advanced Computing. A student can choose to do any course from given program elective set.

**Program Outcomes of CSE (M.Tech.) program:**

The main outcomes of the CSE (M.Tech.) program are given here. At the end of the program a student is expected to have:

1. An understanding of the theoretical foundations and the limits of computing.
2. An ability to adapt existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
3. An ability to design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
4. Understanding and ability to use advanced computing techniques and tools.
5. An ability to undertake original research at the cutting edge of computer science & its related areas.
6. An ability to function effectively individually or as a part of a team to accomplish a stated goal.
7. An understanding of professional and ethical responsibility.
8. An ability to communicate effectively with a wide range of audience.

9. An ability to learn independently and engage in life¬long learning.
10. An understanding of the impact of IT related solutions in an economic, social and environment context

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

**Syllabus, course objective and course outcomes for various post graduation courses.**

**Core Subjects:**

| | |
|---|---|
| **Course Code** | 1CS01 |
| **Course Name** | Mathematical Foundation of Computer Science |
| **Credits** | 3 |
| **Pre-Requisites** | Discrete Mathematics |

Total Number of Lectures:48

| COURSE OBJECTIVE |
|---|
| • To understand the mathematical fundamentals that is prerequisites for avariety of courses like Data mining, Network protocols, analysis of Web traffic, Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning. |
| • To developthe understanding ofthe mathematical and logical basis to many modern techniques in information technology like machine learning, programming language design, and concurrency. |
| • To study various sampling and classification problems. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1**<br>Probability mass, density, and cumulative distribution functions, Parametric families of distributions, Expected value, variance, conditional expectation, Applications of the univariate and multivariate Central Limit Theorem, Probabilistic inequalities, Markov chains | 7 |
| **Unit 2**<br>Random samples, sampling distributions of estimators, Methods of Moments and Maximum Likelihood, | 7 |
| **Unit 3**<br>Statistical inference, Introduction to multivariate statistical models: regression and classification problems, principal components analysis, The problem of overfitting model assessment. | 8 |
| **Unit 4**<br>Graph Theory: Isomorphism, Planar graphs, graph colouring, hamilton circuits | 11 |

| | |
|---|---|
| and euler cycles.<br>Permutations and Combinations with and without repetition.<br>Specialized techniques to solve combinatorial enumeration problems | |
| **Unit 5**<br>**Computer science and engineering applications**<br>Data mining, Network protocols, analysis of Web traffic, Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning. | 10 |
| **Unit 6**<br>Recent Trands in various distribution functions in mathmatical field of computer science for varying fields like bioinformatic, soft computing, and computer vision. | 5 |

| **COURSE OUTCOMES** |
|---|
| After completion of course, students would be able to: |
| • To understand the basic notions of discrete and continuous probability. |
| • To understand the methods of statistical inference, and the role that sampling distributions play in those methods. |
| • To be able to perform correct and meaningful statistical analyses of simple to moderate complexity. |

**References:**

1. John Vince, Foundation Mathematics for Computer Science, Springer.
2. K. Trivedi.Probability and Statistics with Reliability, Queuing, and Computer Science Applications. Wiley.
3. M. Mitzenmacher and E. Upfal.Probability and Computing: Randomized Algorithms and Probabilistic Analysis.
4. Alan Tucker, Applied Combinatorics, Wiley

| | |
|---|---|
| **Course Code** | 1CS02 |
| **Course Name** | Advanced Data Structures |
| **Credits** | 3 |
| **Pre-Requisites** | UG level course in Data Structures |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • The student should be able to choose appropriate data structures, understand the ADT/libraries, and use it to design algorithms for a specific problem. |
| • Students should be able to understand the necessary mathematical abstraction to solve problems. |
| • To familiarize students with advanced paradigms and data structure used to solve algorithmic problems. |
| • Student should be able to come up with analysis of efficiency and proofs of correctness. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1**<br>**Dictionaries:** Definition, Dictionary Abstract Data Type, Implementation of Dictionaries.<br>**Hashing:** Review of Hashing, Hash Function, Collision Resolution Techniques in Hashing, Separate Chaining, Open Addressing, Linear Probing, | 7 |

| | |
|---|---|
| Quadratic Probing, Double Hashing, Rehashing, Extendible Hashing. | |
| **Unit 2**<br>**Skip Lists:** Need for Randomizing Data Structures and Algorithms, Search and Update Operations on Skip Lists, Probabilistic Analysis of Skip Lists, Deterministic Skip Lists | 5 |
| **Unit 3**<br>**Trees:** Binary Search Trees, AVL Trees, Red Black Trees, 2-3 Trees, B-Trees, Splay Trees | 9 |
| **Unit 4**<br>**Text Processing:** Sting Operations, Brute-Force Pattern Matching, The Boyer-Moore Algorithm, The Knuth-Morris-Pratt Algorithm, Standard Tries, Compressed Tries, Suffix Tries, The Huffman Coding Algorithm, The Longest Common Subsequence Problem (LCS), Applying Dynamic Programming to the LCS Problem. | 12 |
| **Unit 5**<br>**Computational Geometry:** One Dimensional Range Searching, Two Dimensional Range Searching, Constructing a Priority Search Tree, Searching a Priority Search Tree, Priority Range Trees, Quadtrees, k-D Trees. | 10 |
| **Unit 6**<br>Recent Trands in Hashing, Trees, and various computational geometry methods for effeciently solving the new evolving problem | 5 |

| **COURSE OUTCOMES** |
|---|
| After completion of course, students would be able to: |
| • Understand the implementation of symbol table using hashing techniques. |
| • Develop and analyze algorithms for red-black trees, B-trees and Splay trees. |
| • Develop algorithms for text processing applications. |
| • Identify suitable data structures and develop algorithms for computational geometry problems. |

**References:**


1. Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, 2nd Edition, Pearson, 2004.
2. M T Goodrich Roberto Tamassia, Algorithm Design, John Willey, 2002.


| **Research Methodology and IPR** | |
|---|---|
| **Teaching Scheme**<br><br>Lectures: 1hrs/week | |

**Course Outcomes:**

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals &

nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.

- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.
-

**Syllabus Contents:**

**Unit 1:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Unit 2:** Effective literature studies approaches, analysis

Plagiarism, Research ethics,

**Unit 3:** Effective technical writing, how to write report, Paper

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**Unit 4:** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Unit 5:** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Unit 6:** New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

**References:**


- Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’”
- Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
- Ranjit Kumar, 2 nd Edition , “Research Methodology: A Step by Step Guide for beginners”
- Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
- Mayall , “Industrial Design”, McGraw Hill, 1992.
- Niebel , “Product Design”, McGraw Hill, 1974.
- Asimov , “Introduction to Design”, Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.
- T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

| | |
|---|---|
| **Course Code** | 2CS05 |
| **Course Name** | Advanced Algorithms |
| **Credits** | 3 |
| **Pre-Requisites** | UG level course in Algorithm Design and Analysis |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • Introduce students to the advanced methods of designing and analyzing algorithms. |
| • The student should be able to choose appropriate algorithms and use it for a specific problem. |
| • To familiarize students with basic paradigms and data structures used to solve advanced algorithmic problems. |
| • Students should be able to understand different classes of problems concerning their computation difficulties. |
| • To introduce the students to recent developments in the area of algorithmic design. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit1**<br>**Sorting:** Review of various sorting algorithms, topological sorting<br>**Graph:** Definitions and Elementary Algorithms: Shortest path by BFS, shortest path in edge-weighted case (Dijkasra's), depth-first search and computation of strongly connected components, emphasis on correctness proof of the algorithm and time/space analysis, example of amortized analysis. | 6 |
| **Unit 2**<br>**Matroids:** Introduction to greedy paradigm, algorithm to compute a maximum weight maximal independent set. Application to MST.<br>**Graph Matching:** Algorithm to compute maximum matching. Characterization of maximum matching by augmenting paths, Edmond's Blossom algorithm to compute augmenting path. | 8 |
| **Unit 3**<br>**Flow-Networks:** Maxflow-mincut theorem, Ford-Fulkerson Method to compute maximum flow, Edmond-Karp maximum-flow algorithm.<br>**Matrix Computations:** Strassen's algorithm and introduction to divide and conquer paradigm, inverse of a triangular matrix, relation between the time complexities of basic matrix operations, LUP-decomposition. | 9 |
| **Unit 4**<br>**Shortest Path in Graphs:** Floyd-Warshall algorithm and introduction to dynamic programming paradigm. More examples of dynamic programming.<br>**Modulo Representation of integers/polynomials:** Chinese Remainder Theorem, Conversion between base-representation and modulo-representation. Extension to polynomials. Application: Interpolation problem.<br>**Discrete Fourier Transform (DFT):** In complex field, DFT in modulo ring. Fast Fourier Transform algorithm. Schonhage-Strassen Integer Multiplication algorithm | 10 |
| **Unit 5**<br>**Linear Programming:** Geometry of the feasibility region and Simplex algorithm<br>**NP-completeness:** Examples, proof of NP-hardness and NP-completeness.<br>**One or more of the following topics based on time and interest**<br>Approximation algorithms, Randomized Algorithms, Interior Point Method, | 10 |

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|---|---|
| Advanced Number Theoretic Algorithm | |
| **Unit 6**<br>Recent Trands in problem solving paradigms using recent searching and sorting techniques by applying recently proposed data structures. | 5 |
| **COURSE OUTCOMES** | |
| After completion of course, students would be able to: | |
| • Analyze the complexity/performance of different algorithms. | |
| • Determine the appropriate data structure for solving a particular set of problems. | |
| • Categorize the different problems in various classes according to their complexity. | |
| • Students should have an insight of recent activities in the field of the advanced data structure. | |

**References:**

1. "Introduction to Algorithms" by Cormen, Leiserson, Rivest, Stein.
2. "The Design and Analysis of Computer Algorithms" by Aho, Hopcroft, Ullman.
3. "Algorithm Design" by Kleinberg and Tardos.

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|---|---|
| **Course Code** | 2CS06 |
| **Course Name** | Soft Computing |
| **Credits** | 3 |
| **Pre-Requisites** | Basic knowledge of mathematics |

Total Number of Lectures:48

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|---|---|
| **COURSE OBJECTIVE** | |
| • To introduce soft computing concepts and techniques and foster their abilities in designing appropriate technique for a given scenario. | |
| • To implement soft computing based solutions for real-world problems. | |
| • To give students knowledge of non-traditional technologies and fundamentals of artificial neural networks, fuzzy sets, fuzzy logic, genetic algorithms. | |
| • To provide studentan hand-on experience on MATLAB to implement various strategies. | |
| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
| **Unit 1**<br>**INTRODUCTION TO SOFT COMPUTING AND NEURAL NETWORKS:** Evolution of Computing: Soft Computing Constituents, From Conventional AI to Computational Intelligence: Machine Learning Basics | 7 |
| **Unit 2**<br>**FUZZY LOGIC:** Fuzzy Sets, Operations on Fuzzy Sets, Fuzzy Relations, Membership Functions: Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems, Fuzzy Expert Systems, Fuzzy Decision Making. | 8 |
| **Unit 3**<br>**NEURAL NETWORKS:** Machine Learning Using Neural Network, Adaptive Networks, Feed forward Networks, Supervised Learning Neural Networks, Radial Basis Function Networks : Reinforcement Learning, Unsupervised Learning Neural Networks, Adaptive Resonance architectures, Advances in Neural networks | 10 |
| **Unit 4**<br>**GENETIC ALGORITHMS:** Introduction to Genetic Algorithms (GA), Applications of GA in Machine Learning : Machine Learning Approach to Knowledge Acquisition. | 5 |
| **Unit 5** | 13 |

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|---|---|
| **Matlab/Python Lib:** Introduction to Matlab/Python, Arrays and array operations, Functions and Files, Study of neural network toolbox and fuzzy logic toolbox, Simple implementation of Artificial Neural Network and Fuzzy Logic | |
| **Unit 6**<br>Recent Trands in deep learning, various classifiers, neural networks and genetic algorithm.<br>Implementation of recently proposed soft computing techniques. | 5 |

| **COURSE OUTCOMES** |
|---|
| After completion of course, students would be able to: |
| • Identify and describe soft computing techniques and their roles in building intelligent machines |
| • Apply fuzzy logic and reasoning to handle uncertainty and solve various engineering problems. |
| • Apply genetic algorithms to combinatorial optimization problems. |
| • Evaluate and compare solutions by various soft computing approaches for a given problem. |

**References:**

1. Jyh:Shing Roger Jang, Chuen:Tsai Sun, EijiMizutani, Neuro:Fuzzy and Soft Computing, Prentice:Hall of India, 2003.
2. George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic:Theory and Applications, Prentice Hall, 1995.
3. MATLAB Toolkit Manual

**Elective Subjects**

| | |
|---|---|
| **Course Code** | 1CS11 |
| **Course Name** | Compiler for HPC |
| **Credits** | 3 |
| **Pre-Requisites** | Data Structure, Compiler Design, Theory of Computation |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • The objective of this course is to introduce structure of compilers and high performance compiler design for students. Concepts of cache coherence and parallel loops in compilers are included. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit1:**<br>**High Performance Systems,** Structure of a Compiler, Programming Language Features, Languages for High Performance. | 7 |
| **Unit2:**<br>**Data Dependence:** Data Dependence in Loops, Data Dependence in Conditionals, Data Dependence in Parallel Loops, Program Dependence Graph.<br>**Scalar Analysis with Factored Use-Def Chains:** Constructing Factored Use-Def Chains, FUD Chains for Arrays, Induction Variables Using FUD Chains, Constant Propagation with FUD Chains, Data Dependence for Scalars. Data Dependence Analysis for Arrays. | 7 |
| **Unit3:**<br>Array Region Analysis, Pointer Analysis, I/O Dependence, Procedure Calls, | 10 |

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| Inter-procedural Analysis.<br>**Loop Restructuring:** Simple Transformations, Loop Fusion, Loop Fission, Loop Reversal, Loop Interchanging, Loop Skewing, Linear Loop Transformations, Strip-Mining, Loop Tiling, Other Loop Transformations, and Inter-procedural Transformations.<br>**Optimizing for Locality:** Single Reference to Each Array, Multiple References, General Tiling, Fission and Fusion for Locality. | |
| **Unit4:**<br>**Concurrency Analysis:** Concurrency from Sequential Loops, Concurrency from Parallel Loops, Nested Loops, Round off Error, Exceptions and Debuggers.<br>**Vector Analysis:** Vector Code, Vector Code from Sequential Loops, Vector Code from For all Loops, Nested Loops, Round off Error, Exceptions, and Debuggers, Multi-vector Computers. | 10 |
| **Unit5:**<br>**Message-Passing Machines:** SIMD Machines, MIMD Machines, Data Layout, Parallel Code for Array Assignment, Remote Data Access, Automatic Data Layout, Multiple Array Assignments, Other Topics.<br>**Scalable Shared-Memory Machines:** Global Cache Coherence, Local Cache Coherence, Latency Tolerant Machines. | 10 |
| **Unit 6:**<br>Recent trends in compiler design for high performance computing and message passing machines and scalable shared memory machine. | 4 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be:** |
| • Familiar with the structure of compiler.<br>• Parallel loops, data dependency and exception handling and debugging in compiler. |

**References:**

1. Michael Wolfe, High-Performance Compilers for Parallel Computing, Pearson

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|---|---|
| **Course Code** | 1CS12 |
| **Course Name** | Operating System Design |
| **Credits** | 3 |
| **Pre-Requisites** | Data Structure, Algorithms, Computer Architecture and Organization |

Total Number of Lectures: 48

| COURSE OBJECTIVE |
|---|
| • The objective of the course is to provide introduction to operating system design and concept of process, process lifecycle and scheduling approaches. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1:**<br>Computer system and operating system overview, Operating system functions and design issues, Design approaches, Types of advanced operating systems. | 8 |
| **Unit 2:**<br>Process abstraction, Process management, system calls, Threads, Symmetric multiprocessing and micro-kernels. | 8 |

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|---|---|
| **Unit 3:**<br>Scheduling: Uniprocessor, Multiprocessor and Real time systems, concurrency, classical problems, mechanisms for synchronization: semaphores, monitors, Process deadlock and deadlock handling strategies. | 10 |
| **Unit 4:**<br>Memory management, Virtual memory concept, Virtual machines, I/O management, File and disk management, Operating system security. | 7 |
| **Unit 5:**<br>Distributed Operating system: Architecture, Design issues, Distributed mutual exclusion, Distributed deadlock detection, shared memory, Distributed scheduling. Multiprocessor operating systems: architecture, operating system design issues, threads, process synchronization, process scheduling, memory management, reliability and fault tolerance. | 11 |
| **Unit 6:**<br>Recent trends in Operating system design and their applicability to HPC. | 4 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be:** |
| • Understanding advanced concepts in operating systems. |
| • Learning principles of Distributed and multiprocessor operating systems |

**References:**

1. Advanced concept in operating system: M. Singhal, N.G. Shivratri
2. Operating system internal and design principles: William Stallings

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|---|---|
| **Course Code** | 1CS13 |
| **Course Name** | Optimization Techniques |
| **Credits** | 3 |
| **Pre-Requisites** | Linear Algebra and Numerical Methods |

Total Number of Lectures: 48

| COURSE OBJECTIVE |
|---|
| The objective of this course is to provide insight to the mathematical formulation of real world problems.<br>To optimize these mathematical problems using nature based algorithms. And the solution is useful specially for NP-Hard problems. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1:**<br>Engineering application of Optimization, Formulation of design problems as mathematical programming problems. | 7 |
| **Unit 2:**<br>General Structure of Optimization Algorithms, Constraints, The Feasible Region. | 7 |

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|---|---|
| **Unit 3:**<br>Branches of Mathematical Programming: Optimization using calculus, Graphical Optimization, Linear Programming, Quadratic Programming, Integer Programming, Semi Definite Programming. | 11 |
| **Unit 4:**<br>Optimization Algorithms like Genetic Optimization, Particle Swarm Optimization, Ant Colony Optimization etc. | 12 |
| **Unit 5:**<br>Real life Problems and their mathematical formulation as standard programming problems. | 6 |
| **Unit 6:**<br>Recent trends: Applications of ant colony optimization, genetics and linear and quadratic programming in real world applications. | 5 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • Formulate optimization problems. |
| • Understand and apply the concept of optimality criteria for various types of optimization problems. |
| • Solve various constrained and unconstrained problems in Single variable as well as multivariable. |
| • Apply the methods of optimization in real life situation. |

**References:**


1. Laurence A. Wolsey (1998). Integer programming. Wiley. ISBN 978-0-471-28366-9.
2. Practical Optimization Algorithms and Engineering Applications Andreas Antoniou.
3. An Introduction to Optimization Edwin K., P. Chong & Stanislaw h. Zak.
4. Dimitris Bertsimas; Robert Weismantel (2005). Optimization over integers. Dynamic Ideas. ISBN 978-0-9759146-2-5.
5. John K. Karlof (2006). Integer programming: theory and practice.CRC Press. ISBN 978-0-8493-1914-3.
6. H. Paul Williams (2009). Logic and Integer Programming. Springer. ISBN 978-0-387-92279-9.
7. Michael Jünger; Thomas M. Liebling; Denis Naddef; George Nemhauser; William R. Pulleyblank; Gerhard Reinelt; Giovanni Rinaldi; Laurence A. Wolsey, eds. (2009). 50 Years of Integer Programming 1958-2008: From the Early Years to the State-of-the- Art. Springer. ISBN 978-3-540-68274-5.
8. Der-San Chen; Robert G. Batson; Yu Dang (2010). Applied Integer Programming: Modeling and Solution. John Wiley and Sons. ISBN 978-0-470-37306-4.


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|---|---|
| **Course Code** | 1CS21 |
| **Course Name** | Cluster and Grid Computing |
| **Credits** | 3 |
| **Pre-Requisites** | Computer Networks, Distributed Systems |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
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| • The course will provide an insight for achieving cost efficient high performance system. |
| • The course will deal with design and architecture of grid and cluster computing. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1:**<br>Introduction: Cluster and Grid computing, Meta-computing, Web services and Grid Computing, e-Governance and the Grid Technologies and Architectures for Grid Computing: Issues in Data Grids, Functional requirements in Grid Computing, Standards for Grid Computing, Recent technology trends in Large Data Grids. Web Services and the Service Oriented Architecture: Service Oriented Architecture, SOAP and WSDL, Creating Web Services, Server Side. | 10 |
| **Unit 2:**<br>OGSA and WSRF: OGSA for Resource Distribution, Stateful Web Services in OGSA, WSRF, WSRF Specification, Globus Toolkit: History, version, Applications, Approaches and Benefits, Infrastructure Management, Monitoring and Discovery, Security, Data Choreography and Coordination, GT4 Architecture, GT4 Containers. The Grid and Databases: Requirements, Storage Request Broker, Integration of Databases with the Grid, Architecture of OGSA-DAI for offering Grid Database services. | 10 |
| **Unit 3:**<br>Cluster Computing: Approaches to Parallel Computing, Definition and Architecture of a Cluster, Categories of clusters. Cluster Middleware: Levels and Layers of Single System Image, Design objectives, Resource Management and Scheduling, Cluster programming Environment and Tools. Networking, Protocols & I/O for clusters: Networking and Interconnection/Switching Devices, Design Issues, Design Architecture, HiPPI, ATM, Myrinet, Memory Channel | 11 |
| **Unit 4:**<br>Setting Up and Administering a Cluster: Setup of simple cluster, setting up nodes, clusters of clusters, System monitoring, Global Clocks Sync. Cluster Technology for High Availability: High availability clusters, high availability parallel computing, types of failures and errors, cluster architectures and configurations for high availability, Failure/Recovery clusters. | 6 |
| **Unit 5:**<br>Process Scheduling: Job management System, Resource management system, policies of resource utilization, Scheduling policies. Load Sharing and Load Balancing: Introduction, Strategies for load balancing, Modelling parameters. | 6 |
| **Unit 6:**<br>Recent trends: technologies and attributes in Cluster and Grid computing. Case study of various cluster architectures, load balancing and scheduling policies. | 5 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be:** |
| • At the end of the course student will have knowledge of Grid Computing, Web Services, and Service-oriented architecture, Architecture for grid computing, Cluster Computing, process scheduling and load balancing. |

**References:**

1. Grid and Cluster Computing by C.S.R. Prabhu, PHI.

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|---|---|
| **Course Code** | 1CS22 |
| **Course Name** | Parallel Programming Tools and Model |
| **Credits** | 3 |
| **Pre-Requisites** | Data Structure, Computer Architecture and Organization |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • Classify parallel architectures parameters that are essential for the classification of modern parallel processing systems.<br>• Describe the methodologies employed for synchronization and memory consistency and cache coherence in shared memory systems.<br>• Describe and compare the different types of interconnects employed in parallel processing systems.<br>• Outline and analyse the features of micro-architecture parallel systems such as superscalar, VLIW, vector, multithreading, CMP multi-core and tile processors.<br>• Describe how the performance of a parallel system can be measured, list possible sources for performance losses and propose ways to improve the performance of a system. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit1:**<br>Introduction to Parallel Computing Architectures, parallel hardware/multi-cores, Processes and threads, Programming models: shared memory and message passing, Amdahl's Law. | 8 |
| **Unit2:**<br>Introduction to parallel hardware: Multi-cores and multiprocessors, shared memory and message passing architectures, cache hierarchy and coherence, sequential consistency. | 9 |
| **Unit3:**<br>Introduction to parallel software: Steps involved in developing a parallel program, Dependence analysis, Domain decomposition, Task assignment: static and dynamic, Performance issues: 4C cache misses, inherent and artifactual communication, false sharing, computation-to-communication ratio as a guiding metric for decomposition, hot spots and staggered communication. | 8 |
| **Unit4:**<br>Shared memory parallel programming: Synchronization Locks and barriers, Hardware primitives for efficient lock implementation, Lock algorithms, Relaxed consistency models, High-level language memory models (such Java and/or C++), Memory fences. Developing parallel programs with UNIX fork model: IPC with shared memory and message passing, UNIX semaphore and its all-or-none semantic. Developing parallel programs with POSIX thread library, Thread creation, Thread join, Mutex, Condition variables. Developing parallel programs with OpenMP directives: Parallel for, Parallel section, Static, dynamic, guided, and runtime scheduling, Critical sections and atomic operations, Barriers Reduction. | 10 |
| **Unit5:** | 8 |

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| Introduction to GPU programming: GPU architecture, Introduction to CUDA programming, Concept of SIMD and SIMT computation, Thread blocks, Warps, Global memory, Shared memory, Thread divergence in control transfer. | |
| **Unit 6:**<br>Recent trends in Parallel Programming Models and Paradigms. Case study of parallel hardware which include shared memory architecture and message passing architectures for efficient computing. | 5 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • Understand the methodologies employed for synchronization and memory consistency and cache coherence in shared memory systems. |

**References:**

1. Peter S Pacheco, An Introduction to Parallel Programming, Morgan Kaufmann,2011.
2. M Herlihy and N Shavit, The Art of Multiprocessor Programming Morgan Kaufmann, 2008.
3. JL Hennessy and DA Patterson, Computer Architecture: A Quantitative Approach,4th Ed., Morgan Kaufmann/Els India, 2006.

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|---|---|
| **Course Code** | 1CS23 |
| **Course Name** | Big Data Analytics |
| **Credits** | 3 |
| **Pre-Requisites** | Data Structure, Computer Architecture and Organization |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • Understand big data for business intelligence. Learn business case studies for big data analytics. Understand nosql big data management. Perform map-reduce analytics using Hadoop and related tools |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>What is big data, why big data, convergence of key trends, unstructured data, industry examples of big data, web analytics, big data and marketing, fraud and big data, risk and big data, credit risk management, big data and algorithmic trading, big data and healthcare, big data in medicine, advertising and big data, big data technologies, introduction to Hadoop, open source technologies, cloud and big data, mobile business intelligence, Crowd sourcing analytics, inter and trans firewall analytics. | 8 |
| **Unit 2:**<br>Introduction to NoSQL, aggregate data models, aggregates, key-value and document data models, relationships, graph databases, schemaless databases, materialized views, distribution models, sharding, master-slave replication, peer-peer replication, sharding and replication, consistency, relaxing consistency, version stamps, map-reduce, partitioning and combining, composing map-reduce calculations. | 8 |

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| **Unit 3:** Data format, analyzing data with Hadoop, scaling out, Hadoop streaming, Hadoop pipes, design of Hadoop distributed file system (HDFS), HDFS concepts, Java interface, data flow, Hadoop I/O, data integrity, compression, serialization, Avro, file-based data structures | 9 |
| **Unit 4:** MapReduce workflows, unit tests with MRUnit, test data and local tests, anatomy of MapReduce job run, classic Map-reduce, YARN, failures in classic Map-reduce and YARN, job scheduling, shuffle and sort, task execution, MapReduce types, input formats, output formats | 10 |
| **Unit 5:** Hbase, data model and implementations, Hbase clients, Hbase examples, praxis.Cassandra, Cassandra data model, Cassandra examples, Cassandra clients, Hadoop integration. | 7 |
| **Unit 6:** Pig, Grunt, pig data model, Pig Latin, developing and testing Pig Latin scripts. Hive, data types and file formats, HiveQL data definition, HiveQL data manipulation, HiveQL queries. | 6 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • Describe big data and use cases from selected business domains<br>• Explain NoSQL big data management<br>• Install, configure, and run Hadoop and HDFS<br>• Perform map-reduce analytics using Hadoop<br>• Use Hadoop related tools such as HBase, Cassandra, Pig, and Hive for big data analytics |

**References:**


1. Michael Minelli, Michelle Chambers, and Ambiga Dhiraj, "Big Data, Big Analytics: Emerging
2. Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.
3. P. J. Sadalage and M. Fowler, "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence", Addison-Wesley Professional, 2012.
4. Tom White, "Hadoop: The Definitive Guide", Third Edition, O'Reilley, 2012.
5. Eric Sammer, "Hadoop Operations", O'Reilley, 2012.
6. E. Capriolo, D. Wampler, and J. Rutherglen, "Programming Hive", O'Reilley, 2012.
7. Lars George, "HBase: The Definitive Guide", O'Reilley, 2011.
8. Eben Hewitt, "Cassandra: The Definitive Guide", O'Reilley, 2010.
9. Alan Gates, "Programming Pig", O'Reilley, 2011.


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|---|---|
| **Course Code** | 2CS31 |
| **Course Name** | Distributed Database |
| **Credits** | 3 |
| **Pre-Requisites** | Distributed Systems |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • The objective of course is to provide insight to distributed database, normalization techniques and integrity rules. It also includes parallel database systems along with object oriented |

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| models. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1:**<br>Introduction: Distributed Data processing, Distributed database system (DDBMS), Promises of DDBMSs, Complicating factors and Problem areas in DDBMSs, Overview Of Relational DBMS Relational Database concepts, Normalization, Integrity rules, Relational Data Languages, Relational DBMS. | 11 |
| **Unit 2:**<br>Distributed DBMS Architecture: DBMS Standardization, Architectural models for Distributed DBMS, Distributed DBMS Architecture. Distributed Database Design: Alternative design Strategies, Distribution design issues, Fragmentation, Allocation. Semantic Data Control: View Management, Data security, Semantic Integrity Control. | 8 |
| **Unit 3:**<br>Overview of Query Processing: Query processing problem, Objectives of Query Processing, Complexity of Relational Algebra operations, characterization of Query processors, Layers of Query Processing.<br>Introduction to Transaction Management: Definition of Transaction, Properties of transaction, types of transaction. Distributed Concurrency Control: Serializability theory, Taxonomy of concurrency control mechanisms, locking bases concurrency control algorithms. | 9 |
| **Unit 4:**<br>Parallel Database Systems: Database servers, Parallel architecture, Parallel DBMS techniques, Parallel execution problems, Parallel execution for hierarchical architecture. | 7 |
| **Unit 5:**<br>Distributed Object Database Management systems: Fundamental Object concepts and Object models, Object distribution design. Architectural issues, Object management, Distributed object storage, Object query processing. Transaction management. Database Interoperability: Database Integration, Query processing. | 8 |
| **Unit 6:**<br>Recent approaches, models and current trends in improving the performance of Distributed Database. | 5 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be:** |
| • Abe to understand relational database management systems, normalization to make efficient retrieval from database and query. |

**References:**

1. Principles of Distributed Database Systems, Second Edition, M. Tamer Ozsu Patrick Valduriez
2. Distributed Databases principles and systems, Stefano Ceri, Giuseppe Pelagatti, Tata McGraw Hill.

| | |
|---|---|
| **Course Code** | 2CS32 |
| **Course Name** | Concurrence, Parallelism and Distributed System |

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|---|---|
| **Credits** | 3 |
| **Pre-Requisites** | Computer Architecture and Organization, Computer Networks |

Total Number of Lectures: 48

| COURSE OBJECTIVE |
|---|
| • This course will cover the basic concept of distributed system, architecture of distributed system, distributed object models, communication between distributed system, The concept of synchronization, agreement, distributed transaction, parallel processing |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1:**<br>Fundamentals of Distributed Computing: Architectural models for distributed and mobile computing systems, Basic concepts in distributed computing. Distributed Operating Systems: Overview, network operating systems, Distributed file systems, Middleware, client/server model for computing. | 8 |
| **Unit 2:**<br>Communication: Layered protocols, RPC, RMI, Remote objects. Basic Algorithms in Message Passing Systems, Leader Election in Rings, and Mutual Exclusion in Shared Memory, Message Passing, PVM and MPI. | 7 |
| **Unit 3:**<br>Process Concepts: Threads, Clients and Servers, Code migration, Agent based Synchronization: Clock synchronization, Logical clocks, Election algorithms, Mutual exclusion, Distributed transactions, Naming concepts, Security in distributed systems, Distributed objects, CORBA, Distributed COM. | 12 |
| **Unit 4:**<br>Distributed Databases: Distributed Data Storage, Fragmentation & Replication, Transparency, Distributed Query Processing and Optimization, Distributed Transaction Modelling and concurrency Control, Distributed Deadlock, Commit Protocols. | 7 |
| **Unit 5:**<br>Parallel Processing: Basic Concepts: Introduction to parallel processing, Parallel processing terminology, Design of parallel algorithms, Design of Parallel Databases, Parallel Query Evaluation. | 10 |
| **Unit 6:**<br>Recent trends in multiprocessor and distributed operating systems designs. Case study of parallel algorithms and optimization techniques. | 4 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be:** |
| • At the end of course the student will know about challenges faced while designing distributed system, architectural, fundamental and security model of distributed system, Remote Method Invocation, Remote Procedure Call, Event Notification system, fragmentation , Commit Protocols, Locking Scheme, Distributed Deadlock and Parallel system design and query |

**References:**

1. Distributed Systems, Principles and Paradigm by Tannenbaum, A, Maarten Van Steen, Prentice Hall India, 2002
2. Distributed Systems by Coulouris, Dollimore and Kindberg, Pearson, 2009.
3. Fundamentals of Database Systems", 4th Edition by Elmarsi, Navathe, Somayajulu, Gupta Pearson Education, 2007
4. Modern Operating Systems 2nd Edition by Tanenbaum, A Prentice Hall India, 2001.

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|---|---|
| **Course Code** | 2CS05 |
| **Course Name** | HPC Architecture, and Ecosystem |
| **Credits** | 3 |
| **Pre-Requisites** | Computer Architecture and Organization, Data Structure |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • The objective of the course is to provide introduction to parallel architectures and different shared and distributed memory architectures. MPI and OpenMP are discussed along with their applications. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>Overview of parallel system organization; | 7 |
| **Unit 2:**<br>Introduction to message passing and MPI programming. | 8 |
| **Unit 3:**<br>Embarrassingly parallel problems; Problem decomposition, graph partitioning, and load balancing. | 10 |
| **Unit 4:**<br>Introduction to shared memory and OpenMP programming. | 9 |
| **Unit 5:**<br>Examples of scientific computing; Parallel Languages. | 8 |
| **Unit 6:**<br>Recent trends in OpenMP programming, application areas of scientific computing. | 6 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • Abe to write parallel algorithms for high performance systems. Problem decomposition and load balancing using MPI and OpenMP. |

**References:**

1. Parallel Programming for Multicore and Cluster Systems by Thomas Rauber and Gudula Runger.
2. Scientific Parallel Computing by Scott, Clark, and Bagheri.
3. Using OpenMP: Portable Shared Memory Parallel Programming by Chapman, Jost, and van der Pas.

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|---|---|
| **Course Code** | 2CS41 |
| **Course Name** | Parallel Algorithms |

| | |
|---|---|
| **Credits** | 3 |
| **Pre-Requisites** | Data Structure, Computer Architecture and Organization |

Total Number of Lectures: 48

| COURSE OBJECTIVE |
|---|
| • The course focuses on an alternative to sequential model, parallel algorithm performance measure, and application of parallel algorithm in different domain |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1:**<br>Sequential model, need of alternative model, parallel computational models such as PRAM, LMCC, Hypercube, Cube Connected Cycle, Butterfly, Perfect Shuffle Computers, Tree model, Pyramid model, Fully Connected model, PRAM-CREW, EREW models, simulation of one model from another one. | 7 |
| **Unit 2:**<br>Performance Measures of Parallel Algorithms, speed-up and efficiency of PA, Cost optimality, An example of illustrate Cost-optimal algorithms- such as summation, Min/Max on various models. | 8 |
| **Unit 3:**<br>Parallel Sorting Networks, Parallel Merging Algorithms on CREW/EREW/MCC/,<br>Parallel Sorting Networks on CREW/EREW/MCC/, linear array | 8 |
| **Unit 4:**<br>Parallel Searching Algorithm, Kth element, Kth element in X+Y on PRAM, Parallel<br>Matrix Transportation and Multiplication Algorithm on PRAM, MCC, Vector-Matrix<br>Multiplication, Solution of Linear Equation, Root finding. | 11 |
| **Unit 5:**<br>Graph Algorithms - Connected Graphs, search and traversal, Combinatorial Algorithms- Permutation, Combinations, Derangements. | 9 |
| **Unit 6:**<br>Case study of parallel sorting networks, which include CREW, EREW and their performance analysis for various problems. | 5 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be:** |
| • at the end of this course the student will know about parallel computing model PRAM, LMCC etc., efficiency of parallel algorithms, parallel sorting network, parallel search algorithm, Permutation, graph algorithm, combinations. |

**References:**

1. Designing Efficient Algorithms for Parallel Computer by M.J. Quinn, McGraw Hill.
2. Design and Analysis of Parallel Algorithms by S.G. Akl
3. Parallel Sorting Algorithm" by S.G. Akl, Academic Press

| | |
|---|---|
| **Course Code** | 2CS42 |
| **Course Name** | Threaded and Message-passing Programming |
| **Credits** | 3 |

| | |
|---|---|
| **Pre-Requisites** | Operating System Design |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • Be familiar with the common attributes and design concerns of message-passing systems<br>• Be able to evaluate the suitability of different message-passing approaches for a particular application<br>• Understand the benefits and costs of formal verification of a concurrent system, and the situations in which it is appropriate<br>• Be able to design multi-core and distributed applications using several modern message-passing programming paradigms<br>• Have experience of implementing multi-core and distributed applications using a variety of message-passing systems.<br>• Be able to familiarise themselves rapidly with new programming languages. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit1:**<br>Introduction to MPI, Topologies, Remote Memory Access, Dynamic Process Management | 9 |
| **Unit 2:**<br>Parallel I/O, Non-contiguous Accesses, Collective I/O, Arrays, Distributed Arrays, Non-blocking I/O, Split Collective I/O, Shared File Pointers, Consistency Semantics, File Interoperability. | 11 |
| **Unit 3:**<br>Synchronization, Remote Memory Operations. | 7 |
| **Unit 4:**<br>Dynamic Process Management: Creating and Connecting MPI Processes, Design of the MPI Dynamic Process Routines. | 8 |
| **Unit 5:**<br>Thread, Thread Safety, Mixed-Model Programming: MPI for SMP Clusters, Decoding Data types, Generalized Requests, Adding New Error Codes and Classes, Attribute Caching, Error Handling. | 8 |
| **Unit 6:**<br>Case study of Remote Memory Access, Dynamic Process Management and Mixed-Model Programming. | 5 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be able to:** |
| • Design MPI for distributed applications.<br>• Familiarize themselves rapidly with new programming languages. |

**References:**

1. William Gropp Ewing Lusk Rajeev Thakur, Using MPI-2: Advanced Features of the Message-Passing Interface, MIT Press.

| | |
|---|---|
| **Course Code** | 3CS51 |
| **Course Name** | High Performance Scientific Computing |
| **Credits** | 3 |

| | |
|---|---|
| **Pre-Requisites** | Linear Algebra and Numerical Methods, Parallel Algorithms |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • The aim of the course is to provide insight to high performance computation techniques, and Parallel heterogeneous computation languages which includes MPI and OpenMP. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>Overview of parallel system organization | 6 |
| **Unit 2:**<br>Introduction to message passing and MPI programming | 9 |
| **Unit 3:**<br>Embarrassingly parallel problems; Problem decomposition, graph partitioning, and load balancing | 11 |
| **Unit 4:**<br>Introduction to shared memory and OpenMP programming; | 10 |
| **Unit 5:**<br>Examples of scientific computing, Parallel Languages. | 6 |
| **Unit 6:**<br>Case study of Problem decomposition, graph partitioning, and load balancing using OpenMP. | 6 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would be:** |
| • Familiar with parallel and shared memory architecture and parallel computation languages which includes MPI and OpenMP. |

**References:**


1. Parallel Programming for Multicore and Cluster Systems by Thomas Rauber and Gudula Runger.
2. Scientific Parallel Computing by Scott, Clark, and Bagheri.
3. Using OpenMP: Portable Shared Memory Parallel Programming by Chapman, Jost, and van der Pas.


| | |
|---|---|
| **Course Code** | 3CS52 |
| **Course Name** | Quantum Computing |
| **Credits** | 3 |
| **Pre-Requisites** | Linear Algebra, Theory of Computation |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • The course will provide an insight of basic of quantum physics from a computer scientist's perspective, and how it describes reality and understand the philosophical implications of quantum computing |

| **LECTURE WITH BREAKUP** | **NO. OF** |
|---|---|

| | LECTURES |
|---|---|
| **Unit 1:**<br>Qubit & Quantum States: The Qubit, Vector Spaces. Linear Combination Of Vectors, Uniqueness of a spanning set, basis & dimensions, inner Products, orthonormality, gram-schmidt orthogonalization, bra-ket formalism, the Cauchy-schwarez and triangle Inequalities. | 8 |
| **Unit 2:**<br>Matrices & Operators: Observables, The Pauli Operators, Outer Products, The Closure Relation, Representation of operators using matrices, outer products & matrix representation, matrix representation of operators in two dimensional spaces, Pauli Matrix, Hermitian unitary and normal operator, Eigen values & Eigen Vectors, Spectral Decomposition, Trace of an operator, important properties of Trace, Expectation Value of Operator, Projection Operator, Positive Operators, | 8 |
| **Unit 3:**<br>Commutator Algebra, Heisenberg uncertainty principle, polar decomposition &singular values, Postulates of Quantum Mechanics. | 7 |
| **Unit 4:**<br>Tensor Products: Representing Composite States in Quantum Mechanics, Computing inner products, Tensor products of column vectors, operators and tensor products of Matrices.<br>Density Operator: Density Operator of Pure & Mix state, Key Properties, Characterizing Mixed State, Practical Trace & Reduce Density Operator, Density Operator & Bloch Vector. | 12 |
| **Unit 5:**<br>Quantum Measurement Theory: Distinguishing Quantum states & Measures, Projective Measurements, Measurement on Composite systems, Generalized Measurements, Positive Operator- Valued Measures. | 8 |
| **Unit 6:**<br>Recent trends in Quantum Computing Research, Quantum Computing Applications of Genetic Programming. | 5 |

| **COURSE OUTCOMES** |
|---|
| **After completion of course, students would have:** |
| • knowledge of Vector spaces, Matrices, Quantum state, Density operator and Quantum Measurement theory. |

**References:**

1. Quantum Computing without Magic by Zdzislaw Meglicki
2. Quantum Computing Explained By DAVID Mc MAHON
3. Quantum Computer Science By Marco Lanzagorta, Jeffrey Uhlmann
4. An Introduction to Quantum Computing Phillip Kaye, Raymond Laflamme, Michele Mosca.

| | |
|---|---|
| **Course Code** | 3CS53 |
| **Course Name** | DNA Computing |
| **Credits** | 3 |
| **Pre-Requisites** | Theory of Computation, Algorithms |

Total Number of Lectures: 48

| COURSE OBJECTIVE |
|---|
| • The course aims to provide introduction of DNA computing and mathematical theory involved in DNA computing |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1:**<br>Introduction: DNA Structure, Sequence and Processing of DNA Introduction to molecular computing | 7 |
| **Unit 2:**<br>Mathematical Theory: Mathematical Theory of DNA Computing; | 8 |
| **Unit 3:**<br>Introduction to language theory, Sticker systems | 8 |
| **Unit 4:**<br>Parallelism of DNA strands; Watson Crick Automata; Insertion-Deletion Systems; Splicing circular strings | 11 |
| **Unit 5:**<br>Distributed H Systems, Splicing revisited. | 7 |
| **Unit 6:**<br>Recent trends and applications of DNA Computing in computer networks. | 7 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be:** |
| • Familiar with DNA sequence matching algorithms. Parallelism in DNA computing algorithms. |

**References:**

1. DNA Computing by Paun, Gheorghe, Rozenberg, Grzegorz, Salomaa, Arto; Springer publication

| | |
|---|---|
| **Course Code** | |
| **Course Name** | Human Centered Computing |
| **Credits** | 3 |
| **Pre-Requisites** | Machine Learning |

Total Number of Lectures: 48

| COURSE OBJECTIVE |
|---|
| • The objective of this course is to introduce human-cantered computing, reviewing a subset of current applications and open problems. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1: Prelims**<br>Intro, logistics, overview, Introduction to small data, Different flavors of mathematical/computational models, Model fitting, evaluation metrics, Parameter estimation, model selection and non-parametric methods. | 8 |
| **Unit 2: Search** | 11 |

| | |
|---|---|
| Classical search/information retrieval, Query completion, Contextual/topical search foci, Information scent and other foraging models, Temporal information retrieval, Serendipity, discovery. | |
| **Unit 3: Preferences**<br>Recommender systems, Collaborative filtering, Feature selection, SVD, Different flavors of recommender systems, Validation, measurement metrics, Diversity. | 8 |
| **Unit 4: Emotions**<br>Theories and schema, Sentiment analysis, Affect measurement (computer vision, survey instruments, activity monitoring), Chatbots to emotebots, Brain-computer interface, Boredom/ennui. | 8 |
| **Unit 5: Goals**<br>Basic goal-directed agents, Hebbian/reinforcement learning, Explore-exploit dilemma, Curiosity, perseverance, intrinsic motivation as goals, Gamification, Deep principles – flow, connectedness, homeostasis, etc. | 8 |
| **Unit 6:**<br>Recent trends and applications of Human Centered Computing. Case study of classical search and information retrieval techniques. | 5 |

| |
|---|
| **COURSE OUTCOMES** |
| **After completion of course, students would be:** |
| • It provides foundational knowledge in important aspects of human-centered systems |
| • It helps to understand humans and model their preferences, interests, and knowledge; analyze explicitly and implicitly generated data; and design systems with natural and intuitive interfaces. |
| • Students able to develop a range of human cantered information systems |

**References:**


1. Croft, Metzler, Strohman. Search engines: Information Retrieval in practice. Pearson Education
2. Pang, B., & Lee, L. (2008).Opinion mining and sentiment analysis. Foundations and trends in information retrieval, 2(1-2), 1-135.
3. Picard, R. W., & Picard, R. (1997).Affective computing (Vol. 252). Cambridge: MIT press.
4. Shapira, B., Ricci, F., Kantor, P. B., & Rokach, L. (2011). Recommender Systems Handbook. Springer Press.
5. Sutton, R. S., & Barto, A. G. (1998).Reinforcement learning: An introduction (Vol. 1, No. 1). Cambridge: MIT press.


## OPEN ELECTIVES
## Business Analytics

**Teaching scheme**

**Lecture: - 3 h/week**

| | |
|---|---|
| **Course Code** | |
| **Course Name** | **Business Analytics** |

| | |
|---|---|
| **Credits**<br>**Prerequisites** | |

Total Number of Lectures: 48

| **Course objective** |
|---|
| 1. Understand the role of business analytics within an organization.<br>2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.<br>3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.<br>4. To become familiar with processes needed to develop, report, and analyze business data.<br>5. Use decision-making tools/Operations research techniques.<br>6. Mange business process using analytical and management tools.<br>**7.** Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit1:**<br>Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.<br>Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview. | 9 |
| **Unit 2:**<br>Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.<br>Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology. | 8 |
| **Unit 3:**<br>Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.<br>Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization. | 9 |
| **Unit 4:** | |

| | |
|---|---|
| Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.<br>Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model. | 10 |
| **Unit 5:**<br>Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. | 8 |
| **Unit 6:**<br>Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism. | 4 |

| **COURSE OUTCOMES** | |
|---|---|
| 1. | Students will demonstrate knowledge of data analytics. |
| 2. | Students will demonstrate the ability of think critically in making decisions based on data and deep analytics. |
| 3. | Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making. |
| **4.** | Students will demonstrate the ability to translate data into clear, actionable insights. |

**Reference:**

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

## OPEN ELECTIVES
## Industrial Safety

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**Unit-II:** Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**Unit-III:** Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**Unit-IV:** Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**Unit-V:** Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

**Reference:**


1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.


## OPEN ELECTIVES
## Operations Research

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes: At the end of the course,** the student should be able to

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

**Syllabus Contents:**

**Unit 1**:

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

**Unit 2**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

**Unit 3**:

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

**Unit 4**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

**Unit 5**

Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic

Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

**References**:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

## Open Elective
## Cost Management of Engineering Projects

**Teaching scheme**

**Lecture: - 3 h/week**

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Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

**References:**

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher

5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

## Open Elective
## Composite Materials

**Teaching scheme**

**Lecture: - 3 h/week**

**UNIT–I**: INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT – II**: REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT – III:** Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT–IV:** Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT – V:** Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

**TEXT BOOKS:**

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

**References:**

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

## Open Elective
## Waste to Energy

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**Unit-II:** Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**Unit-III:** Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**Unit-IV:** Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**Unit-V:** Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

**References:**


1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.


## AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING

**Course objectives:**
Students will be able to:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title

Ensure the good quality of paper at very first-time submission

**Syllabus**

| **Units** | **CONTENTS** | **Hours** |
|---|---|---|
| 1 | Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness | 4 |
| 2 | Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction | 4 |
| 3 | Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check. | 4 |
| 4 | key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, | 4 |

| | | |
|---|---|---|
| 5 | skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions | 4 |
| 6 | useful phrases, how to ensure paper is as good as it could possibly be the first- time submission | 4 |

**Suggested Studies:**

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

## AUDIT 1 and 2: DISASTER MANAGEMENT

**Course Objectives: -**Students will be able to:
1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in

**Syllabus**

| Units | CONTENTS | Hours |
|---|---|---|
| 1 | **Introduction**<br>Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude. | 4 |
| 2 | **Repercussions Of Disasters And Hazards**: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.<br>Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts. | 4 |
| 3 | **Disaster Prone Areas In India**<br>Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics | 4 |
| 4 | **Disaster Preparedness And Management**<br>Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness. | 4 |
| 5 | **Risk Assessment**<br>Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And | 4 |

| | | |
|---|---|---|
| | National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival. | |
| 6 | **Disaster Mitigation**<br>Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India. | 4 |

**SUGGESTED READINGS:**

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

## AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE

***Course Objectives***

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

***Syllabus***

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Alphabets in Sanskrit,<br>• Past/Present/Future Tense,<br>• Simple Sentences | 8 |
| 2 | • Order<br>• Introduction of roots<br>• Technical information about Sanskrit Literature | 8 |
| 3 | • Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics | 8 |

***Suggested reading***

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.

***Course Output***

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

## AUDIT 1 and 2: VALUE EDUCATION

***Course Objectives***

Students will be able to

1.Understand value of education and self- development

2. Imbibe good values in students

3. Let the should know about the importance of character

***Syllabus***

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism.<br>• Moral and non- moral valuation. Standards and principles.<br>• Value judgements | 4 |
| 2 | • Importance of cultivation of values.<br>• Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness.<br>• Honesty, Humanity. Power of faith, National Unity.<br>• Patriotism.Love for nature ,Discipline | 6 |
| 3 | • Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline.<br>• Punctuality, Love and Kindness.<br>• Avoid fault Thinking.<br>• Free from anger, Dignity of labour.<br>• Universal brotherhood and religious tolerance.<br>• True friendship.<br>• Happiness Vs suffering, love for truth.<br>• Aware of self-destructive habits.<br>• Association and Cooperation.<br>• Doing best for saving nature | 6 |
| 4 | • Character and Competence –Holy books vs Blind faith.<br>• Self-management and Good health.<br>• Science of reincarnation.<br>• Equality, Nonviolence ,Humility, Role of Women.<br>• All religions and same message.<br>• Mind your Mind, Self-control.<br>• Honesty, Studying effectively | 6 |

***Suggested reading***

1 Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

***Course outcomes***

Students will be able to

1.Knowledge of self-development

2.Learn the importance of Human values

3.Developing the overall personality

## AUDIT 1 and 2: CONSTITUTION OF INDIA

**Course Objectives:**

Students will be able to:

1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| **1** | • **History of Making of the Indian Constitution:**<br>History<br>Drafting Committee, ( Composition & Working) | 4 |
| **2** | • **Philosophy of the Indian Constitution:**<br>Preamble<br>Salient Features | 4 |
| **3** | • **Contours of Constitutional Rights & Duties:**<br>• Fundamental Rights<br>• Right to Equality<br>• Right to Freedom<br>• Right against Exploitation<br>• Right to Freedom of Religion<br>• Cultural and Educational Rights<br>• Right to Constitutional Remedies<br>• Directive Principles of State Policy<br>• Fundamental Duties. | 4 |
| **4** | • **Organs of Governance:**<br>• Parliament<br>• Composition<br>• Qualifications and Disqualifications<br>• Powers and Functions<br>• Executive<br>• President<br>• Governor<br>• Council of Ministers<br>• Judiciary, Appointment and Transfer of Judges, Qualifications<br>• Powers and Functions | 4 |
| **5** | • **Local Administration:**<br>• District's Administration head: Role and Importance,<br>• Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.<br>• Pachayati raj: Introduction, PRI: Zila Pachayat.<br>• Elected officials and their roles, CEO Zila Pachayat: Position and role.<br>• Block level: Organizational Hierarchy (Different departments),<br>• Village level: Role of Elected and Appointed officials,<br>• Importance of grass root democracy | 4 |
| **6** | • **Election Commission:** | 4 |

| | | |
|---|---|---|
| | • Election Commission: Role and Functioning.<br>• Chief Election Commissioner and Election Commissioners.<br>• State Election Commission: Role and Functioning.<br>• Institute and Bodies for the welfare of SC/ST/OBC and women. | |

**Suggested reading**


1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.


**Course Outcomes:**

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

## AUDIT 1 and 2: PEDAGOGY STUDIES

<table>
<tr><td colspan="3">Course Objectives:<br>Students will be able to:<br>4. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.<br>5. Identify critical evidence gaps to guide the development.</td></tr>
<tr><td colspan="3">Syllabus</td></tr>
<tr><th>Units</th><th>Content</th><th>Hours</th></tr>
<tr><td>1</td><td>• Introduction and Methodology:<br>• Aims and rationale, Policy background, Conceptual framework and terminology<br>• Theories of learning, Curriculum, Teacher education.<br>• Conceptual framework, Research questions.<br>• Overview of methodology and Searching.</td><td>4</td></tr>
<tr><td>2</td><td>• Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.<br>• Curriculum, Teacher education.</td><td>2</td></tr>
<tr><td>3</td><td>• Evidence on the effectiveness of pedagogical practices<br>• Methodology for the in depth stage: quality assessment of included studies.<br>• How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?<br>• Theory of change.<br>• Strength and nature of the body of evidence for effective pedagogical practices.<br>• Pedagogic theory and pedagogical approaches.<br>• Teachers’ attitudes and beliefs and Pedagogic strategies.</td><td>4</td></tr>
<tr><td>4</td><td>• Professional development: alignment with classroom practices and follow-up support</td><td>4</td></tr>
</table>

| | | |
|---|---|---|
| | • Peer support<br>• Support from the head teacher and the community.<br>• Curriculum and assessment<br>• Barriers to learning: limited resources and large class sizes | |
| **5** | • **Research gaps and future directions**<br>• Research design<br>• Contexts<br>• Pedagogy<br>• Teacher education<br>• Curriculum and assessment<br>• Dissemination and research impact. | 2 |

**Suggested reading**


1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.

6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.


**Course Outcomes:**

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

## AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

***Course Objectives***

1. To achieve overall health of body and mind
2. To overcome stress

***Syllabus***

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Definitions of Eight parts of yog. ( Ashtanga ) | 8 |
| 2 | • Yam and Niyam.<br>Do`s and Don't's in life.<br>i) Ahinsa, satya, astheya, bramhacharya and aparigraha | 8 |

| | | |
|---|---|---|
| | ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan | |
| 3 | • Asan and Pranayam<br>i) Various yog poses and their benefits for mind & body<br>ii)Regularization of breathing techniques and its effects-Types of pranayam | 8 |

***Suggested reading***

1. 'Yogic Asanas for Group Tarining-Part-I" : Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

**Course Outcomes:**

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also

2. Improve efficiency

## AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS

***Course Objectives***

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

***Syllabus***

| Unit | Content | Hours |
|---|---|---|
| 1 | Neetisatakam-Holistic development of personality<br>• Verses- 19,20,21,22 (wisdom)<br>• Verses- 29,31,32 (pride & heroism)<br>• Verses- 26,28,63,65 (virtue)<br>• Verses- 52,53,59 (dont's)<br>• Verses- 71,73,75,78 (do's) | 8 |
| 2 | • Approach to day to day work and duties.<br>• Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48,<br>• Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,<br>• Chapter 18-Verses 45, 46, 48. | 8 |
| 3 | • Statements of basic knowledge.<br>• Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68<br>• Chapter 12 -Verses 13, 14, 15, 16,17, 18<br>• Personality of Role model. Shrimad Bhagwad Geeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42,<br>• Chapter 4-Verses 18, 38,39<br>• Chapter18 – Verses 37,38,63 | 8 |

***Suggested reading***

1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

***Course Outcomes***

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

## Course Scheme for M.Tech. Computer Science and Engineering Specialization: Internet of Things

### M.TechSem-I.

| Course Number | Subject | Scheme Of Studies Per Week | | | Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| 1CS01 | Program Core I-<br>Mathematical foundations of Computer Science | 3 | 0 | 0 | 3 |
| 1CS02 | Program Core II-<br>Advanced Data Structures | 3 | 0 | 0 | 3 |
| 1CSxx | Program Elective I-<br>Data Science/ Wireless Access Technologies/ Mobile Applications and Services | 3 | 0 | 0 | 3 |
| 1CSxx | Program Elective II-<br>Machine Learning/ Smart Sensors and Internet of Things/ Logic and Functional programming | 3 | 0 | 0 | 3 |
| 1Axxx | Research Methodology and IPR | 2 | 0 | 0 | 2 |
| 1Axxx | Audit Course | 2 | 0 | 0 | 0 |
| 1CS03 | Laboratory 1 (Advanced Data Structures) | 0 | 0 | 4 | 2 |
| 1CS04 | Laboratory 2 (Based on Electives) | 0 | 0 | 4 | 2 |
| Total Credits: 18 | | | | | |

### M.TechSem- II

| Course Number | Subject | Scheme Of Studies Per Week | | | Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| 2CS05 | Program Core III –<br>Advance Algorithms | 3 | 0 | 0 | 3 |
| 2CS06 | Program Core IV –<br>Soft Computing | 3 | 0 | 0 | 3 |
| 2CSxx | Program Elective III –<br>Sensor Networks and Internet of Things/ Data Visualization/ IoTApplication and Communication Protocol | 3 | 0 | 0 | 3 |
| 2CSxx | Program Elective IV –<br>Big Data Analytics/ Network Security/ Advanced Machine Learning | 3 | 0 | 0 | 3 |
| 2Axxx | Audit Course | 2 | 0 | 0 | 0 |
| 2CS07 | Laboratory 3 (Based on cores) | 0 | 0 | 4 | 2 |
| 2CS08 | Laboratory 4 (Based on Electives) | 0 | 0 | 4 | 2 |
| 2CS09 | Mini Project with Seminar | 2 | 0 | 0 | 2 |
| Total Credits: 18 | | | | | |

*Students be encouraged to go to Industrial Training/Internship for at least 2-3 months during semester break.

**M.TechIII Sem***

| Course No. | Subject | Scheme of Studies Periods Per Week | | | Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| 3CSxx | Program Elective V – Cloud Computing/ IOT and Smart Cities/ Emulation and Simulation Methodologies | 3 | 0 | 0 | 03 |
| 3CSxx | Open Elective<br><br>1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy | 3 | 0 | 0 | 03 |
| 3CS10 | Dissertation-I /Industrial Project | 0 | 0 | 20 | 10 |
| | Total Credits | 16 | | | |
| | | | | | |

***Students going for Industrial Project/Thesis will complete these courses through MOOCs.**

**M.TechSem-IV**

| | Subject | Scheme of Studies Per Week | | | Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| | Dissertation II | 0 | 0 | 32 | 16 |
| | Total Credits: 16 | | | | |

The program offers several elective courses, focusing on different aspects of Internet of Things. A student can choose to do any course from given program elective set.

**Program Outcomes of CSE (M.Tech.) program:**

The main outcomes of the CSE (M.Tech.) program are given here. At the end of the program a student is expected to have:

1. An understanding of the theoretical foundations and the limits of computing.
2. An ability to adapt existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
3. An ability to design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
4. Understanding and ability to use advanced computing techniques and tools.
5. An ability to undertake original research at the cutting edge of computer science & its related areas.
6. An ability to function effectively individually or as a part of a team to accomplish a stated goal.
7. An understanding of professional and ethical responsibility.
8. An ability to communicate effectively with a wide range of audience.

9. An ability to learn independently and engage in life¬long learning.
10. An understanding of the impact of IT related solutions in an economic, social and environment context.

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

**Syllabus, course objective and course outcomes for various post graduation courses.**

**Core Subjects:**

| | |
|---|---|
| **Course Code** | 1CS01 |
| **Course Name** | Mathematical Foundation of Computer Science |
| **Credits** | 3 |
| **Pre-Requisites** | Discrete Mathematics |

Total Number of Lectures:48

| COURSE OBJECTIVE |
|---|
| • To understand the mathematical fundamentals that is prerequisites for avariety of courses like Data mining, Network protocols, analysis of Web traffic, Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning. |
| • To developthe understanding ofthe mathematical and logical basis to many modern techniques in information technology like machine learning, programming language design, and concurrency. |
| • To study various sampling and classification problems. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1**<br>Probability mass, density, and cumulative distribution functions, Parametric families of distributions, Expected value, variance, conditional expectation, Applications of the univariate and multivariate Central Limit Theorem, Probabilistic inequalities, Markov chains | 7 |
| **Unit 2**<br>Random samples, sampling distributions of estimators**,** Methods of Moments and Maximum Likelihood**,** | 7 |
| **Unit 3**<br>Statistical inference**,** Introduction to multivariate statistical models: regression and classification problems, principal components analysis**,** The problem of overfitting model assessment. | 8 |
| **Unit 4**<br>Graph Theory: Isomorphism, Planar graphs, graph colouring, hamilton circuits and euler cycles. | 11 |

| | |
|---|---|
| Permutations and Combinations with and without repetition.<br>Specialized techniques to solve combinatorial enumeration problems | |
| **Unit 5**<br>**Computer science and engineering applications**<br>Data mining, Network protocols, analysis of Web traffic, Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning. | 10 |
| **Unit 6**<br>Recent Trands in various distribution functions in mathmatical field of computer science for varying fields like bioinformatic, soft computing, and computer vision. | 5 |

| **COURSE OUTCOMES** |
|---|
| After completion of course, students would be able to: |
| • To understand the basic notions of discrete and continuous probability. |
| • To understand the methods of statistical inference, and the role that sampling distributions play in those methods. |
| • To be able to perform correct and meaningful statistical analyses of simple to moderate complexity. |

**References:**


1. John Vince, Foundation Mathematics for Computer Science, Springer.
2. K. Trivedi.Probability and Statistics with Reliability, Queuing, and Computer Science Applications. Wiley.
3. M. Mitzenmacher and E. Upfal.Probability and Computing: Randomized Algorithms and Probabilistic Analysis.
4. Alan Tucker, Applied Combinatorics, Wiley


| | |
|---|---|
| **Course Code** | 1CS02 |
| **Course Name** | Advanced Data Structures |
| **Credits** | 3 |
| **Pre-Requisites** | UG level course in Data Structures |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • The student should be able to choose appropriate data structures, understand the ADT/libraries, and use it to design algorithms for a specific problem. |
| • Students should be able to understand the necessary mathematical abstraction to solve problems. |
| • To familiarize students with advanced paradigms and data structure used to solve algorithmic problems. |
| • Student should be able to come up with analysis of efficiency and proofs of correctness. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1**<br>**Dictionaries:** Definition, Dictionary Abstract Data Type, Implementation of Dictionaries.<br>**Hashing:** Review of Hashing, Hash Function, Collision Resolution Techniques in Hashing, Separate Chaining, Open Addressing, Linear Probing, Quadratic Probing, Double Hashing, Rehashing, Extendible Hashing. | 7 |
| **Unit 2** | 5 |

| | |
|---|---|
| **Skip Lists:** Need for Randomizing Data Structures and Algorithms, Search and Update Operations on Skip Lists, Probabilistic Analysis of Skip Lists, Deterministic Skip Lists | |
| **Unit 3**<br>**Trees:** Binary Search Trees, AVL Trees, Red Black Trees, 2-3 Trees, B-Trees, Splay Trees | 9 |
| **Unit 4**<br>**Text Processing:** Sting Operations, Brute-Force Pattern Matching, The Boyer-Moore Algorithm, The Knuth-Morris-Pratt Algorithm, Standard Tries, Compressed Tries, Suffix Tries, The Huffman Coding Algorithm, The Longest Common Subsequence Problem (LCS), Applying Dynamic Programming to the LCS Problem. | 12 |
| **Unit 5**<br>**Computational Geometry:** One Dimensional Range Searching, Two Dimensional Range Searching, Constructing a Priority Search Tree, Searching a Priority Search Tree, Priority Range Trees, Quadtrees, k-D Trees. | 10 |
| **Unit 6**<br>Recent Trands in Hashing, Trees, and various computational geometry methods for effeciently solving the new evolving problem | 5 |

| **COURSE OUTCOMES** |
|---|
| After completion of course, students would be able to: |
| • Understand the implementation of symbol table using hashing techniques. |
| • Develop and analyze algorithms for red-black trees, B-trees and Splay trees. |
| • Develop algorithms for text processing applications. |
| • Identify suitable data structures and develop algorithms for computational geometry problems. |

**References:**

1. Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, 2nd Edition, Pearson, 2004.
2. M T Goodrich, Roberto Tamassia, Algorithm Design, John Wiley, 2002.

| | |
|---|---|
| **Course Code** | 2CS05 |
| **Course Name** | Advanced Algorithms |
| **Credits** | 3 |
| **Pre-Requisites** | UG level course in Algorithm Design and Analysis |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • Introduce students to the advanced methods of designing and analyzing algorithms. |
| • The student should be able to choose appropriate algorithms and use it for a specific problem. |
| • To familiarize students with basic paradigms and data structures used to solve advanced algorithmic problems. |
| • Students should be able to understand different classes of problems concerning their computation difficulties. |
| • To introduce the students to recent developments in the area of algorithmic design. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit1** | 6 |

| | |
|---|---|
| **Sorting:** Review of various sorting algorithms, topological sorting<br>**Graph:** Definitions and Elementary Algorithms: Shortest path by BFS, shortest path in edge-weighted case (Dijkasra's), depth-first search and computation of strongly connected components, emphasis on correctness proof of the algorithm and time/space analysis, example of amortized analysis. | |
| **Unit 2**<br>**Matroids:** Introduction to greedy paradigm, algorithm to compute a maximum weight maximal independent set. Application to MST.<br>**Graph Matching:** Algorithm to compute maximum matching. Characterization of maximum matching by augmenting paths, Edmond's Blossom algorithm to compute augmenting path. | 8 |
| **Unit 3**<br>**Flow-Networks:** Maxflow-mincut theorem, Ford-Fulkerson Method to compute maximum flow, Edmond-Karp maximum-flow algorithm.<br>**Matrix Computations:** Strassen's algorithm and introduction to divide and conquer paradigm, inverse of a triangular matrix, relation between the time complexities of basic matrix operations, LUP-decomposition. | 9 |
| **Unit 4**<br>**Shortest Path in Graphs:** Floyd-Warshall algorithm and introduction to dynamic programming paradigm. More examples of dynamic programming.<br>**Modulo Representation of integers/polynomials:** Chinese Remainder Theorem, Conversion between base-representation and modulo-representation. Extension to polynomials. Application: Interpolation problem.<br>**Discrete Fourier Transform (DFT):** In complex field, DFT in modulo ring. Fast Fourier Transform algorithm. Schonhage-Strassen Integer Multiplication algorithm | 10 |
| **Unit 5**<br>**Linear Programming:** Geometry of the feasibility region and Simplex algorithm<br>**NP-completeness:** Examples, proof of NP-hardness and NP-completeness.<br>**One or more of the following topics based on time and interest**<br>Approximation algorithms, Randomized Algorithms, Interior Point Method, Advanced Number Theoretic Algorithm | 10 |
| **Unit 6**<br>Recent Trands in problem solving paradigms using recent searching and sorting techniques by applying recently proposed data structures. | 5 |

| **COURSE OUTCOMES** |
|---|
| After completion of course, students would be able to: |
| • Analyze the complexity/performance of different algorithms. |
| • Determine the appropriate data structure for solving a particular set of problems. |
| • Categorize the different problems in various classes according to their complexity. |
| • Students should have an insight of recent activities in the field of the advanced data structure. |

**References:**

1. "Introduction to Algorithms" byCormen, Leiserson, Rivest, Stein.
2. "The Design and Analysis of Computer Algorithms" by Aho, Hopcroft, Ullman.
3. "Algorithm Design" by Kleinberg and Tardos.

| Research Methodology and IPR | |
|---|---|
| **Teaching Scheme**<br>Lectures: 1hrs/week | |

**Course Outcomes:**

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

**Syllabus Contents:**

**Unit 1:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Unit 2:** Effective literature studies approaches, analysis

Plagiarism, Research ethics,

**Unit 3:** Effective technical writing, how to write report, Paper

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**Unit 4:** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Unit 5:** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Unit 6:** New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

**References:**


1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2 ndEdition , "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
5. Mayall , "Industrial Design", McGraw Hill, 1992.
6. Niebel , "Product Design", McGraw Hill, 1974.
7. Asimov , "Introduction to Design", Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008


| | |
|---|---|
| **Course Code** | 2CS06 |
| **Course Name** | Soft Computing |
| **Credits** | 3 |
| **Pre-Requisites** | Basic knowledge of mathematics |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • To introduce soft computing concepts and techniques and foster their abilities in designing appropriate technique for a given scenario. |
| • To implement soft computing based solutions for real-world problems. |
| • To give students knowledge of non-traditional technologies and fundamentals of artificial neural networks, fuzzy sets, fuzzy logic, genetic algorithms. |
| • To provide studentan hand-on experience on MATLAB to implement various strategies. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1**<br>**Introduction to Soft Computing and Neural Networks:** Evolution of Computing: Soft Computing Constituents, From Conventional AI to Computational Intelligence: Machine Learning Basics | 7 |
| **Unit 2**<br>**Fuzzy Logic:** Fuzzy Sets, Operations on Fuzzy Sets, Fuzzy Relations, Membership Functions: Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems, Fuzzy Expert Systems, Fuzzy Decision Making. | 8 |
| **Unit 3** | 10 |

| | |
|---|---|
| **Neural Networks:** Machine Learning Using Neural Network, Adaptive Networks, Feed forward Networks, Supervised Learning Neural Networks, Radial Basis Function Networks : Reinforcement Learning, Unsupervised Learning Neural Networks, Adaptive Resonance architectures, Advances in Neural networks | |
| **Unit 4**<br>**Genetic Algorithms:** Introduction to Genetic Algorithms (GA), Applications of GA in Machine Learning : Machine Learning Approach to Knowledge Acquisition. | 5 |
| **Unit 5**<br>**Matlab/Python Lib:** Introduction to Matlab/Python, Arrays and array operations, Functions and Files, Study of neural network toolbox and fuzzy logic toolbox, Simple implementation of Artificial Neural Network and Fuzzy Logic | 13 |
| **Unit 6**<br>Recent Trands in deep learning, various classifiers, neural networks and genetic algorithm.<br>Implementation of recently proposed soft computing techniques. | 5 |

| **COURSE OUTCOMES** |
|---|
| After completion of course, students would be able to: |
| • Identify and describe soft computing techniques and their roles in building intelligent machines |
| • Apply fuzzy logic and reasoning to handle uncertainty and solve various engineering problems. |
| • Apply genetic algorithms to combinatorial optimization problems. |
| • Evaluate and compare solutions by various soft computing approaches for a given problem. |

**References:**


1. Jyh:Shing Roger Jang, Chuen:Tsai Sun, EijiMizutani, Neuro:Fuzzy and Soft Computing, Prentice:Hall of India, 2003.
2. George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic:Theory and Applications, Prentice Hall, 1995.
3. MATLAB Toolkit Manual


**Elective Subjects**

| | |
|---|---|
| **Course Code** | 1CS23 |
| **Course Name** | Big Data Analytics |
| **Credits** | 3 |
| **Pre-Requisites** | Data Structure, Computer Architecture and Organization |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • Understand big data for business intelligence. Learn business case studies for big data analytics. Understand nosql big data management. Perform map-reduce analytics using Hadoop and related tools |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:** | 8 |

| | |
|---|---|
| What is big data, why big data, convergence of key trends, unstructured data, industry examples of big data, web analytics, big data and marketing, fraud and big data, risk and big data, credit risk management, big data and algorithmic trading, big data and healthcare, big data in medicine, advertising and big data, big data technologies, introduction to Hadoop, open source technologies, cloud and big data, mobile business intelligence, Crowd sourcing analytics, inter and trans firewall analytics. | |
| **Unit 2:** Introduction to NoSQL, aggregate data models, aggregates, key-value and document data models, relationships, graph databases, schemaless databases, materialized views, distribution models, sharding, master-slave replication, peer-peer replication, sharding and replication, consistency, relaxing consistency, version stamps, map-reduce, partitioning and combining, composing map-reduce calculations. | 8 |
| **Unit 3:** Data format, analyzing data with Hadoop, scaling out, Hadoop streaming, Hadoop pipes, design of Hadoop distributed file system (HDFS), HDFS concepts, Java interface, data flow, Hadoop I/O, data integrity, compression, serialization, Avro, file-based data structures | 9 |
| **Unit 4:** MapReduce workflows, unit tests with MRUnit, test data and local tests, anatomy of MapReduce job run, classic Map-reduce, YARN, failures in classic Map-reduce and YARN, job scheduling, shuffle and sort, task execution, MapReduce types, input formats, output formats | 10 |
| **Unit 5:** Hbase, data model and implementations, Hbase clients, Hbase examples, praxis.Cassandra, Cassandra data model, Cassandra examples, Cassandra clients, Hadoop integration. | 7 |
| **Unit 6:** Pig, Grunt, pig data model, Pig Latin, developing and testing Pig Latin scripts. Hive, data types and file formats, HiveQL data definition, HiveQL data manipulation, HiveQL queries. | 6 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be:** |
| • Describe big data and use cases from selected business domains<br>• Explain NoSQL big data management<br>• Install, configure, and run Hadoop and HDFS<br>• Perform map-reduce analytics using Hadoop<br>• Use Hadoop related tools such as HBase, Cassandra, Pig, and Hive for big data analytics |

**References:**

1. Michael Minelli, Michelle Chambers, and AmbigaDhiraj, "Big Data, Big Analytics: Emerging
2. Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.
3. P. J. Sadalage and M. Fowler, "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence", Addison-Wesley Professional, 2012.
4. Tom White, "Hadoop: The Definitive Guide", Third Edition, O'Reilley, 2012.
5. Eric Sammer, "Hadoop Operations", O'Reilley, 2012.
6. E. Capriolo, D. Wampler, and J. Rutherglen, "Programming Hive", O'Reilley, 2012.
7. Lars George, "HBase: The Definitive Guide", O'Reilley, 2011.

8. Eben Hewitt, "Cassandra: The Definitive Guide", O'Reilley, 2010.
9. Alan Gates, "Programming Pig", O'Reilley, 2011.

| | |
|---|---|
| **Course Code** | |
| **Course Name** | Data Science |
| **Credits** | 3 |
| **Pre-Requisites** | |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • Provide you with the knowledge and expertise to become a proficient data scientist. |
| • Demonstrate an understanding of statistics and machine learning concepts that are vital for data science; |
| • Produce Python code to statistically analyse a dataset; |
| • Critically evaluate data visualisations based on their design and use for communicating stories from data; |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:** Introduction to core concepts and technologies: Introduction, Terminology, data science process, data science toolkit, Types of data, Example applications. | 6 |
| **Unit 2:** Data collection and management: Introduction, Sources of data, Data collection and APIs, Exploring and fixing data, Data storage and management, Using multiple data sources | 7 |
| **Unit 3:** Data analysis: Introduction, Terminology and concepts, Introduction to statistics, Central tendencies and distributions, Variance,Distribution properties and arithmetic, Samples/CLT, Basic machine learning algorithms, Linear regression, SVM, Naive Bayes. | 10 |
| **Unit 4:** Data visualisation:Introduction, Types of data visualisation,Data for visualisation:Data types, Data encodings, Retinal variables, Mapping variables to encodings, Visual encodings. | 11 |
| **Unit 5:** Applications of Data Science,Technologies for visualisation, Bokeh (Python) | 7 |
| **Unit 6:** Recent trends in various data collection and analysis techniques, various visualization techniques, application development methods of used in data science. | 7 |

| **COURSE OUTCOMES** |
|---|
| **On completion of the course the student should be able to** |
| • Explain how data is collected, managed and stored for data science; |
| • Understand the key concepts in data science, including their real-world applications and the toolkit used by data scientists; |
| • Implement data collection and management scripts using MongoDB |

**References:**

1. Cathy O'Neil and Rachel Schutt. Doing Data Science, Straight Talk From The Frontline. O'Reilly.
2. Jure Leskovek, AnandRajaraman and Jeffrey Ullman. Mining of Massive Datasets. v2.1, Cambridge University Press.

| **Course Code** | |
|---|---|
| **Course Name** | Wireless Access Technologies |
| **Credits** | 3 |
| **Pre-Requisites** | Wireless Networks |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • Overview of wireless access technologies, Fixed wireless access networks. Terminal mobility issues regarding wireless access to Internet |
| • Introduction to various Network topologies, hotspot networks, Communication links: point-to-point, point-to-multipoint, multipoint-to-multipoint. |
| • To provide an overview of Standards for most frequently used wireless access networks: WPAN, UWB, WLAN, WMAN, WWAN. Network services. Wireless access networks planning, design and installation. |
| • To get and insight of Wireless networking security issues, Wireless access network exploitation and management, software requirements, link quality control. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>Necessity for wireless terminals connectivity and networking. Wireless networking advantages and disadvantages, Overview of wireless access technologies. Narrowband and broadband networks, fixed and nomadic networks. Wireless local loop (WLL), Public Switched Telephone Network (PSTN) interfaces. | 8 |
| **Unit 2:** Fixed wireless access (FWA) networks, frequency bands for different networks. Criterions for frequency bands allocation, Network topologies, hotspot networks. Communication links: point-to-point (PTP), point-to-multipoint (PMP), multipoint-to-multipoint (MTM). | 8 |
| **Unit 3:** Standards for most frequently used wireless access networks: WPAN (802.15, Bluetooth, DECT, IrDA), UWB (Ultra-Wideband), WLAN (802.11, Wi-Fi, HIPERLAN, IrDA), WMAN (802.16, WiMAX, HIPERMAN, HIPERACCESS), WWAN (802.20), Other technologies for broadband wireless access, Local Multipoint Distribution Service (LMDS), Multichannel Multipoint Distribution Service (MMDS). Ad Hoc networks, Network services. Services types based on carrier frequency and bandwidth. | 10 |
| **Unit 4:** Wireless access networks planning, design and installation. Services provision, legislative and technical aspects, Technical and economical factors for network planning: expenses, coverage, link capacity, network complexity and carrier-to-interference ratio (C/I). Base station or access point allocation. Base station and access point equipment.<br>Terminal mobility issues regarding wireless access to Internet.<br>Wireless networking security issues. | 9 |
| **Unit 5:** Example of laptop or handheld PC wireless connection in real | 8 |

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|---|---|
| environment. PC wireless interface equipment.<br>Wireless access network exploitation and management, software requirements, link quality control.<br>Business model, wireless network services market, market research and marketing, service providers, wireless data application service providers (WDASP) and their role on public telecommunication services market, billing systems. | |
| **Unit 6:** Recent trends in wireless networking and various access mechanism, new standards of wirelss communication. | 5 |

| COURSE OUTCOMES |
|---|
| On completion of the course the student should be able to |
| • interpret basic terms and characteristics of wireless access networks |
| • compare various wireless access technologies |
| • analyze measurements of wireless access network parameter |
| • assess security issues in wireless networks |
| • choose modulation technique for wireless transmission |

**References:**

1. M. P. Clark, Wireless Access Networks: Fixed Wireless Access and WLL networks -- Design and Operation, John Wiley & Sons, Chichester
2. D. H. Morais, Fixed Broadband Wireless Communications: Principles and Practical Applications, Prentice Hall, Upper Saddle River
3. R. Pandya, Introduction to WLLs: Application and Deployment for Fixed and Broadband Services, IEEE Press, Piscataway

| | |
|---|---|
| **Course Code** | |
| **Course Name** | Mobile Applications and Services |
| **Credits** | 3 |
| **Pre-Requisites** | Wireless Communication and Mobile Computing |

Total Number of Lectures:48

| COURSE OBJECTIVE |
|---|
| • This course presents the three main mobile platforms and their ecosystems, namely Android, iOS, and PhoneGap/WebOS. |
| • .It explores emerging technologies and tools used to design and implement feature-rich mobile applications for smartphones and tablets |
| • It also take into account both the technical constraints relative to storage capacity, processing capacity, display screen, communication interfaces, and the user interface, context and profile |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1:**Introduction:Introduction to Mobile Computing, Introduction to Android Development Environment, Factors in Developing Mobile Applications, Mobile Software Engineering, Frameworks and Tools, Generic UI Development Android User | 8 |
| **Unit 2:** More on Uis: VUIs and Mobile Apps, Text-to-Speech Techniques, Designing the Right UI, Multichannel and Multimodal Uis, . Storing and Retrieving Data, Synchronization and Replication of Mobile Data, Getting the | 8 |

| | |
|---|---|
| Model Right, Android Storing and Retrieving Data, Working with a Content Provider | |
| **Unit 3:** Communications via Network and the Web:State Machine, Correct Communications Model, Android Networking and Web, Telephony<br>Deciding Scope of an App, Wireless Connectivity and Mobile Apps, Android Telephony<br>Notifications and Alarms:Performance, Performance and Memory Management, Android Notifications and Alarms, Graphics, Performance and Multithreading, Graphics and UI Performance, Android Graphics | 10 |
| **Unit 4:** Putting It All Together : Packaging and Deploying, Performance Best Practices, Android Field Service App, Location Mobility and Location Based Services Android<br>Multimedia: Mobile Agents and Peer-to-Peer Architecture, Android Multimedia | 9 |
| **Unit 5:** Platforms and Additional Issues : Development Process, Architecture, Design, Technology Selection, Mobile App Development Hurdles, Testing, Security and Hacking , Active Transactions, More on Security, Hacking Android | 8 |
| **Unit 6:** Recent trends inCommunication protocols for IOT nodes, mobile computimng techniques in IOT, agents based communications in IOT | 5 |

| **COURSE OUTCOMES** |
|---|
| On completion of the course the student should be able to |
| • identify the target platform and users and be able to define and sketch a mobile application |
| • understand the fundamentals, frameworks, and development lifecycle of mobile application platforms including iOS, Android, and PhoneGap |
| • Design and develop a mobile application prototype in one of the platform (challenge project) |

**References:**

1. Wei-Meng Lee, Beginning Android™ 4 Application Development, 2012 by John Wiley & Sons

| | |
|---|---|
| **Course Code** | |
| **Course Name** | Machine learning |
| **Credits** | 3 |
| **Pre-Requisites** | |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • To learn the concept of how to learn patterns and concepts from data without being explicitly programmed in various IOT nodes. |
| • To design and analyse various machine learning algorithms and techniques with a modern outlook focusing on recent advances. |
| • Explore supervised and unsupervised learning paradigms of machine learning. |
| • To explore Deep learning technique and various feature extraction strategies. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>**Supervised Learning (Regression/Classification)** | 10 |

| | |
|---|---|
| • Basic methods: Distance-based methods, Nearest-Neighbours, Decision Trees, Nave Bayes<br>• Linear models: Linear Regression, Logistic Regression, Generalized Linear Models<br>• Support Vector Machines, Nonlinearity and Kernel Methods<br>• Beyond Binary Classification: Multi-class/Structured Outputs, Ranking | |
| **Unit 2:**<br>**Unsupervised Learning**<br>• Clustering: K-means/Kernel K-means<br>• Dimensionality Reduction: PCA and kernel PCA<br>• Matrix Factorization and Matrix Completion<br>• Generative Models (mixture models and latent factor models) | 7 |
| **Unit 3**<br>Evaluating Machine Learning algorithms and Model Selection, Introduction to Statistical Learning Theory, Ensemble Methods (Boosting, Bagging, Random Forests) | 6 |
| **Unit 4**<br>Sparse Modeling and Estimation, Modeling Sequence/Time-Series Data, Deep Learning and Feature Representation Learning | 9 |
| **Unit 5**<br>Scalable Machine Learning (Online and Distributed Learning)<br>A selection from some other advanced topics, e.g., Semi-supervised Learning, Active Learning, Reinforcement Learning, Inference in Graphical Models, Introduction to Bayesian Learning and Inference | 9 |
| **Unit 6:**<br>Recent trends in various learning techniques of machine learning and classification methods for IOT applications. Various models for IOT applications. | 5 |

| **COURSE OUTCOMES** |
|---|
| After completion of course, students would be able to: |
| • Extract features that can be used for a particular machine learning approach in various IOT applications. |
| • To compare and contrast pros and cons of various machine learning techniques and to get an insight of when to apply a particular machine learning approach. |
| • To mathematically analyse various machine learning approaches and paradigms. |

**References:**


1. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer 2009 (freely available online)
3. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.


| | |
|---|---|
| **Course Code** | |
| **Course Name** | Smart Sensors and Internet of Things |
| **Credits** | 3 |
| **Pre-Requisites** | Wireless Networks |

Total Number of Lectures:48

| COURSE OBJECTIVE |
|---|
| • Able to understand the application areas of IOT |
| • Able to realize the revolution of Internet in Mobile Devices, Cloud & Sensor Networks |
| • Able to understand building blocks of Internet of Things and characteristics |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1**: Environmental Parameters Measurement and Monitoring: Why measurement and monitoring are important, effects of adverse parameters for the living being for IOT | 7 |
| **Unit 2:** Sensors: Working Principles: Different types; Selection of Sensors for Practical Applications<br>Introduction of Different Types of Sensors such as Capacitive, Resistive, Surface Acoustic Wave for Temperature, Pressure, Humidity, Toxic Gas etc | 8 |
| **Unit 3:** Important Characteristics of Sensors: Determination of the Characteristics<br>Fractional order element: Constant Phase Impedance for sensing applications such as humidity, water quality, milk quality<br>Impedance Spectroscopy: Equivalent circuit of Sensors and Modelling of Sensors<br>Importance and Adoption of Smart Sensors | 11 |
| **Unit 4:** Architecture of Smart Sensors: Important components, their features<br>Fabrication of Sensor and Smart Sensor: Electrode fabrication: Screen printing, Photolithography, Electroplating Sensing film deposition: Physical and chemical Vapor, Anodization, Sol-gel | 10 |
| **Unit 5:** Interface Electronic Circuit for Smart Sensors and Challenges for Interfacing the Smart Sensor, Usefulness of Silicon Technology in Smart Sensor And Future scope of research in smart sensor | 7 |
| **Unit 6:** Recent trends in smart sensor for day to day life, evolving sensors and their architecture. | 5 |

| COURSE OUTCOMES |
|---|
| On completion of the course the student should be able to |
| • Understand the vision of IoT from a global context. |
| • Determine the Market perspective of IoT. |
| • Use of Devices, Gateways and Data Management in IoT. |
| • Application of IoT in Industrial and Commercial Building Automation and Real World Design Constraints. |
| • Building state of the art architecture in IoT. |

**References:**

1. Yasuura, H., Kyung, C.-M., Liu, Y., Lin, Y.-L., Smart Sensors at the IoT Frontier, Springer International Publishing
2. Kyung, C.-M., Yasuura, H., Liu, Y., Lin, Y.-L., Smart Sensors and Systems, Springer International Publishing

| | |
|---|---|
| **Course Code** | |
| **Course Name** | Logic And Functional Programming |
| **Credits** | 3 |
| **Pre-Requisites** | Computer Programming, Mathematical Logic |

Total Number of Lectures:48

| COURSE OBJECTIVE |
|---|
| • To further the state of the art on the theoretical and practical aspects of developing declarative programming tools in logic programming for IOT data analysis . |
| • To introduce basics of functional programming and constraint logic programming for nodes in IOT. |
| • Introduction into formal concepts used as a theoretical basis for both paradigms, basic knowledge and practical experience. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1: Proposition Logic:** Introduction of logic and Functional Paradigm, Propositional Concepts, Semantic Table , Problem Solving with Semantic Table. | 5 |
| **Unit 2:**<br>**Natural Deduction and Axiomatic Propositional Logic:** Rules of Natural Deduction, Sequent Calculus, Axiomatic Systems, Meta theorems, Important Properties of AL, Resolution, Resolving Arguments | 7 |
| **Unit 3:**<br>**Introduction to Predicate Logic** Objects, Predicates and Quantifiers, Functions, First Order Language, Quantifiers, Scopeand Binding, Substitution, An Axiomatic System for First Order Predicate Logic, Soundness and Completeness, Axiomatic Semantic and Programming | 9 |
| **Unit 4:**<br>**Semantic Tableaux & Resolution in Predicate Logic:** Semantic Tableaux, Instantiation Rules, Problem-solving in Predicate Logic, Normal forms, Herbrand Universes and H-interpretation, Resolution, Unification, Resolution as a computing Tool, Nondeterministic Programming, Incomplete Data Structure, Second Order Programming in Prolog, Logic Grammars: Definite Clause Grammar, A Grammar Interpreter. | 13 |
| **Unit 5:**<br>**Lazy and Eager Evaluation strategies:** Evaluation Strategies, Lazy Evaluation: Evaluation Order and strictness of function,Programming with lazy evaluation, Interactive functional program, Delay of unnecessary Computation, Infinite Data Structure, Eager Evaluation and Reasoning | 9 |
| **Unit 6:** Recent trends in logical and functional programming, predicate logics and various evaluation strategies. | 5 |

| COURSE OUTCOMES |
|---|
| On completion of the course the student should be able to |
| • Understanding of the theory and practice of functional and logic programming For IOT. |
| • The ability to write functional and logic programs for nodes in IOT. |

- The ability to solve problems in and using functional and logic programming.

**References:**

1. John Kelly, "The Essence of Logic", Prentice-Hall India.
2. Saroj Kaushik, "Logic and Prolog Programming", New Age International ltd

| | |
|---|---|
| **Course Code** | |
| **Course Name** | Sensor Networks and Internet of Things |
| **Credits** | 3 |
| **Pre-Requisites** | Wireless Networks |

Total Number of Lectures:45

| **COURSE OBJECTIVE** |
|---|
| • The course gives an overview of various topics related to wireless sensor networks, which are expected to be the basis for the emerging internet-of-things. |
| • The course covers topics with relation to various subdisciplines of computer science such as hardware, operating systems, distributed systems, networking, security and databases. |
| • Able to understand wireless sensor network (WSN) specific issues such as localization, time synchronization, and topology control are addressed as well. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:** Introduction and Applications:smart transportation, smart cities, smart living, smart energy, smart health, and smart learning. Examples of research areas include for instance: Self-Adaptive Systems, Cyber Physical Systems, Systems of Systems, Software Architectures and Connectors, Software Interoperability, Big Data and Big Data Mining, Privacy and Security | 8 |
| **Unit 2:IoT Reference Architecture-** Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views.<br>**Real-World Design Constraints-** Introduction, Technical Design constraints-hardware, Data representation and visualization, Interaction and remote control. | 9 |
| **Unit 3:Industrial Automation-** Service-oriented architecture-based device integration, SOCRADES: realizing the enterprise integrated Web of Things, IMC-AESOP: from the Web of Things to the Cloud of Things, **Commercial Building Automation-** Introduction, Case study: phase one-commercial building automation today, Case study: phase two- commercial building automation in the future. | 9 |
| **Unit 4:** Hardware Platforms and Energy Consumption, Operating Systems, Time Synchronization, Positioning and Localization, Medium Access Control, Topology and Coverage Control, Routing: Transport Protocols, Network Security, Middleware, Databases | 10 |
| **Unit 5:** IOT Physical Devices & Endpoints: What is an IOT Device, Exemplary Device Board, Linux on Raspberry , Interface and Programming & IOT Device | 7 |
| **Unit 6:** Recent trends in sensor network and IOT architecture, Automation in Industrial aspect of IOT | 5 |

| **COURSE OUTCOMES** |
|---|
| On completion of the course the student should be able to |
| • identify requirements from emerging WSN applications on WSN platforms, communication systems, protocols and middleware |

| |
|---|
| • understand, compare and evaluate communication and network protocols used in WSNs |
| • discuss and evaluate mechanisms and algorithms for time synchronization and localization in WSNs<br>• understand and discuss requirements for the design of security mechanisms and middleware systems to be used in WSNs |

**References:**


1. Mandler, B., Barja, J., Mitre Campista, M.E., Cagá□ová, D., Chaouchi, H., Zeadally, S., Badra, M., Giordano, S., Fazio, M., Somov, A., Vieriu, R.-L., Internet of Things. IoT Infrastructures, Springer International Publishing


| | |
|---|---|
| **Course Code** | |
| **Course Name** | Data Visualisation |
| **Credits** | 3 |
| **Pre-Requisites** | Computer Graphics, Image Processing |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • familiarize students with the basic and advanced techniques of information visualization and scientific visualization, |
| • to learn key techniques of the visualization process |
| • a detailed view of visual perception, the visualized data and the actual visualization, interaction and distorting techniques |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>Introduction of visual perception, visual representation of data, Gestalt principles, information overloads. | 8 |
| **Unit 2:**<br>Creating visual representations, visualization reference model, visual mapping, visual analytics, Design of visualization applications. | 8 |
| **Unit 3**:<br>Classification of visualization systems, Interaction and visualization techniques misleading, Visualization of one, two and multi-dimensional data, text and text documents. | 10 |
| **Unit 4:**<br>Visualization of groups, trees, graphs, clusters, networks, software, Metaphorical visualization | 11 |
| **Unit 5:**<br>Visualization of volumetric data, vector fields, processes and simulations, Visualization of maps, geographic information, GIS systems, collaborative visualizations, Evaluating visualizations | 7 |
| **Unit 6:**<br>Recent trends in various perception techniques, various visualization techniques, data structures used in data visualization. | 4 |

| **COURSE OUTCOMES** |
|---|

| **On completion of the course the student should be able to** |
|---|
| • familiar with the design process to develop visualization methods and visualization systems, and methods for their evaluation. |
| • preparation and processing of data, visual mapping and the visualization |
| • have an understanding of large-scale abstract data, |

**References:**

1. WARD, GRINSTEIN, KEIM, .Interactive Data Visualization: Foundations, Techniques, and Applications. Natick : A K Peters, Ltd.
2. E. Tufte, The Visual Display of Quantitative Information, Graphics Press.

| **Course Code** | |
|---|---|
| **Course Name** | IOT Applications and Communication Protocols |
| **Credits** | 3 |
| **Pre-Requisites** | Computer Networks |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • Basic introduction of all the elements of IoT-Mechanical, Electronics/sensor platform, Wireless and wireline protocols, Mobile to Electronics integration, Mobile to enterprise integration |
| • Open source/commercial electronics platform for IoT-Raspberry Pi, Arduino , ArmMbedLPC |
| • Open source /commercial enterprise cloud platform for IoT-Ayla, iO Bridge, Libellium, Axeda, Cisco fog cloud |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1**: Basic function and architecture of a sensor — sensor body, sensor mechanism, sensor calibration, sensor maintenance, cost and pricing structure, legacy and modern sensor network.<br>Development of sensor electronics — IoT vs legacy, and open source vs traditional PCB design style<br>Development of sensor communication protocols, Protocols: Modbus, relay, Zigbee, Zwave, X10,Bluetooth, ANT, etc.<br>Business driver for sensor deployment — FDA/EPA regulation, fraud/tempering detection, supervision, quality control and process management<br>Different kind of calibration Techniques: manual, automation, infield, primary and secondary calibration — and their implication in IoT<br>Powering options for sensors: battery, solar, Witricity, Mobile and PoE | 9 |
| **Unit 2:** Zigbee and Zwave — advantage of low power mesh networking. Long distance Zigbee. Introduction to different Zigbee chips.<br>Bluetooth/BLE: Low power vs high power, speed of detection, class of BLE. Introduction of Bluetooth vendors & their review.<br>Wireless protocols such as Piconet and packet structure for BLE and Zigbee<br>Other long distance RF communication link.<br>LOS vs NLOS links, Capacity and throughput calculation<br>Application issues in wireless protocols:power consumption, reliability, PER, QoS, LOS | 9 |
| **Unit 3:** PCB vs FPGA vs ASIC design<br>Prototyping electronics vs Production electronics | 9 |

| | |
|---|---|
| QA certificate for IoT- CE/CSA/UL/IEC/RoHS/IP65<br>Basic introduction of multi-layer PCB design and its workflow<br>Electronics reliability-basic concept of FIT and early mortality rate<br>Environmental and reliability testing-basic concepts<br>Basic Open source platforms: Arduino, Raspberry Pi, Beaglebone | |
| **Unit 4:** Introduction to Mobile app platform for IoT: Protocol stack of Mobile app for IoT, Mobile to server integration, iBeacon in IoS, Window Azure, Linkafy Mobile platform for IoT, Axeda, Xively | 8 |
| **Unit 5:** Database implementation for IoT : Cloud based IoT platforms, SQL vs NoSQL, Open sourced vs. Licensed Database, Available M2M cloud platform, AxedaXively, Omega NovoTech, Ayla Libellium, CISCO M2M platform, AT &T M2M platform, Google M2M platform | 8 |
| **Unit 6:** Recent trends in home automation, IOT-locks, Energy optimization in home | 5 |

| **COURSE OUTCOMES** |
|---|
| On completion of the course the student should be able to |
| • To understand merging technological options, platforms and case studies of IoT implementation in home & city automation |
| • Determine the Market perspective of IoT. |

**References:**

1. Olivier Hersent, David Boswarthick, Omar Elloumi, The Internet of Things: Key Applications and Protocols, Wiley-Blackwell.

| **Course Code** | |
|---|---|
| **Course Name** | Network Security |
| **Credits** | 3 |
| **Pre-Requisites** | Computer Networks, Web Programming |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • To learn the basics of security and various types of security issues. |
| • To study different cryptography techniques available and various security attacks. |
| • Explore network security and how they are implemented in real world. |
| • To get an insight of various issues of Web security and biometric authentication. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>Data security: Review of cryptography. Examples RSA, DES, ECC. | 6 |
| **Unit 2:**<br>Authentication, non-repudiation and message integrity. Digital signatures and certificates. Protocols using cryptography (example Kerberos). Attacks on protocols | 9 |
| **Unit 3**<br>Network security: Firewalls, Proxy-Servers, Network intrusion detection. Transport security: Mechanisms of TLS, SSL, IPSec. | 9 |
| **Unit 4**<br>Web security – SQL injection, XSS, etc. Software security and buffer overflow. Malware types and case studies. | 11 |

| | |
|---|---|
| Access Control, firewalls and host/network intrusion detection. | |
| **Unit 5**<br>Other topics: Biometric authentication, Secure E-Commerce (ex. SET), Smart Cards, Security in Wireless Communication. | 8 |
| **Unit 6:** recent trends in IOT security, IDS and Biometric. | 5 |

| **COURSE OUTCOMES** |
|---|
| After completion of course, students would be able to: |
| • To have an understanding of basics of security and issues related to it. |
| • Understanding of biometric techniques available and how they are used in today's world. |
| • Security issues in web and how to tackle them. |
| • Learn mechanisms for transport and network security |

**References:**

1. W. R. Cheswick and S. M. Bellovin. Firewalls and Internet Security. Addison Wesley, 1994.
2. W. Stallings. Cryptography and Network Security. Prentice Hall, 1999.
3. B. Schneier. Applied Cryptography. Wiley, 1999.

| | |
|---|---|
| **Course Code** | |
| **Course Name** | Advanced Machine Learning |
| **Credits** | 3 |
| **Pre-Requisites** | Machine Learning, Probability Theory |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • To introduce key concepts in pattern recognition and machine learning; including specific algorithms for classification, regression, clustering and probabilistic modeling. |
| • To give a broad view of the general issues arising in the application of algorithms to analysing data, common terms used, and common errors made if applied incorrectly. |
| • To demonstrate a toolbox of techniques that can be immediately applied to real world problems, or used as a basis for future research into the topic. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:** Key concepts, Supervised/Unsupervised Learning, Loss functions and generalization, Probability Theory, Parametric vs Non-parametric methods, Elements of Computational Learning Theory<br>Ensemble Learning, Bagging, Boosting, Random Forest | 8 |
| **Unit 2:** Kernel Methods for non-linear data, Support Vector Machines, Kernel Ridge Regression, Structure Kernels, Kernel PCA, Latent Semantic Analysis | 8 |
| **Unit 3:** Bayesian methods for using prior knowledge and data, Bayesian inference, Bayesian Belief Networks and Graphical models, Probabilistic Latent Semantic Analysis, The Expectation-Maximisation (EM) algorithm, Gaussian Processes | 8 |
| **Unit 4:** Dimensionality Reduction - CCA, LDA, ICA, NMF - Canonical Variates - Feature Selection vs Feature Extraction | 10 |
| **Unit 5:**Filter Methods - Sub-space approaches - Embedded methods | 9 |

| | |
|---|---|
| Low-Rank approaches - Recommender Systems<br>.Application areas - Security - Business - Scientific | |
| **Unit 6:** Recent trends in supervised and unsupervised learning algorithm, dimensional reducibility, feature selection and extraction | 5 |

| COURSE OUTCOMES |
|---|
| On completion of the course the student should be able to understand |
| • Key concepts, tools and approaches for pattern recognition on complex data sets |
| • Kernel methods for handling high dimensional and non-linear patterns |
| • State-of-the-art algorithms such as Support Vector Machines and Bayesian networks |
| • Solve real-world machine learning tasks: from data to inference |
| • Theoretical concepts and the motivations behind different learning frameworks |

**References:**

1. Christopher M. Bishop, Pattern Recognition and Machine Learning.
2. John Shawe-Taylor and NelloCristianini, Kernel Methods for Pattern Analysis.

| | |
|---|---|
| **Course Code** | |
| **Course Name** | IOT and Smart Cities |
| **Credits** | 3 |
| **Pre-Requisites** | Wireless Communication and Networks |

Total Number of Lectures:48

| COURSE OBJECTIVE |
|---|
| • Explain the basic methodologies and techniques of the arts and humanities, social sciences, business, and science and technology |
| • to describe the current practices and future trends about smart city; |
| • Capacity of critique the current practice and provide recommendations. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit 1:** Introduction and Applications:smart transportation, smart cities, smart living, smart energy, smart health, and smart learning. | 8 |
| **Unit 2:IoT Reference Architecture-** methods to assist local governments to develop international good e-practice | 9 |
| **Unit 3:** Methods to redesign and redefine back and front offices in order to build smarter and transparent governments | 8 |
| **Unit 4:** Methods to design public mobile services aimed at efficiency, cost-saving and participation with attention for e-inclusion | 8 |
| **Unit 5**: Methodologies for user involvement, profiling customers and indentifying needs; test methodologies to transfer these needs in appropriate services; and test techniques to fit the right channel to the specific services and customers thereby setting a framework for a higher level of e-services in the NSR | 10 |
| **Unit 6:**Pilot new service channels, bluetooth services for public transport, online forms in mobile phones and wireless city services | 5 |

| COURSE OUTCOMES |
|---|

| On completion of the course the student should be able to |
|---|
| • understanding the fundamental knowledge of the sustainable and smart city |
| • Ability to understand the technologies used for sustainable and smart cities; |
| • Ability to integrate and apply the learnt knowledge to conduct a case study in an organized way; Ability to present the study clearly to audiences; Demonstration of critical thinking and discovering. |

**References:**


1. Smart City on Future Life - Scientific Planning and Construction by Xianyi Li
2. The Age of Intelligent Cities: Smart Environments and Innovation-for-all Strategies (Regions and Cities) by NicosKomninos
3. Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia by Anthony Townsend


| | |
|---|---|
| **Course Code** | |
| **Course Name** | Emulation and Simulation Methodologies |
| **Credits** | 3 |
| **Pre-Requisites** | Probability Theory, Computer Networks |

Total Number of Lectures:48

| **COURSE OBJECTIVE** |
|---|
| • this module teaches the fundamentals of simulation and emulation methodologies providing guidance on how to design a performance evaluation campaign, |
| • set up a test scenario, select the appropriate models, level of granularity |
| • metrics for statistical correctness, and discuss the differences between simulation and emulation platforms and how to use them for accurate performance evaluation of communications. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:** Fundamentals of Discrete Event Simulations (DES) | 8 |
| **Unit 2:** Model-based representationfor DES, from communication and networking, to mobility and data traffic. | 8 |
| **Unit 3:** Application-based Granularity Requirements: from bit-level, packet-level, to system-level evaluation, and their appropriate selection as a function of the application requirements. | 8 |
| **Unit 4:** Fundamentals on Random Numbers, Fundamentals on Statistical Tools for Performance Evaluation, Simulation vs. Emulations | 12 |
| **Unit 5:** Case study for the evaluation of communications for ITS. | 8 |
| **Unit 6:** Recent trends in simulation and emulation for IOT, model based and application based granularity presentation | 4 |

| **COURSE OUTCOMES** |
|---|
| On completion of the course the student should be able to |
| • Key concepts, tools and approaches for pattern recognition on complex data sets |
| • Kernel methods for handling high dimensional and non-linear patterns |
| • State-of-the-art algorithms such as Support Vector Machines and Bayesian networks |
| • Theoretical concepts and the motivations behind different learning frameworks |
| • Be able to solve real-world machine learning tasks: from data to inference |

**References:**

1. Jack L. Burbank, An Introduction to Network Simulator 3, Wiley

| | |
|---|---|
| **Course Code** | |
| **Course Name** | Cloud Computing |
| **Credits** | 3 |
| **Pre-Requisites** | |

Total Number of Lectures: 48

| **COURSE OBJECTIVE** |
|---|
| • The student will also learn how to apply trust-based security model to real-world security problems. |
| • An overview of the concepts, processes, and best practices needed to successfully secure information within Cloud infrastructures. |
| • Students will learn the basic Cloud types and delivery models and develop an understanding of the risk and compliance responsibilities and Challenges for each Cloud type and service delivery model. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit 1:**<br>**Introduction to Cloud Computing**<br>Online Social Networks and Applications, Cloud introduction and overview, Different clouds, Risks, Novel applications of cloud computing | 4 |
| **Unit 2:**<br>**Cloud Computing Architecture**<br>Requirements, Introduction Cloud computing architecture, On Demand Computing Virtualization at the infrastructure level, Security in Cloud computing environments, CPU Virtualization, A discussion on Hypervisors Storage Virtualization Cloud Computing Defined, The SPI Framework for Cloud Computing, The Traditional Software Model, The Cloud Services Delivery Model<br>**Cloud Deployment Models**<br>Key Drivers to Adopting the Cloud, The Impact of Cloud Computing on Users, Governance in the Cloud, Barriers to Cloud Computing Adoption in the Enterprise | 11 |
| **Unit 3:**<br>**Security Issues in Cloud Computing**<br>Infrastructure Security, Infrastructure Security: The Network Level, The Host Level, The Application Level, Data Security and Storage, Aspects of Data Security, Data Security Mitigation Provider Data and Its Security<br>**Identity and Access Management**<br>Trust Boundaries and IAM, IAM Challenges, Relevant IAM Standards and Protocols for Cloud Services, IAM Practices in the Cloud, Cloud Authorization Management | 10 |
| **Unit 4:**<br>**Security Management in the Cloud**<br>Security Management Standards, Security Management in the Cloud, | 11 |

| | |
|---|---|
| Availability Management: SaaS, PaaS, IaaS<br>**Privacy Issues**<br>Privacy Issues, Data Life Cycle, Key Privacy Concerns in the Cloud, Protecting Privacy, Changes to Privacy Risk Management and Compliance in Relation to Cloud Computing, Legal and Regulatory Implications, U.S. Laws and Regulations, International Laws and Regulations | |
| **Unit 5:**<br>**Audit and Compliance**<br>Internal Policy Compliance, Governance, Risk, and Compliance (GRC), Regulatory/External Compliance, Cloud Security Alliance, Auditing the Cloud for Compliance, Security-as-a-Cloud | 8 |
| **Unit 6:**<br>**ADVANCED TOPICS**<br>Recent devlopments in hybrid cloud and cloud security . | 4 |

| COURSE OUTCOMES |
|---|
| **After completion of course, students would be able to:** |
| • Identify security aspects of each cloud model |
| • Develop a risk-management strategy for moving to the Cloud |
| • Implement a public cloud instance using a public cloud service provider |
| • Apply trust-based security model to different layer |

**References:**


1. Cloud Computing Explained: Implementation Handbook for Enterprises, John Rhoton, Publication Date: November 2, 2009
2. Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance (Theory in Practice), Tim Mather, ISBN-10: 0596802765,O'Reilly Media, September 2009


## OPEN ELECTIVES
## Business Analytics

**Teaching scheme**

**Lecture: - 3 h/week**

| | |
|---|---|
| **Course Code** | |
| **Course Name** | **Business Analytics** |
| **Credits**<br>**Prerequisites** | |

Total Number of Lectures: 48

| Course objective |
|---|
| 1. Understand the role of business analytics within an organization. |
| 2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization. |

| | |
|---|---|
| 3. | To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making. |
| 4. | To become familiar with processes needed to develop, report, and analyze business data. |
| 5. | Use decision-making tools/Operations research techniques. |
| 6. | Mange business process using analytical and management tools. |
| **7.** | Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc. |

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit1:**<br>Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.<br>Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview. | 9 |
| **Unit 2:**<br>Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.<br>Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology. | 8 |
| **Unit 3:**<br>Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.<br>Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization. | 9 |
| **Unit 4:**<br>Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.<br>Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model. | 10 |
| **Unit 5:**<br>Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of | 8 |

| | |
|---|---|
| Information, Utility and Decision Making. | |
| **Unit 6:**<br>Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism. | 4 |

| **COURSE OUTCOMES** | |
|---|---|

1. Students will demonstrate knowledge of data analytics.
2. Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.
3. Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.
4. Students will demonstrate the ability to translate data into clear, actionable insights.

**Reference:**


1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.


## OPEN ELECTIVES
### Industrial Safety

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**Unit-II:** Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**Unit-III:** Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**Unit-IV:** Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**Unit-V:** Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

**Reference:**

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

## OPEN ELECTIVES
## Operations Research

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes: At the end of the course,** the student should be able to

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

**Syllabus Contents:**

**Unit 1**:

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

**Unit 2**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

**Unit 3**:

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

**Unit 4**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

**Unit 5**

Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

**References:**

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010

6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

## Open Elective
## Cost Management of Engineering Projects

**Teaching scheme**

**Lecture: - 3 h/week**

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Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

**References:**

2. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
3. Charles T. Horngren and George Foster, Advanced Management Accounting
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
5. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
6. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

## Open Elective
## Composite Materials

**Teaching scheme**

**Lecture: - 3 h/week**

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**UNIT–I**: INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix.

Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT – II**: REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT – III:** Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT–IV:** Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT – V:** Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

**TEXT BOOKS:**

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

**References:**

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

**Open Elective**
**Waste to Energy**

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**Unit-II:** Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**Unit-III:** Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**Unit-IV:** Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**Unit-V:** Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

**References:**

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

## AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING

**Course objectives:**
Students will be able to:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title

Ensure the good quality of paper at very first-time submission

**Syllabus**

| **Units** | **CONTENTS** | **Hours** |
|---|---|---|
| 1 | Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness | 4 |
| 2 | Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction | 4 |
| 3 | Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check. | 4 |
| 4 | key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, | 4 |
| 5 | skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions | 4 |
| 6 | useful phrases, how to ensure paper is as good as it could possibly be the first- time submission | 4 |

**Suggested Studies:**

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

## AUDIT 1 and 2: DISASTER MANAGEMENT

**Course Objectives: -**Students will be able to:

1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in

**Syllabus**

| Units | CONTENTS | Hours |
|---|---|---|
| 1 | **Introduction**<br>Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude. | 4 |
| 2 | **Repercussions Of Disasters And Hazards**: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.<br>Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts. | 4 |
| 3 | **Disaster Prone Areas In India**<br>Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics | 4 |
| 4 | **Disaster Preparedness And Management**<br>Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness. | 4 |
| 5 | **Risk Assessment**<br>Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival. | 4 |

| | | |
|---|---|---|
| 6 | **Disaster Mitigation**<br>Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India. | 4 |

**SUGGESTED READINGS:**

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.
2. Sahni, PardeepEt.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

## AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE

***Course Objectives***

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

***Syllabus***

| Unit | *Content* | *Hours* |
|---|---|---|
| 1 | • Alphabets in Sanskrit,<br>• Past/Present/Future Tense,<br>• Simple Sentences | 8 |
| 2 | • Order<br>• Introduction of roots<br>• Technical information about Sanskrit Literature | 8 |
| 3 | • Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics | 8 |

***Suggested reading***

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-VempatiKutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.

***Course Output***

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

## AUDIT 1 and 2: VALUE EDUCATION

***Course Objectives***

Students will be able to

1. Understand value of education and self- development

2. Imbibe good values in students

3. Let the should know about the importance of character

***Syllabus***

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism.<br>• Moral and non- moral valuation. Standards and principles.<br>• Value judgements | 4 |
| 2 | • Importance of cultivation of values.<br>• Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness.<br>• Honesty, Humanity. Power of faith, National Unity.<br>• Patriotism.Love for nature ,Discipline | 6 |
| 3 | • Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline.<br>• Punctuality, Love and Kindness.<br>• Avoid fault Thinking.<br>• Free from anger, Dignity of labour.<br>• Universal brotherhood and religious tolerance.<br>• True friendship.<br>• Happiness Vs suffering, love for truth.<br>• Aware of self-destructive habits.<br>• Association and Cooperation.<br>• Doing best for saving nature | 6 |
| 4 | • Character and Competence –Holy books vs Blind faith.<br>• Self-management and Good health.<br>• Science of reincarnation.<br>• Equality, Nonviolence ,Humility, Role of Women.<br>• All religions and same message.<br>• Mind your Mind, Self-control.<br>• Honesty, Studying effectively | 6 |

***Suggested reading***

1 Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

***Course outcomes***

Students will be able to

1.Knowledge of self-development

2.Learn the importance of Human values

3.Developing the overall personality

## AUDIT 1 and 2: CONSTITUTION OF INDIA

| **Course Objectives:** |
|---|
| Students will be able to:<br>1. Understand the premises informing the twin themes of liberty and freedom from a civil rights |

perspective.

2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| **1** | • **History of Making of the Indian Constitution:**<br>History<br>Drafting Committee, ( Composition & Working) | 4 |
| **2** | • **Philosophy of the Indian Constitution:**<br>Preamble<br>Salient Features | 4 |
| **3** | • **Contours of Constitutional Rights & Duties:**<br>• Fundamental Rights<br>• Right to Equality<br>• Right to Freedom<br>• Right against Exploitation<br>• Right to Freedom of Religion<br>• Cultural and Educational Rights<br>• Right to Constitutional Remedies<br>• Directive Principles of State Policy<br>• Fundamental Duties. | 4 |
| **4** | • **Organs of Governance:**<br>• Parliament<br>• Composition<br>• Qualifications and Disqualifications<br>• Powers and Functions<br>• Executive<br>• President<br>• Governor<br>• Council of Ministers<br>• Judiciary, Appointment and Transfer of Judges, Qualifications<br>• Powers and Functions | 4 |
| **5** | • **Local Administration:**<br>• District's Administration head: Role and Importance,<br>• Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.<br>• Pachayati raj: Introduction, PRI: ZilaPachayat.<br>• Elected officials and their roles, CEO ZilaPachayat: Position and role.<br>• Block level: Organizational Hierarchy (Different departments),<br>• Village level: Role of Elected and Appointed officials,<br>• Importance of grass root democracy | 4 |

| | | |
|---|---|---|
| **6** | • **Election Commission:**<br>• Election Commission: Role and Functioning.<br>• Chief Election Commissioner and Election Commissioners.<br>• State Election Commission: Role and Functioning.<br>• Institute and Bodies for the welfare of SC/ST/OBC and women. | 4 |

**Suggested reading**

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

**Course Outcomes:**

Students will be able to:
1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

## AUDIT 1 and 2: PEDAGOGY STUDIES

**Course Objectives:**

Students will be able to:

4. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
5. Identify critical evidence gaps to guide the development.

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| **1** | • **Introduction and Methodology:**<br>• Aims and rationale, Policy background, Conceptual framework and terminology<br>• Theories of learning, Curriculum, Teacher education.<br>• Conceptual framework, Research questions.<br>• Overview of methodology and Searching. | 4 |
| **2** | • Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.<br>• Curriculum, Teacher education. | 2 |
| **3** | • Evidence on the effectiveness of pedagogical practices<br>• Methodology for the in depth stage: quality assessment of included studies.<br>• How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? | 4 |

| | | |
|---|---|---|
| | • Theory of change.<br>• Strength and nature of the body of evidence for effective pedagogical practices.<br>• Pedagogic theory and pedagogical approaches.<br>• Teachers' attitudes and beliefs and Pedagogic strategies. | |
| **4** | • Professional development: alignment with classroom practices and follow-up support<br>• Peer support<br>• Support from the head teacher and the community.<br>• Curriculum and assessment<br>• Barriers to learning: limited resources and large class sizes | 4 |
| **5** | • **Research gaps and future directions**<br>• Research design<br>• Contexts<br>• Pedagogy<br>• Teacher education<br>• Curriculum and assessment<br>• Dissemination and research impact. | 2 |

**Suggested reading**


1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.


**Course Outcomes:**

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

## AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

***Course Objectives***

1. To achieve overall health of body and mind
2. To overcome stress

***Syllabus***

| Unit | *Content* | *Hours* |
|---|---|---|
| 1 | • Definitions of Eight parts of yog. ( Ashtanga ) | 8 |
| 2 | • Yam and Niyam.<br>Do`s and Don't's in life.<br>i) Ahinsa, satya, astheya, bramhacharya and aparigraha<br>ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan | 8 |
| 3 | • Asan and Pranayam<br>i) Various yog poses and their benefits for mind & body<br>ii)Regularization of breathing techniques and its effects-Types of pranayam | 8 |

***Suggested reading***

1. 'Yogic Asanas for Group Tarining-Part-I" :Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, AdvaitaAshrama (Publication Department), Kolkata

**Course Outcomes:**

Students will be able to:
1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

## AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS

***Course Objectives***

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

***Syllabus***

| Unit | Content | Hours |
|---|---|---|
| 1 | Neetisatakam-Holistic development of personality<br>• Verses- 19,20,21,22 (wisdom)<br>• Verses- 29,31,32 (pride & heroism)<br>• Verses- 26,28,63,65 (virtue)<br>• Verses- 52,53,59 (dont's)<br>• Verses- 71,73,75,78 (do's) | 8 |
| 2 | • Approach to day to day work and duties.<br>• Shrimad BhagwadGeeta : Chapter 2-Verses 41, 47,48,<br>• Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,<br>• Chapter 18-Verses 45, 46, 48. | 8 |

| | | |
|---|---|---|
| 3 | • Statements of basic knowledge.<br>• Shrimad BhagwadGeeta: Chapter2-Verses 56, 62, 68<br>• Chapter 12 -Verses 13, 14, 15, 16,17, 18<br>• Personality of Role model. Shrimad BhagwadGeeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42,<br>• Chapter 4-Verses 18, 38,39<br>• Chapter18 – Verses 37,38,63 | 8 |

***Suggested reading***

1. “Srimad Bhagavad Gita” by Swami SwarupanandaAdvaita Ashram (Publication Department), Kolkata
2. Bhartrihari’s Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

***Course Outcomes***

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

# MODEL CURRICULUM

of

Engineering & Technology PG Courses

# Electrical Engineering

**ALL INDIA COUNCIL FOR TECHNICAL EDUCATION**
Nelson Mandela Marg, Vasant Kunj, New Delhi 110 070
www.aicte-india.org

M. Tech. (Electrical Engineering) Specialization: Power Electronics & Drives

| Sr. No. | Core/Elective | Course Name |
|---|---|---|
| | | |
| 1 | Core1 | Electric Drives System |
| 2 | Core2 | Modeling and Analysis of Electrical Machines |
| 3 | PE1 | Advanced Power Electronic Circuits/Optimal and Adaptive Control/Power Quality/Dynamics of Electrical Machines |
| 4 | PE2 | Static VAR Controllers and Harmonic Filtering/PWM converter and Applications/Power Semiconductor Devices & Modeling |
| | | Research Methodology and IPR |
| 5 | Lab1 | Electrical Drives Laboratory |
| 6 | Lab2 | Electrical Machines Laboratory/Power Quality lab |
| 7 | Audit-I | Audit I |

Semester II

| Sr. No. | Core/Elective | Course Name |
|---|---|---|
| | | |
| 1 | Core3 | Power Electronic Converters |
| 2 | Core4 | Digital Control of Power Electronic and Drive Systems |
| 3 | PE3 | Switched Mode and Resonant Converters/Industrial Load Modeling and Control /Advanced Digital Signal Processing |
| 4 | PE4 | Advanced Microcontroller based Systems/Distributed Generation/Smart Grids |
| | | Mini Project with Seminar |
| 5 | Lab3 | Power Electronics Laboratory |
| 6 | Lab4 | Micro-controller Lab / Digital Signal Processing Lab (based on core 4) |
| 7 | Audit-II | Audit II |

Semester III

| Sr. No. | Core/Elective | Course Name |
|---|---|---|
| | | |
| 1 | PE5 | SCADA Systems and Applications/FACTS and Custom Power Devices/HVDC |
| 2 | OE | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy |
| 3 | Major Project | Phase-I Dissertation |

Semester IV

| Sr. No. | Core/Elective | Course Name |
|---|---|---|
| 1 | Major Project | Phase-II Dissertation |

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

M. Tech. (Electrical Engineering)Specialization: Control Systems

Semester I

| Sr. No. | Core/Elective | Course Name |
|---|---|---|
| 1 | Core1 | Mathematical Methods in Control |
| 2 | Core2 | Non-Linear Systems |
| 3 | PE1 | Robotics and Automation / Digital Control/ Non Linear |

| | | |
|---|---|---|
| | | Control |
| 4 | PE2 | Systems Biology/ SCADA system and Applications / Design Aspects in Control |
| 5 | | Research Methodology and IPR |
| 6 | Lab1 | Control Lab 1 |
| 7 | Lab2 | Control Lab 2 |
| 8 | Audit-I | Audit I |

Semester II

| Sr. No. | Core/Elective | Course Name |
|---|---|---|
| | | |
| 1 | Core3 | Optimal Control Theory |
| 2 | Core4 | Stochastic Filtering and Identification |
| 3 | PE3 | Advance Control System/ Advanced Robotics/ Adaptive Learning and Control |
| 4 | PE4 | Model Reduction in Control/ Robust Control/ Networked and Multi-agent Control Systems/Advanced DSP |
| | | Mini Project with Seminar |
| 5 | Lab3 | Advanced Control Lab 1 |
| 6 | Lab4 | Advanced Control Lab 2 |
| 7 | Audit-II | Audit-II |

Semester III

| Sr. No. | Core/Elective | Course Name |
|---|---|---|
| | | |
| 1 | PE5 | Modeling and Control of Distributed Parameter Systems/ Stochastic Control/Computational Methods |
| 2 | OE | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy |
| 3 | Major Project | Phase – I Dissertation |

Semester IV

| Sr. No. | Core/Elective | Course Name |
|---|---|---|
| | | |
| 1 | Major Project | Phase – II Dissertation |

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education

5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

M. Tech. (Electrical Engineering) Specialization: Power Systems

Semester I

| Sr. No. | Core/Elective | Course Name |
|---|---|---|
| | | |
| 1 | Core1 | Power System Analysis |
| 2 | Core2 | Power System Dynamics-I |
| 3 | PE1 | Renewable Energy System/Smart grids/High Power Converters /Wind and Solar Systems |
| 4 | PE2 | Electrical Power Distribution System /Mathematical Methods for Power Engineering/Pulse Width Modulation for PE Converters/Electric and Hybrid Vehicles |
| 5 | | Research Methodology and IPR |
| 6 | Lab1 | Power System Steady State Analysis Lab |
| 7 | Lab2 | Power System Dynamics Lab/Renewable Energy Lab |
| 8 | Audit-I | Audit I |

Semester II

| Sr. No. | Core/Elective | Course Name |
|---|---|---|
| | | |
| 1 | Core3 | Digital Protection of Power System |
| 2 | Core4 | Power System Dynamics-II |
| 3 | PE3 | Restructured Power Systems/Advanced Digital Signal Processing/Dynamics of Electrical Machines/Power Apparatus Design |
| 4 | PE4 | Advanced Micro-Controller Based<br><br>Systems/SCADA System and Applications/Power Quality/AI Techniques |

| | | |
|---|---|---|
| 5 | | Mini Project |
| 6 | Lab3 | Power System Protection Lab/Power Quality Lab |
| 7 | Lab4 | Artificial Intelligence Lab/Power Electronics Applications to Power Systems Lab/Smart Grids Lab |
| 8 | Audit-II | Audit II |

Semester III

| Sr. No. | Core/Elective | Course Name |
|---|---|---|
| | | |
| 1 | PE5 | Power System Transients/FACTS and Custom Power Devices/Industrial Load Modeling and Control/Dynamics Of Linear Systems |
| 2 | OE | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy |
| 3 | Major Project | Phase – I Dissertation |

Semester IV

| Sr. No. | Core/Elective | Course Name |
|---|---|---|
| | | |
| 1 | Major Project | Phase-II Dissertation |

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies

7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

M. Tech. (Electrical Engineering) Specialization: Power & Energy Systems

Semester I

| Sr. No. | Core/Elective | Course Name |
|---|---|---|
| | | |
| 1 | Core1 | Distributed Generation |
| 2 | Core2 | Renewable Energy Systems |
| 3 | PE1 | Engineering Optimization/ Power System Dynamics/High Voltage Engineering |
| 4 | PE2 | Switched Mode Power Control/ Optimal and Adaptive Control/ FACTS and custom Power Devices |
| 5 | | Research Methodology and IPR |
| 6 | Lab1 | Power Systems Lab/Distributed Generation lab |
| 7 | Lab2 | Renewable Energy lab |
| 8 | Audit-I | Audit-1 |

Semester II

| Sr. No. | Core/Elective | Course Name |
|---|---|---|
| | | |
| 1 | Core3 | Digital Power System Protection |
| 2 | Core4 | Non-Conventional Electrical Energy Systems |
| 3 | PE3 | Artificial intelligence I Techniques /Smart Grids /Energy Conversion Processes |
| 4 | PE4 | Electric and Hybrid Vehicles/Power Quality /Industrial Load Modeling and Control |
| | | Mini Project with Semina |
| 5 | Lab3 | Power System Protection Lab/Power System Analysis lab |
| 6 | Lab4 | Artificial Intelligence lab /Power Quality Lab/Non-Conventional Energy Sources lab |
| 7 | Audit-II | Audit-II |

Semester III

| Sr. No. | Core/Elective | Course Name |
|---|---|---|
| | | |
| 1 | PE5 | Power System Analysis / Power system Transients /Reliability Analysis and Protection |
| 2 | OE | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials |

| | | |
|---|---|---|
| | | 6. Waste to Energy |
| 3 | Major Project | Phase – I Dissertation |

Semester IV

| Sr. No. | Core/Elective | Course Name |
|---|---|---|
| | | |
| 1 | Major Project | Phase-II Dissertation |

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

# Course Scheduling for M.Tech. (Electrical Engineering), Specialization: Power Electronics and Drives

| Semester 1 | | | | | | |
|---|---|---|---|---|---|---|
| Sr. No. | Core/Elective | Course Name | | | | Credits |
| | | | L | T | P | |
| 1 | Core1 | Electric Drives System | 3 | 0 | 0 | 3 |
| 2 | Core2 | Modeling and Analysis of Electrical Machines | 3 | 0 | 0 | 3 |
| 3 | PE1 | Advanced Power Electronic Circuits/Optimal and Adaptive Control/Power Quality/Dynamics of Electrical Machines | 3 | 0 | 0 | 3 |
| 4 | PE2 | Static VAR Controllers and Harmonic Filtering/PWM converter and Applications/Power Semiconductor Devices & Modeling | 3 | 0 | 0 | 3 |
| | | Research Methodology and IPR | 2 | 0 | 0 | 2 |
| 5 | Lab1 | Electrical Drives Laboratory | 0 | 0 | 4 | 2 |
| 6 | Lab2 | Electrical Machines Laboratory/Power Quality lab | 0 | 0 | 4 | 2 |
| 7 | Audit-I | Audit I | 2 | 0 | 0 | 0 |
| 8 | Total Credits | | | 18 | | |
| **Semester 2** | | | | | | |
| Sr. No. | Core/Elective | Course Name | | | | Credits |
| | | | L | T | P | |
| 1 | Core3 | Power Electronic Converters | 3 | 0 | 0 | 3 |
| 2 | Core4 | Digital Control of Power Electronic and Drive Systems | 3 | 0 | 0 | 3 |
| 3 | PE3 | Switched Mode and Resonant Converters/Industrial Load Modeling and Control /Advanced Digital Signal Processing | 3 | 0 | 0 | 3 |
| 4 | PE4 | Advanced Microcontroller based Systems/Distributed Generation/Smart Grids | 3 | 0 | 0 | 3 |
| | | Mini Project with Seminar | 0 | 0 | 4 | 2 |
| 5 | Lab3 | Power Electronics Laboratory | 0 | 0 | 4 | 2 |
| 6 | Lab4 | Micro-controller Lab / Digital Signal Processing Lab (based on core 4) | 0 | 0 | 4 | 2 |
| 7 | Audit-II | Audit II | 2 | 0 | 0 | 0 |
| 8 | Total Credits | | | 18 | | |

| Semester 3 | | | | | | |
|---|---|---|---|---|---|---|
| Sr. No. | Core/Elective | Course Name | | | | Credits |
| | | | L | T | P | |
| 1 | PE5 | SCADA Systems and Applications/FACTS and Custom Power Devices/HVDC | 3 | 0 | 0 | 3 |
| 2 | OE | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy | 3 | 0 | 0 | 3 |
| 3 | Major Project | Phase-I Dissertation | 0 | 0 | 20 | 10 |
| 4 | Total Credits | | | 16 | | |

| Semester 4 | | | | | | |
|---|---|---|---|---|---|---|
| Sr. No. | Core/Elective | Course Name | | | | Credits |
| | | | L | T | P | |
| 1 | Major Project | Phase-II Dissertation | 0 | 0 | 32 | 16 |
| 2 | Total Credits | | | | | 16 |

**GRAND TOTAL CREDITS** **68**

**Programme Outcomes**

**PO1** Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.

**PO2** Design the modern electric machines, drives, power converters, and control circuits for specific application.

**PO3** Use modern tools, professional software platforms, embedded systems for the diversified applications.

**PO4** Explore ideas for inculcating research skills.

**PO5** Solve the problems which need critical and independent thinking to show reflectivelearning.

**PO6** Imagine the larger picture and correlate the domain knowledge with the globalindustrial problems.

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge

4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

**FIRST SEMESTER**

**CORE -1: ELECTRIC DRIVE SYSTEM**

| **Course Objectives:**<br>Students will be able to:<br>1. Understand Basic electrical drives and their analysis.<br>2. Learn Design of controller for drives.<br>3. Understand Scalar control of electrical drives. | |
|---|---|
| **Syllabus** | |
| **Units** | **Content** |
| **1** | • Dynamics of Electric Drives: Fundamentals of torque equation.<br>Speed torque convention and ulti-quadrant operation, components of load torques. |
| **2** | • Classification of load torques steady state stability.<br>• Load equation, Speed control and drive classification.<br>Close loop control of drives. |
| **3** | • DC motor Drives-Modeling of DC machines.<br>• Steady state characteristics with armature and speed control.<br>Phase controlled DC motor drives, chopper controlled DC motor drives. |
| **4** | • Poly-phase induction machines- Dynamic modeling of induction machines.<br>• Small signal equations, control characteristics of induction machines.<br>• Phase-controlled induction machines.Stator voltage control.<br>Slip energy recovery scheme, frequency control and vector control of induction motor drives. |
| **5** | • Traction motor: Starting.Speed-Time characteristics.Braking.<br>Traction motors used in practice. |
| **6** | • Industrial Drives-Digital Control of Electric Drives.<br>Stepper motor.Servo motor and their Applications. |

**Suggested reading**

1. G.K, Dubey, "Power semiconductor controlled Drives", Prentice Hall international, New Jersey, 1989.
2. R.Krishanam, "Electric motor drives modeling, analysis and control", PHI-India-2009.
3. G. K. Dubey,"Fundamentals of electric Drives, Narosa Publishing House", 2nd edition, 2011.
4. W. Leonhard, "Control of Electrical drives", Springer, 3rd edition, 2001.
5. P.C. Krause –, "Analysis of Electric Machine", Wiley-IEEE press 3rdedition.
6. K. Bose,"Modern Power Electronics and AC Drives", Prentice Hall publication, 1st edition, 2001.

**Course Outcomes:**

Students will be able to:
1. Model and simulate electric drive systems
2. Design modulation strategies of power electronics converters, for drives application
3. Design appropriate current/voltage regulators for electric drives

4. Select and implement the drives for Industrial Process
5. Implement various variable speed drives in Electrical Energy Conversion System

## CORE-2: MODELING AND ANALYSIS OF ELECTRICAL MACHINES

**Course Objectives:**

Students will be able to:

1. To understand the operation of an electrical machine mathematically.
2. To understand how a machine can be represented as its mathematical equivalent.
3. To develop mathematical model of AC & DC machines and perform transient analysis on them.

**Syllabus**

| Units | Content |
|---|---|
| **1** | • Principles of Electromagnetic Energy Conversion.<br>• General expression of stored magnetic energy.<br>• Co-energy and force/torque, example using single and doubly excited system. |
| **2** | • Basic Concepts of Rotating Machines-Calculation of air gap mmf and per phase machine inductance using physical machine data; Voltage and torque equation of dc machine. |
| **3** | • Three phase symmetrical induction machine and salient pole synchronous machines in phase variable form<br>• Application of reference frame theory to three phase symmetrical induction and synchronous machines<br>• Dynamic direct and quadrature axis model in arbitrarily rotating reference frames. |
| **4** | • Determination of Synchronous machine dynamic equivalent circuit parameters<br>• Analysis and dynamic modeling of two phase asymmetrical induction machine and single phase induction machine. |
| **5** | • Special Machines - Permanent magnet synchronous machine<br>• Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines<br>• Construction and operating principle<br>• Dynamic modelling and self-controlled operation. |
| **6** | • Analysis of Switch Reluctance Motors.<br>• Brushless D.C. Motor for space Applications<br>• Recent trends. |

**Suggested reading**

1. Charles Kingsle,Jr., A.E. Fitzgerald, Stephen D.Umans, “Electric Machinery”, Tata Mcgraw Hill
2. R. Krishnan, “Electric Motor & Drives: Modeling, Analysis and Control”, Prentice Hall of India
3. Miller, T.J.E., “Brushless Permanent Magnet and Reluctance Motor Drives”, Clarendon Press
4. P.C.Krause “Analysis of Electric Machine” Wiley IEEE Press 3rd Edition

**Course Outcomes:**

Students will be able to:

1. Knowledge about the dynamic behavior rotating machines.
2. Able to understand equivalent circuit of synchronous machines.
3. To understand various practical issues of different machines.

## PE 1: ADVANCED POWER ELECTRONIC CIRCUITS

**Course Objectives:**

Students will be able to:

1. Understand the operation of advanced power electronic circuit topologies.
2. Understand the control strategies involved.
3. Learn few practical circuits, used in practice.

**Syllabus**

| Units | Content |
|---|---|
| **1** | • Boost type APFC and control. |
| **2** | • Three phase utility interphases and control-Buck, Boost, Buck-Boost SMPS Topologies. |
| **3** | • Modes of operation –Push-Pull and Forward Converter Topologies - Voltage Mode Control.<br>• Half and Full Bridge Converters. |
| **4** | • Flyback Converter.<br>• Introduction to Resonant Converters.<br>• Load Resonant Converter. Zero Voltage Switching Clamped Voltage Topologies. |
| **5** | • Resonant DC Link Inverters with Zero Voltage Switching.<br>• High Frequency Link Integral Half Cycle Converter. |
| **6** | • Modelling and design of DC-DC Converters for various renewable energy conversion.<br>• Few power electronic circuits used in practice for controlling electric drives. |

**Suggested reading**


1. Rashid "Power Electronics" Prentice Hall India 2007.
2. G.K.Dubey et.al "Thyristorised Power Controllers" Wiley Eastern Ltd., 2005, 06.
3. Dewan&Straughen "Power Semiconductor Circuits" John Wiley &Sons., 1975.
4. G.K. Dubey& C.R. Kasaravada "Power Electronics & Drives" Tata McGraw Hill., 1993
5. Cyril W Lander "Power Electronics" McGraw Hill., 2005.
6. B. K Bose "Modern Power Electronics and AC Drives" Pearson Education (Asia)., 2007
7. Abraham I Pressman "Switching Power Supply Design" McGraw Hill Publishing Company., 2001.


**Course Outcomes:**

Students will be able to:

1: Knowledge about analysis and design of Load Commutated CSI and PWM CSI

2: Learn analysis and design of series Inverters.

3: Acquire knowledge about analysis and design of Switched Mode Rectifiers,APFC, DC-DC converters &Resonant converters

## PE 1: OPTIMAL AND ADAPTIVE CONTROL

| **Course Objectives:**<br>Students will be able to:<br>1. To know the operation of closed and open loop optimal control.<br>2. Understand the adaptive control strategies.<br>3. Learn dynamic programming method. | | |
|---|---|---|
| | **Syllabus** | |
| **Units** | **Content** | **Hours** |
| **1** | • Optimal control problem – fundamental concepts and theorems of calculus of variations–Euler - Language equation and extremal of functional. | 5 |
| **2** | • Variational approach to solving optimal control problems.<br>• Hamiltonian and different boundary conditions for optimal control problem. | 8 |
| **3** | • Linear regulator problem - Pontryagin's minimum principle. | 6 |
| **4** | • Dynamic programming - Principle of optimality and its application to optimal control problem. | 6 |
| **5** | • Hamilton-Jacobi-Bellman equation - model reference adaptive systems (MRAS) - Design hypothesis. | 8 |
| **6** | • Introduction to design method based on the use of Liapunov function.<br>• Design and simulation of variable structure adaptive model following control. | 8 |

**Suggested reading**


1. Donald E. Kirk, "Optimal Control Theory, An introduction", Prentice Hall Inc., 2004
2. A.P. Sage, "Optimum Systems Control", Prentice Hall, 1977
3. HSU and Meyer , "Modern Control, Principles and Applications", McGraw Hill, 1968
4. Yoan D. Landu, "Adaptive Control (Model Reference Approach)", Marcel Dekker. 1981
5. K.K.D.Young, "Design of Variable Structure Model Following Control Systems", IEEE Transactions on Automatic Control, Vol. 23, pp 1079-1085, 1978.


**Course Outcomes:**

Students will be able to:
1. Knowledge in the mathematical area of calculus of variation so as to apply the same for solving optimal control problems.
2. Problem formulation, performance measure and mathematical treatment of optimal control problems.
3. Acquire knowledge on solving optimal control design problems by taking into consideration the physical constraints on practical control systems.
4. To obtain optimal solutions to controller design problems taking into consideration the limitation on control energy in the real practical world.

**PE 1: POWER QUALITY**

| **Course Objectives:**<br>Students will be able to:<br>1. Understand the different power quality issues to be addressed<br>2. Understand the recommended practices by various standard bodies like IEEE, IEC, etc. on voltage & frequency, harmonics<br>3. Understanding STATIC VAR Compensators | | |
|---|---|---|
| | **Syllabus** | |
| **Units** | **Content** | **Hours** |

| | | |
|---|---|---|
| **1** | • Introduction-power quality-voltage quality-overview of power<br>• Quality phenomena classification of power quality issues.<br>• Power quality measures and standards-THD-TIF-DIN-C-message weights.<br>• Flicker factor transient phenomena-occurrence of power quality problems<br>• Power acceptability curves-IEEE guides<br>• Standards and recommended practices. | 5 |
| **2** | • Harmonics-individual and total harmonic distortion<br>• RMS value of a harmonic waveform<br>• Triplex harmonics. Important harmonic introducing devices.SMPS<br>• Three phase power converters-arcing devices saturable devices<br>• Harmonic distortion of fluorescent lamps-effect of power system harmonics on power system equipment and loads. | 8 |
| **3** | • Modeling of networks and components under non-sinusoidal conditions<br>• Transmission and distribution systems<br>• Shunt capacitors-transformers.Electric machines.<br>• Ground systems loads that cause power quality problems.<br>• Power quality problems created by drives and its impact on drive. | 6 |
| **4** | • Power factor improvement- Passive Compensation.<br>• Passive Filtering.Harmonic Resonance.Impedance Scan Analysis<br>• Active Power Factor Corrected Single Phase Front End<br>• Control Methods for Single Phase APFC.<br>• Three Phase APFC and Control Techniques<br>• PFC based on Bilateral Single Phase and Three Phase Converter. | 6 |
| **5** | • Hamilton-Jacobi-Bellman equation - model reference adaptive systems (MRAS) - Design hypothesis**.** | 8 |
| **6** | • Introduction to design method based on the use of Liapunov function.<br>• Design and simulation of variable structure adaptive model following control. | 8 |

**Suggested reading**


1. G.T. Heydt, “Electric power quality”, McGraw-Hill Professional, 2007
2. Math H. Bollen, “Understanding Power Quality Problems”, IEEE Press, 2000
3. J. Arrillaga, “Power System Quality Assessment”, John wiley, 2000
4. J. Arrillaga, B.C. Smith, N.R. Watson & A. R.Wood ,”Power system Harmonic Analysis”, Wiley, 1997


**Course Outcomes:**

Students will be able to:

1. Acquire knowledge about the harmonics, harmonic introducing devices and effect of harmonicson system equipment and loads
2. develop analytical modeling skills needed for modeling and analysis of harmonics innetworks and components
3. To introduce the student to active power factor correction based on static VAR compensators andits control techniques
4. To introduce the student to series and shunt active power filtering techniques for harmonics.

**PE 1: DYNAMICS OF ELECTRICAL MACHINES**

**Course Objectives:**

Students will be able to:

1. Learn Performance characteristics of machine.
2. To understand the dynamics of the machine.
3. To understand how to determine stability of machine.
4. Learn the synchronous machine analysis.

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| **1** | • Stability.<br>• Primitive 4 Winding Commutator Machine. Commutator Primitive Machine.<br>• Complete Voltage Equation of Primitive 4 Winding Commutator Machine. | 6 |
| **2** | • Torque Equation. Analysis of Simple DC Machines using the Primitive Machine Equations.<br>• The Three Phase Induction Motor.Transformed Equations.<br>• Different Reference Frames for Induction Motor Analysis Transfer Function Formulation. | 10 |
| **3** | • Three Phase Salient Pole Synchronous Machine.<br>• Parks Transformation- Steady State Analysis. | 6 |
| **4** | • Large Signal Transient. Small Oscillation Equations in State Variable form<br>• Dynamical Analysis of Interconnected Machines. | 6 |
| **5** | • Large Signal Transient Analysis using Transformed Equations.<br>• DC Generator /DC Motor System. | 8 |
| **6** | • Alternator /Synchronous Motor System. | 4 |

**Suggested reading**

1. D.P. Sengupta & J.B. Lynn," Electrical Machine Dynamics", The Macmillan Press Ltd. 1980
2. R Krishnan "Electric Motor Drives, Modeling, Analysis, and Control", Pearson Education., 2001
3. P.C. Kraus, "Analysis of Electrical Machines", McGraw Hill Book Company, 1987
4. I. Boldia & S.A. Nasar,,"Electrical Machine Dynamics", The Macmillan Press Ltd. 1992
5. C.V. Jones, "The Unified Theory of Electrical Machines", Butterworth, London. 1967

**Course Outcomes**

Students will be able to:

1. Formulation of electrodynamic equations of all electric machines and analyze the performance characteristics
2. Knowledge of transformations for the dynamic analysis of machines
3. Knowledge of determination of stability of the machines under small signal and transient conditions
4. Study about synchronous machine

**PE 2 STATIC VAR CONTROLLER AND HARMONIC FILTERING**

**Course Objectives:**
Students will be able to:
1. Understand the various static converters
2. Understand the static converter control strategies
3. Understand the active and reactive power compensation and their control
4. Understand harmonic filtering and its control design.

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| **1** | • Fundamentals of Load Compensation.<br>• Steady-State Reactive Power Control in Electric Transmission Systems.<br>• Reactive Power Compensation and<br>• Dynamic Performance of Transmission Systems. | 6 |
| **2** | • Power Quality Issues: Sags, Swells, Unbalance, Flicker, Distortion.<br>• Current Harmonics.Sources of Harmonics in Distribution Systems and Ill Effects . | 6 |
| **3** | • Static Reactive Power Compensators and their control.Shunt Compensators.<br>• SVCs of Thyristor Switched and Thyristor Controlled types and their control,<br>• STATCOMs and their control.<br>• Series Compensators of thyristor Switched and Controlled Type and their Control.<br>• SSSC and its Control, Sub-Synchronous Resonance and damping.<br>• Use of STATCOMs and SSSCs for Transient and Dynamic Stability Improvement in Power System. | 10 |
| **4** | • Converters for Static Compensation.<br>• Single Phase and Three Phase Converters and Standard Modulation Strategies (Programmed Harmonic Elimination and SPWM).<br>• GTO Inverters. Multi-Pulse Converters and Interface Magnetics.<br>• Multi-Level Inverters of Diode Clamped Type and Flying Capacitor Type and suitable modulation strategies (includes SVM).<br>• Multi-level inverters of Cascade Type and their modulation. Current Control of Inverters. | 8 |
| **5** | • Passive Harmonic Filtering.<br>• Single Phase Shunt Current Injection Type Filter and its Control.<br>• Three Phase Three-wire Shunt Active Filtering and their control using p-q theory and d-q modeling.<br>• Three phase four wire shunt active filters.<br>• Hybrid Filtering using Shunt Active Filters.<br>• Dynamic Voltage Restorer and its control.<br>• Power Quality Conditioner | 8 |
| **6** | • Series Active Filtering in Harmonic Cancellation Mode.<br>• Series Active Filtering in Harmonic Isolation Mode. | 4 |

**Suggested reading**

1. Ned Mohan et.al, "Power Electronics",John Wiley and Sons,2006.
2. G. Massobrio, P. Antognet," Semiconductor Device Modeling with Spice", McGraw-Hill, Inc.,1988.
3. B. J. Baliga," Power Semiconductor Devices",Thomson, 2004
4. V. Benda, J. Gowar, D. A. Grant," Power Semiconductor Devices. Theory and Applications",JohnWiley& Sons1994.

**Course Outcomes**

Students will be able to:
1. Acquire knowledge about the fundamental principles of Passive and Active Reactive PowerCompensation Schemes at Transmission and Distribution level in Power Systems.
2. To introduce the student to various single phase and three-phase Static VAR Compensationschemes and their controls
3. To develop analytical modeling skills needed for modeling and analysis of such Static VAR

**PE 2: PWM CONVERTERS AND APPLICATION**

| Course Objectives: | | |
|---|---|---|
| Students will be able to:<br>1. Understand the concepts and basic operation of PWM converters, including basic circuit operation and design.<br>2. Understand the steady-state and dynamic analysis of PWM converters along with the applications like solid state drives and power quality. | | |
| **Syllabus** | | |
| **Units** | **Content** | **Hours** |
| **1** | • AC/DC and DC/AC power conversion<br>• Overview of applications of voltage source converters and current source converters. | 6 |
| **2** | • Pulse width modulation techniques for bridge converters<br>• Bus clamping PWM.Space vector based PWM.<br>• Advanced PWM techniques. | 6 |
| **3** | • Practical devices in converter.<br>• Calculation of switching and conduction power losses. | 4 |
| **4** | • Compensation for dead time and DC voltage regulation.<br>• Dynamic model of PWM converter.Multilevel converters.<br>• Constant V/F induction motor drives. | 8 |
| **5** | • Estimation of current ripple and torque ripple in inverter fed drives.<br>• Line-side converters with power factor compensation. | 8 |
| **6** | • Active power filtering.Reactive power compensation.<br>• Harmonic current compensation.<br>• Selective harmonic elimination PWM technique for high power electric drives. | 8 |

**Suggested reading**

1. Mohan, Undeland and Robbins, "Power Electronics: Converters, Applications and Design", John's Wiley and Sons.
2. Erickson RW, "Fundamentals of Power Electronics", Chapman and Hall.
3. Vithyathil. J, "Power Electronics: Principles and Applications", McGraw Hill.

**Course Outcomes:**

Students will be able to:
1. Knowledge concepts and basic operation of PWM converters, including basic circuit operation and design
2. Learn the steady-state and dynamic analysis of PWM converters along with the applications like solid state drives and power quality
3. Able to recognize and use the following concepts and ideas:Steady-State and transient modelling and analysis of power converters with various PWM techniques.

## PE 2:POWER SEMICONDUCTOR DEVICES AND MODELING

**Course Objectives:**

Students will be able to:
1. Understand the concepts and basic operation of PWM converters, including basic circuit operation and design
2. Understand the steady-state and dynamic analysis of PWM converters along with the applications like solid state drives and power quality

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| **1** | • Energy auditing: Types and objectives.<br>• Audit instruments- ECO assessment and Economic methods specific energy analysis.<br>• Minimum energy paths-consumption models-Case study. | 6 |
| **2** | • Electric Motors-Energy efficient controls and starting Efficiency.<br>• Motor Efficiency and Load Analysis.<br>• Energy efficient /high efficient Motors-Case study.<br>• Load Matching and selection of motors. Variable speed drives.<br>• Pumps and Fans-Efficient Control strategies.<br>• Optimal selection and sizing.Optimal operation and Storage: Case study. | 8 |
| **3** | • Transformer Loading/Efficiency analysis.<br>• Feeder/cable loss evaluation: Case study.Reactive Power Management.<br>• Capacitor Sizing-Degree of compensation.<br>• Capacitor losses-Location-Placement Maintenance, Case study. | 6 |
| **4** | • Peak Demand controls- Methodologies.<br>• Types of Industrial loads-Optimal Load<br>• Scheduling-case study. Lighting- Energy efficient light sources.<br>• Energy conservation in Lighting Schemes.<br>• Electronic ballast-Power quality issues.<br>• Uminaries: case study | 8 |
| **5** | • Cogeneration-types and Schemes.<br>• Optimal operation of cogeneration plants-case study.<br>• Electric loads of Air conditioning & Refrigeration.<br>• Energy conservation measures.<br>• Cool storage. Types-optimal operation case study. | 8 |
| **6** | • Electric water heating, Gysers, Solar Water Heaters<br>• Power Consumption in Compressors.<br>• Energy conservation measures. | 8 |

| | | |
|---|---|---|
| | • Electrolytic Process. Computer Controls. Software-EMS. | |

**Suggested reading**


1. Giovanni Petrecca,. "Industrial Energy Management: Principles and Applications", TheKluwer international series -207,1999
2. Anthony J. Pansini, Kenneth D. Smalling,. "Guide to Electric Load Management", Pennwell Pub;(1998)
3. Handbook on Energy Audit and Environment Management , Y P Abbi and Shashank Jain, TERI, 2006
4. Handbook of Energy Audits Albert Thumann, William J. Younger, Terry Niehus, 2009.


**Course Outcomes:**

Students will be able to:

1. Acquire the background required for engineers to meet the role of energy managers and toacquire the skills and techniques required to implement energy management.
2. Identify and quantify the energy intensive business activities in an organization.
3. Knowledge about standard methodologies for measuring energy in the workplace and energy audit instruments.
4. Knowledge about energy efficient motors, load matching and selection of motors.
5. Acquire knowledge about reactive power management, capacitor sizing and degree of compensation.

**LAB 1- ELECTRICAL DRIVES LABORATORY**

**List of experiments:**

1. Study of Thyristor controlled D.C Drive.
2. Study of Chopper Fed DC Motor.
3. Study of A.C single phase motor speed control using TRIAC.
4. PWM inverter fed three phase induction motor control using PSPICE/MATLAB/PSIM software.
5. VSI/CSI fed induction motor drive analysis using MATLAB/PSPICE/PSIM software.
6. Study of V/f control operation of three phase induction motor.
7. Study of permanent magnet synchronous motor drive fed by PWM inverter using software.
8. Regenerative/ Dynamic breaking operatation for DC motor study using software.
9. Regenerative/ Dynamic breaking operatation for AC motor study using software.
10. PC/PLC based AC/DC motor control operation.

**LAB 2- ELECTRICAL MACHINES LABORATORY/POWER QUALITY LABORATORY**

**Electrical machines lab**

**List of experiments:**

1. Load test on dc shunt motor to draw speed – torque and horse power – efficiency characteristics.
2. Field Test on dc series machines.
3. Speed control of dc shunt motor by armature and field control.
4. Swinburne's Test on dc motor.
5. Retardation test on dc shunt motor.
6. Regenerative test on dc shunt machines.
7. Load test on three phase induction motor.

8. No load and Blocked rotor test on three phase induction motor to draw (i) equivalent circuit and (ii) circle diagram. Determination of performance parameters at different load conditions from (i) and (ii).
9. Load test on induction generator.
10. Load test on single phase induction motor to draw output versus torque, current, power and efficiency characteristics.
11. Conduct suitable tests to draw the equivalent circuit of single phase induction motor and determine performance parameters.
12. Conduct an experiment to draw V and □ curves of synchronous motor at no load and load conditions.

**Power Quality Lab**

1. To study the effect of non linear loads on power quality.
2. To demonstrate the voltage and current distortions experimentally.
3. To reduce the current harmonics with filters.
4. To study the voltage sag due to starting of large induction motor.
5. To study the capacitor switching transients.
6. To study the effect of balanced non linear load on neutral current , in a three phase circuit
7. To study the effect of ground loop.
8. To study the effect of voltage flicker .
9. To calculate the distortion power factor.
10. Study the effect of harmonics on energy meter reading.
11. To study effect of voltage sag on electrical equipments.
12. To obtain the current harmonics drawn by power electronics interface using PSCAD software

## Research Methodology and IPR

**Teaching Scheme**

Lectures: 1hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

**Syllabus Contents:**

**Unit 1:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Unit 2:** Effective literature studies approaches, analysis

Plagiarism, Research ethics,

**Unit 3:** Effective technical writing, how to write report, Paper

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**Unit 4:** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Unit 5:** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Unit 6:** New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

**References:**


- Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
- Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
- Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
- Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
- Mayall , "Industrial Design", McGraw Hill, 1992.
- Niebel , "Product Design", McGraw Hill, 1974.
- Asimov , "Introduction to Design", Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
- T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008


**SEMESTER 2**

**CORE 3:POWER ELECTRONIC CONVERTERS**

**Course Objectives:** Students will be able to:

1. Understand the concepts and basic operation of PWM converters, including basic circuit operation and design.
2. Understand the steady-state and dynamic analysis of PWM converters along with the applications like solid state drives and power quality.

**Syllabus**

| Units | Content | Hours |
|---|---|---|

| | | |
|---|---|---|
| **1** | • Analysis of power semiconductor switched circuits with R, L, RL, RC loads<br>• D.C. motor load. Battery charging circuit. | 6 |
| **2** | • Single-Phase and Three-Phase AC to DC converters.<br>• Half controlled configurations-operating domains of three phase full converters and semi-converters. Reactive power considerations. | 8 |
| **3** | • Analysis and design of DC to DC converters.<br>• Control of DC-DC converters: Buck converters, Boost converters, Buck-Boost converters, Cuk converters. | 6 |
| **4** | • Single phase and three phase inverters.<br>• Voltage source and Current source inverters.<br>• Voltage control and harmonic minimization in inverters. | 8 |
| **5** | • AC to AC power conversion using voltage regulators.<br>• Choppers and cyclo-converters.<br>• Consideration of harmonics, introduction to Matrix converters. | 8 |
| **6** | • Design aspects of converters, Few practical applications. | 8 |

**Suggested reading**

1. Ned Mohan, Undeland and Robbin, "Power Electronics: converters, Application and design", John's Wiley and sons. Inc, Newyork.
2. M.H.Rashid, "Power Electronics", Prentice Hall of India 1994.

**Course Outcomes:**

Students will be able to:
1. To give a systematic approach for transient and steady state analysis of all power electronic converters with passive and active loads.
2. To know and carry out transient and steady state analysis of different power converters of different types of loads and switching sequences.

**CORE 4:DIGITAL CONTROL OF POWER ELECTRONICS AND DRIVESYSTEMS**

**Course Objectives:**
Students will be able to:
1. To understand different control strategies
2. To understand state space modeling of different converters
3. To perform simulation of different power converters

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| **1** | • Review of numerical methods.<br>• Application of numerical methods to solve transients in D.C.<br>• Switched R, L, R-L, R-C and R-L-C circuits. Extension to AC circuits. | 6 |
| **2** | • Modelling of diode in simulation.<br>• Diode with R, R-L, R-C and R-L-C load with AC supply.<br>• Modelling of SCR, TRIAC, IGBT and Power Transistors in simulation.<br>• Application of numerical methods to R, L, C circuits with power electronic switches.<br>• Simulation of gate/base drive circuits, simulation of snubber circuits. | 8 |
| **3** | • State space modelling and simulation of linear systems. | 6 |

| | | |
|---|---|---|
| | • Introduction to electrical machine modelling: induction, DC, and synchronous machines, simulation of basic electric drives, stability aspects. | |
| **4** | • Simulation of single phase and three phase uncontrolled and controlled (SCR) rectifiers.<br>• Converters with self-commutated devices- simulation of power factor correction schemes. | 8 |
| **5** | • Simulation of converter fed DC motor drives.<br>• Simulation of thyristor choppers with voltage.<br>• Current and load commutation schemes.<br>• Simulation of chopper fed DC motor. | 8 |
| **6** | • Simulation of single and three phase inverters with thyristors and self-commutated devices.<br>• Space vector representation.<br>• Pulse-width modulation methods for voltage control.<br>• Waveform control. Simulation of inverter fed induction motor drives. | 8 |

**Suggested reading**

1. Simulink Reference Manual, Math works, USA

**Course Outcomes**

Students will be able to:
1. To provide knowledge on modelling and simulation of power simulation circuits and systems.
2. The candidate will be able to simulate power electronic systems and analyse the system response.

**PE3:SWITCHED MODE AND RESONANT CONVERTERS**

**Course Objectives:**
Students will be able to:
1. To understand different types of converters
2. To understand different switch mode topologies & control methods
3. To understand different resonant converter topologies.

| Syllabus | | |
|---|---|---|
| **Units** | **Content** | **Hours** |
| **1** | • Buck, Boost, Buck-Boost SMPS Topologies.<br>• Basic Operation-Waveforms - modes of operation -switching stresses.<br>• Switching and conduction losses. Optimum switching frequency.<br>• Practical voltage, current and power limits - design relations.<br>• Voltage mode control principles.<br>• Push-Pull and Forward Converter Topologies - Basic Operation, Waveforms.<br>• Flux Imbalance Problem and Solutions | 6 |
| **2** | • Transformer Design. Output Filter Design. Switching Stresses and Losses.<br>• Forward Converter Magnetics. Voltage Mode Control.<br>• Half and Full Bridge Converters. Basic Operation and Waveforms.<br>• Magnetics, Output Filter, Flux Imbalance, Switching Stresses and Losses, Power Limits, Voltage Mode Control. | 8 |
| **3** | • Classification of Resonant Converters. Basic Resonant Circuit Concepts.<br>• Load Resonant Converter, Resonant Switch Converter, Zero. | 6 |

| | | |
|---|---|---|
| | • Voltage Switching Clamped Voltage Topologies.<br>• Resonant DC Link Inverters with Zero Voltage Switching.<br>• High Frequency Link Integral Half Cycle Converter.<br>• Fly back Converter- discontinuous mode operation, waveforms, control.<br>• Magnetics- Switching Stresses and Losses, Disadvantages - Continuous Mode Operation, waveforms, control, design relations. | |
| **4** | • Voltage Mode Control of SMPS- Loop Gain and Stability Considerations.<br>• Error Amp– frequency Response and Transfer Function.<br>• Trans-conductance Current Mode Control of SMPS.<br>• Current Mode Control Advantages, Current Mode Vs Voltage Mode. | 8 |
| **5** | • Current Mode Deficiencies.<br>• Slope Compensation.<br>• Study of a typical Current Mode PWM Control IC UC3842. Modeling of SMPS.<br>• Small Signal Approximation- General Second Order Linear Equivalent Circuits.<br>• Study of popular PWM Control ICs (SG 3525,TL 494,MC34060 etc.) | 8 |
| **6** | • DC Transformer, Voltage Mode SMPS Transfer Function.<br>• General Control Law Consideration.<br>• EMI Generation and Filtering in SMPS - Conducted and Radiated Emission Mechanisms in SMPS.<br>• Techniques to reduce Emissions, Control of Switching Loci.<br>• Shielding and Grounding, Power Circuit Layout for minimum EMI.<br>• EMI Filtering at Input and Output, Effect of EMI Filter on SMPS Control Dynamics. Introduction to Resonant Converters. | 8 |

**Suggested reading**

1. Abraham I Pressman, “Switching Power Supply Design,”. McGraw Hill Publishing Company,2001.
2. Daniel M Mitchell,“DC-DC Switching Regulator Analysis,” McGraw Hill Publishing Company-1988.
3. Ned Mohan et.al, “Power Electronics,” John Wiley and Sons 2006.

**Course Outcomes**

1. Acquire knowledge about the principles of operation of non-isolated and isolatedhard-switched DC-DC converters.
2. Acquire knowledge on various loss components in a switched mode converter andchoice of switching frequency with a view towards design of such converters.

**PE 3: INDUSTRIAL LOAD MODELING AND CONTROL**

| |
|---|
| **Course Objectives:**<br>Students will be able to:<br>1. To understand the energy demand scenario<br>2. To understand the modeling of load and its ease to study load demand industrially<br>3. To know Electricity pricing models<br>4. Study Reactive power management in Industries |
| **Syllabus** |

| Units | Content | Hours |
|---|---|---|
| **1** | • Electric Energy Scenario-Demand Side Management-Industrial Load Management.<br>• Load Curves-Load Shaping Objectives-Methodologies.<br>• Barriers; Classification of Industrial Loads- Continuous and Batch processes -Load Modeling. | 6 |
| **2** | • Electricity pricing – Dynamic and spot pricing –Models.<br>• Direct load control- Interruptible load control.<br>• Bottom up approach- scheduling- Formulation of loadmodels- Optimization and control algorithms - Case studies. | 8 |
| **3** | • Reactive power management in industries-controls-power quality impacts-application of filters Energy saving in industries. | 6 |
| **4** | • Cooling and heating loads- load profiling- Modeling.<br>• Cool storage-Types- Control strategies.<br>• Optimal operation-Problem formulation- Case studies. | 8 |
| **5** | • Captive power units- Operating and control strategies- Power Pooling-Operation models.<br>• Energy banking-Industrial Cogeneration | 8 |
| **6** | • Selection of Schemes Optimal Operating Strategies.<br>• Peak load saving-Constraints-Problem formulation- Case study.<br>• Integrated Load management for Industries | 8 |

**Suggested reading**


1. C.O. Bjork “Industrial Load Management - Theory, Practice and Simulations", Elsevier, the Netherlands,1989.
2. C.W. Gellings and S.N. Talukdar, “Load management concepts,” IEEE Press, New York, 1986, pp. 3-28.
3. Y. Manichaikul and F.C. Schweppe ," Physically based Industrial load", IEEE Trans. on PAS, April 1981.
4. H. G. Stoll, "Least cost Electricity Utility Planning”, Wiley Interscience Publication, USA, 1989.
5. I.J.Nagarath and D.P.Kothari, .Modern Power System Engineering., Tata McGraw Hill publishers, New Delhi, 1995.
6. IEEE Bronze Book- “Recommended Practice for Energy Conservation and cost effective planningin Industrial facilities”, IEEE Inc, USA.


**Course Outcomes:**

Students will be able to:

1. Knowledge about load control techniques in industries and its application.
2. Different types of industrial processes and optimize the process using tools like LINDO and LINGO.
3. Apply load management to reduce demand of electricity during peak time.
4. Apply different energy saving opportunities in industries.

**PE 3: ADVANCED DIGITAL SIGNAL PROCESSING**

| |
|---|
| **Course Objectives:-**Students will be able to: |
| 1. To understand the difference between discrete-time and continuous-time signals |

| 2. To understand and apply Discrete Fourier Transforms (DFT) | | |
|---|---|---|
| **Syllabus** | | |
| **Units** | **Content** | **Hours** |
| 1 | • Discrete time signals<br>• Linear shift invariant systems-<br>• Stability and causality<br>• Sampling of continuous time signals-<br>• Discrete time Fourier transform- Discrete Fourier series- Discrete Fourier transform<br>• Z transform-Properties of different transforms | 8 |
| 2 | • Linear convolution using DFT<br>• Computation of DFT Design of IIR digital filters from analog filters<br>• Impulse invariance method<br>• Bilinear transformation method | 8 |
| 3 | • FIR filter design using window functions<br>• Comparison of IIR and FIR digital filters<br>• Basic IIR and FIR filter realization structures<br>• Signal flow graph representations Quantization process and errors<br>• Coefficient quantisation effects in IIR and FIR filters | 8 |
| 4 | • A/D conversion noise- Arithmetic round-off errors<br>• Dynamic range scaling<br>• Overflow oscillations and zeroInput limit cycles in IIR filters<br>• Linear Signal Models | 8 |
| 5 | • All pole, All zero and Pole-zero models<br>• Power spectrum estimation- Spectral analysis of deterministic signals.<br>• Estimation of power spectrum of stationary random signals | 6 |
| 6 | • Optimum linear filters<br>• Optimum signal estimation<br>• Mean square error estimation<br>• Optimum FIR and IIR Filters | 6 |

**Suggested reading**

1. Sanjit K Mitra, "Digital Signal Processing: A computer-based approach ",TataMc Grow-Hill Edition 1998
2. Dimitris G .Manolakis, Vinay K. Ingle and Stephen M. Kogon, "Statistical and Adaptive Signal Processing", Mc Grow Hill international editions .-2000

**Course Outcomes :**

Students will be able to:

1. Knowledge about the time domain and frequency domain representations as well analysis of discrete time

signals and systems

2. Study the design techniques for IIR and FIR filters and their realization structures.

3. Acquire knowledge about the finite word length effects in implementation of digital filters.

4. Knowledge about the various linear signal models and estimation of power spectrum of stationary random

signals
5. Design of optimum FIR and IIR filters

### PE 4 : ADVANCED MICRO-CONTROLLER BASED SYSTEMS

**Course Objectives:**
Students will be able to:
1. To understand the architecture of advance microcontrollers
2. To understand the applications of these controllers
3. To get some introduction to FPGA.

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| **1** | • Basic Computer Organization.<br>• Accumulator based processes-Architecture-Memory<br>• Organization-I/O Organization | 6 |
| **2** | • Micro-Controllers-Intel 8051, Intel 8056- Registers, Memories.<br>• I/O Ports, Serial Communication. Timers, Interrupts, Programming. | 8 |
| **3** | • Intel 8051 – Assembly language programming-Addressing-Operations-Stack & Subroutines,Interrupts-DMA. | 6 |
| **4** | • PIC 16F877- Architecture Programming.<br>• Interfacing Memory/ I/O Devices, Serial I/Oand data communication | 8 |
| **5** | • Digital Signal Processor (DSP) - Architecture – Programming, Introduction to FPGA | 8 |
| **6** | • Microcontroller development for motor control applications.<br>• Stepper motor control using micro controller. | 8 |

**Suggested reading**


1. John.F.Wakerly: "Microcomputer Architecture and Programming", John Wiley and Sons 1981.
2. Ramesh S.Gaonker: "Microprocessor Architecture, Programming and Applications with the 8085", Penram International Publishing (India), 1994.
3. Raj Kamal: "The Concepts and Features of Microcontrollers", Wheeler Publishing, 2005.
4. Kenneth J. Ayala, "The 8051 microcontroller", Cengage Learning, 2004.
5. John Morton," The PIC microcontroller: your personal introductory course", Elsevier, 2005.
6. Dogan Ibrahim," Advanced PIC microcontroller projects in C: from USB to RTOS with the PIC18F Series", Elsevier, 2008.
7. Microchip datasheets for PIC16F877.


**Course Outcomes**

Students will be able to:
1. To learn how to program a processor in assembly language and develop an advanced processor based system
2. To learn configuring and using different peripherals in a digital system
3. To compile and debug a Program
4. To generate an executable file and use it

### PE 4:DISTRIBUTED GENERATION

**Course Objectives:**

| |
|---|
| Students will be able to:<br>1. To understand renewable energy sources.<br>2. To gain understanding of the working of off-grid and grid-connected renewable energy generation schemes. |

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| 1 | • Need for Distributed generation.<br>• Renewable sources in distributed generation and current scenario in Distributed Generation. | 6 |
| 2 | • Planning of DGs.<br>• Sitting and sizing of DGs optimal placement of DG sources in distribution systems.<br>• Grid integration of DGs Different types of interfaces, Inverter based DGs and rotating machine based interfaces.<br>• Aggregation of multiple DG units. | 8 |
| 3 | • Technical impacts of DGs.<br>• Transmission systems Distribution Systems De-regulation Impact of DGs upon protective relaying.<br>• Impact of DGs upon transient and dynamic stability of existing distribution systems, Steady-state and Dynamic analysis. | 6 |
| 4 | • Economic and control aspects of DGs Market facts.<br>• Issues and challenges Limitations of DGs, Voltage control techniques.<br>• Reactive power control, Harmonics Power quality issues, Reliability of DG based systems. | 8 |
| 5 | • Introduction to micro-grids.<br>• Types of micro-grids: autonomous and non-autonomous grids Sizing of micro-grids.<br>• Modeling & analysis of Micro-grids with multiple DGs.<br>• Micro-grids with power electronic interfacing units. | 8 |
| 6 | • Transients in micro-grids, Protection of micro-grids, Case studies,Advanced topics. | 8 |

**Suggested reading**

1. H. Lee Willis, Walter G. Scott, “Distributed Power Generation – Planning and Evaluation”, Marcel Decker Press.
2. M.GodoySimoes, Felix A.Farret, “Renewable Energy Systems – Design and Analysis with Induction Generators”, CRC press.
3. Stuart Borlase. “Smart Grid: Infrastructure Technology Solutions” CRC Press

***Course outcomes***

Students will be able to:
1. To understand the planning and operational issues related to Distributed Generation.
2. Acquire Knowledge about Distributed Generation Learn Micro-Grids

**PE 4:SMART GRIDS**

| **Course Objectives:** |
|---|

| Students will be able to:<br>1. Understand concept of smart grid and its advantages over conventional grid.<br>2. Know smart metering techniques.<br>3. Learn wide area measurement techniques.<br>4. Understanding the problems associated with integration of distributed generation & its solution through smart grid. | | |
|---|---|---|
| **Syllabus** | | |
| **Units** | **Content** | **Hours** |
| **1** | • Introduction to Smart Grid, Evolution of Electric Grid.<br>• Concept of Smart Grid, Definitions, Need of Smart Grid.<br>• Concept of Robust &Self-Healing Grid, Present development & International policies in Smart Grid | 6 |
| **2** | • Introduction to Smart Meters, Real Time Prizing, Smart Appliances.<br>• Automatic Meter Reading (AMR).<br>• Outage Management System (OMS).<br>• Plug in Hybrid Electric Vehicles(PHEV).<br>• Vehicle to Grid, Smart Sensors.<br>• Home & Building Automation, Smart Substations, Substation Automation, Feeder Automation | 8 |
| **3** | • Geographic Information System (GIS).<br>• Intelligent Electronic Devices (IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro.<br>• Compressed Air Energy Storage.<br>• Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU). | 6 |
| **4** | • Concept of micro-grid, need & applications of micro-grid.<br>• Formation of micro-grid, Issues of interconnection.<br>• Protection & control of micro-grid.<br>• Plastic & Organic solar cells, Thin film solar cells.<br>• Variable speed wind generators, fuel-cells, micro-turbines.<br>• Captive power plants, Integration of renewable energy sources. | 8 |
| **5** | • Power Quality & EMC in Smart Grid.<br>• Power Quality issues of Grid connected Renewable Energy Sources.<br>• Power Quality Conditioners for Smart Grid.<br>• Web based Power Quality monitoring, Power Quality Audit | 8 |
| **6** | • Advanced Metering Infrastructure (AMI), Home Area Network (HAN).<br>• Neighbourhood Area Network (NAN), Wide Area Network (WAN).<br>• Bluetooth, ZigBee, GPS, Wi-Fi, Wi-Max based communication.<br>• Wireless Mesh Network.Basics of CLOUD Computing &Cyber Security for Smart Grid.<br>• Broadband over Power line (BPL). IP based protocols | 8 |

**Suggested reading**

1. Ali Keyhani, “Design of smart power grid renewable energy systems”, Wiley IEEE,2011.
2. Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”, CRC Press, 2009.

3. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, “Smart Grid: Technology and Applications”, Wiley 2012.
4. Stuart Borlas’e, “Smart Grid:Infrastructure, Technology and solutions “CRC Press.
5. A.G.Phadke , “Synchronized Phasor Measurement and their Applications”,Springer.

**Course Outcomes**

Students will be able to:

1. Appreciate the difference between smart grid & conventional grid.
2. Apply smart metering concepts to industrial and commercial installations.
3. Formulate solutions in the areas of smart substations, distributed generation and wide area measurements.
4. Come up with smart grid solutions using modern communication technologies

**LAB 3- POWER ELECTRONICS LABORATORY**

1. To study V-I characteristics of SCR and measure latching and holding currents.
2. To study UJT trigger circuit for half wave and full wave control.
3. To study single-phase half wave controlled rectified with (i) resistive load (ii) inductive load with and without freewheeling diode.
4. To study single phase (i) fully controlled (ii) half controlled bridge rectifiers with resistive and inductive loads.
5. To study three-phase fully/half controlled bridge rectifier with resistive and inductive loads.
6. To study single-phase ac voltage regulator with resistive and inductiveloads.
7. To study single phase cyclo-converter.
8. To study triggering of (i) IGBT (ii) MOSFET (iii) power transistor.
9. To study operation of IGBT/MOSFET chopper circuit.
10. To study MOSFET/IGBT based single-phase series-resonant inverter.
11. To study MOSFET/IGBT based single-phase bridge inverter.

**LAB 4–MICROCONTROLLER LAB/DIGITAL SIGNAL PROCESSING LAB**
**Microcontroller Lab**

**EXPERIMENTS ON ASSEMBLY PROGRAMMING**

1. Write a program to multiplication and division using MUL and DIV instructions.
2. Write a program to transfer a block of data from internal memory to external memory.
3. Write a program to exchange two set of eight-byte data.
4. Write a program to find the sum of two numbers in decimal.
5. Write a program to convert decimal number to hexadecimal.
6. Write a program to add a number n, m number of times.
7. Write program to find the largest from a set of n numbers.
8. Write program for sorting the given set of numbers.

**EXPERIMENTS ON 8051 INTERFACING**

1. Write an assembly language program for generating a triangular wave.
2. Write a program to find the largest from a set of ten numbers and display it usingLEDs.
3. Write a program to for displaying the decimal numbers in 7 Segment display.
4. Write a program to read the DIP switches for displaying the reading using 7 Segmentdisplay.

5. Write a program to rotate the given motor in clockwise direction.
6. Write a program to rotate the given motor in anticlockwise direction.
7. Write a program to generate a square wave.
8. Write a program to display a message in LCD display.

**Digital Signal Processing Lab**

1.Introduction to Code Composer Studio-I
2.Introduction to Code Composer Studio-II
3.Introduction to the Addressing Modes
4. FFT and Bit Reversal Operation
5. FFT and its Applications
6. Audio Codec and its Applications
7. Real Time Data Exchange
8. IR filtering by interfacing Matlab with Code Composer Studio
9. Introduction to Interrupts
10. Digital communication using Binary Phase Shift Keying

**SEMESTER -3**

**PE 5:SCADA SYSTEM AND APPLICATIONS**

| | | |
|---|---|---|
| **Course Objectives:**<br>Students will be able to:<br>1. To understand what is meant by SCADA and its functions.<br>2. To know SCADA communication.<br>3. To get an insight into its application. | | |
| **Syllabus** | | |
| **Units** | **Content** | **Hours** |
| **1** | • Introduction to SCADA: Data acquisition systems, Evolution of SCADA,<br>• Communication technologies. | 6 |
| **2** | • Monitoring and supervisory functions, SCADA applications in Utility Automation,<br>• Industries SCADA | 8 |
| **3** | • Industries SCADA System Components: Schemes- Remote Terminal Unit (RTU),<br>• Intelligent Electronic Devices (IED), Programmable Logic Controller (PLC), Communication Network, SCADA Server, SCADA/HMI Systems | 6 |
| **4** | • SCADA Architecture: Various SCADA architectures, advantages and disadvantages of each system - single unified standard architecture -IEC 61850. | 6 |
| **5** | • SCADA Communication: various industrial communication technologies -wired and wireless methods and fiber optics. open standard communication protocols. | 6 |
| **6** | • SCADA Applications: Utility applications- Transmission and Distribution sector-<br>• operations, monitoring, analysis and improvement. Industries - oil, gas | 8 |

| | | |
|---|---|---|
| | and water.<br>• Case studies, Implementation, Simulation Exercises | |

**Suggested reading**


1. Stuart A. Boyer: "SCADA-Supervisory Control and Data Acquisition", Instrument Society of AmericaPublications, USA,2004.
2. Gordon Clarke, Deon Reynders: "Practical Modern SCADA Protocols: DNP3, 60870.5 and RelatedSystems", Newnes Publications, Oxford, UK,2004.
3. William T. Shaw, "Cybersecurity for SCADA systems", PennWell Books, 2006.
4. David Bailey, Edwin Wright, "Practical SCADA for industry", Newnes, 2003.
5. Wiebe, "A guide to utility automation: AMR, SCADA, and IT systems for electric power",PennWell 1999.


**Course Outcomes**

1. Describe the basic tasks of Supervisory Control Systems (SCADA) as well as their typicalapplications**.**
2. Acquire knowledge about SCADA architecture, various advantages and disadvantages of eachsystem.
3. Knowledge about single unified standard architecture IEC 61850.
4. To learn about SCADA system components: remote terminal units, PLCs, intelligent electronic devices, HMI systems, SCADA server.
5. Learn and understand about SCADA applications in transmission and distribution sector, industries etc.

**PE 5: FACTS AND CUSTOM POWER DEVICES**

| | | |
|---|---|---|
| **Course Objectives:**<br>Students will be able to:<br>1. To learn the active and reactive power flow control in power system<br>2. To understand the need for static compensators<br>3. To develop the different control strategies used for compensation | | |
| **Syllabus** | | |
| **Units** | **Content** | **Hours** |
| **1** | • Reactive power flow control in Power Systems – Control of dynamic power unbalances in Power System.<br>• Power flow control -Constraints of maximum transmission line loading – Benefits of FACTS Transmission line compensation.<br>• Uncompensated line -Shunt compensation - Series compensation –Phase angle control. Reactive power compensation.<br>• Shunt andSeries compensation principles – Reactive compensation at transmission and distribution level . | 6 |
| **2** | • Static versus passive VAR compensator, Static shunt compensators: SVC and STATCOM - Operation and control of TSC, TCR and STATCOM - Compensator control.<br>• Comparison between SVC and STATCOM. | 8 |
| **3** | • Static series compensation: TSSC, SSSC -Static voltage and phase angle regulators – TCVR and TCPAR Operation and Control –Applications, Static series compensation – GCSC,TSSC, TCSC and Static synchronous | 6 |

| | | |
|---|---|---|
| | series compensators and their Control. | |
| **4** | • SSR and its damping Unified Power Flow Controller: Circuit Arrangement, Operation and control of UPF.<br>• Basic Principle of P and Q control- Independent real and reactivepower flow control- Applications. | 6 |
| **5** | • Introduction to interline power flow controller. Modeling and analysis of FACTS Controllers – Simulation of FACTS controllers Power quality problems in distribution systems, harmonics.<br>• Loads that create harmonics, modeling, harmonic propagation, series and parallel resonances, mitigation of harmonics, passive filters, active filtering – shunt , series and hybrid and their control. | 6 |
| **6** | • Voltage swells, sags, flicker, unbalance and mitigation of these problems by<br>• power line conditioners- IEEE standards on power quality. | 6 |

**Suggested reading**


1. K R Padiyar, "FACTS Controllers in Power Transmission and Distribution", New AgeInternationalPublishers, 2007**.**
2. X P Zhang, C Rehtanz, B Pal, "Flexible AC Transmission Systems- Modelling and Control",Springer Verlag, Berlin, 2006.
3. N.G. Hingorani, L. Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems", IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001.
4. K.S.Sureshkumar, S.Ashok , "FACTS Controllers & Applications", E-book edition, Nalanda Digital Library, NIT Calicut, 2003.
5. G. T.Heydt, "Power Quality", McGraw-Hill Professional, 2007.
6. T. J. E. Miller, "Static Reactive Power Compensation", John Wiley and Sons, Newyork, 1982.


**Course Outcomes:**
Students will be able to:

1. Acquire knowledge about the fundamental principles of Passive and Active Reactive Power Compensation Schemes at Transmission and Distribution level in Power Systems.
2. Learn various Static VAR Compensation Schemes like Thyristor/GTO Controlled.
3. Reactive Power Systems, PWM Inverter based Reactive Power Systems and their controls.
4. To develop analytical modeling skills needed for modeling and analysis of such Static VARSystems.

**PE5: HVDC**

**Course Objectives:**
Students will be able to:
1. Understand state of the art HVDC technology.
2. Learn the Methods to carry out modeling and analysis of HVDC system frontier-area power flow regulation.

| Syllabus | | |
|---|---|---|
| **Units** | **Content** | **Hours** |
| **1** | • Development of HVDC Technology, DC versus AC Transmission,Selection of converter configuration. | 6 |
| **2** | • Rectifier and Inverter operation, Digital Simulation of converters, Control of HVDC converters and Systems. | 8 |

| | | |
|---|---|---|
| **3** | • Individual phase control, Equidistant firing controls, Higher level controls. Characteristics and non-characteristics harmonics filter design. Fault development and protection. | 6 |
| **4** | • Interaction between AC-DC power systems. Over voltages on AC/DC side, multi-terminal HVDC systems, control of MTDC systems. | 6 |
| **5** | • Modelling of HVDC systems, per unit system, Representation for power flow solution, representation for stability studies. | 6 |
| **6** | • Introduction to relevant national and international standards, safe clearances for HV, Study regulations for HV tests, Digital techniques in HV measurements. | 6 |

**Suggested reading**

1. J. Arrillaga, “High Voltage Direct Transmission”, Peter Peregrinus Ltd. London, 1983.
2. K. R. Padiyar, “HVDC Power Transmission Systems”, Wiley Eastern Ltd., 1990.
3. E. W. Kimbark, “Direct Current Transmission”, Vol. I, Wiley Interscience, 1971.
4. Erich Uhlmann, “Power Transmission by Direct Current”, B.S. Publications, 2004.

**Course Outcomes:**

Students will be able to:
1. To expose the students to the state of the art HVDC technology.
2. Knowledge of modelling and analysis of HVDC system for inter-area power flow regulation.
3. Study of Neetishatakam will help in developing.

## OPEN ELECTIVES
## Business Analytics

**Teaching scheme**

**Lecture: - 3 h/week**

| | |
|---|---|
| **Course Code** | |
| **Course Name** | **Business Analytics** |
| **Credits**<br>**Prerequisites** | |

Total Number of Lectures: 48

| **Course objective** |
|---|
| 1. Understand the role of business analytics within an organization. |
| 2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization. |
| 3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making. |
| 4. To become familiar with processes needed to develop, report, and analyze business data. |
| 5. Use decision-making tools/Operations research techniques. |
| 6. Mange business process using analytical and management tools. |
| **7.** Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc. |

| **LECTURE WITH BREAKUP** | **NO. OF** |
|---|---|

| | **LECTURES** |
|---|---|
| **Unit1:**<br>Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.<br>Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview. | 9 |
| **Unit 2:**<br>Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.<br>Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology. | 8 |
| **Unit 3:**<br>Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.<br>Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization. | 9 |
| **Unit 4:**<br>Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.<br>Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model. | 10 |
| **Unit 5:**<br>Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. | 8 |
| **Unit 6:**<br>Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism. | 4 |

| **COURSE OUTCOMES** | |
|---|---|
| | |
| 1. | Students will demonstrate knowledge of data analytics. |
| 2. | Students will demonstrate the ability of think critically in making decisions based on data and deep analytics. |
| 3. | Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making. |
| **4.** | Students will demonstrate the ability to translate data into clear, actionable insights. |

**Reference:**


1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.


## OPEN ELECTIVES
## Industrial Safety

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**Unit-II:** Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**Unit-III:** Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**Unit-IV:** Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**Unit-V:** Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

**Reference:**


1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

## OPEN ELECTIVES
## Operations Research

**Teaching Scheme**
Lectures: 3 hrs/week

**Course Outcomes: At the end of the course,** the student should be able to

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

**Syllabus Contents:**

**Unit 1**:
Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

**Unit 2**
Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

**Unit 3**:
Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

**Unit 4**
Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

**Unit 5**
Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

**References**:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

## Open Elective
## Cost Management of Engineering Projects

**Teaching scheme**

**Lecture: - 3 h/week**

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Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

**References:**


2. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
3. Charles T. Horngren and George Foster, Advanced Management Accounting
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
5. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
6. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.


## Open Elective
## Composite Materials

**Teaching scheme**

**Lecture: - 3 h/week**

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**UNIT–I**: INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT – II**: REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT – III:** Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix

Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT–IV:** Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT – V:** Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

**TEXT BOOKS:**

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

**References:**

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

**Open Elective**
**Waste to Energy**

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**Unit-II:** Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**Unit-III:** Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**Unit-IV:** Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**Unit-V:** Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion -

Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

**References:**


1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.


## AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING

**Course objectives:**
Students will be able to:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title

Ensure the good quality of paper at very first-time submission

**Syllabus**

| Units | CONTENTS | Hours |
|---|---|---|
| 1 | Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness | 4 |
| 2 | Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction | 4 |
| 3 | Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check. | 4 |
| 4 | key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, | 4 |
| 5 | skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions | 4 |
| 6 | useful phrases, how to ensure paper is as good as it could possibly be the first- time submission | 4 |

**Suggested Studies:**


1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011


## AUDIT 1 and 2: DISASTER MANAGEMENT

**Course Objectives: -**Students will be able to:
1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.

2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in

**Syllabus**

| **Units** | **CONTENTS** | **Hours** |
|---|---|---|
| 1 | **Introduction**<br>Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude. | 4 |
| 2 | **Repercussions Of Disasters And Hazards**: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.<br>Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts. | 4 |
| 3 | **Disaster Prone Areas In India**<br>Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics | 4 |
| 4 | **Disaster Preparedness And Management**<br>Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness. | 4 |
| 5 | **Risk Assessment**<br>Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival. | 4 |
| 6 | **Disaster Mitigation**<br>Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India. | 4 |

## SUGGESTED READINGS:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

## AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE

***Course Objectives***

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

***Syllabus***

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Alphabets in Sanskrit,<br>• Past/Present/Future Tense,<br>• Simple Sentences | 8 |
| 2 | • Order<br>• Introduction of roots<br>• Technical information about Sanskrit Literature | 8 |
| 3 | • Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics | 8 |

***Suggested reading***

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.

***Course Output***

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

## AUDIT 1 and 2: VALUE EDUCATION

***Course Objectives***

Students will be able to

1. Understand value of education and self- development
2. Imbibe good values in students
3. Let the should know about the importance of character

***Syllabus***

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism.<br>• Moral and non- moral valuation. Standards and principles.<br>• Value judgements | 4 |
| 2 | • Importance of cultivation of values.<br>• Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness.<br>• Honesty, Humanity. Power of faith, National Unity.<br>• Patriotism.Love for nature ,Discipline | 6 |
| 3 | • Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline. | 6 |

| | | |
|---|---|---|
| | • Punctuality, Love and Kindness.<br>• Avoid fault Thinking.<br>• Free from anger, Dignity of labour.<br>• Universal brotherhood and religious tolerance.<br>• True friendship.<br>• Happiness Vs suffering, love for truth.<br>• Aware of self-destructive habits.<br>• Association and Cooperation.<br>• Doing best for saving nature | |
| 4 | • Character and Competence –Holy books vs Blind faith.<br>• Self-management and Good health.<br>• Science of reincarnation.<br>• Equality, Nonviolence ,Humility, Role of Women.<br>• All religions and same message.<br>• Mind your Mind, Self-control.<br>• Honesty, Studying effectively | 6 |

***Suggested reading***

1 Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

***Course outcomes***

Students will be able to
1.Knowledge of self-development
2.Learn the importance of Human values
3.Developing the overall personality

## AUDIT 1 and 2: CONSTITUTION OF INDIA

**Course Objectives:**

Students will be able to:

1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| **1** | • **History of Making of the Indian Constitution:**<br>History<br>Drafting Committee, ( Composition & Working) | 4 |
| **2** | • **Philosophy of the Indian Constitution:**<br>Preamble<br>Salient Features | 4 |
| **3** | • **Contours of Constitutional Rights & Duties:**<br>• Fundamental Rights | 4 |

| | | |
|---|---|---|
| | • Right to Equality<br>• Right to Freedom<br>• Right against Exploitation<br>• Right to Freedom of Religion<br>• Cultural and Educational Rights<br>• Right to Constitutional Remedies<br>• Directive Principles of State Policy<br>• Fundamental Duties. | |
| **4** | • **Organs of Governance:**<br>• Parliament<br>• Composition<br>• Qualifications and Disqualifications<br>• Powers and Functions<br>• Executive<br>• President<br>• Governor<br>• Council of Ministers<br>• Judiciary, Appointment and Transfer of Judges, Qualifications<br>• Powers and Functions | 4 |
| **5** | • **Local Administration:**<br>• District's Administration head: Role and Importance,<br>• Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.<br>• Pachayati raj: Introduction, PRI: Zila Pachayat.<br>• Elected officials and their roles, CEO Zila Pachayat: Position and role.<br>• Block level: Organizational Hierarchy (Different departments),<br>• Village level: Role of Elected and Appointed officials,<br>• Importance of grass root democracy | 4 |
| **6** | • **Election Commission:**<br>• Election Commission: Role and Functioning.<br>• Chief Election Commissioner and Election Commissioners.<br>• State Election Commission: Role and Functioning.<br>• Institute and Bodies for the welfare of SC/ST/OBC and women. | 4 |

**Suggested reading**


1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.


**Course Outcomes:**

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.

4. Discuss the passage of the Hindu Code Bill of 1956.

## AUDIT 1 and 2: PEDAGOGY STUDIES

**Course Objectives:**
Students will be able to:
4. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
5. Identify critical evidence gaps to guide the development.

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| **1** | • **Introduction and Methodology:**<br>• Aims and rationale, Policy background, Conceptual framework and terminology<br>• Theories of learning, Curriculum, Teacher education.<br>• Conceptual framework, Research questions.<br>• Overview of methodology and Searching. | 4 |
| **2** | • Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.<br>• Curriculum, Teacher education. | 2 |
| **3** | • Evidence on the effectiveness of pedagogical practices<br>• Methodology for the in depth stage: quality assessment of included studies.<br>• How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?<br>• Theory of change.<br>• Strength and nature of the body of evidence for effective pedagogical practices.<br>• Pedagogic theory and pedagogical approaches.<br>• Teachers' attitudes and beliefs and Pedagogic strategies. | 4 |
| **4** | • Professional development: alignment with classroom practices and follow-up support<br>• Peer support<br>• Support from the head teacher and the community.<br>• Curriculum and assessment<br>• Barriers to learning: limited resources and large class sizes | 4 |
| **5** | • **Research gaps and future directions**<br>• Research design<br>• Contexts<br>• Pedagogy<br>• Teacher education<br>• Curriculum and assessment<br>• Dissemination and research impact. | 2 |

**Suggested reading**

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.

3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.


**Course Outcomes:**

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

## AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

***Course Objectives***

1. To achieve overall health of body and mind
2. To overcome stress

***Syllabus***

| Unit | *Content* | *Hours* |
|---|---|---|
| 1 | • Definitions of Eight parts of yog. ( Ashtanga ) | 8 |
| 2 | • Yam and Niyam.<br>Do`s and Don't's in life.<br>i) Ahinsa, satya, astheya, bramhacharya and aparigraha<br>ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan | 8 |
| 3 | • Asan and Pranayam<br>i) Various yog poses and their benefits for mind & body<br>ii)Regularization of breathing techniques and its effects-Types of pranayam | 8 |

***Suggested reading***

1. 'Yogic Asanas for Group Tarining-Part-I" : Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

**Course Outcomes:**

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also

2. Improve efficiency

## AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS

***Course Objectives***

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

***Syllabus***

| Unit | Content | Hours |
|---|---|---|
| 1 | Neetisatakam-Holistic development of personality<br>• Verses- 19,20,21,22 (wisdom)<br>• Verses- 29,31,32 (pride & heroism)<br>• Verses- 26,28,63,65 (virtue)<br>• Verses- 52,53,59 (dont's)<br>• Verses- 71,73,75,78 (do's) | 8 |
| 2 | • Approach to day to day work and duties.<br>• Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48,<br>• Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,<br>• Chapter 18-Verses 45, 46, 48. | 8 |
| 3 | • Statements of basic knowledge.<br>• Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68<br>• Chapter 12 -Verses 13, 14, 15, 16,17, 18<br>• Personality of Role model. Shrimad Bhagwad Geeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42,<br>• Chapter 4-Verses 18, 38,39<br>• Chapter18 – Verses 37,38,63 | 8 |

***Suggested reading***

1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

***Course Outcomes***

Students will be able to
1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

# CourseM.Tech. (Electrical Engineering), Specialization: Control Systems

| Semester 1 | | | | | | |
|---|---|---|---|---|---|---|
| Sr. No. | Core/Elective | Course Name | | | | Credits |
| | | | L | T | P | |
| 1 | Core1 | Mathematical Methods in Control | 3 | 0 | 0 | 3 |
| 2 | Core2 | Non-Linear Systems | 3 | 0 | 0 | 3 |
| 3 | PE1 | Robotics and Automation / Digital Control/ Non Linear Control | 3 | 0 | 0 | 3 |
| 4 | PE2 | Systems Biology/ SCADA system and Applications / Design Aspects in Control | 3 | 0 | 0 | 3 |
| 5 | | Research Methodology and IPR | 2 | 0 | 0 | 2 |
| 6 | Lab1 | Control Lab 1 | 0 | 0 | 4 | 2 |
| 7 | Lab2 | Control Lab 2 | 0 | 0 | 4 | 2 |
| 8 | Audit-I | Audit I | 2 | 0 | 0 | 0 |
| 9 | Total Credits18 | | | | | |

| Semester 2 | | | | | | |
|---|---|---|---|---|---|---|
| Sr. No. | Core/Elective | Course Name | | | | Credits |
| | | | L | T | P | |
| 1 | Core3 | Optimal Control Theory | 3 | 0 | 0 | 3 |
| 2 | Core4 | Stochastic Filtering and Identification | 3 | 0 | 0 | 3 |
| 3 | PE3 | Advance Control System/ Advanced Robotics/ Adaptive Learning and Control | 3 | 0 | 0 | 3 |
| 4 | PE4 | Model Reduction in Control/ Robust Control/ Networked and Multi-agent Control Systems/Advanced DSP | 3 | 0 | 0 | 3 |
| | | Mini Project with Seminar | 0 | 0 | 4 | 2 |
| 5 | Lab3 | Advanced Control Lab 1 | 0 | 0 | 4 | 2 |
| 6 | Lab4 | Advanced Control Lab 2 | 0 | 0 | 4 | 2 |
| 7 | Audit-II | Audit-II | 2 | 0 | 0 | 0 |
| 8 | Total Credits18 | | | | | |

| Semester 3 | | | | | | |
|---|---|---|---|---|---|---|
| Sr. No. | Core/Elective | Course Name | | | | Credits |
| | | | L | T | P | |
| 1 | PE5 | Modeling and Control of Distributed Parameter Systems/ Stochastic Control/Computational Methods | 3 | 0 | 0 | 3 |
| 2 | OE | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering | 3 | 0 | 0 | 3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Projects<br>5. Composite Materials<br>6. Waste to Energy | | | | |
| 3 | Major Project | Phase – I Dissertation | 0 | 0 | 20 | 10 |
| 4 | Total Credits | | | | | 16 |
| | | **Semester 4** | | | | |
| Sr. No. | Core/Elective | Course Name | | | | Credits |
| | | | L | T | P | |
| 1 | Major Project | Phase – II Dissertation | 0 | 0 | 32 | 16 |
| 2 | Total Credits16 | | | | | |

**GRAND TOTAL CREDITS 68**

**Programme Outcomes**

At the end of Post Graduate Program, students will have

**PO 1** An ability to apply knowledge of mathematics, allied sciences, and engineering to problems related to System Engineering and Control.

**PO2** An ability to conduct independent research both of an academic and applied nature in the area of mathematical and applied control theory.

**PO3**An ability to use the techniques, skills, and modern control engineering tools necessary for engineering practice.

**PO4**An ability to be conversant with practical control system

**PO5** Design, operation, control, and testing issues. An ability to communicate effectively to convey the ideas acquired through research.

**PO 6** Enhanced knowledge and skill set required in control

**PO7** Engineering program for problem solving so as to arrive at appropriate technological solutions.

**PO8**An understanding of professional and ethical responsibility

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

## CORE 1: MATHEMATICAL METHODS IN CONTROL

***Course Objectives***

1. To give the students an understanding of foundational concepts in linear algebra and random processes for use in control systems
2. To understand Probability, Random variables

***Syllabus***

| Unit | Content |
|---|---|
| 1 | • Linear Spaces – Vectors and Matrices<br>• Transformations, Norms<br>• Matrix Factorization |
| 2 | • Eigenvalue, Eigenvectors and Applications<br>• SVD and Applications<br>• Projections and Least Square Solutions |
| 3 | • Probability, Random variables<br>• Probability distribution and density functions, Joint density and conditional distribution<br>• Functions of random variables and random vectors |
| 4 | • Characteristic functions and correlation matrices |
| 5 | • Random Processes and properties |
| 6 | • Response of Linear systems to stochastic inputs, PSD theorem |

***Suggested reading***


1. G. Strang, “Introduction to Linear Algebra”, 4 th Edition, Wellesley-Cambridge Press, 2009
2. Papoulis & Pillai, “Probability, random variable and stochastic processes”, Mcgraw Hill, 2002
3. H. Stark & J.W. Woods, “Probability and random processes with application to signal processing”, Pearson Education Asia, 2002
4. J A Gubner: “Probability and Random processes for Electrical and Computer engineers”, Cambridge Univ. Press. 2006


***Course Outcomes***

Students will be able to

1. Apply matrix properties and functions to a given problem
2. Use eigen values and eigen vectors
3. Find out responses of linear systems to any given input signal

## CORE2: NON - LINEAR SYSTEMS

***Course Objectives***

1. Introduce fundamental concepts of nonlinear dynamical systems
2. Understanding basic tools for mathematical analysis as well as applications

***Syllabus***

| Unit | Content |
|---|---|
| 1 | • Introduction to nonlinear systems: Examples of phenomena, models & derivation of system equations |
| 2 | • Fundamental properties: Existence & uniqueness, Dependence on initial conditions & parameters.<br>• Phase plane analysis |
| 3 | • Limit cycles & oscillations. Describing function method and applications.<br>• Circle criterion |
| 4 | • Lyapunov stability of autonomous systems |
| 5 | • Perturbation theory & Averaging.<br>• Singular perturbation model and stability analysis |
| 6 | • Basic results on Lie algebra. Controllability and Observability of nonlinear systems.<br>• Bifurcations. Chaos. Synchronization |

***Suggested reading***

1. H. K. Khalil, "*Nonlinear systems"*, 3rd edition, Prentice Hall, 2001
2. J. J. E. Slotine and W. Li, "*Applied nonlinear systems"*, Prentice Hall, 1991
3. A. Nijemjer and A. van der schaft, "*Nonlinear dynamical control systems"*, Springer, 1989
4. M. Vidyasagar, "*Nonlinear Systems Analysis*, Society for Industrial and Applied Mathematics", 2002
5. S. Strogatz, "*Nonlinear Dynamics and Chaos"*, Westview Press, 2001

***Course Outcomes***

Students will be able to

1.Explore tools for stability analysis and response evaluation of control problems with significant nonlinearities

2. Identify the design problem and distinguish between the controls strategies
3. Correlate between design parameters and the system performance

**PE 1: ROBOTICS AND AUTOMATION**

***Course objectives***

1. To study the various parts of robots and fields of robotics
2. To study the various kinematics and inverse kinematics of robots
3. To study the trajectory planning for robot
4. To study the control of robots for some specific applications

***Syllabus***

| Unit | Content |
|---|---|
| 1 | • BASIC CONCEPTS: Definition and origin of robotics, different types of robotics<br>• Various generations of robots, degrees of freedom, Asimov's laws of robotics, dynamic stabilization of robots |
| 2 | • POWER SOURCES AND SENSORS : Hydraulic, pneumatic and electric drives<br>• Determination of HP of motor and gearing: ratio, variable speed arrangements, |

| | |
|---|---|
| | path determination, micro machines in robotics<br>• Machine vision, ranging, laser, acoustic, magnetic, fiber optic and tactile sensors |
| 3 | • MANIPULATORS, ACTUATORS AND GRIPPERS : Construction of manipulators , manipulator dynamics and force control<br>• Electronic andpneumatic manipulator control circuits , end effectors |
| 4 | • KINEMATICS AND PATH PLANNING: Solution of inverse kinematics problem<br>• Multiple solution Jacobian work envelop, hillclimbing techniques, Robot programming languages |
| 5 | • Manufacturing and non- manufacturing applications, robot cell design, selection of robot |
| 6 | • Robot Control: Linear methods, Non-linear methods |

***Suggested reading***

1. Mikell P. Weiss G.M., Nagel R.N., Odraj N.G. "Industrial Robotics", McGraw-Hill Singapore, 1996
2. Ghosh, "Control in Robotics and Automation: Sensor Based Integration", Allied Publishers, Chennai, 1998
3. Deb.S.R., "Robotics technology and flexible Automation", John Wiley, USA 1992
4. Asfahl C.R., "Robots and manufacturing Automation", John Wiley, USA 1992

***Course Outcomes***

Students will be able to
1. Obtain forward, reverse kinematics and dynamics model of the industrial robot arm
2. Propose and synthesize control law for a given application
3. Classify robots and decide specifications depending on the applications

**PE 1: DIGITAL CONTROL**

***Course Objectives***

1. To familiarize the student with the concept of discretization
2. Introduction to discrete-time system representations and digital control
3. Learn to design controller for digital systems

***Syllabus***

| Unit | Content |
|---|---|
| 1 | • Introduction to discrete-time systems |
| 2 | • Frequency domain approach – Analysis and discretization<br>• Time domain approach, analysis and discretization<br>• State space formulation for discretized systems |
| 3 | • Engineering aspects of computer controlled systems |
| 4 | • Sampled data systems<br>• Control of Sampled data systems |
| 5 | • Concept of differential sampling, Closed loop analysis of differentially sampled systems<br>• Control design based on differential sampling |
| 6 | • Recent applications of Digital Control |

***Suggested reading***

1. K. Ogata, "Discrete-time Control Systems', Ed. 2, Prentice-Hall, 1995.

2. Benjamin C. Kuo, "Digital Control Systems", Ed. 2, Oxford Uiversity Press, 1999

***Course Outcomes***

Students will be able to
1. Model digital filters and systems
2. Analyse digital systems in time domain and frequency domain
3. Model and analyse digital systems in state space representation
4. Design controllers for digital systems in state space representation

**PE 1:NONLINEAR CONTROL**

***Course Objectives***

1. To study concepts and techniques for stability analysis
2. Learning control design of nonlinear systems

***Syllabus***

| Unit | Content |
|---|---|
| 1 | • Overview of nonlinear Control-Introduction to Advanced Calculus, Elementary notions of Topology<br>• Smooth Manifolds, Sub-manifolds, Tangent Vectors, Vector Fields |
| 2 | • Lyapunov stability for autonomous and non-autonomous systems<br>• Input-Output Stability and Input-to-State Stability Absolute Stability |
| 3 | • Passivity analysis and applications to control design,Lyapunov-based feedback control design.<br>• Feedback linearization and backstepping |
| 4 | • Sussmann's Theorem and global Decompositions<br>• The Control Lie Algebra, the observation space. |
| 5 | • Local Co-ordinates, Transformations, Exact Linearization Via Feedback<br>• The Zero dynamics, Local Asymptotic Stabilization<br>• Asymptotic Output Tracking |
| 6 | • Disturbance Decoupling, High Gain Feedback,<br>• Additional Results on Exact Linearization, Observers with Linear Error Dynamics |

***Suggested reading***

1. H. K. Khalil, "Nonlinear Systems", 3rd edition, Prentice Hall, 2001
2. H. K. Khalil, "Nonlinear Control", Pearson, 2015
3. J. J. E. Slotine and W. Li, "Applied nonlinear systems", Prentice Hall, 1991
4. A. Nijemjer and A. van der schaft, "Nonlinear dynamical control systems", Springer, 1989
5. M. Vidyasagar, "Nonlinear Systems Analysis, Society for Industrial and Applied Mathematics", 2002
6. Alberto Isidori, "Nonlinear Control Systems", Third Edition, Springer, 1995

***Course Outcomes***

Students will be able to
1. Application of deeper ideas from mathematics and specifically from geometry to engineering problems
2. Analyze and design nonlinear controllers with the aid of software tools

**PE 2: SYSTEMS BIOLOGY**

***Course Objectives***

1. Introduction to Mathematical Model and Frame Work
2. Learning of core –Process ,Pulses and Oscillations
3. Introduction to Feed Forward Loops, Fundamental trade offs

***Syllabus***

| Unit | Content |
|---|---|
| 1 | • Mathematical models and frameworks: Law of mass action, Master equation<br>• Deterministic vs stochastic, Spatial aspects |
| 2 | • Examples of core processes: Gene expression, Protein degradation, Phosphorylation Equilibrium solutions & their Bifurcations Switches & Bistability |
| 3 | • Pulses and Oscillations,<br>• Circadian Rhythms and Clocks Spatial patterns<br>• Morphogenesis and Development |
| 4 | • Robustness to Perturbations,<br>• Integral Feedback Control,<br>• Homeostasis and Perfect Adaptation |
| 5 | • Feed-forward Loops,<br>• Fold Change Detection |
| 6 | • Fundamental Tradeoffs,<br>• Internal Model Principle |

***Suggested reading***

1. N. G. van Kampen, "Stochastic Processes in Physics and Chemistry", North-Holland 3rd edition 2007
2. U. Alon, "An Introduction to Systems Biology, Chapman & Hall/ CRC Mathematical and Computational Biology", 2006
3. J. D. Murray, "Mathematical Biology parts I & II", Springer 3rd edition, 2007
4. E. Klippet. al, "Systems Biology", Wiley-Blackwell, 2009
5. S. Strogatz, "Nonlinear Dynamics and Chaos", Westview Press, 2001
6. D. D. Vecchio& R. M. Murray, "Biomolecular Feedback Systems", Princeton University Press, 2014

***Course Outcomes***

Students will be able to

1. Understand and apply mathematical models to design a particular system
2. Apply feed-forward loops to design a biological control system

**PE 2: SCADA SYSTEM AND APPLICATIONS**

***Course Objectives***

1. To understand what is meant by SCADA and its functions
2. To know SCADA communication
3. To get an insight into its application

***Syllabus***

| Unit | Content |
|---|---|

| | |
|---|---|
| 1 | • Introduction to SCADA: Data acquisition systems,<br>• Evolution of SCADA,<br>• Communication technologies |
| 2 | • Monitoring and supervisory functions,<br>• SCADA applications in Utility Automation,<br>• Industries SCADA |
| 3 | • Industries SCADA System Components: Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices(IED), Programmable Logic Controller (PLC),<br>• Communication Network,<br>• SCADA Server, SCADA/HMI Systems |
| 4 | • SCADA Architecture: Various SCADA architectures, advantages and disadvantages of each system - single unified standard architecture -IEC 61850. |
| 5 | • SCADA Communication: various industrial communication technologies - wired and wireless methods and fiber optics<br>• open standard communication protocols |
| 6 | • SCADA Applications: Utility applications- Transmission and Distribution sector-operations, monitoring, analysis and improvement<br>• Industries - oil, gas and water.<br>• Case studies, Implementation, Simulation Exercises |

***Suggested reading***

1. Stuart A. Boyer: "SCADA-Supervisory Control and Data Acquisition", Instrument Society of America
Publications,USA,2004
2. Gordon Clarke, Deon Reynders: "Practical Modern SCADA Protocols: DNP3, 60870.5 and Related
Systems", Newnes Publications, Oxford, UK,2004
3. William T. Shaw, "Cybersecurity for SCADA systems", PennWell Books, 2006
4. David Bailey, Edwin Wright, "Practical SCADA for industry", Newnes, 2003
5. Michael Wiebe, "A guide to utility automation: AMR, SCADA, and IT systems for electric power",
PennWell 1999

***Course Outcomes***

Students will be able to

1. Describe the basic tasks of Supervisory Control Systems (SCADA) as well as their typicalapplications
2. Acquire knowledge about SCADA architecture, various advantages and disadvantages of eachsystem
3. Knowledge about single unified standard architecture IEC 61850
4. To learn about SCADA system components: remote terminal units, PLCs, intelligentelectronic devices, HMI systems, SCADA server
5. Learn and understand about SCADA applications in transmission and distribution sector, industries,etc

## PE 2: DESIGN ASPECTS IN CONTROL

***Course Objectives***

1. The student is introduced to the tools and techniques of control system design
2. Introduction to various aspects of controller design philosophy
3. Learning PID Controller

***Syllabus***

| Unit | Content |
|---|---|
| 1 | • System Modelling,<br>• review of concepts |
| 2 | • FOPDT and SOPDT systems and identification Smith Predictor and its variations |
| 3 | • PID Controllers – review PID Tuning – Ziegler Nichols, Cohen-Coon techniques |
| 4 | • State feedback review – pole placement, Eigen structure assignment, Eigen structure – time response relation,<br>• Controller gain selection, controller robustness, disturbance rejection |
| 5 | • Frequency Domain Loop Shaping<br>• Lag, Lead and Lag-lead compensators,<br>• Zero dynamics in servo control, Unstable zero dynamics – control design |
| 6 | • Observer – concept and design, Case studies - Applications |

***Suggested reading***

1. Karl J. Astrom, Richard M. Murray, "Feedback Sytems : An Introduction for Scientists and Engineers", Princeton University Press, 2010.
2. Thomas Kailath : "Linear Systems", Prentice-Hall

***Course Outcomes***

Students will be able to
1. Model a control system given its parameters
2. Decide gains of the controllers like PI,PID in a given control system

## LAB 1 - CONTROL LAB 1

***Syllabus***

| S.No. | List of experiment |
|---|---|
| 1 | Design and simulation of Linearised models using MATLAB/PSPICE. |
| 2 | Simulation and analysis of State space models for continuous time and discrete time systems using MATLAB/PSPICE |
| 3 | Design and Simulation of LTI models of Feedback Control System using MATLAB/PSPICE |
| 4 | Simulation and analysis of Digital Control System using MATLAB/PSPICE. |
| 5 | Simulation and Stability analysis of control system with common non-linearities using MATLAB/PSPICE |

| | |
|---|---|
| 6 | Familiarization and use of MATLAB command associated with Robust Control Systems. |
| 7 | Familiarization and use of PSIM software. |

**LAB 2 - CONTROL LAB 2**

***Syllabus***

| S. No. | List of experiment |
|---|---|
| 1 | Designing of Ladder logic for various practical applications |
| 2 | Execution of the Ladders using PLC's. |
| 3 | Study of Analog and Digital Servo Systems |
| 4 | Experiment on Position Control System |
| 5 | Experiment on Velocity Control System, |
| 6 | Experiment on Adaptive Control System |
| 7 | Experiment on Non-Linear Control Systems. |

## Research Methodology and IPR

**Teaching Scheme**
Lectures: 1hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

**Syllabus Contents:**

**Unit 1:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Unit 2:** Effective literature studies approaches, analysis

Plagiarism, Research ethics,

**Unit 3:** Effective technical writing, how to write report, Paper

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**Unit 4:** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Unit 5:** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Unit 6:** New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

**References:**


- Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
- Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
- Ranjit Kumar, 2nd Edition , "Research Methodology: A Step by Step Guide for beginners"
- Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
- Mayall , "Industrial Design", McGraw Hill, 1992.
- Niebel , "Product Design", McGraw Hill, 1974.
- Asimov , "Introduction to Design", Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
- T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008


## CORE3: OPTIMAL CONTROL THEORY

***Course Objectives***

1. Introduce the basic and fundamental concepts of optimal control theory, controller design
2. Introduction to computational aspects of optimal control

***Syllabus***

| **Unit** | ***Content*** |
|---|---|
| 1 | • Review of Matrix Computations |
| 2 | • Maximization of functional of a single and several functions using calculus of variations,<br>• Constrained externals,<br>• Euler-Lagrange Equation,<br>• Necessary conditions for optimal control,<br>• Pontryagin's minimum principle and state inequality constraints,<br>• Minimum time problems, Minimum control effort problems |

| | |
|---|---|
| 3 | • Linear quadratic regulator problems,<br>• Riccati Equation,<br>• Singular intervals in optimal control problems |
| 4 | • The principle of optimality, Application of the principle of optimality to decision making,<br>• Dynamic programming applied to routing problems |
| 5 | • Solving optimal control problems using dynamic programming,<br>• Discrete linear regulator problem,<br>• Hamilton -Jacobi -Bellman Equation |
| 6 | • Numerical Techniques to determine optimal trajectories,<br>• Numerical Aspects of Optimization |

***Suggested reading***


1. M. Athans and P. L. Falb, "Optimal Control: An Introduction to the Theory and Its Applications", Dover Books on Engineering, 2006.
2. D. S. Naidu, "Optimal Control Systems", CRC Press, 2002.
3. D. Liberzon, "Calculus Of Variations and Optimal Control Theory: A Concise Introduction", Princeton University Press, Dec 2011
4. Frank L. Lewis, DragunaVrabie, Vassilis L. Syrmos, Optimal Control, 3rd Edition, Wiley, 2012


***Course Outcomes***

Students will be able to

1. Combine the mathematical methods used in optimal control to derive the solution to variations of the problems studied in the course
2. Use the standard algorithms for numerical solution of optimal control problems and use Matlab to solve fairly simple but realistic problems
3. Integrate the tools learnt during the course and apply them to more complex problems

## CORE 4: STOCHASTIC FILTERING AND IDENTIFICATION

***Course Objectives***

1. To introduce fundamental concepts of stochastic filtering, prediction, control
2. To introduce non-linear system identification

***Syllabus***

| **Unit** | ***Content*** |
|---|---|
| 1 | • Introduction to Parameter Estimation and System Identification,<br>• MMSE estimation including LMS,<br>• Gaussian case |
| 2 | • Wiener filtering & prediction,<br>• Kalman filtering & prediction, Extended Kalman filtering and its variations,<br>• Predictors for difference equation based models including ARMA, Box Jenkins & others |
| 3 | • Statistical properties of Least Squares estimation and its relationship with Bayes estimation (ML, MAP),<br>• convergence analysis, CR bound, |

| | |
|---|---|
| | • Recursive Least Squares, Iterative methods for nonlinear Least Squares Identification problem: Different approaches for linear dynamical system,<br>• Offline identification methods including Least Squares,<br>• Prediction error framework,<br>• Pseudo-linear regression (PLR) & Instrument variable methods |
| 4 | • Recursive Identification of linear dynamical system: RLS, PLR,<br>• Prediction error framework & its application to ARMA & Innovations representation,<br>• Convergence Analysis of Recursive Identification methods: Associated ODE, Martingale |
| 5 | • Nonlinear system identification,<br>• Subspace based method of system identification |
| 6 | • Applications including LQG and adaptive control |

***Suggested reading***


1. Papoulis & Pillai, "Probability, random variable and stochastic processes", McGraw Hill, 2002
2. T. Soderstrom and P. Stoica: "System Identification", Prentice-Hall, 1989
3. LennartLjung: "System Identification, Prentice-Hall", 2nd edition, 1999
4. S. Thomas Alexander: "Adaptive Signal processing, Theory and applications", Springer-Verlag, 1986
5. R. Isermann and M. Munchhof: "Identification of Dynamic Systems", Springer-Verlag, 2011
6. B. D. O. Anderson and J. B. Moore: "Optimal Filtering, Dover Books on Electrical Engineering", 2005


***Course Outcomes***

Students will be able to

1. Develop skills in analyzing and interpreting the results
2. Master essential stochastic modeling tools including Markov chains and queuing theory
3. Formulate and solve problems which involve setting up stochastic models

**PE 3: ADVANCE CONTROL SYSTEM**

***Course Objectives***

1. The course provides glimpses into the advanced methods of modeling and analysis of the dynamical systems
2. The course is a strong step in inculcating the research aptitude in the students

***Syllabus***

| **Unit** | ***Content*** |
|---|---|
| 1 | • Math Modelling of Dynamical Systems: Newtonian and Lagrangian approaches,<br>• Concept of dynamical state of a system, Concept of equilibrium point, linearization of non-linear model |
| 2 | • Review of Linear Algebra concepts: Field, Vector space, linear combination, linear independence, bases of a vector space,<br>• representation of any vector on different basis, matrix representation of a linear operator, change of basis, rank, nullity, range space and null space of a matrix, |

| | |
|---|---|
| | • Eigen value and Eigen vector of a matrix, similarity transform, Diagonalisation |
| 3 | • Modern Control Analysis: Concept and computation of systems modes,<br>• controllability theorem and its proof,<br>• Observability theorem and its proof,<br>• Controllable and observable subspaces |
| 4 | • Stability Analysis: Stability of linear systems, stability types and their definitions for any general system,<br>• Stability of an equilibrium point, Lyapunov stability theory for LTI systems,<br>• Quadratic forms and Lyapunov functions |
| 5 | • Modern Control Design: Converting the math model to controllable canonical form and its use for pole placement,<br>• Concept of linear observer and its design,<br>• Design of reduced order observer,<br>• Compensator design using separation principle,<br>• Poles of compensator,<br>• Open loop and close-loop systems |
| 6 | • Optimal Control Theory: Introduction to the philosophy of optimal control, formulation of optimal control problem, different performance criterion,<br>• Linear quadratic regulator (LQR) and optimum gain matrix,<br>• Riccati equations, conceptual models and statistical models for random processes, Kalman filter |

***Suggested reading***

1. Bernard Friedland, "Control System Design: An Introduction to State-Space Methods", Dover Publications, Inc. Mineola, New York, 2012

2. Thomas Kailath, "Linear Systems", Prentice-Hall Inc., New Jersey, 1986

3. M. Gopal, "Modern Control System Theory", , New Age International (P) Limited, New Delhi, 2000

***Course Outcomes***

Students will be able to

1. Apply the concepts of linear algebra and their applications to control system
2. Analyze the system dynamics and Lyapunov stability theory
3. Design linear quadratic controller

**PE 3: ADVANCED ROBOTICS**

***Course Objectives***

1. This course gives an in-depth view into the mathematical methods for modeling and control of robotic manipulator
2. Introduction to Mobile Robots

***Syllabus***

| **Unit** | ***Content*** |
|---|---|
| 1 | • Review of Transformations,<br>• DH Convention and Kinematics, |

| | |
|---|---|
| | • Velocity kinematics and Jacobian |
| 2 | • Robot Dynamics,<br>• Motion Planning |
| 3 | • Robot control – Linear Control Techniques,<br>• Nonlinear Control Techniques |
| 4 | • Holonomic and Non-holonomic Systems,<br>• Vision based Robotic Control |
| 5 | • Mobile Robots – Modeling,<br>• Odometry Analysis |
| 6 | • Navigation with Obstacle Avoidance,<br>• Motion Capturing Systems |

***Suggested reading***

1. Mark W. Spong, Seth Huchinson and M. Vidyasagar, "Robot Modeling and Control", John Wiley and Sons, Inc., 2005
2. John J. Craig, “Introduction to Robotics: Mechanics & Control”, 3rd Edition, Prentice Hall, 2004
3. Richard Murray, A. Lee, S. Sastry, “A Mathematical Introduction to Robotic Manipulation”, CRC Press, 1994

***Course Outcomes***

Students will be able to

1. Able to design a robotic control
2. Able to apply non-linear techniques to any control problem
3. Able to model mobile robot

**PE 3: ADAPTIVE LEARNING AND CONTROL**

***Course Objectives***

1. To introduce adaptive and learning techniques for control design for uncertain dynamical systems
2. Introduction to learning based control

***Syllabus***

| **Unit** | ***Content*** |
|---|---|
| 1 | • Introduction to adaptive control,<br>• Direct and indirect adaptive control,<br>• Model reference adaptive control,<br>• Parameter convergence,Persistence of excitation |
| 2 | • Review of Lyapunov stability theory |
| 3 | • Adaptive back stepping,<br>• Adaptive control of nonlinear systems,<br>• Composite adaptation,Robust adaptive control |
| 4 | • Neural Network-based control |
| 5 | • Reinforcement learning-based control |

| | |
|---|---|
| 6 | • Repetitive learning control<br>• Predictive control,<br>• Robust adaptive control |

***Suggested reading***

1. H. K. Khalil, "Nonlinear Systems", 3rd edition, Prentice Hall, 2002
2. S. Sastry and M. Bodson, "Adaptive Control", Prentice-Hall, 1989
3. K. S. Narendra and A. M. Annaswamy, "Stable Adaptive Systems", Prentice-Hall, 1989
4.J.J.E. Slotine, and W. Li, "Applied Nonlinear Control", Prentice-Hall, 1991
5.P. Ioannou& B. Fidan, "Adaptive Control Tutorial", SIAM, Philadelpia, PA, 2006

***Course Outcomes***

Students will be able to
1. Understand detailed knowledge of classical system identification and the development and properties of various methods
2. Understand detailed knowledge of on-line parameter estimation
3. Understand knowledge of adaptive control systems and their development and properties
4. Understand knowledge of methods and tools for stability analysis of adaptive systems

**PE 4: MODEL REDUCTION IN CONTROL**

***Course Objectives***

1. Introduce the concept of model reduction of large scale dynamics models which from various engineering disciplines.
2. Introduction to model reduction in control

***Syllabus***

| **Unit** | ***Content*** |
|---|---|
| 1 | • Introduction to Model Reduction,<br>• Source of Large Models – Circuits, EM systems,<br>• Mechanical Systems |
| 2 | • Classical Model Reduction Methods – Modal reduction |
| 3 | • Pade approximation and moment matching,<br>• Routh Approximants |
| 4 | • Modern Methods - SVD (Grammian) based methods , Krylov based methods ,<br>• SVD-Krylov based methods ,<br>• MOR for Nonlinear Systems – SVD & POD Methods |
| 5 | • Model Reduction in Control |
| 6 | • Sliding Mode Control – Review,<br>• SMC as model reducing control,<br>• Higher Order Sliding Mode |

***Suggested reading***

1. A. C. Antoulas, "Approximation of Large Scale Dynamical Systems", SIAM, 2005
2. Ed. AlfioQuarteroni&GianluigiRozza, "Reduced Order Methods for Modeling and Computational Reduction", Springer, 2014
3. M. Jamshidi, "Large-scale systems: modelling & control", North Holland, New York, 1983.

4. C. Edwards and S. Spurgeon, "Sliding Mode Control : Theory and Applications", CRC Press,1998
5. B. Bandyopadhyay, S. Janardhanan and S. Spurgeon, "Advances in Sliding Mode", Springer, 2013

***Course Outcomes***

Students will be able to
1. Apply model reduction techniques for a given control design problem
2. Design control loops for all techniques
3. Know modern methods

**PE 4: ROBUST CONTROL**

***Course Objectives***
1. Introduction to control techniques with greater emphasis on robustness to modeling uncertainty
2. Introduction to parameter variations, and presence of disturbances and noise

***Syllabus***

| Unit | Content |
|---|---|
| 1 | • Modeling of uncertain systems,<br>• Signals and Norms |
| 2 | • Lyapunov theory for LTI systems |
| 3 | • Passive systems – frequency domain<br>• Passive systems – time domain |
| 4 | • Robust Stability and performance,<br>• Stabilizing controllers – Coprime factorization |
| 5 | • LQR, LQG problems, Ricatti equations and solutions,<br>• Ricatti equation solution through LMI |
| 6 | • H-infinity control and mu-synthesis,<br>• Linear matrix inequalities for robust control |

***Suggested reading***

1. L. Fortuna, M. Frasca (Eds.), "Optimal and Robust Control", CRC Press, 2012
2.K. Zhou, J. C. Doyle and K. Glover, "Robust and Optimal Control", Prentice Hall, 1996
3.J. C. Doyle, B. A. Francis and A. R. Tannenbaum, "Feedback Control Theory", Macmillan, 1992

***Course Outcomes***

Students will be able to
1. Understand LTI systems and its applications
2. Apply Lyapunov theorem for any stability problem
3. Design passive systems in frequency and time domain

**PE 4: NETWORKED AND MULTI-AGENT CONTROL SYSTEMS**

***Course Objectives***
1. To analyze and design control systems for networked and multi-agent systems
2. Understand network optimization techniques

***Syllabus***

| Unit | Content |
|---|---|

| | |
|---|---|
| 1 | • Overview of networked systems,<br>• Graph Theory Fundamentals |
| 2 | • Graph-based Network Models,<br>• Network Optimization |
| 3 | • Consensus Problem: cooperative control, leader-follower architecture |
| 4 | • Control under Communication Constraints<br>• Formation Control, Swarming and Flocking,<br>• Collision Avoidance |
| 5 | • Game Theoretic Control of Multi-Agent Systems |
| 6 | • Applications: Multi-robot/vehicle coordination, Sensor Networks,<br>• Social Networks, Smart Grids, Biological Networks |

***Suggested reading***

1. C. Godsil and G. Royle, “Algebraic Graph Theory”, Springer, 2001
2.M. Mesbahi and M. Egerstedt , “Graph Theoretic Methods in Multi-Agent Networks”, Princeton University Press, 2010
3.F. Bullo, J. Cortes, and S. Martinez, “Distributed Control of Robotic Networks”, Princeton, 2009
4.Wei Ren, Randal W. Beard, “Distributed Consensus in Multi-vehicle Cooperative Control, Communications and Control Engineering Series”, Springer-Verlag, London, 2008

***Course Outcomes***

Students will be able to

1. Understand multi-agent control systems
2. Know network optimization techniques and its applications
3. Design multi-robot or vehicle coordination systems

**PE 4: ADVANCED DIGITAL SIGNAL PROCESSING**

***Course Objectives***

1. To understand the difference between discrete-time and continuous-time signals
2. To understand and apply Discrete Fourier Transforms (DFT)

***Syllabus***

| Unit | Content |
|---|---|
| 1 | • Discrete time signals- Linear shift invariant systems- Stability and causality- Sampling of Continuous time signals<br>• Discrete time Fourier transform- Discrete Fourier series- Discrete Fourier transform- Z transform-Properties of different transforms |
| 2 | • Linear convolution using DFT- Computation of DFT Design of IIR digital filters from analog filter<br>• Impulse invariance method and Bilinear transformation method |
| 3 | • FIR filter design using window functions- Comparison of IIR and FIR digital filters- Basic IIR and FIR filter realization structures- Signal flow graph representations Quantization process and errors<br>• Coefficient quantisation effects in IIR and FIR filters |

| | |
|---|---|
| 4 | • A/D conversion noise- Arithmetic round-off errors- Dynamic range scaling-Overflow oscillations and zero Input limit cycles in IIR filters,<br>• Linear Signal Models. |
| 5 | • All pole, All zero and Pole-zero models<br>• Power spectrum estimation- Spectral analysis of deterministic signals<br>• Estimation of power spectrum of stationary random signals |
| 6 | • Optimum linear filters- Optimum signal estimation-Mean square error estimation - Optimum FIR and IIR Filters |

***Suggested reading***

1. Sanjit K Mitra, “Digital Signal Processing: A computer-based approach “,TataMc Grow-Hill Edition 1998
2. Dimitris G .Manolakis, Vinay K. Ingle and Stephen M. Kogon, “Statistical and Adaptive Signal Processing”, Mc Grow Hill international editions .-2000

***Course Outcomes***

Students will be able to

1. Gain knowledge about the time domain and frequency domain representations as well analysis of discrete time
signals and systems
2. Study the design techniques for IIR and FIR filters and their realization structures.
3. Acquire knowledge about the finite word length effects in implementation of digital filters.
4. Acquire knowledge about the various linear signal models and estimation of power spectrum of stationary random signals
5. Design of optimum FIR and IIR filters

**LAB 3 – ADVANCE CONTROL LAB 1**

| **S. No.** | **List of experiment** |
|---|---|
| 1 | State space modeling of discrete time systems and study of responses. |
| 2 | Pole placement design for regulator and tracking discrete time systems. |
| 3 | Observer design for discrete time systems |
| 4 | Design of digital kalman filter |
| 5 | Optimal control design of digital systems |
| 6 | Analysis of non linear systems using describing function method |
| 7 | Phase plane analysis of non linear systems. |

**LAB 4 – ADVANCE CONTROL LAB 2**

| **S.No.** | **List of experiment** |
|---|---|
| 1 | Characteristics of Synchros:<br>(a) Synchro transmitter characteristics. (b) Implementation of error detector using |

| | |
|---|---|
| | synchro pair. |
| 2 | Determination of Magnetic Amplifier Characteristics with different possible connections |
| 3 | To determine the time response of closed loop second order process with P Control, PI Control and PID control and to determine the effect of disturbance on a process. |
| 4 | To study the compensation of the second order process by using: (a) Lead Compensator. (b) Lag Compensator. (c) Lead- Lag Compensator |
| 5 | To determination of AC servomotor Characteristics. |
| 6 | To study the position control of DC servomotor with P, PI control actions. |

**PE 5: MODELING AND CONTROL OF DISTRIBUTED PARAMETER SYSTEMS**

***Course Objectives***

1. Introduction to modeling, analysis and control of distributed parameter systems
2. Introduction to finite discretization

***Syllabus***

| Unit | Content |
|---|---|
| 1 | • Overview: Motivation and examples (wave propagation, fluid flow, network traffic, electromagnetism) |
| 2 | • Modeling of Distributed Parameter Systems: Parabolic and Hyperbolic PDEs,Analytic and Numerical Solution of PDEs |
| 3 | • Lyapunov stability of DPS,<br>• Boundary control and Observer Design of DPS |
| 4 | • Finite Difference discretization of DPS,<br>• Finite Element discretization of DPS,<br>• Boundary Elements discretization of DPS |
| 5 | • Reduction of discretized models |
| 6 | • Applications: Control of systems with time delays, control of fluid flow, network control |

***Suggested reading***

1. MiroslavKrstic and AndreySmyshlyaev, “Boundary Control of PDEs: A Course on Backstepping Designs”, SIAM, 2008
2.Panagiotis D. Christofides, Birkhauser”Nonlinear and Robust Control of PDE Systems”, 2001
3.Hassan K. Khalil”Nonlinear Systems”, Third Edition, Prentice Hall 2002

***Course Outcomes***

Students will be able to
1. Able to mathematically model a distributed parameter system
2. Able to obtain numerical solutions for distributed parameter system
3. Able to reduce the complexity of discretized models

**PE 5: STOCHASTIC CONTROL**

***Course Objectives***
1. To understand dynamics of stochastic systems and their control strategies
2. Introduction to Filtering

***Syllabus***

| Unit | Content |
|---|---|
| 1 | • Overview of stochastic systems with examples,<br>• Modeling of Stochastic Systems: Continuous and Discrete-time models subjected to noise, Markov Decision Processes. |
| 2 | • Introduction to Stochastic Calculus and Stochastic Differential Equations |
| 3 | • Stochastic Stability , Stochastic Optimal Control with complete and partial observations,<br>• finite and infinite horizon problems |
| 4 | • Linear and Nonlinear Filtering,<br>• Separation Principle, Linear quadratic Gaussian Problem |
| 5 | • Linear and Nonlinear Filtering,<br>• Separation Principle, Linear quadratic Gaussian Problem |
| 6 | • Applications: Finance, operations research, biology |

***Suggested reading***
1. Dimitri P. Bertsekas, "Dynamic Programming and Optimal Control", Vol I (2005) ,Vol II (2012), Athena
Scientific
2. Karl J. Astrom, "Introduction to Stochastic Control Theory", Dover, 2006.
3.B. Oeksendal, "Stochastic Differential Equations: An Introduction with Applications", 2003.
4.P.R. Kumar, P. Varaiya, "Stochastic Systems: Estimation, Identification and Adaptive Control", Prentice Hall,
1986.

***Course Outcomes***
Students will be able to
1. Apply design Schotastic models for a given system
2. Design Stochastic Stability problems
3. Design linear and non-linear filtering systems

**PE 5: COMPUTATIONAL METHODS**

***Course Objectives***
1. Understand mathematical models of lower level engineering problems
2. Learn how to solve nonlinear equations numerically
3. Introduction to fundamental matrix algebra concepts
4. Solving simultaneous linear equations numerically

***Syllabus***

| Unit | *Content* |
|---|---|
| 1 | • Formulation and solution of linear system of equations, Gauss elimination, LU, QR decomposition,<br>• iteration methods (Gauss-Seidal), convergence of iteration methods, |

| | |
|---|---|
| | • Singular value decomposition and the sensitivity of rank to small perturbation |
| 2 | • Newton's divided difference, interpolation polynomials, Lagrange interpolation polynomials |
| 3 | • Non-linear regression, multiple linear regression, general linear least squares |
| 4 | • Vector spaces, Basis vectors, Orthogonal/Unitary transform,<br>• Fourier transform, Laplace transform |
| 5 | • Local and global minima, Line searches, Steepest descent method,<br>• Conjugate gradient method, Quasi Newton method, Penalty function |
| 6 | • Graphs and Matrices, simple graph, cyclic graph, complete graph, properties of the Laplacian matrix and relation with graph connectivity<br>• Non-negative matrices. Applications of graph theory to engineering problems |

***Suggested reading***

1. Steven C. Chapra and Raymond P. Canale "Numerical Methods for Engineers", , McGraw Hill
2. Hines and Montrogmery, John"Probability and Statistics in Engineering and Management Studies",
3. R. B. Bapat "Graphs and Matrices", , TRIM Series, Hindustan Book Agency, 2011

***Course Outcomes***

Students will be able to

1. Know the concept and steps of problem solving - mathematical modelling , solution and implementation
2. Knowledge and understanding of, and the ability to use, mathematical techniques
3. Understand and apply mathematical reasoning

## OPEN ELECTIVES

## Business Analytics

**Teaching scheme**

**Lecture: - 3 h/week**

| | |
|---|---|
| **Course Code** | |
| **Course Name** | **Business Analytics** |
| **Credits**<br>**Prerequisites** | |

Total Number of Lectures: 48

| **Course objective** |
|---|
| 1. Understand the role of business analytics within an organization.<br>2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.<br>3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making. |

4. To become familiar with processes needed to develop, report, and analyze business data.
5. Use decision-making tools/Operations research techniques.
6. Mange business process using analytical and management tools.
7. Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.

| **LECTURE WITH BREAKUP** | **NO. OF LECTURES** |
|---|---|
| **Unit1:**<br>Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.<br>Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview. | 9 |
| **Unit 2:**<br>Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.<br>Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology. | 8 |
| **Unit 3:**<br>Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.<br>Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization. | 9 |
| **Unit 4:**<br>Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.<br>Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using | 10 |

| | |
|---|---|
| Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model. | |
| **Unit 5:**<br>Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. | 8 |
| **Unit 6:**<br>Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism. | 4 |

| **COURSE OUTCOMES** | |
|---|---|
| | |
| 1. Students will demonstrate knowledge of data analytics.<br>2. Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.<br>3. Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.<br>**4.** Students will demonstrate the ability to translate data into clear, actionable insights. | |

**Reference:**

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

## OPEN ELECTIVES
## Industrial Safety

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**Unit-II:** Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**Unit-III:** Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**Unit-IV:** Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**Unit-V:** Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

**Reference:**


1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.


## OPEN ELECTIVES

## Operations Research

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes: At the end of the course,** the student should be able to

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

**Syllabus Contents:**

**Unit 1**:

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

**Unit 2**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

**Unit 3**:

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

**Unit 4**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

**Unit 5**

Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

**References**:


1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010


## Open Elective
## Cost Management of Engineering Projects

**Teaching scheme**

**Lecture: - 3 h/week**

Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

**References:**

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

## Open Elective
## Composite Materials

**Teaching scheme**

**Lecture: - 3 h/week**

**UNIT–I**: INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT – II**: REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

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**UNIT – III:** Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT–IV:** Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT – V:** Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

**TEXT BOOKS:**

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

**References:**

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

## Open Elective
## Waste to Energy

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**Unit-II:** Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**Unit-III:** Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**Unit-IV:** Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**Unit-V:** Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

**References:**

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

## AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING

**Course objectives:**
Students will be able to:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title

Ensure the good quality of paper at very first-time submission

**Syllabus**

| Units | CONTENTS | Hours |
|---|---|---|
| 1 | Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness | 4 |
| 2 | Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction | 4 |
| 3 | Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check. | 4 |
| 4 | key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, | 4 |

| | | |
|---|---|---|
| | skills needed when writing a Review of the Literature, | |
| 5 | skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions | 4 |
| 6 | useful phrases, how to ensure paper is as good as it could possibly be the first- time submission | 4 |

**Suggested Studies:**

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

## AUDIT 1 and 2: DISASTER MANAGEMENT

**Course Objectives: -**Students will be able to:
1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in

**Syllabus**

| **Units** | **CONTENTS** | **Hours** |
|---|---|---|
| 1 | **Introduction**<br>Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude. | 4 |
| 2 | **Repercussions Of Disasters And Hazards**: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.<br>Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts. | 4 |
| 3 | **Disaster Prone Areas In India**<br>Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics | 4 |
| 4 | **Disaster Preparedness And Management**<br>Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness. | 4 |
| 5 | **Risk Assessment** | 4 |

| | | |
|---|---|---|
| | Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival. | |
| 6 | **Disaster Mitigation**<br>Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India. | 4 |

**SUGGESTED READINGS:**

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

## AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE

***Course Objectives***

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

***Syllabus***

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Alphabets in Sanskrit,<br>• Past/Present/Future Tense,<br>• Simple Sentences | 8 |
| 2 | • Order<br>• Introduction of roots<br>• Technical information about Sanskrit Literature | 8 |
| 3 | • Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics | 8 |

***Suggested reading***

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.

***Course Output***

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

## AUDIT 1 and 2: VALUE EDUCATION

***Course Objectives***

Students will be able to

1.Understand value of education and self- development

2. Imbibe good values in students

3. Let the should know about the importance of character

***Syllabus***

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism.<br>• Moral and non- moral valuation. Standards and principles.<br>• Value judgements | 4 |
| 2 | • Importance of cultivation of values.<br>• Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness.<br>• Honesty, Humanity. Power of faith, National Unity.<br>• Patriotism.Love for nature ,Discipline | 6 |
| 3 | • Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline.<br>• Punctuality, Love and Kindness.<br>• Avoid fault Thinking.<br>• Free from anger, Dignity of labour.<br>• Universal brotherhood and religious tolerance.<br>• True friendship.<br>• Happiness Vs suffering, love for truth.<br>• Aware of self-destructive habits.<br>• Association and Cooperation.<br>• Doing best for saving nature | 6 |
| 4 | • Character and Competence –Holy books vs Blind faith.<br>• Self-management and Good health.<br>• Science of reincarnation.<br>• Equality, Nonviolence ,Humility, Role of Women.<br>• All religions and same message.<br>• Mind your Mind, Self-control.<br>• Honesty, Studying effectively | 6 |

***Suggested reading***

1 Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

***Course outcomes***

Students will be able to

1.Knowledge of self-development

2.Learn the importance of Human values

3.Developing the overall personality

## AUDIT 1 and 2: CONSTITUTION OF INDIA

**Course Objectives:**

Students will be able to:

1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| 1 | • **History of Making of the Indian Constitution:**<br>History<br>Drafting Committee, ( Composition & Working) | 4 |
| 2 | • **Philosophy of the Indian Constitution:**<br>Preamble<br>Salient Features | 4 |
| 3 | • **Contours of Constitutional Rights & Duties:**<br>• Fundamental Rights<br>• Right to Equality<br>• Right to Freedom<br>• Right against Exploitation<br>• Right to Freedom of Religion<br>• Cultural and Educational Rights<br>• Right to Constitutional Remedies<br>• Directive Principles of State Policy<br>• Fundamental Duties. | 4 |
| 4 | • **Organs of Governance:**<br>• Parliament<br>• Composition<br>• Qualifications and Disqualifications<br>• Powers and Functions<br>• Executive<br>• President<br>• Governor<br>• Council of Ministers<br>• Judiciary, Appointment and Transfer of Judges, Qualifications<br>• Powers and Functions | 4 |
| 5 | • **Local Administration:**<br>• District's Administration head: Role and Importance,<br>• Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.<br>• Pachayati raj: Introduction, PRI: Zila Pachayat.<br>• Elected officials and their roles, CEO Zila Pachayat: Position and role.<br>• Block level: Organizational Hierarchy (Different departments),<br>• Village level: Role of Elected and Appointed officials,<br>• Importance of grass root democracy | 4 |
| 6 | • **Election Commission:** | 4 |

| | | |
|---|---|---|
| | • Election Commission: Role and Functioning.<br>• Chief Election Commissioner and Election Commissioners.<br>• State Election Commission: Role and Functioning.<br>• Institute and Bodies for the welfare of SC/ST/OBC and women. | |

**Suggested reading**


1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.


**Course Outcomes:**

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

## AUDIT 1 and 2: PEDAGOGY STUDIES

**Course Objectives:**

Students will be able to:

4. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
5. Identify critical evidence gaps to guide the development.

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| 1 | • **Introduction and Methodology:**<br>• Aims and rationale, Policy background, Conceptual framework and terminology<br>• Theories of learning, Curriculum, Teacher education.<br>• Conceptual framework, Research questions.<br>• Overview of methodology and Searching. | 4 |
| 2 | • Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.<br>• Curriculum, Teacher education. | 2 |
| 3 | • Evidence on the effectiveness of pedagogical practices<br>• Methodology for the in depth stage: quality assessment of included studies.<br>• How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?<br>• Theory of change.<br>• Strength and nature of the body of evidence for effective pedagogical practices. | 4 |

| | | |
|---|---|---|
| | • Pedagogic theory and pedagogical approaches.<br>• Teachers' attitudes and beliefs and Pedagogic strategies. | |
| **4** | • Professional development: alignment with classroom practices and follow-up support<br>• Peer support<br>• Support from the head teacher and the community.<br>• Curriculum and assessment<br>• Barriers to learning: limited resources and large class sizes | 4 |
| **5** | • **Research gaps and future directions**<br>• Research design<br>• Contexts<br>• Pedagogy<br>• Teacher education<br>• Curriculum and assessment<br>• Dissemination and research impact. | 2 |

**Suggested reading**


1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.


**Course Outcomes:**

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

## AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

***Course Objectives***

1. To achieve overall health of body and mind
2. To overcome stress

***Syllabus***

| Unit | *Content* | *Hours* |
|---|---|---|
| 1 | • Definitions of Eight parts of yog. ( Ashtanga ) | 8 |
| 2 | • Yam and Niyam.<br>Do`s and Don't's in life.<br>i) Ahinsa, satya, astheya, bramhacharya and aparigraha<br>ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan | 8 |
| 3 | • Asan and Pranayam<br>i) Various yog poses and their benefits for mind & body<br>ii)Regularization of breathing techniques and its effects-Types of pranayam | 8 |

***Suggested reading***

1. 'Yogic Asanas for Group Tarining-Part-I" : Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

**Course Outcomes:**

Students will be able to:
1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

## AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS

***Course Objectives***

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

***Syllabus***

| Unit | Content | Hours |
|---|---|---|
| 1 | Neetisatakam-Holistic development of personality<br>• Verses- 19,20,21,22 (wisdom)<br>• Verses- 29,31,32 (pride & heroism)<br>• Verses- 26,28,63,65 (virtue)<br>• Verses- 52,53,59 (dont's)<br>• Verses- 71,73,75,78 (do's) | 8 |
| 2 | • Approach to day to day work and duties.<br>• Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48,<br>• Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,<br>• Chapter 18-Verses 45, 46, 48. | 8 |

| | | |
|---|---|---|
| 3 | • Statements of basic knowledge.<br>• Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68<br>• Chapter 12 -Verses 13, 14, 15, 16,17, 18<br>• Personality of Role model. Shrimad Bhagwad Geeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42,<br>• Chapter 4-Verses 18, 38,39<br>• Chapter18 – Verses 37,38,63 | 8 |

***Suggested reading***

1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath,Rashtriya Sanskrit Sansthanam, New Delhi.

***Course Outcomes***

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

# Course Scheduling for M.Tech.(Electrical Engineering), Specialization: Power Systems

| Semester 1 | | | | | | |
|---|---|---|---|---|---|---|
| Sr. No. | Core/Elective | Course Name | | | | Credits |
| | | | L | T | P | |
| 1 | Core1 | Power System Analysis | 3 | 0 | 0 | 3 |
| 2 | Core2 | Power System Dynamics-I | 3 | 0 | 0 | 3 |
| 3 | PE1 | Renewable Energy System/Smartgrids/High Power Converters /Wind and Solar Systems | 3 | 0 | 0 | 3 |
| 4 | PE2 | Electrical Power Distribution System /Mathematical Methods for Power Engineering/Pulse Width Modulation for PE Converters/Electric and Hybrid Vehicles | 3 | 0 | 0 | 3 |
| 5 | | Research Methodology and IPR | 2 | 0 | 0 | 2 |
| 6 | Lab1 | Power System Steady State Analysis Lab | 0 | 0 | 4 | 2 |
| 7 | Lab2 | Power System Dynamics Lab/Renewable Energy Lab | 0 | 0 | 4 | 2 |
| 8 | Audit-I | Audit I | 2 | 0 | 0 | 0 |
| 9 | Total Credits 18 | | | | | |

| Semester 2 | | | | | | |
|---|---|---|---|---|---|---|
| Sr. No. | Core/Elective | Course Name | | | | Credits |
| | | | L | T | P | |
| 1 | Core3 | Digital Protection of Power System | 3 | 0 | 0 | 3 |
| 2 | Core4 | Power System Dynamics-II | 3 | 0 | 0 | 3 |
| 3 | PE3 | Restructured Power Systems/Advanced Digital Signal Processing/Dynamics of Electrical Machines/Power Apparatus Design | 3 | 0 | 0 | 3 |
| 4 | PE4 | Advanced Micro-Controller Based Systems/SCADA System and Applications/Power Quality/AI Techniques | 3 | 0 | 0 | 3 |
| 5 | | Mini Project | 0 | 0 | 4 | 2 |
| 6 | Lab3 | Power System Protection Lab/Power Quality Lab | 0 | 0 | 4 | 2 |
| 7 | Lab4 | Artificial Intelligence Lab/Power Electronics Applications to Power Systems Lab/Smart Grids Lab | 0 | 0 | 4 | 2 |
| 8 | Audit-II | Audit II | 2 | 0 | 0 | 0 |
| 9 | Total Credits 18 | | | | | |

| Semester 3 |
|---|

| Sr. No. | Core/Elective | Course Name | | | | Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1 | PE5 | Power System Transients/FACTS and Custom Power Devices/Industrial Load Modeling and Control/Dynamics Of Linear Systems | 3 | 0 | 0 | 3 |
| 2 | OE | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy | 3 | 0 | 0 | 3 |
| 3 | Major Project | Phase – I Dissertation | 0 | 0 | 20 | 10 |
| 4 | Total Credits | | | | | 16 |

| **Semester 4** | | | | | | |
|---|---|---|---|---|---|---|
| Sr. No. | Core/Elective | Course Name | | | | Credits |
| | | | L | T | P | |
| 1 | Major Project | Phase-II Dissertation | 0 | 0 | 32 | 16 |
| 2 | Total Credits 16 | | | | | |

**GRAND TOTAL CREDITS 68**

**Programme Outcomes of Power Systems Stream**

**PO1**Ability to apply the enhanced knowledge in advanced technologies for modeling, analyzing and solvingcontemporary issues in power sector with a global perspective.

**PO2**Ability to critically analyze and carry out detailed investigation on multifaceted complex Problemsinarea of Power Systems and envisage advanced research in thrust areas.

**PO3**Ability to identify, analyze and solve real-life engineering problems in the area of Power Systems andprovide strategic solutions satisfying the safety, cultural, societal and environmental aspects/ needs.

**PO4**Ability for continued pursuance of research and to design, develop and propose theoretical and practicalmethodologies towards research and development support for the Power System infrastructure.

**PO5**Ability to develop and utilize modern tools for modeling, analyzing and solving various Engineeringproblems related to Power Systems.

**PO6 Willingness** and ability to work in a team of engineers/ researchers with mutual understandings to take unsophisticated challenges, in the field of Power Systems, lead

and motivate the group to inculcatemultidisciplinary and collaborative approach.
**PO7 Willingness** and ability to take up administrative challenges including the management of various projects of interdisciplinary nature and carry out the same in an efficient manner giving due considerationto societal, environmental, economical and financial factors.

**PO8 Ability** to express ideas clearly and communicate orally as well as in writing with othersin an effectivemanner, adhering to various national and international standards and practices for the documentation andpresentation of the contents.

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

**FIRST SEMESTER**
**CORE-1: POWER SYSTEM ANALYSIS**

<table>
<tr><td colspan="2">Course Objectives-<br>Students will be able to:<br>1. Study various methods of load flow and their advantages and disadvantages<br>2. Understand how to analyze various types of faults in power system<br>3. Understand power system security concepts and study the methods to rank the contingencies<br>4. Understand need of state estimation and study simple algorithms for state estimation<br>5. Study voltage instability phenomenon</td></tr>
<tr><td colspan="2" align="center">Syllabus</td></tr>
<tr><td align="center">Units</td><td align="center">Content</td></tr>
<tr><td align="center">1</td><td>• Load flow :Overview of Newton-Raphson ,Gauss-Siedel<br>• fast decoupled methods, convergence properties, sparsity techniques, handling Q-max violations in constant matrix, inclusion in frequency effects<br>• AVR in load flow, handling of discrete variable in load flow.</td></tr>
<tr><td align="center">2</td><td>• Fault Analysis: Simultaneous faults,<br>• open conductors faults,<br>• generalized method of fault analysis.</td></tr>
<tr><td align="center">3</td><td>• Security Analysis: Security state diagram, contingency analysis, generator shift distribution factors<br>• line outage distribution factor, multiple line outages,<br>• overload index ranking</td></tr>
<tr><td align="center">4</td><td>• Power System Equivalents : WARD<br>• REI.equivalents</td></tr>
<tr><td align="center">5</td><td>• State Estimation : Sources of errors in measurement<br>• Virtual and Pseudo,<br>• Measurement, Observability,<br>• Tracking state estimation,</td></tr>
</table>

| | |
|---|---|
| | • WSL method, bad data correction. |
| 6 | • Voltage Stability : Voltage collapse,<br>• P-V curve, multiple power flow solution,<br>• continuation power flow, optimal multiplies load flow,<br>• voltage collapse proximity indices. |

**Suggested reading**

1. J.J. Grainger &W.D.Stevenson, "Power system analysis ", McGraw Hill ,2003

1. A. R. Bergen & Vijay Vittal , "Power System Analysis" ,Pearson , 2000

2. L.P. Singh , "Advanced Power System Analysis and Dynamics", New Age International, 2006

3. G.L. Kusic, "Computer aided power system analysis" ,Prentice Hall India, 1986

4. A.J. Wood, " Power generation, operation and control" , John Wiley, 1994

5. P.M. Anderson, "Faulted power system analysis" , IEEE Press , 1995

**Course outcomes-**

Students will be able to:

1. Able to calculate voltage phasors at all buses , given the data using various methods of load flow
2. Able to calculate fault currents in each phase
3. Rank various contingencies according to their severity
4. Estimate the bus voltage phasors given various quantities viz. power flow, voltages, taps , CB status etc
5. Estimate closeness to voltage collapse and calculate PV curves using continuation power flow

**CORE-2: POWER SYSTEM DYNAMICS-I**

**Course Objectives**:- Students will be able to:

1. Study of system dynamics and its physical interpretation
2. Development of mathematical models for synchronous machine
3. Modeling of induction motor

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| 1 | • Synchronous Machines: Per unit systems<br>• Park's Transformation (modified)<br>• Flux-linkage equations. | 8 |
| 2 | • Voltage and current equations<br>• Formulation of State-space equations<br>• Equivalent circuit. | 8 |
| 3 | • Sub-transient and transient inductance and Time constants, Simplified models of synchronous machines | 6 |
| 4 | • Small signal model: Introduction to frequency model. | 8 |
| 5 | • Excitation systems and Philips-Heffron model<br>• PSS Load modeling. | 8 |
| 6 | • Modeling of Induction Motors<br>• Prime mover controllers. | 6 |

**Suggested reading:-**

1. P. M. Anderson & A. A. Fouad "Power System Control and Stability", Galgotia , New Delhi, 1981

2. J Machowski, J Bialek& J. R W. Bumby, "Power System Dynamics and Stability", John Wiley & Sons, 1997

3. P.Kundur, "Power System Stability and Control", McGraw Hill Inc., 1994.
4. E.W. Kimbark, "Power system stability", Vol. I & III, John Wiley & Sons, New York 2002

**Course Outcomes:**

Students will be able to:

1. Understand the modeling of synchronous machine in details
2. Carry out simulation studies of power system dynamics using MATLAB-SIMULINK, MI POWER
3. Carry out stability analysis with and without power system stabilizer (PSS)
4. Understand the load modeling in power system

**PE 1 : RENEWABLE ENERGY SYSTEM**

**Course Objectives:-** Students will be able to:

1. To learn various renewable energy sources
2. To gain understanding of integrated operation of renewable energy sources
3. To understand Power Electronics Interface with the Grid

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| 1 | • Introduction, Distributed vs Central Station Generation<br>• Sources of Energy such as Micro-turbines<br>• Internal Combustion Engines. | 8 |
| 2 | • Introduction to Solar Energy, Wind Energy, Combined Heat and Power<br>• Hydro Energy, Tidal Energy, Wave Energy<br>• Geothermal Energy, Biomass and Fuel Cells. | 8 |
| 3 | • Power Electronic Interface with the Grid | 6 |
| 4 | • Impact of Distributed Generation on the Power System<br>• Power Quality Disturbances | 8 |
| 5 | • Transmission System Operation<br>• Protection of Distributed Generators | 8 |
| 6 | • Economics of Distributed Generation<br>• Case Studies | 6 |

**Suggested reading**

1. RanjanRakesh, Kothari D.P, Singal K.C, "Renewable Energy Sources and Emerging Technologies",
2nd Ed. Prentice Hall of India ,2011
2. Math H.Bollen, Fainan Hassan, "Integration of Distributed Generation in the Power System", July 2011,
Wiley –IEEE Press
3. Loi Lei Lai, Tze Fun Chan, "Distributed Generation: Induction and Permanent Magnet Generators",
October 2007, Wiley-IEEE Press.
4.Roger A.Messenger, Jerry Ventre, "Photovoltaic System Engineering", 3rd Ed, 2010
5.James F.Manwell, Jon G.McGowan, Anthony L Rogers, "Wind energy explained: Theory Design and Application", John Wiley and Sons 2nd Ed, 2010

**Course Outcomes:-** Students will be able to:

1. Knowledge about renewable energy
2. Understand the working of distributed generation system in autonomous/grid connected modes
3. Know the Impact of Distributed Generation on Power System

## PE 1: SMART GRIDS

**Course Objectives:-** Students will be able to:

1. Understand concept of smart grid and its advantages over conventional grid
2. Know smart metering techniques
3. Learn wide area measurement techniques
4. Understanding the problems associated with integration of distributed generation & its solution through smart grid.

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| 1 | • Introduction to Smart Grid, Evolution of Electric Grid<br>• Concept of Smart Grid, Definitions<br>• Need of Smart Grid, Concept of Robust & Self Healing Grid Present development & International policies in Smart Grid | 8 |
| 2 | • Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading(AMR)<br>• Outage Management System(OMS)<br>• Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation<br>• Smart Substations, Substation Automation, Feeder Automation . | 8 |
| 3 | • Geographic Information System(GIS)<br>• Intelligent Electronic Devices(IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System(WAMS)<br>• Phase Measurement Unit(PMU) | 8 |
| 4 | • Concept of micro-grid, need & applications of micro-grid, formation of micro-grid, Issues of interconnection, protection & control of micro-grid.<br>• Plastic & Organic solar cells, Thin film solar cells, Variable speed wind generators, fuel-cells, micro-turbines<br>• Captive power plants, Integration of renewable energy sources | 8 |
| 5 | • Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources<br>• Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring<br>• Power Quality Audit | 6 |
| 6 | • Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area<br>• Network (NAN), Wide Area Network (WAN)<br>• Bluetooth, ZigBee, GPS, Wi-Fi, Wi-Max based communication,<br>• Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid<br>• Broadband over Power line (BPL)<br>• IP based protocols | 6 |

**Suggested reading**

1. Ali Keyhani, “Design of smart power grid renewable energy systems”, Wiley IEEE, 2011
2. Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”, CRC Press , 2009
3. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, “Smart Grid: Technology and Applications”, Wiley 2012
4. Stuart Borlase, “Smart Grid: Infrastructure, Technology and solutions “ CRC Press
5.A.G.Phadke, “Synchronized Phasor Measurement and their Applications”, Springer

**Course Outcomes**

Students will be able to:

1. Appreciate the difference between smart grid & conventional grid
2. Apply smart metering concepts to industrial and commercial installations
3. Formulate solutions in the areas of smart substations,distributed generation and wide area measurements
4. Come up with smart grid solutions using modern communication technologies

**PE 1 : HIGH POWER CONVERTERS**

**Course Objectives:-** Students will be able to:
1. Understand the requirements of high power rated converters
2. Understand the different topologies involved for these converters
3. Able to understand the design of protection circuits for these converters

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| 1 | • Power electronic systems<br>• An overview of PSDs, multipulse diode rectifier, multipulse<br>• SCR rectifier. | 6 |
| 2 | • Phase shifting transformers, multilevel voltage source inverters: two level voltage source inverter,<br>• cascaded<br>• H bridge multilevel inverter. | 8 |
| 3 | • Diode clamped multilevel inverters, flying capacitor multilevel inverter | 6 |
| 4 | • PWM current source inverters,<br>• DC to DC switch mode converters | 6 |
| 5 | • AC voltage controllers : Cyclo-converters, matrix converter,<br>• Power conditioners and UPS. | 8 |
| 6 | • Design aspects of converters, protection of devices and circuits | 6 |

**Suggested reading**

1. N. Mohan, T. M. Undeland and W. P. Robbins, “Power Electronics: Converter, Applications and Design”,
John Wiley and Sons, 1989
2. M.H. Rashid, “Power Electronics”, Prentice Hall of India, 1994
3. B. K .Bose, “Power Electronics and A.C. Drives”, Prentice Hall, 1986
4. Bin Wu, “High power converters and drives”, IEEE press, Wiley Enter science

**Course Outcomes:-**

Students will be able to:

1. Learn the characteristics of PSDs such as SCRs, GTOs, IGBTs and use them in practical systems
2. Knowledge of working of multi-level VSIs, DC-DC switched mode converters, cyclo-converters

and PWM techniques and the ability to use them properly
3. Acquire knowledge of power conditioners and their applications
4. Ability to design power circuit and protection circuit of PSDs and converters

**PE 1 : WIND AND SOLAR SYSTEMS**

| | | |
|---|---|---|
| **Course Objectives:-**Students will be able to:<br>1. To get exposure to wind and solar systems<br>2. To understand the factors involved in installation and commissioning of a Solar or Wind plant.<br>3. Learning the dynamics involved when interconnected with power system grid | | |
| **Syllabus** | | |
| **Units** | **Content** | **Hours** |
| 1 | • Historical development and current status<br>• characteristics of wind power generation<br>• network integration issues | 8 |
| 2 | • Generators and power electronics for wind turbines,<br>• power quality standards for wind turbines,<br>• Technical regulations for interconnections of wind farm with power systems. | 8 |
| 3 | • Isolated wind systems,<br>• reactive power and voltage control,<br>• economic aspects. | 8 |
| 4 | • Impacts on power system dynamics,<br>• power system interconnection | 8 |
| 5 | • Introduction of solar systems,<br>• merits and demerits, concentrators, various applications. | 6 |
| 6 | • Solar thermal power generation,<br>• PV power generation,<br>• Energy Storage device.<br>• Designing the solarsystem for small installations. | 6 |

**Suggested reading**

1. Thomas Ackermann, Editor, “Wind power in Power Systems”, John Willy and sons ltd.2005
2. Siegfried Heier, “Grid integration of wind energy conversion systems”, John Willy and sons ltd., 2006
3. K. Sukhatme and S.P. Sukhatme, “Solar Energy”. Tata MacGraw Hill, Second Edition, 1996

**Course Outcomes:-**

Students will be able to:
1. Appreciate the importance of energy growth of the power generation from the renewable energy sources and participate in solving these problems
2. Demonstrate the knowledge of the physics of wind power and solar power generation and all associated issues so as to solve practical problems
3. Demonstrate the knowledge of physics of solar power generation and the associated issues
4. Identify, formulate and solve the problems of energy crises using wind and solar energy

**PE 2: ELECTRIC POWER DISTRIBUTION SYSTEM**

| |
|---|
| **Course Objectives:-**Students will be able to:<br>1. Learning about power distribution system<br>2. Learning of SCADA System<br>3. Understanding Distribution Automation |

| Syllabus | | |
|---|---|---|
| **Units** | **Content** | **Hours** |
| 1 | • Distribution of Power, Management, Power Loads,<br>• Load Forecasting Short-term & Long-term,<br>• Power System Loading, Technological Forecasting. | 8 |
| 2 | • Advantages of Distribution Management System (D.M.S.) Distribution Automation: Definition,<br>• Restoration / Reconfiguration of Distribution Network, Different Methods and Constraints<br>• Power Factor Correction | 8 |
| 3 | • Interconnection of Distribution,<br>• Control & Communication Systems,<br>• Remote Metering,<br>• Automatic Meter Reading and its implementation | 8 |
| 4 | • SCADA: Introduction, Block Diagram,<br>• SCADA Applied To Distribution Automation.<br>• Common Functions of SCADA,<br>• Advantages of Distribution Automation through SCADA | 8 |
| 5 | • Calculation of Optimum Number of Switches, Capacitors, Optimum Switching Device Placement in Radial,<br>• Distribution Systems, Sectionalizing Switches – Types, Benefits,<br>• Bellman's Optimality Principle,<br>• Remote Terminal Units,<br>• Energy efficiency in electrical distribution & Monitoring | 6 |
| 6 | • Maintenance of Automated Distribution Systems<br>• Difficulties in Implementing Distribution.<br>• Automation in Actual Practice, Urban/Rural Distribution, Energy Management, AI techniques applied to Distribution Automation | 6 |

**Suggested reading**

1. A.S. Pabla, " Electric Power Distribution", Tata McGraw Hill Publishing Co. Ltd., Fourth Edition.
2. M.K. Khedkar, G.M. Dhole, "A Text Book of Electrical power Distribution Automation", University Science Press, New Delhi
3. Anthony J Panseni, "Electrical Distribution Engineering", CRC Press
4. James Momoh, "Electric Power Distribution, automation, protection & control", CRC Press

**Course Outcomes :-**Students will be able to:
1. Knowledge of power distribution system
2. Study of Distribution automation and its application in practice
3. To learn SCADA system

### PE 2: MATHEMATICAL METHODS FOR POWER ENGINEERING

| **Course Objectives: -**Students will be able to:<br>1. To understand the relevance of mathematical methods to solve engineering problems.<br>2. To understand how to apply these methods for a given engineering problem. | | |
|---|---|---|
| Syllabus | | |
| **Units** | **Content** | **Hours** |
| 1 | • Vector spaces,<br>• Linear transformations | 6 |

| | | |
|---|---|---|
| | • Matrix representation of linear transformation | |
| 2 | • Eigen values and Eigen vectors of linear operator | 6 |
| 3 | • Linear Programming Problems<br>• Simplex Method<br>• Duality<br>• Non Linear Programming problems | 8 |
| 4 | • Unconstrained Problems<br>• Search methods<br>• Constrained Problems | 8 |
| 5 | • Lagrange method<br>• Kuhn-Tucker conditions<br>• Random Variables<br>• Distributions | 8 |
| 6 | • Independent Random Variables<br>• Marginal and Conditional distributions<br>• Elements of stochastic processes | 8 |

**Suggested reading**

1. Kenneth Hoffman and Ray Kunze, "Linear Algebra", 2nd Edition, PHI, 1992
2. Erwin Kreyszig, "Introductory Functional Analysis with Applications", John Wiley & Sons, 2004
3. Irwin Miller and Marylees Miller, John E. Freund's "Mathematical Statistics", 6th Edn, PHI, 2002
4. J. Medhi, "Stochastic Processes", New Age International, New Delhi., 1994
5. A Papoulis, "Probability, Random Variables and Stochastic Processes", 3rd Edition, McGraw Hill, 2002
6. John B Thomas, "An Introduction to Applied Probability and Random Processes", John Wiley, 2000
7. Hillier F S and Liebermann G J, "Introduction to Operations Research", 7th Edition, McGraw Hill, 2001
8. Simmons D M, "Non Linear Programming for Operations Research", PHI, 1975

**Course Outcomes: -**

Students will be able to:

1. Knowledge about vector spaces, linear transformation, eigenvalues and eigenvectors of linear operators
2. To learn about linear programming problems and understanding the simplex method for solving linear programming problems in various fields of science and technology
3. Acquire knowledge about nonlinear programming and various techniques used for solving constrained and unconstrained nonlinear programming problems
4. Understanding the concept of random variables, functions of random variable and their probability distribution
5. Understand stochastic processes and their classification

## PE 2 : PULSE WIDTH MODULATION FOR PE CONVERTERS

**Course Objectives:-**Students will be able to:

1. To understand Necessity and Importance of PWM techniques
2. Implementation of PWM controllers

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| 1 | • Introduction to PE converters | 8 |

| | | |
|---|---|---|
| | • Modulation of one inverter phase leg<br>• Modulation of single phase<br>• VSI and 3 phase VSI | |
| 2 | • Zero space vector placement modulation strategies<br>• Losses-Discontinuous modulation<br>• Modulation of CSI | 8 |
| 3 | • Over modulation of converters<br>• programme modulation strategies | 8 |
| 4 | • Pulse width modulation for multilevel inverters<br>• Implementation of modulation controller | 8 |
| 5 | • Continuing developments in modulation as random PWM<br>• PWM for voltage unbalance | 6 |
| 6 | • Effect of minimum pulse width and dead time | 6 |

**Suggested reading**

1. D. Grahame Holmes, Thomas A. Lipo, "Pulse width modulation of Power Converter: Principles and Practice", John Wiley & Sons, 03-Oct-2003
2. Bin Vew, "High Power Converter", Wiley Publication
3. Marian K. Kazimicrczuk, "Pulse width modulated dc-dc power converter", Wiley Publication

**Course Outcomes :-**Students will be able to:

1.Appreciate importance of PWM techniques
2.Implement PWM using different strategies
3.Control CSI and VSI using PWM
4.Compare performance of converter for different PWM techniques

## PE 2 : ELECTRIC AND HYBRID VECHILES

**Course Objectives:-**Students will be able to:
1. To understand upcoming technology of hybrid system
2. To understand different aspects of drives application
3. Learning the electric Traction

| Units | Content | Hours |
|---|---|---|
| | **Syllabus** | |
| 1 | • History of hybrid and electric vehicles,<br>• Social and environmental importance of hybrid and electric vehicles<br>• Impact of modern drive-trains on energy supplies<br>• Basics of vehicle performance, vehicle power source characterizationTransmission characteristics<br>• Mathematical models to describe vehicle performance | 8 |
| 2 | • Basic concept of hybrid traction,<br>• Introduction to various hybrid drive-train topologies<br>• Power flow control in hybrid drive-train topologies<br>• Fuel efficiency analysis. | 8 |
| 3 | • Basic concept of hybrid traction,<br>• Introduction to various hybrid drive-train topologies<br>• Power flow control in hybrid drive-train topologies<br>• Fuel efficiency analysis. | 8 |

| | | |
|---|---|---|
| 4 | • Introduction to electric components used in hybrid and electric vehicles<br>• Configuration and control of DC Motor drives<br>• Configuration and control of Introduction Motor drives configuration and control of Permanent Magnet Motor drives Configuration and control of Switch Reluctance<br>• Motor drives, drive system efficiency | 8 |
| 5 | • Matching the electric machine and the internal combustion engine (ICE)<br>• Sizing the propulsion motor, sizing the power electronics Selecting the energy storage technology<br>• Communications, supporting subsystems | 8 |
| 6 | • Introduction to energy management and their strategies used in hybrid and electric vehicle<br>• Classification of different energy management strategies Comparison of different energy management strategies Implementation issues of energy strategies | 6 |

**Suggested reading**

1.Sira -Ramirez, R. Silva Ortigoza, "Control Design Techniques in Power Electronics Devices", Springer.

2. Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, "Sliding mode control of switching Power Converters"

**Course Outcomes :-**

Students will be able to:

1. Acquire knowledge about fundamental concepts, principles, analysis and design of hybrid and electric vehicles.
2. To learn electric drive in vehicles / traction.

**LAB 1- POWER SYSTEM STEADY STATE ANALYSIS LAB**

| S.No | Experiments | Hours |
|---|---|---|
| 1 | Power Systems & Power Electronics Lab | |
| 2 | Computer Simulation Lab | |
| 3 | Simulation of IGBT Inverters. | |
| 4 | Simulation of Thyristor Converters. | |
| 5 | Transient Stability Studies. | |
| 6 | Short Circuit Studies. | |
| 7 | Load Flow Studies | |
| 8 | Load Forecasting and Unit Commitment | |

**LAB2- POWER SYSTEM DYNAMICS LAB/RENEWABLE ENERGY LAB**

**List of experiments:**

| S.No | Experiments |
|---|---|
| 1 | Power Curves |
| 2 | Build a Wind Farm |

| | |
|---|---|
| 3 | Test the Capabilities of the Hydrogen Fuel Cells and Capacitors |
| 4 | Effect of Temperature on Solar Panel Output |
| 5 | Variables Affecting Solar Panel Output |
| 6 | Effect of Load on Solar Panel Output |
| 7 | Wind Turbine Output: The Effect of Load |
| 8 | Test the Capabilities of Solar Panels and Wind Turbines |

## Research Methodology and IPR

**Teaching Scheme**

Lectures: 1hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.
-

**Syllabus Contents:**

**Unit 1:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Unit 2:** Effective literature studies approaches, analysis

Plagiarism, Research ethics,

**Unit 3:** Effective technical writing, how to write report, Paper

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**Unit 4:** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Unit 5:** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Unit 6:** New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

**References:**


- Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’”
- Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
- Ranjit Kumar, 2nd Edition , “Research Methodology: A Step by Step Guide for beginners”
- Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
- Mayall , “Industrial Design”, McGraw Hill, 1992.
- Niebel , “Product Design”, McGraw Hill, 1974.
- Asimov , “Introduction to Design”, Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.
- T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008


**SECOND SEMESTER**

**CORE - 3 : DIGITAL PROTECTION OF POWER SYSTEM**

**Course Objectives:-**Students will be able to:

1. Study of numerical relays
2. Developing mathematical approach towards protection
3. Study of algorithms for numerical protection

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| 1 | • Evolution of digital relays from electromechanical relays<br>• Performance and operational characteristics of digital protection | 6 |
| 2 | • Mathematical background to protection algorithms<br>• Finite difference techniques | 6 |
| 3 | • Interpolation formulae<br>• Forward, backward and central difference interpolation<br>• Numerical differentiation<br>• Curve fitting and smoothing<br>• Least squares method<br>• Fourier analysis<br>• Fourier series and Fourier transform<br>• Walsh function analysis | 8 |
| 4 | • Basic elements of digital protection<br>• Signal conditioning: transducers, surge protection, analog filtering, analog multiplexers<br>• Conversion subsystem: the sampling theorem, signal aliasing | 8 |

| | | |
|---|---|---|
| | • Error, sample and hold circuits, multiplexers, analog to digital conversion<br>• Digital filtering concepts,<br>• The digital relay as a unit consisting of hardware and software | |
| 5 | • Sinusoidal wave based algorithms<br>• Sample and first derivative (Mann and Morrison) algorithm.<br>• Fourier and Walsh based algorithms | 8 |
| 6 | • Fourier Algorithm: Full cycle window algorithm, fractional cycle window algorithm.<br>• Walsh function based algorithm.<br>• Least Squares based algorithms. Differential equation based algorithms.<br>• Traveling Wave based Techniques.<br>• Digital Differential Protection of Transformers.<br>• Digital Line Differential Protection.<br>• Recent Advances in Digital Protection of Power Systems. | 8 |

**Suggested reading**

1. A.G. Phadke and J. S. Thorp, "Computer Relaying for Power Systems", Wiley/Research studies Press, 2009

2. A.T. Johns and S. K. Salman, "Digital Protection of Power Systems", IEEE Press,1999
3. Gerhard Zeigler, "Numerical Distance Protection", Siemens Publicis Corporate Publishing, 2006
4.S.R.Bhide "Digital Power System Protection" PHI Learning Pvt.Ltd.2014

**Course Outcomes:-**

Students will be able to:
1. Learn the importance of Digital Relays
2. Apply Mathematical approach towards protection
3. Learn to develop various Protection algorithms

**CORE - 4:POWER SYSTEM DYNAMICS-II**

| | | |
|---|---|---|
| **Course Objectives:-**Students will be able to:<br>1. Study of power system dynamics<br>2. Interpretation of power system dynamic phenomena<br>3. Study of various forms of stability | | |
| **Syllabus** | | |
| **Units** | **Content** | **Hours** |
| 1 | • Basic Concepts of Dynamic Systems and Stability Definition<br>• Small Signal Stability (Low Frequency Oscillations) of Unregulated and Regulated System | 8 |
| 2 | • Effect of Damper, Flux Linkage Variation and AVR | 8 |
| 3 | • Large Signal Rotor Angle Stability<br>• Dynamic Equivalents And Coherency<br>• Direct Method of Stability Assessment<br>• Stability Enhancing Techniques<br>• Mitigation Using Power System Stabilizer | 8 |
| 4 | • Asynchronous Operation and Resynchronization<br>• Multi-Machine Stability | 6 |
| 5 | • Dynamic Analysis of Voltage Stability | 6 |

| | | |
|---|---|---|
| | • Voltage Collapse | |
| 6 | • Frequency Stability<br>• Automatic Generation Control<br>• Primary and Secondary Control<br>• Sub-Synchronous Resonance and Counter Measures | 8 |

**Suggested reading**

1. P. Kundur, "Power System Stability and Control", McGraw Hill Inc, 1994
2. J. Machowski, Bialek, Bumby, "Power System Dynamics and Stability", John Wiley & Sons, 1997

3. L. Leonard Grigsby (Ed.); "Power System Stability and Control", Second edition, CRC Press, 2007
4. V. Ajjarapu, "Computational Techniques for voltage stability assessment & control"; Springer, 2006

**Course Outcomes:-**
Students will be able to:
1. Gain valuable insights into the phenomena of power system including obscure ones.
2. Understand the power system stability problem.
3. Analyze the stability problems and implement modern control strategies.
4. Simulate small signal and large signal stability problems.

**PE 3: RESTRUCTURED POWER SYSTEMS**

**Course Objectives: -**Students will be able to:
1. Understand what is meant by restructuring of the electricity market
2. Understand the need behind requirement for deregulation of the electricity market
3. Understand the money, power & information flow in a deregulated power system

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| 1 | • Fundamentals of restructured system<br>• Market architecture<br>• Load elasticity<br>• Social welfare maximization | 8 |
| 2 | • OPF: Role in vertically integrated systems and in restructured markets<br>• congestion management | 8 |
| 3 | • Optimal bidding<br>• Risk assessment<br>• Hedging<br>• Transmission pricing<br>• Tracing of power | 8 |
| 4 | • Ancillary services<br>• Standard market design<br>• Distributed generation in restructured markets | 8 |
| 5 | • Developments in India<br>• IT applications in restructured markets | 6 |
| 6 | • Working of restructured power systems<br>• PJM, Recent trends in Restructuring | 6 |

**Suggested reading**

1. LorrinPhilipson, H. Lee Willis, “Understanding electric utilities and de-regulation”, Marcel Dekker Pub.,1998.
2. Steven Stoft, “Power system economics: designing markets for electricity”, John Wiley and Sons, 2002.
3. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, “Operation of restructured power systems”, Kluwer Academic Pub., 2001.
4. Mohammad Shahidehpour, MuwaffaqAlomoush, “Restructured electrical power systems: operation, trading and volatility”, Marcel Dekker.

**Course Outcomes:** -Students will be able to:

1. Describe various types of regulations in power systems.
2. Identify the need of regulation and deregulation.
3. Define and describe the Technical and Non-technical issues in Deregulated Power Industry.
4. Identify and give examples of existing electricity markets.
5. Classify different market mechanisms and summarize the role of various entities in the market.

**PE 3:ADVANCED DIGITAL SIGNAL PROCESSING**

**Course Objectives:** -Students will be able to:
1. To understand the difference between discrete-time and continuous-time signals
2. To understand and apply Discrete Fourier Transforms (DFT)

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| 1 | • Discrete time signals<br>• Linear shift invariant systems-<br>• Stability and causality<br>• Sampling of continuous time signals-<br>• Discrete time Fourier transform- Discrete Fourier series- Discrete Fourier transform<br>• Z transform-Properties of different transforms | 8 |
| 2 | • Linear convolution using DFT<br>• Computation of DFT Design of IIR digital filters from analog filters<br>• Impulse invariance method<br>• Bilinear transformation method | 8 |
| 3 | • FIR filter design using window functions<br>• Comparison of IIR and FIR digital filters<br>• Basic IIR and FIR filter realization structures<br>• Signal flow graph representations Quantization process and errors<br>• Coefficient quantisation effects in IIR and FIR filters | 8 |
| 4 | • A/D conversion noise- Arithmetic round-off errors<br>• Dynamic range scaling<br>• Overflow oscillations and zeroInput limit cycles in IIR filters<br>• Linear Signal Models | 8 |
| 5 | • All pole, All zero and Pole-zero models<br>• Power spectrum estimation- Spectral analysis of deterministic signals.<br>• Estimation of power spectrum of stationary random signals | 6 |
| 6 | • Optimum linear filters<br>• Optimum signal estimation<br>• Mean square error estimation | 6 |

| | | |
|---|---|---|
| | • Optimum FIR and IIR Filters | |

**Suggested reading**

1. Sanjit K Mitra, "Digital Signal Processing: A computer-based approach ",TataMc Grow-Hill Edition1998
2. Dimitris G .Manolakis, Vinay K. Ingle and Stephen M. Kogon, "Statistical and Adaptive Signal Processing", Mc Grow Hill international editions. -2000

**Course Outcomes:-**

Students will be able to:

1. Knowledge about the time domain and frequency domain representations as well analysis of discrete time signals and systems
2. Study the design techniques for IIR and FIR filters and their realization structures.
3. Acquire knowledge about the finite word length effects in implementation of digital filters.
4. Knowledge about the various linear signal models and estimation of power spectrum of stationary random signals
5. Design of optimum FIR and IIR filters

## PE 3: DYNAMICS OF ELECTRICAL MACHINES

**Course objective:** -Students will be able to-
1. Learn Performance characteristics of machine
2. To understand the dynamics of the machine
3. To understand how to determine stability of machine
4. Learn the synchronous machine

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| 1 | • Stability,Primitive 4 Winding Commutator Machine<br>• Commutator Primitive Machine<br>• Complete Voltage Equation of Primitive 4 Winding Commutator Machine | 8 |
| 2 | • Torque EquationAnalysis of Simple DC Machines using the Primitive Machine Equations<br>• The Three Phase Induction Motor.<br>• Transformed Equations<br>• Different Reference Frames for Induction Motor Analysis Transfer Function Formulation | 8 |
| 3 | • Three Phase Salient Pole Synchronous Machine<br>• Parks Transformation, Steady State Analysis | 8 |
| 4 | • Large Signal Transient<br>• Small Oscillation Equations in State Variable form<br>• Dynamical Analysis of Interconnected Machines | 8 |
| 5 | • Large Signal Transient Analysis using Transformed Equations<br>• DC Generator /DC Motor System | 6 |
| 6 | • Alternator /Synchronous Motor System | 6 |

**Suggested reading**

1. D.P. Sengupta& J.B. Lynn," Electrical Machine Dynamics", The Macmillan Press Ltd. 1980
2. R Krishnan "Electric Motor Drives, Modeling, Analysis, and Control", Pearson Education., 2001
3. P.C. Kraus, "Analysis of Electrical Machines", McGraw Hill Book Company,1987

4. I. Boldia& S.A. Nasar,,"Electrical Machine Dynamics", The Macmillan Press Ltd. 1992
5. C.V. Jones, "The Unified Theory of Electrical Machines", Butterworth, London. 1967

**Course Outcomes: -**
Students will be able to:
1:Formulation of electrodynamic equations of all electric machines and analyze the performance characteristics
2: Knowledge of transformations for the dynamic analysis of machines
3: Knowledge of determination of stability of the machines under small signal and transient conditions
4: Study about synchronous machine

## PE 3 : POWER APPARTUS DESIGN

**Course Objectives: -**Students will be able to:
1. Study the modelling analysis of rotating machine.
2. Learning electromagnetic energy conversion
3. To know about rating of machines.

**SYLLABUS**

| Units | Content | Hours |
|---|---|---|
| 1 | • Principles of Design of Machines -Specific loadings, choice of magnetic and electric loadings<br>• Real and apparent flux densities, temperature rise calculation, Separation of main dimension for DC machines<br>• Induction machines and synchronous machines<br>• Design of Transformers-General considerations, output equation, emf per turn, choice of flux density and current density, main dimensions, leakage reactance and conductor size, design of tank and cooling | 8 |
| 2 | • Specific loadings, choice of magnetic and electric loadings Real and apparent flux -densities, temperature rise calculation<br>• Separation of main dimension for DC machines<br>• Induction machines and synchronous machines<br>• Heating and cooling of machines, types of ventilation, continuous and intermittent rating | 8 |
| 3 | • General considerations, output equation, emf per turn, choice of flux density and current density, main dimensions, leakage reactance and conductor size, design of tank and cooling tubes<br>• Calculation of losses, efficiency and regulation<br>• Forces winding during short circuit | 8 |
| 4 | • General considerations, output equation<br>• Choice of specific electric and magnetic loadings, efficiency, power factor<br>• Number of slots in stator and rotor<br>• Elimination of harmonic torques | 8 |
| 5 | • Design of stator and rotor winding, slot leakage flux<br>• Leakage reactance, equivalent resistance of squirrel cage rotor, Magnetizing current, efficiency from design data | 6 |

| | | |
|---|---|---|
| 6 | • Types of alternators, comparison, specific loadings, output co-efficient, design of main dimensions<br>• Introduction to Computer Aided Electrical Machine Design Energy efficient machines | 6 |

**Suggested reading**

1. Clayton A.E, "The Performance and Design of D.C. Machines", Sir I. Pitman & sons, Ltd.
2. M.G. Say, "The Performance and Design of A.C. Machines ", Pitman
3. Sawhney A.K, "A course in Electrical Machine Design", DhanpatRai & Sons, 5th Edition

**Course Outcomes: -**

Students will be able to:

1. To give a systematic approach for modeling and analysis of all rotating machines under both transient and steady state conditions with the dimensions and material used
2. Ability to model and design all types of rotation machines including special machines

**PE4 : ADVANCED MICRO-CONTROLLER BASED SYSTEMS**

**Course Objectives:-**Students will be able to:

1. To understand the architecture of advance microcontrollers
2. To understand the applications of these controllers
3. To get some introduction to FPGA

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| 1 | • Basic Computer Organization<br>• Accumulator based Processes-Architecture<br>• Memory Organization-I/O Organization | 8 |
| 2 | • Micro-Controllers-Intel 8051,<br>• Intel 8056- Registers, Memories<br>• I/O Ports, Serial Communication<br>• Timers, Interrupts, Programming | 8 |
| 3 | • Intel 8051 – Assembly language programming<br>• Addressing-Operations<br>• Stack & Subroutines<br>• Interrupts-DMA | 8 |
| 4 | • PIC 16F877- Architecture Programming<br>• Interfacing Memory/ I/O Devices<br>• Serial I/O and data communication | 8 |
| 5 | • Digital Signal Processor (DSP)<br>• Architecture – Programming<br>• Introduction to FPGA | 6 |
| 6 | • Microcontroller development for motor control applications<br>• Stepper motor control using micro controller | 6 |

**Suggested reading**

1. John.F.Wakerly: "Microcomputer Architecture and Programming", John Wiley and Sons 1981
2. Ramesh S.Gaonker: "Microprocessor Architecture, Programming and Applications with the 8085",

Penram International Publishing (India), 1994
3. Raj Kamal: “The Concepts and Features of Microcontrollers”, Wheeler Publishing, 2005
4. Kenneth J. Ayala, “The 8051 microcontroller”, Cengage Learning, 2004
5. John Morton,” The PIC microcontroller: your personal introductory course”, Elsevier, 2005
6. Dogan Ibrahim,” Advanced PIC microcontroller projects in C: from USB to RTOS with the PIC18F
Series”, Elsevier, 2008
7. Microchip datasheets for PIC16F877

**Course Outcomes: -**

Students will be able to:
1. To learn how to program a processor in assembly language and develop an advanced processorbased system
2. To learn configuring and using different peripherals in a digital system
3. To compile and debug a Program
4. To generate an executable file and use it

**PE 4 : SCADA SYSTEM AND APPLICATIONS**

**Course Objectives:-**Students will be able to:
1. To understand what is meant by SCADA and its functions
2. To know SCADA communication
3. To get an insight into its application

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| 1 | • Introduction to SCADA<br>• Data acquisition systems<br>• Evolution of SCADA<br>• Communication technologies | 8 |
| 2 | • Monitoring and supervisory functions<br>• SCADA applications in Utility Automation<br>• Industries SCADA | 6 |
| 3 | • Industries SCADA System Components<br>• Schemes- Remote Terminal Unit (RTU)<br>• Intelligent Electronic Devices(IED)<br>• Programmable Logic Controller (PLC)<br>• Communication Network, SCADA Server, SCADA/HMI Systems | 8 |
| 4 | • SCADA Architecture<br>• Various SCADA architectures, advantages and disadvantages of each system<br>• single unified standard architecture -IEC 61850. | 8 |
| 5 | • SCADA Communication<br>• various industrial communication technologies<br>• wired and wireless methods and fiber optics<br>• Open standard communication protocols | 8 |
| 6 | • SCADA Applications: Utility applications<br>• Transmission and Distribution sector operations, monitoring, analysis and improvement<br>• Industries - oil, gas and water | 6 |

| | | |
|---|---|---|
| | • Case studies, Implementation, Simulation Exercises | |

**Suggested reading**


1. Stuart A. Boyer: "SCADA-Supervisory Control and Data Acquisition", Instrument Society of America
Publications,USA,2004
2. Gordon Clarke, Deon Reynders: "Practical Modern SCADA Protocols: DNP3, 60870.5 and Related
Systems", Newnes Publications, Oxford, UK,2004
3. William T. Shaw, "Cybersecurity for SCADA systems", PennWell Books, 2006
4. David Bailey, Edwin Wright, "Practical SCADA for industry", Newnes, 2003
5. Michael Wiebe, "A guide to utility automation: AMR, SCADA, and IT systems for electric power", PennWell 1999


**Course Outcomes:-**

Students will be able to:
1Describe the basic tasks of Supervisory Control Systems (SCADA) as well as their typical applications
2Acquire knowledge about SCADA architecture, various advantages and disadvantages of each system
3 Knowledge about single unified standard architecture IEC 61850
4: To learn about SCADA system components: remote terminal units, PLCs, intelligent electronic devices, HMI systems, SCADA server
6: Learn and understand about SCADA applications in transmission and distribution sector, industries etc

## PE 4: POWER QUALITY

**Course Objectives: -**Students will be able to:
1. Understand the different power quality issues to be addressed
2. Understand the recommended practices by various standard bodies like IEEE,IEC, etc on voltage& frequency, harmonics
3. Understanding STATIC VAR Compensators

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| 1 | • Introduction-power quality-voltage quality-overview of power quality phenomena<br>• classification of power quality issues-power quality measures and standards-THD-TIF-DIN-C<br>• message weights-flicker factor transient phenomena-occurrence of power quality problems<br>• power acceptability curves-IEEE guides, standards and recommended practices. | 8 |
| 2 | • Harmonics-individual and total harmonic distortion<br>• RMS value of a harmonic waveform-<br>• Triplex harmonics-important harmonic introducing devices-SMPS-<br>• Three phase power converters-<br>• arcing devices saturable devices-harmonic distortion of fluorescent lamps-effect of power system harmonics on power system equipment and loads. | 8 |
| 3 | • Modeling of networks and components under non-sinusoidal | 8 |

| | | |
|---|---|---|
| | conditions transmission and distribution systems<br>• Shunt capacitors-transformers-electric machines-ground<br>• systems loads that cause power quality problems<br>• power quality problems created by drives and its impact on drive | |
| 4 | • Power factor improvement- Passive Compensation<br>• Passive Filtering , Harmonic<br>• Resonance<br>• Impedance Scan Analysis- Active Power Factor Corrected Single Phase Front End,<br>• Control Methods for Single Phase APFC<br>• Three Phase APFC and Control Techniques, PFC<br>• Based on Bilateral Single Phase and Three Phase Converter | 8 |
| 5 | • Static VAR compensators-SVC and STATCOM Active Harmonic Filtering-Shunt Injection<br>• Filter for single phase, three-phase three-wire and three-phase four-wire systems<br>• d-q domain control of three phase shunt active filters uninterruptible power supplies constant voltage<br>• transformers<br>• series active power filtering techniques for harmonic cancellation and isolation. | 8 |
| 6 | • Dynamic Voltage Restorers for sag , swell and flicker problems. Grounding and wiring introduction<br>• NEC grounding requirements-reasons for grounding<br>• typical grounding and wiring problems solutions to grounding and wiring problems | 8 |

**Suggested reading**

1. G.T. Heydt, “Electric power quality”, McGraw-Hill Professional, 2007
2. Math H. Bollen, “Understanding Power Quality Problems”, IEEE Press, 2000
3. J. Arrillaga, “Power System Quality Assessment”, John wiley, 2000
4. J. Arrillaga, B.C. Smith, N.R. Watson & A. R.Wood ,”Power system Harmonic Analysis”, Wiley, 1997

**Course Outcomes: -**

Students will be able to:
1: Acquire knowledge about the harmonics, harmonic introducing devices and effect of harmonics on system equipment and loads
2: To develop analytical modeling skills needed for modeling and analysis of harmonics in networks and components
3: To introduce the student to active power factor correction based on static VAR compensators and its control techniques
4: To introduce the student to series and shunt active power filtering techniques for harmonics.

**PE 4 – ARTIFICIAL INTELLIGENCE TECHNIQUES**

| |
|---|
| **Course Objectives:-**Students will be able to:<br>1. Understanding fuzzy logic, ANN<br>2. Understanding GA & EP |

| Syllabus | | |
|---|---|---|
| **Units** | **Content** | **Hours** |
| 1 | • Biological foundations to intelligent Systems<br>• Artificial Neural Networks, Single layer and Multilayer Feed Forward NN<br>• LMS and Back Propagation Algorithm<br>• Feedback networks and Radial Basis Function Networks | 8 |
| 2 | • Fuzzy Logic<br>• Knowledge Representation and Inference Mechanism<br>• Defuzzification Methods | 8 |
| 3 | • Fuzzy Neural Networks<br>• some algorithms to learn the parameters of the network like GA | 8 |
| 4 | System Identification using Fuzzy and Neural Network | 6 |
| 5 | • Genetic algorithm<br>• Reproduction cross over, mutation<br>• Introduction to evolutionary program | 8 |
| 6 | Applications of above mentioned techniques to practical problems | 6 |

**Suggested reading**


1. J M Zurada , “An Introduction to ANN”,Jaico **Publishing** House
2. Simon Haykins, “Neural Networks”, Prentice Hall
3. Timothy Ross, “Fuzzy Logic with Engg.Applications”, McGraw. Hill
4. Driankov, Dimitra, “An Introduction to Fuzzy Control”, Narosa Publication
5. Golding, “Genetic Algorithms”, Addison-Wesley **Publishing** Com


**Course Outcomes: -**

Students will be able to:

1. Learn the concepts of biological foundations of artificial neural networks
2. Learn Feedback networks and radial basis function networks and fuzzy logics
3. Identifications of fuzzy and neural network
4. Acquire the knowledge of GA

**LAB 3-POWER SYSTEM PROTECTION LAB /POWER QUALITY LAB**

| S.No | **List of experiments:** |
|---|---|
| 1 | Introduction to Power System Protection |
| 2 | Impact of Induction Motor Starting on Power System |
| 3 | Modelling of Differential Relay using MATLAB |
| 4 | Radial Feeder Protection |
| 5 | Parellel Feeder Protection |
| 6 | Principle of Reverse Power Protection |
| 7 | Differential Protection of Transformer |
| 8 | To the study time vs.voltage characteristcs of over voltage induction relay |

**LAB 4- ARTIFICIAL INTELLIGENCE/POWER ELECTRONICS/APPLICATIONTO POWER SYSTEM LAB/SMART GRID LAB**

| S. No | **List of experiments:** |
|---|---|
| 1 | Write A Program For Best First Search |
| 2 | Write A Program to Generate the output for A* Algorithm. |

| | |
|---|---|
| 3 | Write a Program To Show the Tic Tac Toe Game for 0 and X. |
| 4 | Write A Program For Expert System By Using Forward Chaining. |
| 5 | Comparing the Search Methods |
| 6 | Implement the Greedy Search Algorithm |
| 7 | Implement the min-max Algorithm |
| 8 | Adding a Heuristic |

**THIRD SEMESTER**

**PE 5: POWER SYSTEM TRANSIENTS**

**Course Objectives: -**Students will be able to:
1. Learn the reasons for occurrence of transients in a power system
2. Understand the change in parameters like voltage & frequency during transients
3. To know about the lightning phenomenon and its effect on power system

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| 1 | • Fundamental circuit analysis of electrical transients<br>• Laplace Transform method of solving simple Switching transients<br>• Damping circuits -Abnormal switching transients, Three-phase circuits and transients<br>• Computation of power system transients | 8 |
| 2 | • Principle of digital computation – Matrix method of solution<br>• Modal analysis- Z transform- Computation using EMTP<br>• Lightning, switching and temporary over voltages, Lightning<br>• Physical phenomena of lightning. | 8 |
| 3 | • Interaction between lightning and power system<br>• Influence of tower footing resistance and Earth Resistance<br>• Switching: Short line or kilometric fault<br>• Energizing transients - closing and<br>• re-closing of lines<br>• line dropping, load rejection – over voltages induced by faults | 8 |
| 4 | • Switching HVDC lineTravelling waves on transmission line<br>• Circuits with distributed Parameters Wave Equation<br>• Reflection, Refraction, Behaviour of Travelling waves at the line terminations<br>• Lattice Diagrams – Attenuation and Distortion<br>• Multi-conductor system<br>• and Velocity wave | **8** |
| **5** | • Insulation co-ordination: Principle of insulation co-ordination in Air Insulated substation (AIS) and Gas Insulated Substation (GIS) Co-ordination between insulation and protection level<br>• Statistical approach | **6** |
| **6** | • Protective devices<br>• Protection of system against over voltages<br>• lightning arresters, substation earthling | **6** |

**Suggested reading**

1. Allan Greenwood, “Electrical Transients in Power System”, Wiley & Sons Inc. New York, 1991

**Course Outcomes: -**

Students will be able to:

1: Knowledge of various transients that could occur in power system and their mathematical formulation
2: Ability to design various protective devices in power system for protecting equipment and personnel
3: Coordinating the insulation of various equipments in power system
4: Modelling the power system for transient analysis

## PE 5:FACTS AND CUSTOM POWER DEVICES

| **Course Objectives:-**Students will be able to:<br>1. To learn the active and reactive power flow control in power system<br>2. To understand the need for static compensators<br>3. To develop the different control strategies used for compensation | | |
|---|---|---|
| | **Syllabus** | |
| **Units** | **Content** | **Hours** |
| 1 | • Reactive power flow control in Power Systems<br>• Control of dynamic power unbalances in Power System - Power flow control<br>• Constraints of maximum transmission line loading<br>• Benefits of FACTS Transmission line compensation<br>• Uncompensated line -Shunt compensation, Series compensation Phase angle control<br>• Reactive power compensation Shunt and Series compensation principles<br>• Reactive compensation at transmission and distribution level | 8 |
| 2 | • Static versus passive VAR compensator,<br>• Static shunt compensators: SVC and<br>• STATCOM<br>• Operation and control of TSC, TCR and STATCOM -Compensator control<br>• Comparison between SVC and STATCOM | 8 |
| 3 | • Static series compensation: TSSC, SSSC -Static voltage and phase angle regulators<br>• TCVR and TCPAR Operationand Control<br>• Applications, Static series compensation<br>• GCSC,TSSC, TCSC and Static synchronous series compensators and their Control | 8 |
| 4 | • SSR and its dampingUnified Power Flow Controller<br>• Circuit Arrangement, Operation<br>• and control of UPFC<br>• Basic Principle of P and Q control<br>• Independent real and reactivepower flow control- Applications. | 8 |
| 5 | • Introduction to interline power flow controller.<br>• Modeling and analysis of FACTS<br>• Controllers<br>• Simulation of FACTS controllers Power quality problems in distribution systems,<br>• harmonics, loads that create harmonics<br>• modeling, harmonic propagation, series and parallel resonances mitigation of harmonics<br>• passive filters, active filtering – shunt , series and hybrid and their | 6 |

| | | |
|---|---|---|
| | control | |
| 6 | • Voltage swells , sags, flicker, unbalance and mitigation of these problems by power line conditioners<br>• IEEE standards on power quality. | 6 |

**Suggested reading**

1. K R Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age InternationalPublishers, 2007

2. X P Zhang, C Rehtanz, B Pal, “Flexible AC Transmission Systems- Modelling and Control”, SpringerVerlag, Berlin, 2006

3. N.G. Hingorani, L. Gyugyi, “Understanding FACTS: Concepts and Technology of Flexible ACTransmission Systems”, IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001.

4. K.S.Sureshkumar ,S.Ashok , “FACTS Controllers & Applications”, E-book edition, Nalanda DigitalLibrary, NIT Calicut,2003

5. G T Heydt , “Power Quality”, McGraw-Hill Professional, 2007

6. T J E Miller, “Static Reactive Power Compensation”, John Wiley and Sons, Newyork, 1982.

**Course Outcomes: -**

Students will be able to:

1. Acquire knowledge about the fundamental principles of Passive and Active Reactive PowerCompensation Schemes at Transmission and Distribution level in Power Systems.

2.Learn various Static VAR Compensation Schemes like Thyristor/GTOControlled Reactive Power Systems, PWM_Inverter based Reactive Power Systems and theircontrols.

3. To develop analytical modeling skills needed for modeling and analysis of such Static VARSystems.

**PE 5:IDUSTRIAL LOAD MODELING AND CONTROL**

**Course Objectives:-**Students will be able to:

1. To understand the energy demand scenario
2. To understand the modeling of load and its ease to study load demand industrially
3. To know Electricity pricing models
4. Study Reactive power management in Industries

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| 1 | • Electric Energy Scenario-Demand Side Management-Industrial Load Management<br>• Load Curves-Load Shaping Objectives<br>• Methodologies-Barriers<br>• Classification of Industrial<br>• Loads<br>• Continuous and Batch processes -Load Modeling | 8 |
| 2 | • Electricity pricing – Dynamic and spot pricing -Models<br>• Direct load control- Interruptible load control<br>• Bottom up approach- scheduling- Formulation of load<br>• Models<br>• Optimization and control algorithms - Case studies | 8 |
| 3 | • Reactive power management in industries<br>• controls-power quality impacts<br>• application of filters Energy saving in industries | 8 |
| 4 | • Cooling and heating loads | 8 |

| | | |
|---|---|---|
| | • load profiling<br>• Modeling- Cool storage<br>• Types-Control strategies<br>• Optimal operation<br>• Problem formulation- Case studies | |
| 5 | • Captive power units<br>• Operating and control strategies<br>• Power Pooling- Operation models<br>• Energy banking<br>• Industrial Cogeneration | 6 |
| 6 | • Selection of Schemes Optimal Operating Strategies<br>• Peak load saving<br>• Constraints Problem formulation- Case study<br>• Integrated Load management for Industries | 6 |

**Suggested reading**


1. C.O. Bjork " Industrial Load Management - Theory, Practice and Simulations", Elsevier, the Netherlands,1989
2. C.W. Gellings and S.N. Talukdar,. Load management concepts. IEEE Press, New York, 1986, pp. 3-28
3. Y. Manichaikul and F.C. Schweppe ," Physically based Industrial load", IEEE Trans. on PAS, April 1981
4. H. G. Stoll, "Least cost Electricity Utility Planning", Wiley Interscience Publication, USA, 1989.
5. I.J.Nagarath and D.P.Kothari, .Modern Power System Engineering., Tata McGraw Hill publishers, NewDelhi, 1995
6. IEEE Bronze Book- "Recommended Practice for Energy Conservation and cost effective planning in Industrial facilities", IEEE Inc, USA


**Course Outcomes: -**

Students will be able to:

1: Knowledge about load control techniques in industries and its application

2: Learn different types of industrial processes and optimize the process using tools like LINDO and LINGO

3: Apply load management to reduce demand of electricity during peak time

4: Apply different energy saving opportunities in industries

**PE 5: DYNAMICS OF LINEAR SYSTEMS**

| | | |
|---|---|---|
| **Course Objectives:-**Students will be able to:<br>1. To understand the linear system and its functions<br>2. To understand the stability analysis of linear systems and implement the same in MATLAB | | |
| | **Syllabus** | |
| **Units** | **Content** | **Hours** |
| 1 | • State variable representations of systems<br>• transfer function and transfer function matrix<br>• solutions of state equations | 8 |
| 2 | • Observability and controllability<br>• minimal realization of MIMO systems<br>• analysis of linear time varying systems<br>• the concepts of stability | 8 |

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|---|---|---|
| 3 | • Lyapunov stability analysis<br>• Lyapunov function and its properties<br>• controllability by state variable feedback | 8 |
| 4 | • Ackerman’s Formula - stabilisation by output feedback<br>• asymptotic observers for state measurement<br>• observer design | 6 |
| 5 | • State space representation of discrete systems<br>• solution of state equations, controllability and observabilty stability analysis using Lyapunov method | 6 |
| 6 | • State feedback of linear discrete timesystems<br>• design of observers - MATLAB Exercises | 8 |

**Suggested reading**

1. Thomas Kailath, “Linear Systems”, Prentice Hall Inc., Englewood Cliffs, N.J. 1980.
2. K. Ogata, “State Space Analysis of Control Systems”, Prentice Hall Inc., Englewood Cliffs, N.J., 1965.
3. K. Ogata, “Modern Control Engineering, (second edition)” , Prentice Hall Inc., Englewood Cliffs, N.J., 1990
4. M.Gopal, “Digital Control and State Variable Methods”, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997
5. C.T. Chen, “Linear System Theory and Design”, New York: Holt Rinehart and Winston ,1984
6. R.C. Dorf, and R. T. “Bishop, Modern Control Systems”, Addison Wesley Longman Inc., 1999.

**Course Outcomes:-**
Students will be able to:
1: To learn linear system modeling, analysis and design so as to obtain theability to apply the same to engineering problems in a global perspective
2: Knowledge on carrying out detailed stability analysis of both linear and nonlinear systems
3: Design observers and controllers for linear systems
4: Acquire knowledge of discrete time linear systems modeling, analysis and design
5: Develop and utilize modern software tools for analysis and designof linear continuous and discrete time systems

**PE 6: POWER SEMICONDUCTOR DEVICES AND MODELING**

**Course Objectives:-**Students will be able to:
1. Understand the basic operation and I-V characteristics of various power semiconductor devices
2. Study the circuit model of various devices
3. Understand the protection and control circuit for these semiconductor devices

**Syllabus**

| **Units** | **Content** | **Hours** |
|---|---|---|
| 1 | • Energy auditing: Types and objectives - audit instruments- ECO assessment<br>• Economic methods specific energy analysis<br>• Minimum energy paths-consumption models- Case study | 8 |
| 2 | • Electric motors-Energy efficient controls and starting efficiency<br>• Motor Efficiency and Load Analysis- Energy efficient /high efficient Motors-Case study<br>• Load Matching and selection of motors. Variable speed drives; Pumps and Fans-Efficient Control strategies | 8 |

| | | |
|---|---|---|
| | • Optimalselection and sizing – Optimal operation and Storage; Case study | |
| 3 | • Transformer Loading/Efficiency analysis, Feeder/cable loss evaluation, Case study<br>• Reactive Power management-Capacitor Sizing-Degree of Compensation-Capacitor losses<br>• Location-Placement Maintenance, Case study | 8 |
| 4 | • Peak Demand controls- Methodologies-Types of Industrial loads-Optimal Load<br>• scheduling-case study<br>• Lighting- Energy efficient light sources-Energy conservation in Lighting Schemes<br>• Electronic ballast-Power quality issues-Luminaries, Case study | 8 |
| 5 | • Cogeneration-Types and Schemes-Optimal operation of cogeneration plants-case study<br>• Electric loads of Air conditioning & Refrigeration-Energy conservation measures- Cool storage types Optimal operation case study | 6 |
| | • Electric water heating-Gysers-Solar Water Heaters<br>• Power Consumption in Compressors<br>• Energy conservation measures Electrolytic Process<br>• Computer Controls- software – EMS | 8 |

**Suggested reading**

1. Giovanni Petrecca, "Industrial Energy Management: Principles and Applications", The Kluwerinternational series -207, 1999
2. Anthony J. Pansini, Kenneth D. Smalling, "Guide to Electric Load Management", Pennwell Pub; (1998)
3. Handbook on Energy Audit and Environment Management , Y P Abbi and Shashank Jain, TERI, 2006
4. Handbook of Energy Audits Albert Thumann, William J. Younger, Terry Niehus, 2009

**Course Outcomes:-**

Students will be able to:
1. Acquire the background required for engineers to meet the role of energy managers and to acquire the skills and techniques required to implement energy management
2. Identify and quantify the energy intensive business activities in an organization
3.Knowledge about standard methodologies for measuring energy in the workplace and energy audit instruments
4.Knowledge about energy efficient motors, load matching and selection of motors
5. Acquire knowledge about reactive power management, capacitor sizing and degree of Compensation

**PE 6:ENGINEERING OPTIMIZATION**

**Course Objectives:-**Students will be able to:
1. To understand the need for optimization and different techniques involved and also constraints.
2. To know Linear/Non-linear Programming.
3. To understand the importance of optimization to solve Engineering problems

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|---|---|---|
| 4. To know genetic algorithm for Engineering Optimization | | |
| **Syllabus** | | |
| **Units** | **Content** | **Hours** |
| 1 | • Concepts of optimization: Engineering applications<br>• Statement of optimization<br>• Problem<br>• Classification - type and size of the problem<br>• Classical Optimization Techniques: Single and multi variable problems-Types of Constraints<br>• Semi definite case-saddle point | 8 |
| 2 | • Linear programming: Standard form-Geometry of LP problems-Theorem of LP<br>• Relation to convexity - formulation of LP problems - simplex method and algorithm<br>• Matrix form- two phase method. Duality<br>• dual simplex method- LU Decomposition | 8 |
| 3 | • Sensitivity analysis .Artificial variables and complementary solutions-QP.<br>• Engineering Applications:Minimum cost flow problem<br>• Network problems-transportation,<br>• assignment & allocation, scheduling<br>• Karmarkar method-unbalanced and routing problems. | 8 |
| 4 | • Nonlinear programming: Non linearity concepts-convex and concave functions<br>• non-linear programming -gradient and Hessian. Unconstrained optimization<br>• First &<br>• Second order necessary conditions- Minimisation & Maximisation<br>• Local & Global convergence-<br>• Speed of convergence | 6 |
| 5 | • Basic decent methods: Fibonacci & Golden section search - Gradient methods - Newton<br>• Method-Lagrange multiplier method - Kuhn-tucker conditions<br>• Quasi-Newton method- separable<br>• convex programming -Frank and Wolfe method, Engineering Applications<br>• Nonlinear programming- Constrained optimization: Characteristics of constraints-Direct methods- SLP,SQP-Indirect<br>• Methods.<br>• Transformation techniques-penalty function-Langrange multiplier methods checking convergence- Engineering applications | 8 |
| 6 | • Dynamic programming: Multistage decision process- Concept of sub optimization and principle<br>• Of optimality<br>• Computational procedure- Engineering applications. Genetic algorithms-Simulated<br>• Annealing Methods - Optimization programming, tools and Software | 6 |

| | | |
|---|---|---|
| | packages | |

**Suggested reading**

1. David G Luenberger, “Linear and Non Linear Programming”, 2nd Ed, Addison-Wesley Pub.Co.,Massachusetts, 2003
2. W.L.Winston, “Operation Research-Applications & Algorithms”,2nd Ed., PWS-KENT Pub.Co.,Boston, 2007
3. S.S.Rao, “Engineering Optimization”, 3rd Ed.,New Age International (P) Ltd,New Delhi, 2007
4. W.F.Stocker, “Design of Thermal Systems”, 3rd Ed., McGraw Hill, New York. 1990
5. G.B.Dantzig, “Linear Programming and Extensions” Princeton University Press, N.J., 1963.
6. L.C.W.Dixton, ”Non Linear Optimisation: theory and algorithms” Birkhauser, Boston, 1980

**Course Outcomes:-**

Students will be able to:
1: Apply optimization techniques to typical engineering problems
2: Learn the concepts and techniques of nonlinear and unconstrained optimization
3: Acquire knowledge on direct and indirect methods for constrained optimization
4: Learn the application of dynamic programming and genetic algorithms for engineering Optimization

**PE 6: HIGH VOLTAGE ENGINEERING**

**Course Objectives:-**Students will be able to:
1. To get introduced to high voltage engineering
2. To understand different high voltage measurements and the necessary instruments

| Units | Content | Hours |
|---|---|---|
| 1 | • Voltage doubler - cascade circuits<br>• electrostatic machines | 6 |
| 2 | • Generation of Impulse voltages and curreningle stage and multistage circuits<br>• wave shaping-tripping and control of impulse generators | 8 |
| 3 | • Generation of switching surge voltage and impulse current Measurement of high<br>• voltages and currents<br>• DC,AC and impulse voltages and currents<br>• DSO-electrostatic and peak<br>• Voltmeters sphere gaps-factors affecting measurements-potential dividers(capacitive and resistive)<br>ries impedance ammeters-rogowski coils-hall effect generators<br>• Digital techniques in HV measurements | 8 |
| 4 | • Measurement of electric field, Sources of EMI<br>• Principles of EMC, Filtering, Shielding<br>• Grounding techniques | 8 |
| 5 | • Introduction to relevant national and international standards<br>• Layout and clearances as<br>• well as shielding and grounding of HV lab | 8 |
| 6 | • Safety regulations for high voltage tests, Calibration of HV measuring instruments<br>• Indian Standards for HV clearances. Recent trends in HV Engineering | 8 |

**Suggested reading**

1. M. S. Naidu, V. Kamaraju, "High Voltage Engineering", McGraw-Hill, 1995.
2. M. Khalifa, "High Voltage Engineering: Theory and Practice", Dekker, 1990
3. H. M. Ryan, "High Voltage Engineering and Testing", Peter Peregrinus, 1994
4. Wadhwa C L."High Voltage Engineering", Wiley Eastern Limited, NewDelhi,1994
5. Ott, H.W.,"Noise Reduction Techniques in Electronic Systems", John Wiley, New York, 1989

**Course Outcomes:-**

Students will be able to:
1. Knowledge about the need for high voltage generation
2. Acquaint with the different methods for generating high voltage AC/DC and impulse voltages and current
3. Knowledge about the measurement techniques for high voltage AC/DC and impulsevoltages and currents
4. To learn sources of EMI and its mitigation techniques
5. Safety precautions to be taken while designing an HV lab

**OE -ENERGY AUDITING AND MANAGEMENT**

**Course Objectives:-**Students will be able to:
1. To understand the need for energy auditing
2. Understanding of various loads involved based on power consumption for auditing
3. To know about different audit instruments used in practice

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| 1 | • System approach and End use approach to efficient use of Electricity<br>• Electricity tariff types<br>• Energy auditing: Types and objectives - audit instruments<br>• ECO assessment and Economic methods<br>• Specific energy analysis-Minimum energy paths-consumption models-Case study | 6 |
| 2 | • Electric motors-Energy efficient controls and starting efficiency-Motor Efficiency and Load<br>• Analysis Energy efficient /high efficient Motors-Case study<br>• Load Matching and selection of motors<br>• Variable speed drives; Pumps and Fans-Efficient Control strategies-Optimal selection and sizing<br>• Optimal operation and Storage; Case study | 8 |
| 3 | • Transformer Loading/Efficiency analysis<br>• Feeder/cable loss evaluation, case study<br>• Reactive Power management-Capacitor<br>• Sizing-Degreeof Compensation-Capacitor losses<br>• Location-Placement<br>• Maintenance ,Case study | 8 |
| 4 | • Peak Demand controls- Methodologies<br>• Types of Industrial loads-Optimal Load<br>• scheduling-case study<br>• Lighting- Energy efficient light sources-Energy conservation in Lighting | 8 |

| | | |
|---|---|---|
| | • Schemes<br>• Electronic ballast-Power quality issues-Luminaries, case study | |
| 5 | • Cogeneration-Types and Schemes<br>• Optimal operation of cogeneration plants-case study<br>• Electric loads of Air conditioning &Refrigeration<br>• Energy conservation measures- Cool storage<br>• Types-Optimal operation case study | 8 |
| 6 | • Electric water heating-<br>• Geysers-Solar Water Heaters<br>• Power Consumption in Compressors<br>• Energy conservation measures<br>• Electrolytic Process<br>• Computer Controls- software-EMS | 6 |

**Suggested reading**

1. Anthony J. Pansini, Kenneth D. Smalling, .Guide to Electric Load Management., Pennwell Pub; (1998)
2. Howard E. Jordan, .Energy-Efficient Electric Motors and Their Applications., Plenum Pub Corp; 2ndedition (1994)
3. Giovanni Petrecca, .Industrial Energy Management: Principles and Applications., The Kluwerinternational series -207,1999
4. Handbook on Energy Audit and Environment Management , Y P Abbi and Shashank Jain, TERI,2006
5. Handbook of Energy Audits Albert Thumann, William J. Younger, Terry Niehus, 2009

**Course Outcomes:-**Students will be able to:

1. Acquire the background required for engineers to meet the role of energy managers and to acquire the skills and techniques required to implement energy management
2. Identify and quantify the energy intensive business activities in an organization
3. Able to perform Basic Energy Audit in an Organization

## OPEN ELECTIVES

## Business Analytics

**Teaching scheme**

**Lecture: - 3 h/week**

| | |
|---|---|
| **Course Code** | |
| **Course Name** | **Business Analytics** |
| **Credits**<br>**Prerequisites** | |

Total Number of Lectures: 48

| **Course objective** |
|---|
| 1. Understand the role of business analytics within an organization.<br>2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.<br>3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.<br>4. To become familiar with processes needed to develop, report, and analyze business data. |

| | |
|---|---|
| 5. | Use decision-making tools/Operations research techniques. |
| 6. | Mange business process using analytical and management tools. |
| **7.** | Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit1:**<br>Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.<br>Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview. | 9 |
| **Unit 2:**<br>Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.<br>Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology. | 8 |
| **Unit 3:**<br>Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.<br>Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization. | 9 |
| **Unit 4:**<br>Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.<br>Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model. | 10 |
| **Unit 5:**<br>Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. | 8 |
| **Unit 6:**<br>Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism. | 4 |

| COURSE OUTCOMES | |
|---|---|
| | |

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|---|---|
| 1. | Students will demonstrate knowledge of data analytics. |
| 2. | Students will demonstrate the ability of think critically in making decisions based on data and deep analytics. |
| 3. | Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making. |
| 4. | Students will demonstrate the ability to translate data into clear, actionable insights. |

**Reference:**

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

## OPEN ELECTIVES

### Industrial Safety

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**Unit-II:** Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**Unit-III:** Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**Unit-IV:** Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**Unit-V:** Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

**Reference:**


1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.


## OPEN ELECTIVES

## Operations Research

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes: At the end of the course,** the student should be able to

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

**Syllabus Contents:**

**Unit 1**:

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

**Unit 2**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

**Unit 3**:

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

**Unit 4**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

**Unit 5**

Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

**References**:


1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.

3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

## Open Elective
## Cost Management & Engineering Projects

**Teaching scheme**

**Lecture: - 3 h/week**

Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution : conception to commissioning. Project execution as conglomeration of technical and non technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team : Role of each member. Importance Project site : Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

**References:**

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of CostAccounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

## Open Elective
## Composite Materials

**Teaching scheme**

**Lecture: - 3 h/week**

**UNIT–I**: INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT – II**: REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT – III:** Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT–IV:** Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT – V:** Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

**TEXT BOOKS:**

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

**REFERENCES:**

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

## Open Elective
## Waste to Energy

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**Unit-II:** Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**Unit-III:** Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**Unit-IV:** Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**Unit-V:** Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

**References:**

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

## AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING

**Course objectives:**

Students will be able to:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title

Ensure the good quality of paper at very first-time submission

**Syllabus**

| Units | CONTENTS | Hours |
|---|---|---|
| 1 | Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness | 4 |
| 2 | Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction | 4 |
| 3 | Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check. | 4 |
| 4 | key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, | 4 |
| 5 | skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions | 4 |
| 6 | useful phrases, how to ensure paper is as good as it could possibly be the | 4 |

| | | |
|---|---|---|
| | first- time submission | |

**Suggested Studies:**


1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011


## UDIT 1 and 2: DISASTER MANAGEMENT

**Course Objectives:-**Students will be able to:
1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in

**Syllabus**

| Units | CONTENTS | Hours |
|---|---|---|
| 1 | **Introduction**<br>Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude. | 4 |
| 2 | **Repercussions Of Disasters And Hazards**: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.<br>Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts. | 4 |
| 3 | **Disaster Prone Areas In India**<br>Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics | 4 |
| 4 | **Disaster Preparedness And Management**<br>Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness. | 4 |
| 5 | **Risk Assessment**<br>Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival. | 4 |
| 6 | **Disaster Mitigation** | 4 |

| | | |
|---|---|---|
| | Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India. | |

**SUGGESTED READINGS:**

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.

2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.

3. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

## AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE

***Course Objectives***

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

***Syllabus***

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Alphabets in Sanskrit,<br>• Past/Present/Future Tense,<br>• Simple Sentences | 8 |
| 2 | • Order<br>• Introduction of roots<br>• Technical information about Sanskrit Literature | 8 |
| 3 | • Technical concepts of Engineering-Electrical,Mechanical, Architecture, Mathematics | 8 |

***Suggested reading***

1. "Abhyaspustakam" – Dr.Vishwas, Sanskrit-Bharti Publication,New Delhi

2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication

3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.

***Course Output***

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood

3. Being a logical language will help to develop logic in students

# AUDIT 1 and 2: VALUE EDUCATION

***Course Objectives***

Students will be able to

1. Understand value of education and self- development

2. Imbibe good values in students

3. Let the should know about the importance of character

***Syllabus***

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism.<br>• Moral and non- moral valuation. Standards and principles.<br>• Value judgements | 4 |
| 2 | • Importance of cultivation of values.<br>• Sense of duty. Devotion, Self-reliance.Confidence,Concentration.Truthfulness, Cleanliness.<br>• Honesty ,Humanity.Power of faith, National Unity.<br>• Patriotism.Love for nature ,Discipline | 6 |
| 3 | • Personality and Behaviour Development - Soul and Scientific attitude.Positive Thinking.Integrity and discipline.<br>• Punctuality, Love and Kindness.<br>• Avoid fault Thinking.<br>• Free from anger, Dignity of labour.<br>• Universal brotherhood and religious tolerance.<br>• True friendship.<br>• Happiness Vs suffering, love for truth.<br>• Aware of self-destructive habits.<br>• Association and Cooperation.<br>• Doing best for saving nature | 6 |
| 4 | • Character and Competence –Holy books vs Blind faith.<br>• Self-management and Good health.<br>• Science of reincarnation.<br>• Equality ,Non violence ,Humility, Role of Women.<br>• All religions and same message.<br>• Mind your Mind ,Self-control.<br>• Honesty, Studying effectively | 6 |

***Suggested reading***

1 Chakroborty , S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press ,New Delhi

***Course outcomes***

Students will be able to

1.Knowledge of self-development 2.Learn the importance of Human values

3.Developing the overall personality

## AUDIT 1 and 2: CONSTITUTION OF INDIA

**Course Objectives:**

Students will be able to:

1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

**Syllabus**

| **Units** | **Content** | **Hours** |
|---|---|---|
| **1** | • **History of Making of the Indian Constitution:**<br>History<br>Drafting Committee, ( Composition & Working) | 4 |
| **2** | • **Philosophy of the Indian Constitution:**<br>Preamble<br>Salient Features | 4 |
| **3** | • **Contours of Constitutional Rights & Duties:**<br>• Fundamental Rights<br>• Right to Equality<br>• Right to Freedom<br>• Right against Exploitation<br>• Right to Freedom of Religion<br>• Cultural and Educational Rights<br>• Right to Constitutional Remedies<br>• Directive Principles of State Policy<br>• Fundamental Duties. | 4 |
| **4** | • **Organs of Governance:**<br>• Parliament<br>• Composition<br>• Qualifications and Disqualifications<br>• Powers and Functions<br>• Executive<br>• President<br>• Governor<br>• Council of Ministers | 4 |

| | | |
|---|---|---|
| | • Judiciary, Appointment and Transfer of Judges, Qualifications<br>• Powers and Functions | |
| **5** | • **Local Administration:**<br>• District's Administration head: Role and Importance,<br>• Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.<br>• Pachayati raj: Introduction, PRI: Zila Pachayat.<br>• Elected officials and their roles, CEO Zila Pachayat: Position and role.<br>• Block level: Organizational Hierarchy (Different departments),<br>• Village level: Role of Elected and Appointed officials,<br>• Importance of grass root democracy | 4 |
| **6** | • **Election Commission:**<br>• Election Commission: Role and Functioning.<br>• Chief Election Commissioner and Election Commissioners.<br>• State Election Commission: Role and Functioning.<br>• Institute and Bodies for the welfare of SC/ST/OBC and women. | 4 |

**Suggested reading**


1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.


**Course Outcomes:**

Students will be able to:
1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

## AUDIT 1 and 2: PEDAGOGICAL STUDIES

| | | |
|---|---|---|
| **Course Objectives:**<br>Students will be able to:<br>4. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.<br>5. Identify critical evidence gaps to guide the development. | | |
| **Syllabus** | | |
| **Units** | **Content** | **Hours** |
| **1** | • **Introduction and Methodology:**<br>• Aims and rationale, Policy background, Conceptual framework and terminology<br>• Theories of learning, Curriculum, Teacher education.<br>• Conceptual framework, Research questions.<br>• Overview of methodology and Searching. | 4 |

| | | |
|---|---|---|
| **2** | • Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.<br>• Curriculum, Teacher education. | 2 |
| **3** | • Evidence on the effectiveness of pedagogical practices<br>• Methodology for the in depth stage: quality assessment of included studies.<br>• How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?<br>• Theory of change.<br>• Strength and nature of the body of evidence for effective pedagogical practices.<br>• Pedagogic theory and pedagogical approaches.<br>• Teachers' attitudes and beliefs and Pedagogic strategies. | 4 |
| **4** | • Professional development: alignment with classroom practices and follow-up support<br>• Peer support<br>• Support from the head teacher and the community.<br>• Curriculum and assessment<br>• Barriers to learning: limited resources and large class sizes | 4 |
| **5** | • **Research gaps and future directions**<br>• Research design<br>• Contexts<br>• Pedagogy<br>• Teacher education<br>• Curriculum and assessment<br>• Dissemination and research impact. | 2 |

**Suggested reading**


1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.


**Course Outcomes:**

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

## AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

***Course Objectives***

1. To achieve overall health of body and mind
2. To overcome stress

***Syllabus***

| Unit | *Content* | *Hours* |
|---|---|---|
| 1 | • Definitions of Eight parts of yog. ( Ashtanga ) | 8 |
| 2 | • Yam and Niyam.<br>Do`s and Don't's in life.<br>i) Ahinsa, satya, astheya, bramhacharya and aparigraha<br>ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan | 8 |
| 3 | • Asan and Pranayam<br>i) Various yog poses and their benefits for mind & body<br>ii)Regularization of breathing techniques and its effects-Types of pranayam | 8 |

***Suggested reading***

1. 'Yogic Asanas for Group Tarining-Part-I" : Janardan Swami Yogabhyasi Mandal, Nagpur

2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

**Course Outcomes:**

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also

2. Improve efficiency

## AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE and ENLIGHTENMENT SKILLS

***Course Objectives***

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

***Syllabus***

| Unit | Content | Hours |
|---|---|---|

| | | |
|---|---|---|
| 1 | Neetisatakam-Holistic development of personality<br>• Verses- 19,20,21,22 (wisdom)<br>• Verses- 29,31,32 (pride & heroism)<br>• Verses- 26,28,63,65 (virtue)<br>• Verses- 52,53,59 (dont's)<br>• Verses- 71,73,75,78 (do's) | 8 |
| 2 | • Approach to day to day work and duties.<br>• Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48,<br>• Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,<br>• Chapter 18-Verses 45, 46, 48. | 8 |
| 3 | • Statements of basic knowledge.<br>• Shrimad Bhagwad Geeta : Chapter2-Verses 56, 62, 68<br>• Chapter 12 -Verses 13, 14, 15, 16,17, 18<br>• Personality of Role model. Shrimad Bhagwad Geeta : Chapter2-Verses 17,Chapter 3-Verses 36,37,42,<br>• Chapter 4-Verses 18, 38,39<br>• Chapter18 – Verses 37,38,63 | 8 |

***Suggested reading***

1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata

2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

***Course Outcomes***

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life

2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity

3. Study of Neetishatakam will help in developing versatile personality of students.

## Course Scheduling for M.Tech. (Electrical Engineering), Specialization: Power & Energy Systems

| Semester 1 | | | | | | |
|---|---|---|---|---|---|---|
| Sr. No. | Core/Elective | Course Name | | | | Credits |
| | | | L | T | P | |
| 1 | Core1 | Distributed Generation | 3 | 0 | 0 | 3 |
| 2 | Core2 | Renewable Energy Systems | 3 | 0 | 0 | 3 |
| 3 | PE1 | Engineering Optimization/ Power System Dynamics/High Voltage Engineering | 3 | 0 | 0 | 3 |
| 4 | PE2 | Switched Mode Power Control/ Optimal and Adaptive Control/ FACTS and custom Power Devices | 3 | 0 | 0 | 3 |
| 5 | | Research Methodology and IPR | 2 | 0 | 0 | 2 |
| 6 | Lab1 | Power Systems Lab/Distributed Generation lab | 0 | 0 | 4 | 2 |
| 7 | Lab2 | Renewable Energy lab | 0 | 0 | 4 | 2 |
| 8 | Audit-I | Audit-1 | 2 | 0 | 0 | 0 |
| 9 | Total Credits | | | | | 18 |

| Semester 2 | | | | | | |
|---|---|---|---|---|---|---|
| Sr. No. | Core/Elective | Course Name | | | | Credits |
| | | | L | T | P | |
| 1 | Core3 | Digital Power System Protection | 3 | 0 | 0 | 3 |
| 2 | Core4 | Non-Conventional Electrical Energy Systems | 3 | 0 | 0 | 3 |
| 3 | PE3 | Artificial intelligence I Techniques /Smart Grids /Energy Conversion Processes | 3 | 0 | 0 | 3 |
| 4 | PE4 | Electric and Hybrid Vehicles/Power Quality /Industrial Load Modeling and Control | 3 | 0 | 0 | 3 |
| | | Mini Project with Semina | 0 | 0 | 4 | 2 |
| 5 | Lab3 | Power System Protection Lab/Power System Analysis lab | 0 | 0 | 4 | 2 |
| 6 | Lab4 | Artificial Intelligence lab /Power Quality Lab/Non-Conventional Energy Sources lab | 0 | 0 | 4 | 2 |
| 7 | Audit-II | Audit-II | 2 | 0 | 0 | 0 |
| 8 | Total Credits | | | | | 18 |

| Semester 3 | | | | | | |
|---|---|---|---|---|---|---|
| Sr. No. | Core/Elective | Course Name | | | | Credits |
| | | | L | T | P | |
| 1 | PE5 | Power System Analysis / Power system | 3 | 0 | 0 | 3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Transients /Reliability Analysis and Protection | | | | |
| 2 | OE | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy | 3 | 0 | 0 | 3 |
| 3 | Major Project | Phase – I Dissertation | 0 | 0 | 20 | 10 |
| 4 | Total Credits | | | | | 16 |
| **Semester 4** | | | | | | |
| Sr. No. | Core/Elective | Course Name | | | | Credits |
| | | | L | T | P | |
| 1 | Major Project | Phase-II Dissertation | 0 | 0 | 32 | 16 |
| 2 | Total Credits | | | | | 16 |

**GRAND TOTAL CREDITS** **68**

**Programme Outcomes**

**PO 1** The ability to apply knowledge of mathematics, science, and engineering in solving real life engineering problems.

**PO 2** The ability to design a component, system or process related to Power and Energy Systems (PES) for a defined objective and conduct experiments, as well as to analyze data.

**PO 3** An ability to design a component, system or process related to PES to meet desired needs within realistic constraints such as safety, environmental, economic, social, ethical, manufacturability and sustainability.

**PO 4** The ability to function on multidisciplinary tasks and with multidisciplinary teams.

**PO 5** The ability to perform literature survey to identify, formulate and solve power engineering problems using modern engineering tools (softwares and hardwares).

**PO 6** The ability to demonstrate the knowledge of professional and ethical responsibilities.

**PO 7** The ability to communicate effectively in both oral and written forms.

**O 8** The ability to analyze the impact of engineering solutions in global, economic, environmental and social perspectives.

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education

5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

# FIRST SEMESTER

# CORE 1: DISTRIBUTED GENERATION

## *Course Objectives*

Students will be able to

1. Understand renewable energy sources.
2. Gain understanding of the working of off-grid and grid-connected renewable energy generation schemes.

## *Syllabus*

| Unit | *Content* | *Hours* |
|---|---|---|
| 1 | • Need for Distributed generation.<br>• Renewable sources in distributed generation.<br>• Current scenario in Distributed Generation. | 8 |
| 2 | • Planning of DGs, Sitting and sizing of DGs optimal placement of DG sources in distribution systems.<br>• Grid integration of DGs Different types of interfaces.<br>• Inverter based DGs and rotating machine based interfaces.<br>• Aggregation of multiple DG units. | 4 |
| 3 | • Technical impacts of DGs.<br>• Transmission systems Distribution systems De-regulation Impact of DGs upon protective relaying.<br>• Impact of DGs upon transient and dynamic stability of existing.distribution systems, Steady-state and Dynamic analysis | 10 |
| 4 | • Economic and control aspects of DGs Market facts.<br>• issues and challenges Limitations of DGs.<br>• Voltage control techniques.<br>• Reactive power control.<br>• Harmonics Power quality issues.<br>• Reliability of DG based systems. | 6 |
| 5 | • Introduction to micro-grids .<br>• Types of micro-grids: autonomous and non-autonomous grids Sizing of micro-grids.<br>• Modeling & analysis of Micro-grids with multiple DGs.<br>• Micro-grids with power electronic interfacing units. | 8 |
| 6 | • Transients in micro-grids.<br>• Protection of micro-grids.<br>• Case studies.<br>• Advanced topics | 4 |

### *Suggested reading*

1. H. Lee Willis, Walter G. Scott,"Distributed Power Generation – Planning and Evaluation", Marcel Decker Press.
2. M.GodoySimoes, Felix A.Farret, "Renewable Energy Systems – Design and Analysis with Induction Generators", CRC press.
3.Stuart Borlase."Smart Grid: Infrastructure Technology Solutions" CRC Press

### *Course outcomes*

Students will be able to

1. Understand the planning and operational issues related to Distributed Generation.
2. Acquire Knowledge about Distributed Generation
3. Learn Micro-Grids

# CORE 2: RENEWABLE ENERGY SYSTEM

### *Course Objectives*

Students wiil be able to

1. Learn various renewable energy sources
2. Gain understanding of integrated operation of renewable energy sources
3. Understand Power Electronics Interface with the Grid

### *Syllabus*

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Introduction<br>• Distributed vs Central Station Generation<br>• Sources of Energy such as Micro-turbines.<br>• Internal Combustion Engines. | 8 |
| 2 | • Introduction to Solar Energy.<br>• Wind Energy.<br>• Combined Heat and Power, Hydro Energy, Tidal Energy.<br>• Wave Energy, Geothermal Energy, Biomass, Fuel Cells | 10 |
| 3 | • Power Electronic Interface with the Grid | 4 |
| 4 | • Impact of Distributed Generation on the Power System.<br>• Power Quality Disturbances | 6 |
| 5 | • Transmission System Operation.<br>• Protection of Distributed Generators. | 8 |
| 6 | • Economics of Distributed Generation.<br>• Case Studies | 4 |

### *Suggested reading*

1. RanjanRakesh, Kothari D.P, Singal K.C, "Renewable Energy Sources and Emerging Technologies", 2nd Ed. Prentice Hall of India ,2011
2. Math H.Bollen, FainanHassan,"Integration of Distributed Generation in the Power System", July 2011, Wiley –IEEE Press
3.Loi Lei Lai, Tze Fun Chan, "Distributed Generation: Induction and Permanent Magnet Generators", October 2007, Wiley-IEEE Press.
4.Roger A.Messenger, Jerry Ventre, "Photovoltaic System Engineering", 3rd Ed, 2010
5.James F.Manwell, Jon G.McGowan, Anthony L Rogers, "Wind energy explained: Theory Design and Application", John Wiley and Sons 2nd Ed, 2010

### *Course Outcomes*

Students will be able to

1. Gain Knowledge about renewable energy

2. Understand the working of distributed generation system in autonomous/grid connected modes
3. Know the Impact of Distributed Generation on Power System

# PE 1: ENGINEERING OPTIMIZATION

## *Course Objectives*

Students will be able to

1. Understand the need for optimization and different techniques involved and also constraints.
2. Know Linear/Non linear Programming.
3. Understand the importance of optimization to solve Engineering problems
4. Know genetic algorithm for Engineering Optimization

## *Syllabus*

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Concepts of optimization: Engineering applications-Statement of optimization problem-Classification - type and size of the problem.<br>• Classical Optimization Techniques: Single andmulti variable problems- Types of Constraints.<br>• Semi definite case-saddle point. | 8 |
| 2 | • Linear programming: Standard form<br>• Geometry of LP problems, Theorem of LP- Relation to convexity<br>• Formulation of LP problems, Simplex method and algorithm.<br>• Matrix form- two phase method, Duality- dual simplex method.<br>• LU Decomposition | 8 |
| 3 | • Sensitivity analysis.<br>• Artificial variables and complementary solutions-QP.<br>• Engineering Applications:Minimum cost flow problem.<br>• Network problems-transportation.<br>• Assignment&allocation.<br>• Scheduling, Karmarkar method-unbalanced and routing problems. | 4 |
| 4 | • Nonlinear programming: Non linearity concepts.<br>• Convex and concave functions.<br>• Non-linear programming -gradient and Hessian.<br>• Unconstrained optimization: First &Second order necessary conditions.<br>• Minimisation&Maximisation- Local & Global convergence- Speed of convergence. | 6 |
| 5 | • Basic decent methods: Fibonacci & Golden section search.<br>• Gradient methods - Newton Method-Lagrange multiplier method.<br>• Kuhn-tucker conditions .<br>• Quasi-Newton method- separable convex programming -Frank and Wolfe method.<br>• Engineering Applications. Nonlinear program mming.<br>• Constrained optimization: Characteristics of constraints-Direct methods- SLP,SQP.<br>• Indirect methods-Transformation techniques-penalty function.<br>• Langrange multiplier methods checking convergence. | 10 |

| | | |
|---|---|---|
| | • Engineering applications. | |
| 6 | • Dynamic programming: Multistage decision process.<br>• Concept of sub optimization and principle Of optimality.<br>• Computational procedure.<br>• Engineering applications. Genetic algorithms.<br>• Simulated Annealing Methods .<br>• Optimization programming, tools and Software packages | 8 |

### *Suggested reading*

1. David G Luenberger, "Linear and Non Linear Programming", 2nd Ed, Addison-Wesley Pub.Co.,Massachusetts, 2003
2. W.L.Winston, "Operation Research-Applications & Algorithms",2nd Ed., PWS-KENT Pub.Co.,Boston, 2007
3. S.S.Rao, "Engineering Optimization", 3rd Ed.,New Age International (P) Ltd,New Delhi, 2007
4. W.F.Stocker, "Design of Thermal Systems", 3rd Ed., McGraw Hill, New York. 1990
5. G.B.Dantzig, "Linear Programming and Extensions" Princeton University Press, N.J.,1963
6. L.C.W.Dixton, "Non Linear Optimisation: theory and algorithms" Birkhauser, Boston, 1980

### *Course Outcomes*

Students will be able to

1: Apply optimization techniques to typical engineering problems
2: Learn the concepts and techniques of nonlinear and unconstrained optimization
3: Acquire knowledge on direct and indirect methods for constrained optimization
4: Learn the application of dynamic programming and genetic algorithms for engineering Optimization

# PE 1: POWER SYSTEM DYNAMICS

### *Course Objectives*

Students will be able to

1. Study of system dynamics and its physical interpretation
2. Development of mathematical models for synchronous machine
3. Modeling of induction motor

### *Syllabus*

| **Unit** | ***Content*** |
|---|---|
| 1 | • Synchronous Machines: Per unit systems.<br>• Park's Transformation (modified), Flux-linkage equations |
| 2 | • Voltage and current equations.<br>• Formulation of State-space equations, Equivalent circuit |
| 3 | • Sub-transient and transient inductance and Time constants.<br>• Simplified models of synchronous machines<br>• |
| 4 | • Small signal model: Introduction to frequency model |
| 5 | • Excitation systems and Philips-Heffron model, PSS Load modeling |
| 6 | • Modeling of Induction Motors, Prime mover controllers |

### *Suggested reading*

1. P. M. Anderson & A. A. Fouad "Power System Control and Stability", Galgotia , New Delhi, 1981
2. J Machowski, J Bialek& J. R W. Bumby, "Power System Dynamics and Stability", John Wiley & Sons, 1997
3. P.Kundur, "Power System Stability and Control", McGraw Hill Inc., 1994.
4. E.W. Kimbark, "Power system stability", Vol. I & III, John Wiley & Sons, New York 2002

### *Course Outcomes*

Students will be able to

1. Understand the modeling of synchronous machine in details
2. Carry out simulation studies of power system dynamics using MATLAB-SIMULINK, MI POWER
3. Carry out stability analysis with and without power system stabilizer (PSS)
4. Understand the load modeling in power system

# PE 1: HIGH VOLTAGE ENGINEERING

## *Course Objectives*

Students will be able to

1. Get introduced to high voltage engineering
2. Understand different high voltage measurements and the necessary instruments

## *Syllabus*

| Unit | *Content* | *Hours* |
|---|---|---|
| 1 | • Voltage doubler.<br>• Cascade circuits.<br>• Electrostatic machines | 4 |
| 2 | • Generation of Impulse voltages and currents: single stage and multistage circuits.<br>• Wave shaping-tripping and control of impulse generators. | 6 |
| 3 | • Generation of switching surge voltage and impulse current Measurement of high voltages and currents.<br>• DC,AC and impulse voltages and currents.<br>• DSO-electrostatic and peak voltmeters-sphere gaps-factors affecting measurements.<br>• Potential dividers(capacitive and resistive)-series impedance ammeters.<br>• Rogowski coils-hall effect generators Digital techniques in HV measurements. | 8 |
| 4 | • Measurement of electric field.<br>• Sources of EMI, Principles of EMC, Filtering.<br>• Shielding, Grounding techniques. | 4 |
| 5 | • Introduction to relevant national and international standards.<br>• Layout and clearances as well as shielding and grounding of HV lab | 4 |
| 6 | • Safety regulations for high voltage tests.<br>• Calibration of HV measuring instruments.<br>• Indian Standards for HV clearances.<br>• Recent trends in HV Engineering. | 6 |

## *Suggested reading*

1. M. S. Naidu, V. Kamaraju, "High Voltage Engineering", McGraw-Hill, 1995.
2. M. Khalifa, "High Voltage Engineering: Theory and Practice", Dekker, 1990
3. H. M. Ryan, "High Voltage Engineering and Testing", Peter Peregrinus, 1994
4. Wadhwa C L."High Voltage Engineering", Wiley Eastern Limited, NewDelhi,1994
5. Ott, H.W.,"Noise Reduction Techniques in Electronic Systems", John Wiley, New York, 1989

## *Course Outcomes*

Students will be able to

1. Haveknowledge about the need for high voltage generation
2. Acquaint with the different methods for generating high voltage AC/DC and impulse voltages and current
3. Haveknowledge about the measurement techniques for high voltage AC/DC and impulse voltages and currents
4. Learn sources of EMI and its mitigation techniques
5. Havesafety precautions to be taken while designing an HV lab

# PE 2 :SWITCHED MODE POWER CONTROL

## *Course Objectives*

Students will be able to
1. Understand different switch mode topologies & control methods

2. Understand different application of semiconductor devices

## *Syllabus*

| Unit | *Content* | *Hours* |
|---|---|---|
| 1 | • Introduction of Available Sources & Demanding loads<br>• Sources - AC mains, Lab supplies, Batteries, Solar Cells<br>• Loads - Requirements of load, battery as load | 4 |
| 2 | • Selection of Topology : Step-Up / Step-Down, Multiple outputs<br>• Continuous & discontinuous modes of operation | 4 |
| 3 | • Isolated converters<br>• Various Configurations of Converters<br>• Selection of Components: Selection of Resistors, Chokes, Capacitors, Diodes<br>• MoSFETs& IGBTs, Connectors | 8 |
| 4 | • Design of Magnetics Fundamentals & ideal conditions<br>• Design of High frequency chokes & transformers<br>• Selection of wire gauge, Sealing of magnetics | 6 |
| 5 | • Guide to Instrumentation<br>• Basics of measurements using DMM, Oscilloscope, Electronic loads, etc | 4 |
| 6 | • Design of Feedback circuits<br>• Basic control requirements, Current & voltage mode control fundamentals & system stability conditions<br>• Design of Control and Monitoring circuits.<br>• Practical Control circuitry & Monitoring circuitry requirements. | 6 |

## *Suggested Reading*

1. Ned Mohan ,Undeland and Robbins, "Power Electronics Converters, Applications and Design", John Wiley & sons.
2. Abraham I Pressman, Keith Billings, Taylor Morey, "Switching Power Supply Design",

## *Course Outcomes*

Students will be able to
1. Give practical step by step approach for design and assembly of Power Supplies and apply the necessary recent technology to comply the standards and certification requirements.
2. Have ability to design a system / component/ process.

# PE 2 : OPTIMAL AND ADAPTIVE CONTROL

## *Course Objectives*

Students will be able to

1. Know the operation of closed and open loop optimal control
2. Understand the adaptive control strategies
3. Learn dynamic programming method

## *Syllabus*

| Unit | *Content* | *Hours* |
|---|---|---|
| 1 | • Optimal control problem<br>• Fundamental concepts and theorems of calculus of variations<br>• Euler-Lagrange equation and external of functional. | 4 |
| 2 | • Variational approach to solving optimal control problems<br>•<br>• Hamiltonian and different boundary conditions for optimal control problem | 4 |
| 3 | • Linear regulator problem<br>• Pontryagin's minimum principle | 2 |
| 4 | • Dynamic programming<br>• Principle of optimality and its application to optimal control problem | 6 |
| 5 | • Hamilton-Jacobi-Bellman equation<br>• Model reference adaptive systems (MRAS) - Design hypothesis | 4 |
| 6 | • Introduction to design method based on the use of Liapunov function<br>• Design and simulation of variable structure adaptive model following control. | 4 |

## *Suggested reading*

1. Donald E. Kirk, "Optimal Control Theory, An introduction." Prentice Hall Inc., 2004
2. A.P. Sage, "Optimum Systems Control", Prentice Hall, 1977
3. HSU and Meyer , "Modern Control, Principles and Applications," McGraw Hill, 1968
4. Yoan D. Landu, "Adaptive Control" (Model Reference Approach), Marcel Dekker. 1981
5. K.K.D.Young, Design of Variable Structure Model Following Control Systems., IEEE Transactions on Automatic Control, Vol. 23, pp 1079-1085, 1978.

## *Course Outcomes*

Students will be able to

1. Have knowledge in the mathematical area of calculus of variation so as to apply the same for solving optimal control problems
2. Know Problem formulation, performance measure and mathematical treatment of optimal control problems
3. Acquire knowledge on solving optimal control design problems by taking into consideration the physical constraints on practical control systems
4. Obtain optimal solutions to controller design problems taking into consideration the limitation on control energy in the real practical world

# PE 2: FACTS AND CUSTOM POWER DEVICES

## *Course Objectives*

Students will be able to

1. Learn the active and reactive power flow control in power system
2. Understand the need for static compensators
3. Develop the different control strategies used for compensation

## *Syllabus*

| Unit | *Content* | *Hours* |
|---|---|---|
| 1 | • Reactive power flow control in Power Systems<br>• Control of dynamic power unbalances in Power System<br>• Power flow control-Constraints of maximum transmission line loading<br>• Benefits of FACTS Transmission line compensation- Uncompensated line - Shunt compensation - Series compensation –Phase angle control.<br>• Reactive power compensation – Shunt and Series compensation principles – Reactive compensation at transmission and distribution level . | 8 |
| 2 | • Static versus passive VAR compensator,Static shunt compensators: SVC and<br>• STATCOM - Operation and control of TSC, TCR and STATCOM - Compensator control<br>• Comparison between SVC and STATCOM. | 4 |
| 3 | • Static series compensation: TSSC, SSSC -Static voltage and phase angle regulators – TCVR and TCPAR<br>• Operation and Control –Applications<br>• Static series compensation –<br>GCSC,TSSC, TCSC<br>• Static synchronous series compensators and their Control | 6 |
| 4 | • SSR and its damping Unified Power Flow Controller: Circuit Arrangement<br>• Operation and control of UPFC- Basic Principle of P and Q control<br>• Independent real and reactivepower flow control- Applications. | 4 |
| 5 | • Introduction to interline power flow controller.<br>• Modeling and analysis of FACTS Controllers – Simulation of FACTS controllers Power quality problems in distribution systems<br>• Harmonics, loads that create harmonics, modeling, harmonic propagation, series and parallel resonances, mitigation of harmonics<br>• Passive filters, active filtering – shunt , series and hybrid and their control. | 6 |
| 6 | • Voltage swells , sags, flicker, unbalance and mitigation of these problems by power line conditioners<br>• IEEE standards on power quality. | 4 |

## *Suggested reading*

1. K R Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New AgeInternationalPublishers, 2007

2. X P Zhang, C Rehtanz, B Pal, “Flexible AC Transmission Systems- Modelling and Control”,Springer Verlag, Berlin, 2006
3. N.G. Hingorani, L. Gyugyi, “Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems”, IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001.
4. K.S.Sureshkumar ,S.Ashok , “FACTS Controllers & Applications”, E-book edition, Nalanda Digital Library, NIT Calicut,2003
5. G T Heydt , “Power Quality”, McGraw-Hill Professional, 2007
6. T J E Miller, “Static Reactive Power Compensation”, John Wiley and Sons, Newyork, 1982.

### *Course Outcomes*

Students will be able to

1. Acquire knowledge about the fundamental principles of Passive and Active Reactive PowerCompensation Schemes at Transmission and Distribution level in Power Systems.
2. Learn various Static VAR Compensation Schemes like Thyristor/GTO Controlled Reactive Power Systems, PWM_Inverter based Reactive Power Systems and their controls .
3. Develop analytical modeling skills needed for modeling and analysis of such Static VARSystems.

# LAB 1 – POWER SYSTEMS LAB/DISTRIBUTED GENERATION LAB

**Power Systems lab**

| S.No | Experiments |
|---|---|
| 1 | Determination of sequence impedance of an alternator by fault analysis |
| 2 | Measurement of sequence impedance of a 3 phase transformer. |
| 3 | Power angle characteristics of a salient pole synchronousmachine. |
| 4 | Scott connection of transformers. |
| 5 | ABCD parameter. |
| 6 | Break down characteristics of a sphere gap |
| 7 | Determination of breakdown strength of transformer oil. |
| 8 | Determination of leakage current of pin insulator. |
| 9 | Voltage distribution across the string insulator |

**Distributed Generation lab**

1. Single PV module I-V and P-V characteristics with radiation and temperature changing effect.

2. I-V and P-V characteristics with series and parallel combination of modules.

3. Effect of shading and Effect of tilt angle on I-V and P-V characteristics of solar module.

4. Study of Stand-alone system using Combine AC and DC load system with battery.

5. Finding MPP by varying the resistive load by varying the duty cycle of DC-DC converter.

6. Finding $P_{max}$ with different values of perturbation (delta D) .

7. Perform the experiment with battery in the circuit.

8. Observe the output voltage waveform of inverter in auto mode.

9. Observe the RMS value and waveform of output voltage with both 180 and 120 degree control.

# LAB 2 – RENEWABLE ENERGY LAB

| S.No | Experiments |
|---|---|
| 1 | To determine the efficiency of Solar PV panel at different irradiance levels |
| 2 | To determine the efficiency of a wind turbine for different wind speeds |

| | |
|---|---|
| 3 | Test the Capabilities of the Hydrogen Fuel Cells and Capacitors |
| 4 | Effect of Temperature on Solar Panel Output |
| 5 | Variables Affecting Solar Panel Output |
| 6 | Effect of Load on Solar Panel Output |
| 7 | Wind Turbine Output: The Effect of Load |
| 8 | Test the Capabilities of Solar Panels and Wind Turbines |

## Research Methodology and IPR

**Teaching Scheme**

Lectures: 1hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.
-

**Syllabus Contents:**

**Unit 1:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Unit 2:** Effective literature studies approaches, analysis

Plagiarism, Research ethics,

**Unit 3:** Effective technical writing, how to write report, Paper

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**Unit 4:** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of

Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Unit 5:** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Unit 6:** New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

**References:**


- Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
- Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
- Ranjit Kumar, 2nd Edition , "Research Methodology: A Step by Step Guide for beginners"
- Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
- Mayall , "Industrial Design", McGraw Hill, 1992.
- Niebel , "Product Design", McGraw Hill, 1974.
- Asimov , "Introduction to Design", Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
- T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008


# SECOND SEMESTER

# CORE - 3: DIGITAL POWER SYSTEM PROTECTION

## *Course Objectives*

Students will be able to

1. Study numerical relays
2. Develop mathematical approach towards protection
3. Study algorithms for numerical protection

## *Syllabus*

| Unit | *Content* | *Hours* |
|---|---|---|
| 1 | • Evolution of digital relays from electromechanical relays,<br>• Performance and operational characteristics of digital protection | 4 |
| 2 | • Mathematical background to protection algorithms: Finite difference techniques | 4 |
| 3 | • Interpolation formulae: Forward, backward and central difference interpolation<br>• Numerical differentiation, Curve fitting and smoothing<br>• Least squares method,<br>• Fourier analysis, Fourier series and Fourier transform,<br>• Walsh function analysis<br>• | 6 |
| 4 | • Basic elements of digital protection: Signal conditioning: transducers, surge protection, analog filtering, analog multiplexers | 8 |

| | | |
|---|---|---|
| | • Conversion subsystem: the sampling theorem, signal aliasing error, sample and hold circuits, multiplexers, analog to digital conversion,<br>• Digital filtering concepts,<br>• The digital relay as a unit consisting of hardware and software<br>• | |
| 5 | • Sinusoidal wave based algorithms: Sample and first derivative (Mann and Morrison) algorithm.<br>• Fourier and Walsh based algorithms<br>• | 4 |
| 6 | • Fourier Algorithm: Full cycle window algorithm, fractional cycle window algorithm.<br>• Walsh function based algorithm.<br>• Least Squares based algorithms.<br>• Differential equation based algorithms.<br>• Traveling Wave based Techniques.<br>• Digital Differential Protection of Transformers.<br>• Digital Line Differential Protection.<br>• Recent Advances in Digital Protection of Power Systems.<br>• | 8 |

### *Suggested reading*

1. A.G. Phadke and J. S. Thorp, “Computer Relaying for Power Systems”, Wiley/Research studies Press, 2009
2. A.T. Johns and S. K. Salman, “Digital Protection of Power Systems”, IEEE Press,1999
3. Gerhard Zeigler, “Numerical Distance Protection”, Siemens Publicis Corporate Publishing, 2006
4. S.R. Bhide “Digital Power System Protection” PHI Learning Pvt. Ltd. 2014

### *Course Outcomes*

Students will be able to

1. Learn the importance of Digital Relays.
2. Apply Mathematical approach towards protection
3. Learn to develop various Protection algorithms

## CORE 4 :NON CONVENTIONAL ELECTRICAL ENERGY SYSTEMS

### *Course Objectives*

Students will be able to

1. Understand important concepts of energy generation through non-conventional ways
2. Understand different sources like:- Hydro ,Solar , Biomass, Wind , Tidel
3. Learn about Fusion

### *Syllabus*

| Unit | *Content* | *Hours* |
|---|---|---|
| 1 | • Solar energy principles and applications.<br>• Efficiency of solar thermal and PV systems.<br>• Storage and enrichment.<br>• Shadow effect | 4 |

| | | |
|---|---|---|
| 2 | • Biomass: generationcharacterization.<br>• Biogas: aerobic and anaerobic bio-conversion processes.<br>• Microbial reactions purification.<br>• Properties of biogas | 4 |
| 3 | • Tidal and wind energy potential and conversion efficiency | 4 |
| 4 | • Fusion: Basic concepts.<br>• Fusion reaction physics.<br>• Thermonuclear fusion reaction criteria.<br>• Confinement schemes.<br>• Inertial and magnetic confinement fusion.<br>• Current status Geothermal: Geothermal regions.<br>• Geothermal sources.<br>• Dry rock and hot aquifer analysis Geothermal energy conversion technologies.<br>• OTEC. | 6 |
| 5 | • Mini/micro hydro power: classification of hydropower schemes.<br>• Classification of water turbine.<br>• Turbine theory.<br>• Essential components of hydroelectric system.<br>• System efficiency | 4 |
| 6 | • Integrated operation of non-conventional energy sources/Islanding preventive schemes | 4 |

### *Suggested reading*

1. J.Twidell and T.Weir, "Renewable Energy Resources", Taylor and Francis Group 2007
2. G.N.Tiwari and MK Ghosal, "Renewable Energy Resources Basic Principles and Application", Narosa Publishing House 2005.
3. J.A.Duffie and WA Beckman, "Solar Engineering and Thermal Processes", 2nd Edition John Wiley and sons. 2001.
4. G.N.Tiwari, "Solar Energy", Narosa Publishing House, 2002.
5. R.A.Gross, "Fusion Energy", John Wiley and Sons, 1984.

### *Course Outcomes*

Students will be able to

1. Have knowledge about Hydro,Wind,Biomass ,Tidal sources
2. Learn about Dry rock and Hot Aquifier Analysis
3. Acquire the knowledge about fusion

# PE 3 : ARTIFICIAL INTELLIGENCE TECHNIQUES

### *Course Objectives*

Students will be able to

1. Understand fuzzy logic,ANN

2. Understand GA & EP

### *Syllabus*

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Biological foundations to intelligent Systems: Artificial Neural Networks.<br>• Single layer and Multilayer Feed Forward NN.<br>• LMS and Back Propagation Algorithm.<br>• Feedback networks and Radial Basis Function Networks | 4 |
| 2 | • Fuzzy Logic,<br>• Knowledge Representation and Inference Mechanism.<br>• Defuzzification Methods | 6 |
| 3 | • Fuzzy Neural Networks and some algorithms to learn the parameters of the network like GA | 4 |
| 4 | • System Identification using Fuzzy and Neural Network | 4 |
| 5 | • Genetic algorithm :Reproduction.<br>• Cross over.<br>• Mutation.<br>• Introduction to evolutionary program | 4 |
| 6 | • Applications of above mentioned techniques to practical problems. | 4 |

### *Suggested Reading*

1. J M Zurada , "An Introduction to ANN",Jaico **Publishing** House
2. Simon Haykins, "Neural Networks", Prentice Hall
3. Timothy Ross, "Fuzzy Logic with Engg.Applications", McGraw. Hill
4. Driankov, Dimitra, "An Introduction to Fuzzy Control", Narosa Publication
5. Golding, "Genetic Algorithms", Addison-Wesley **Publishing** Com

### *Course Outcomes*

Students will be able to

1. Learn the concepts of biological foundations of artificial neural networks
2. Learn Feedback networks and radial basis function networks and fuzzy logics
3. Identify fuzzy and neural network
4. Acquire the knowledge of GA

## PE 3: SMART GRIDS

### *Course Objectives*

Students will be able to

1. Understand concept of smart grid and its advantages over conventional grid

2. Know smart metering techniques

3. Learn wide area measurement techniques

4. Understand the problems associated with integration of distributed generation & its solution through smart grid.

### *Syllabus*

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Introduction to Smart Grid.<br>• Evolution of Electric Grid. | 4 |

| | | |
|---|---|---|
| | • Concept of Smart Grid, Definitions.<br>• Need of Smart Grid.<br>• Concept of Robust &Self Healing Grid.<br>• Present development & International policies in Smart Grid | |
| 2 | • Introduction to Smart Meters.<br>• Real Time Prizing.<br>• Smart Appliances.<br>• Automatic Meter Reading(AMR).<br>• Outage Management System(OMS).<br>• Plug in Hybrid Electric Vehicles(PHEV).<br>• Vehicle to Grid.<br>• Smart Sensors.<br>• Home& Building Automation.<br>• Smart Substations.<br>• Substation Automation.<br>• Feeder Automation | 6 |
| 3 | • Geographic Information System(GIS).<br>• Intelligent Electronic Devices(IED) & their application for monitoring & protection.<br>• Smart storage like Battery.<br>• SMES.<br>• Pumped Hydro.<br>• Compressed Air Energy Storage.<br>• Wide Area Measurement System(WAMS).<br>• Phase Measurement Unit(PMU) | 8 |
| 4 | • Concept of micro-grid.<br>• Need & applications of micro-grid.<br>• Formation of micro-grid.<br>• Issues of Interconnection.<br>• Protection & control of micro-grid.<br>• Plastic & Organic solar cells.<br>• Thin film solar cells.<br>• Variable speed wind generators.<br>• Fuel-cells.<br>• Micro-turbines.<br>• Captive power plants.<br>• Integration of renewable energy sources. | 6 |
| 5 | • Power Quality & EMC in Smart Grid.<br>• Power Quality issues of Grid connected Renewable Energy Sources.<br>• Power Quality Conditioners for Smart Grid.<br>• Web based Power Quality monitoring.<br>• Power Quality Audit | 4 |
| 6 | • Advanced Metering Infrastructure (AMI).<br>• Home Area Network (HAN),<br>• Neighborhood Area Network (NAN). | 4 |

| | | |
|---|---|---|
| | • Wide Area Network (WAN).<br>• Bluetooth.<br>• ZigBee.<br>• GPS, Wi-Fi.<br>• Wi-Max based communication.<br>• Wireless Mesh Network.<br>• Basics of CLOUD Computing & Cyber Security for Smart Grid. Broadband over Powerline (BPL).<br>• IP based protocols | |

***Suggested reading***


1. Ali Keyhani, "Design of smart power grid renewable energy systems", Wiley IEEE,2011
2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press , 2009
3. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, "Smart Grid: Technology and Applications", Wiley 2012
4.StuartBorlase,"Smart Grid :Infrastructure , Technology and solutions " CRC Press
5. A.G.Phadke, "Synchronized Phasor Measurement and their Applications", Springer


***Course Outcomes***

Students will be able to

1. Appreciate the difference between smart grid & conventional grid
2. Apply smart metering concepts to industrial and commercial installations
3. Formulate solutions in the areas of smart substations ,distributed generation and wide area measurements
4. Come up with smart grid solutions using modern communication technologies

# PE 3: ENERGY CONVERSION PROCESSES

## *Course Objectives*

Students will be able to

1. Analysis of different energy system like solar
2. Understand design aspects of MHD generators
3. Understand Fuel cell & their applications

## *Syllabus*

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Basic science of energy conversion.<br>• Indirect verses direct conversion | 4 |
| 2 | • Physics of semiconductor junctions for photovoltaic and photo-electrochemical conversion of solar energy.<br>• Fabrication and evaluation of various solar cells in photovoltaic power generation systems | 4 |
| 3 | • Technology and physics of thermo-electric generations.<br>• Thermal-electric materials and optimization studies | 4 |
| 4 | • Basic concepts and designconsiderations of MHD generatorsCycle analysis of MHD systems | 6 |
| 5 | • Thermonic power conversion and plasma diodes.<br>• Thermo dynamicsand Performance of fuel cells and their | 4 |

| | | |
|---|---|---|
| | applications. | |
| 6 | • Advanced topics in Energy Conversion Process | 4 |

## *Suggested reading*

1. S. S. L. Chang, "Energy Conversion", Prentice Hall, 1963. 16
2. S. W. Angrist, "Direct Energy Conversion", Pearson, 1982
3. R. J. Rosa, "Magneto hydrodynamic Energy Conversion", Springer, 1987
4. V. S. Bagotsky, "Fuel Cell Problems and Solutions", John Wiley & Sons, 2009

## *Course Outcomes*

Students will be able to

1. Have knowledge about Physics of semiconductor junctions for photovoltaic and photo- electro chemical conversion
2. Carry out Cycle analysis of MHD systems
3. Know Different thermo-electric processes of electric materials and their efficient use

# PE 4: ELECTRIC AND HYBRID VECHILES

## *Course Objectives*

Students will be able to

1. Understand upcoming technology of hybrid system
2. Understand different aspects of drives application
3. Learn the electric Traction

| ***Syllabus*** **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • History of hybrid and electric vehicles.<br>• Social and environmental importance of hybrid and electric vehicles.<br>• Impact of modern drive-trains on energy supplies.<br>• Basics of vehicle performance.<br>• Vehicle power source characterization.<br>• Transmission characteristics.<br>• Mathematical models to describe vehicle performance | 6 |
| 2 | • Basic concept of hybrid traction.<br>• Introduction to various hybrid drive-train topologies.<br>• Power flow control in hybrid drive-train topologies.<br>• Fuel efficiency analysis | 4 |
| 3 | • Basic concepts of electric traction.<br>• Introduction to various electric drive-train topologies.<br>• Power flow control in hybrid drive-train topologies.<br>• Fuel efficiency analysis | 4 |
| 4 | • Introduction to electric components used in hybrid and electric vehicles.<br>• Configuration and control of DC Motor drives. | 6 |

| | | |
|---|---|---|
| | • Configuration and control of Introduction Motor drives.<br>• Configurationand control of Permanent Magnet Motor drives.<br>• Configuration and control of Switch Reluctance Motor drives.<br>• Drive system efficiency | |
| 5 | • Matching the electric machine and the internal combustion engine (ICE).<br>• Sizing the propulsion motor.<br>• Sizing the power electronics.<br>• Selecting the energy storage technology.<br>• Communications.<br>• Supporting subsystems | 4 |
| 6 | • Introduction to energy management and their strategies used in hybrid and electric vehicle.<br>• Classification of different energy management strategies.<br>• Comparison of different energy management strategies.<br>• Implementation issues of energy strategies. | 4 |

### *Suggested reading*

1.Sira -Ramirez, R. Silva Ortigoza, "Control Design Techniques in Power Electronics Devices", Springer.

2. Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, "Sliding mode control of switching Power Converters"

### *Course Outcomes*

Students will be able to

1. Acquire knowledge about fundamental concepts, principles, analysis and design of hybrid and electric vehicles.
2. Learn electric drive in vehicles / traction.

## PE 4: POWER QUALITY

### *Course Objectives*

Students will be able to

1. Understand the different power quality issues to be addressed
2. Understand the recommended practices by various standard bodies like IEEE, IEC, etc on voltage & frequency, harmonics
3. Understand STATIC VAR Compensators

### *Syllabus*

| Unit | *Content* | *Hours* |
|---|---|---|
| 1 | • Introduction-power quality.<br>• Voltage quality-overview of power quality phenomena.<br>• Classification of power quality issues.<br>• Power quality measures and standards-THD-TIF-DIN-C.<br>• Message weights-flicker factor transient phenomena-occurrence of power quality problems.<br>• Power acceptability curves-IEEE guides. | 8 |

| | | |
|---|---|---|
| | • Standards and recommended practices. | |
| 2 | • Harmonics-individual and total harmonic distortion.<br>• RMS value of a harmonic waveform.<br>• Triplex harmonics-important harmonic introducing devices-SMPS.<br>• Three phase power converters-arcing devices saturable devices-harmonic distortion of fluorescent lamps.<br>• Effect of power system harmonics on power system equipment and loads. | 6 |
| 3 | • Modeling of networks and components under non-sinusoidal conditionstransmission and distribution systems.<br>• Shunt capacitors-transformers.<br>• Electric machines-ground systems loads that cause power quality problems-power quality problems created by drives and its impact on drive | 4 |
| 4 | • Power factor improvement.<br>• Passive Compensation . Passive Filtering . Harmonic Resonance.<br>• Impedance Scan Analysis- Active Power Factor Corrected Single Phase Front End.<br>• Control Methods for Single Phase APFC, Three Phase APFC and Control Techniques.<br>• PFC Based on Bilateral Single Phase and Three Phase Converter. | 4 |
| 5 | • Static VAR compensators-SVC and STATCOM Active Harmonic Filtering-Shunt InjectionFilter for single phase.<br>• Three-phase three-wire and three-phase four-wire systems.<br>• d-q domain control of three phase shunt active filters uninterruptible power supplies constant voltage transformers.<br>• Series active power filtering techniques for harmonic cancellation andisolation. | 8 |
| 6 | • Dynamic Voltage Restorers for sag.<br>• Swell and flicker problems.<br>• Grounding and wiring introduction- NEC grounding requirements-reasons for grounding-typical grounding<br>and wiring problems solutions to grounding and wiring problems. | 4 |

## *Suggested reading*

1. G.T. Heydt, “Electric power quality”, McGraw-Hill Professional, 2007

2. Math H. Bollen, “Understanding Power Quality Problems”, IEEE Press, 2000

3. J. Arrillaga, “Power System Quality Assessment”, John wiley, 2000

4. J. Arrillaga, B.C. Smith, N.R. Watson & A. R.Wood ,”Power system Harmonic Analysis”, Wiley, 1997

## *Course Outcomes*

Students will be able to

1: Acquire knowledge about the harmonics, harmonic introducing devices and effect of harmonicson system equipment and loads

2: Develop analytical modeling skills needed for modeling and analysis of harmonics in networks and components

3: Introduce the student to active power factor correction based on static VAR compensators andits control techniques

4: Introduce the student to series and shunt active power filtering techniques for harmonics.

# PE 4: INDUSTRIAL LOAD MODELING AND CONTROL

## *Course Objectives*

Students will be able to

1. Understand the energy demand scenario
2. Understand the modeling of load and its ease to study load demand industrially
3. Know Electricity pricing models
4. Study Reactive power management in Industries

## *Syllabus*

| Unit | *Content* | *Hours* |
|---|---|---|
| 1 | • Electric Energy Scenario-Demand Side Management-Industrial Load Management.<br>• Load Curves-Load Shaping Objectives-Methodologies-Barriers.<br>• Classification of Industrial Loads- Continuous and Batch processes -Load Modelling | 4 |
| 2 | • Electricity pricing – Dynamic and spot pricing –Models.<br>• Direct load control- Interruptible load control.<br>• Bottom up approach- scheduling- Formulation of load models.<br>• Optimization and control algorithms.<br>• Case studies | 6 |
| 3 | • Reactive power management in industries-controls.<br>• Power quality impacts-application of filters Energy saving in industries | 4 |
| 4 | • Cooling and heating loads.<br>• Load profiling- Modeling.<br>• Cool storage-Types-Control strategies.<br>• Optimal operation.<br>• Problem formulation.<br>• Case studies | 4 |
| 5 | • Captive power units- Operating and control strategies.<br>• Power Pooling- Operation models.<br>• Energy banking.<br>• Industrial Cogeneration | 4 |
| 6 | • Selection of Schemes Optimal Operating Strategies-Peak load saving.<br>• Constraints.<br>• Problem formulation- Case study.<br>• Integrated Load management for Industries | 4 |

## *Suggested reading*

1. C.O. Bjork " Industrial Load Management - Theory, Practice and Simulations", Elsevier, the

Netherlands,1989
2. C.W. Gellings and S.N. Talukdar, . Load management concepts. IEEE Press, New York, 1986,pp. 3-28
3. Y. Manichaikul and F.C. Schweppe ," Physically based Industrial load", IEEE Trans. on PAS,April 1981
4. H. G. Stoll, "Least cost Electricity Utility Planning", Wiley Interscience Publication, USA, 1989.
5. I.J.Nagarath and D.P.Kothari, .Modern Power System Engineering., Tata McGraw Hill publishers,NewDelhi, 1995
6. IEEE Bronze Book- "Recommended Practice for Energy Conservation and cost effective planninginIndustrial facilities", IEEE Inc, USA

### *Course Outcomes*

Students will be able to

1: Know about load control techniques in industries and its application
2: Learn different types of industrial processes and optimize the process using tools like LINDO and LINGO
3: Apply load management to reduce demand of electricity during peak time
4: Apply different energy saving opportunities in industries

# LAB 3 – POWER SYSTEM PROTECTION LAB/POWER SYSTEM ANALYSIS LAB

**Power System Protection Lab**

| S.No | Experiments |
|---|---|
| 1 | Apply a relay for phase sequence, phase failure and voltage asymmetry to a three-phase circuit |
| 2 | To use a timer with different time functions to extend the protection relays operation |
| 3 | Modelling of Differential Relay using MATLAB |
| 4 | Radial Feeder Protection |
| 5 | Parallel Feeder Protection |
| 6 | Principle of Reverse Power Protection |
| 7 | Differential Protection of Transformer |
| 8 | To the study time Vs voltagecharacteristics of over voltage induction relay |

**Power System Analysis lab**

| S.No | Experiments |
|---|---|
| 1 | Write a program to form Y bus by Inspection method. |
| 2 | Write a program for formation of Y bus by singular matrix transformation |
| 3 | Study of load flow methods<br>a) Gauss-Siedel method<br>b) Newton Raphson Method |
| 4 | Write a program for fault analysis for<br>a) LG b)LLG c)LLL |
| 5 | Write a program for security analysis using load flow & ranking of contingency |
| 6 | Write a program for ranking of contingency using overload security analysis |
| 7 | Study of ready-made industry standard / commercial software packages for above analysis |
| 8 | Write a program to form $Z_{bus}$ matrix. |

# LAB 4 – ARTIFICIAL INTELLIGENCE LAB /POWER QUALITY LAB/NON-CONVENTIONAL ENERGY SOURCES LAB.

**Artificial Intelligence lab**

| S.No | Experiments |
|---|---|

| | |
|---|---|
| 1 | Write a program to simulate a perceptron network for pattern classification and function approximation. |
| 2 | Write a program to solve a XOR function using feed-forward neural network trained using back-propagation algorithm. |
| 3 | Write a program to implement adaptive noise cancellation using ADALINE neural network. |
| 4 | Given the region to be de-fuzzified, write programs to discuss the various methods that might be chosen. |
| 5 | Implementation of simple Over Current Relay using fuzzy logic. |
| 6 | Simulation and comparison of fuzzy PID controller with conventional PID controller for a given plant. |
| 7 | Solve optimal relay coordination as a linear programming problem using Genetic Algorithm. |
| 8 | Solve optimal relay coordination as a non-Linear programming problem using Genetic algorithm. |
| 9 | Solve economic load dispatch problem using Genetic algorithm. |
| 10 | Write a program to simulate a perceptron network for pattern classification and function approximation. |

**Power Quality Lab**

| S.No | Experiments |
|---|---|
| 1 | To study the effect of non linear loads on power quality |
| 2 | To demonstrate the voltage and current distortions experimentally. |
| 3 | To reduce the current harmonics with filters. |
| 4 | To study the voltage sag due to starting of large induction motor. |
| 5 | To study the capacitor switching transients. |
| 6 | To study the effect of balanced non linear load on neutral current , in a three phase circuit |
| 7 | To study the effect of ground loop. |
| 8 | To study the effect of voltage flicker . |
| 9 | To calculate the distortion power factor. |
| 10 | Study the effect of harmonics on energy meter reading |
| 11 | To study effect of voltage sag on electrical equipments. |
| 12 | To obtain the current harmonics drawn by power electronics interface using PSCAD software. |

**Non-Conventional Energy Sources Lab**

| S. No | Experiments |
|---|---|
| 1 | Determine the efficiency of Solar PV Grid-Tied system. |
| 2 | Determine the efficiency of Wind Energy System. |
| 3 | Field Visit to Solar Street Lighting System. |
| 4 | Determine the power output of a biogas plant |
| 5 | Study of a geothermal system |
| 6 | Determine the efficiency of a fuel cell |
| 7 | Determine the efficiency of a mini hydro plant |

| | |
|---|---|
| 8 | Study of grid integration of multiple renewable energy sources |

# PE 5 : POWER SYSTEM ANALYSIS

## *Course Objectives*

Students will be able to

1. Study various methods of load flow and their advantages and disadvantages
2. Understand how to analyze various types of faults in power system
3. Understand power system security concepts and study the methods to rank the contingencies
4. Understand need of state estimation and study simple algorithms for state estimation
5. Study voltage instability phenomenon

## *Syllabus*

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Load flow **:**Overview of Newton-Raphson.<br>• Gauss-Siedel andfast decoupled methods.<br>• Convergence properties, sparsity techniques.<br>• Handling Q-max violations in constant matrix, inclusion in frequency effects.<br>• AVR in load flow.<br>• Handling of discrete variable in load flow | 6 |
| 2 | • Fault Analysis: Simultaneous faults.<br>• Open conductors faults.<br>• Generalized method of fault analysis | 4 |
| 3 | • Security Analysis: Security state diagram.<br>• Contingency analysis, generator shift distribution factors.<br>• Line outage distribution factor.<br>• Multiple line outages, overload index ranking | 6 |
| 4 | • Power System Equivalents :WARD and REI equivalents | 4 |
| 5 | • State Estimation : Sources of errors in measurement.<br>• Virtual and Pseudo.<br>• Measurement, Observability.<br>• Tracking state estimation.<br>• WSL method.<br>• bad data correction | 4 |
| 6 | • Voltage Stability : Voltage collapse.<br>• P-V curve.<br>• Multiple power flow solution, continuation power flow.<br>• Optimal multiplies load flow.<br>• Voltage collapse proximity indices | 6 |

## *Suggested reading*

1. J.J. Grainger &W.D.Stevenson, "Power system analysis ", McGraw Hill ,2003

1. A. R. Bergen & Vijay Vittal , "Power System Analysis" ,Pearson , 2000

2. L.P. Singh , "Advanced Power System Analysis and Dynamics", New Age International, 2006
3. G.L. Kusic, "Computer aided power system analysis" ,Prentice Hall India, 1986
4. A.J. Wood, " Power generation, operation and control" , John Wiley, 1994
5. P.M. Anderson, "Faulted power system analysis" , IEEE Press , 1995

### *Course outcomes*

Students will be able to

1. Able to calculate voltage phasors at all buses , given the data using various methods of load flow
2. Able to calculate fault currents in each phase
3. Rank various contingencies according to their severity
4. Estimate the bus voltage phasors given various quantities viz. power flow, voltages, taps , CB status etc
5. Estimate closeness to voltage collapse and calculate PV curves using continuation power flow

# PE 5: POWER SYSTEM TRANSIENTS

### *Course Objectives*

Students will be able to

1. Learn the reasons for occurrence of transients in a power system
2. Understand the change in parameters like voltage & frequency during transients
3. Know about the lightning phenomenon and its effect on power system

### *Syllabus*

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Fundamental circuit analysis of electrical transients.<br>• Laplace Transform method of solving simple Switching transients.<br>• Damping circuits -Abnormal switching transients.<br>• Three-phase circuits and transients.<br>• Computation of power system transients. | 4 |
| 2 | • Principle of digital computation – Matrix method of solution.<br>• Modal analysis- Z transform.<br>• Computation using EMTP. Lightning, switching and temporary over voltages.<br>• Lightning: Physical phenomena of lightning. | 6 |
| 3 | • Interaction between lightning and power system.<br>• Influence of tower footing resistance and Earth Resistance.<br>• Switching: Short line or kilometric fault.<br>• Energizing transients - closing and re-closing of lines.<br>• Line dropping, load rejection.<br>• Over voltages induced by faults. | 4 |
| 4 | • Switching HVDC lineTravelling waves on transmission line : Circuits with distributed Parameters.<br>• Wave Equation.<br>• Reflection, Refraction.<br>• Behaviour of Travelling waves at the line terminations.<br>• Lattice Diagrams – Attenuation and Distortion.<br>• Multi-conductor system and Velocity wave. | 6 |
| 5 | • Insulation co-ordination: Principle of insulation co-ordination in Air Insulated substation (AIS)and Gas Insulated Substation (GIS). | 4 |

| | | |
|---|---|---|
| | • Co-ordination between insulation and protection level.<br>• Statistical approach. | |
| 6 | • Protective devices- Protection of system against over voltages.<br>• Lightning arresters.<br>• Substationearthing. | 4 |

### *Suggested reading*

1. Allan Greenwood, "Electrical Transients in Power System", Wiley & Sons Inc. New York, 1991

### *Course Outcomes*

Students will be able to

1:Have knowledge of various transients that could occur in power system and their mathematical formulation

2: Have ability to design various protective devices in power system for protecting equipment and personnel

3: Coordinate the insulation of various equipments in power system

4: Model the power system for transient analysis

# PE 5 : RELIABILITY ANALYSIS AND PROTECTION

### *Course Objectives*

Students will be able to

1. Understand proper planning and analysis of reliability
2. Learn different methods to estimate different electric quantities

### *Syllabus*

| Unit | *Content* | *Hours* |
|---|---|---|
| 1 | • Long and short term planning.<br>• Load forecasting, characteristics of loads.<br>• Methodology of forecasting, energy forecasting.<br>• Peak demand forecasting, total forecasting.<br>• Annual and monthly peak demand forecasting. | 4 |
| 2 | • Reliability concepts, exponential distributions.<br>• Meantime to failure, series and parallel system, MARKOV process.<br>• Recursive technique. Generator system reliability analysis.<br>• Probability models for generators unit and loads.<br>• Reliability analysis of isolated and interconnected system, generator system cost analysis, corporate model.<br>• Energy transfer and off peak loading. | 8 |
| 3 | • Transmission system reliability model analysis: Monte Carlo simulation.<br>• Average interruption rate.<br>• LOLP method, frequency and duration method. | 4 |
| 4 | • Two plant single load system.<br>• Two plant two load system.<br>• Load forecasting uncertainly interconnections benefits. | 6 |
| 5 | • Introduction to system modes of failure.<br>• The loss of load approach. | 4 |

| | | |
|---|---|---|
| | • Frequency& duration approach.spare value assessment.<br>• Multiple bridge equivalents | |
| 6 | • Distribution system reliability analysis.<br>• Calculation of indices SAIFI.<br>• SAIDI, CAIDI, etc. | 4 |

### *Suggested reading*

1. Sullivan, R.L., "Power System Planning", Heber Hill.
2. Roy Billington, "Power System Reliability Evaluation", Gordan& Breach Scain Publishers.

### *Course Outcomes*

Students will be able to

1. Have knowledge of different methods to estimate different electrical quantities
2. Acquire skills in planning and building reliable power system.
3. Manage skills required in the field of power system engineering are enhanced.

## OE: ENERGY AUDITING AND MANAGEMENT

### *Course Objectives*

Students will be able to

1. Understand the need for energy auditing
2. Understand of various loads involved based on power consumption for auditing
3. Know about different audit instruments used in practice

### *Syllabus*

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • System approach and End use approach to efficient use of Electricity.<br>• Electricity tariff types.<br>• Energy auditing: Types and objectives - audit instruments.<br>• ECO assessment and Economic methods specific energy analysis.<br>• Minimum energy paths-consumption models-Case study. | 6 |
| 2 | • Electric motors-Energy efficient controls and starting efficiency.<br>• Motor Efficiency and LoadAnalysis Energy efficient /high efficient Motors-Case study.<br>• Load Matching and selection of motors.<br>• Variable speed drives; Pumps and Fans.<br>• Efficient Control strategies.<br>• Optimal selection and sizing .<br>• Optimal operation and Storage; Case study | 6 |
| 3 | • Transformer Loading/Efficiency analysis.<br>• Feeder/cable loss evaluation.<br>• Case study.<br>• Reactive Power management-Capacitor-Sizing.<br>• Degreeof Compensation.<br>• Capacitor losses-Location.<br>• Placement Maintenance.<br>• Case study. | 6 |
| 4 | • Peak Demand controls- Methodologies. | 6 |

| | | |
|---|---|---|
| | • Types of Industrial loads.<br>• Optimal Load scheduling-case study, Lighting- Energy efficient light sources.<br>• Energy conservation in Lighting Schemes, Electronic ballast.<br>• Power quality issues-Luminaries, Case study. | |
| 5 | • Cogeneration-Types and Schemes.<br>• Optimal operation of cogeneration plants.<br>• case study.<br>• Electric loads of Air conditioning & Refrigeration.<br>• Energy conservation measures.<br>• Cool storage, Types-Optimal operation case study. | 6 |
| 6 | • Electric water heating, Geysers-Solar Water Heaters.<br>• Power Consumption in Compressors.<br>• Energy conservation measures, Electrolytic Process.<br>• Computer Controls- software-EMS | 4 |

## *Suggested reading*

1. Anthony J. Pansini, Kenneth D. Smalling, .Guide to Electric Load Management., PennwellPub;(1998)
2. Howard E. Jordan, .Energy-Efficient Electric Motors and Their Applications., Plenum Pub Corp; 2nd edition (1994)
3. Giovanni Petrecca, .Industrial Energy Management: Principles and Applications., The Kluwerinternational series -207,1999
4. Handbook on Energy Audit and Environment Management , Y P Abbi and Shashank Jain, TERI,2006
5. Handbook of Energy Audits Albert Thumann, William J. Younger, Terry Niehus, 2009

## *Course Outcomes*

Students will be able to

1. Acquire the background required for engineers to meet the role of energy managers and to acquire the skills and techniques required to implement energy management
2. Identify and quantify the energy intensive business activities in an organization
3. Perform Basic Energy Audit in an Organization.

## OPEN ELECTIVES
## Business Analytics

**Teaching scheme**

**Lecture: - 3 h/week**

| | |
|---|---|
| **Course Code** | |
| **Course Name** | **Business Analytics** |
| **Credits**<br>**Prerequisites** | |

Total Number of Lectures: 48

| **Course objective** |
|---|
| 1. Understand the role of business analytics within an organization.<br>2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.<br>3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making. |

| | |
|---|---|
| 4. | To become familiar with processes needed to develop, report, and analyze business data. |
| 5. | Use decision-making tools/Operations research techniques. |
| 6. | Mange business process using analytical and management tools. |
| **7.** | Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc. |

| LECTURE WITH BREAKUP | NO. OF LECTURES |
|---|---|
| **Unit1:**<br>Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.<br>Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview. | 9 |
| **Unit 2:**<br>Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.<br>Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology. | 8 |
| **Unit 3:**<br>Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.<br>Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization. | 9 |
| **Unit 4:**<br>Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.<br>Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model. | 10 |
| **Unit 5:**<br>Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. | 8 |
| **Unit 6:**<br>Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism. | 4 |

| **COURSE OUTCOMES** | |
|---|---|
| | |
| 1. Students will demonstrate knowledge of data analytics.<br>2. Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.<br>3. Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.<br>**4.** Students will demonstrate the ability to translate data into clear, actionable insights. | |

**Reference:**


1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.


## OPEN ELECTIVES

### Industrial Safety

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**Unit-II:** Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**Unit-III:** Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**Unit-IV:** Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**Unit-V:** Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

**Reference:**


1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.


## OPEN ELECTIVES
## Operations Research

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes: At the end of the course,** the student should be able to

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

**Syllabus Contents:**

**Unit 1**:

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

**Unit 2**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

**Unit 3**:

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

**Unit 4**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

**Unit 5**

Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

**References**:


1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010


## Open Elective
## Cost Management of Engineering Projects

**Teaching scheme**

**Lecture: - 3 h/week**

Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

**References:**

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

## Open Elective
## Composite Materials

**Teaching scheme**

**Lecture: - 3 h/week**

**UNIT–I**: INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT – II**: REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT – III:** Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT–IV:** Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT – V:** Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

**TEXT BOOKS:**

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

**References:**

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

## Open Elective
## Waste to Energy

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**Unit-II:** Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**Unit-III:** Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**Unit-IV:** Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**Unit-V:** Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

**References:**

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

## AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING

**Course objectives:**
Students will be able to:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title

Ensure the good quality of paper at very first-time submission

**Syllabus**

| Units | CONTENTS | Hours |
|---|---|---|
| 1 | Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness | 4 |
| 2 | Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction | 4 |
| 3 | Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check. | 4 |
| 4 | key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, | 4 |
| 5 | skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions | 4 |
| 6 | useful phrases, how to ensure paper is as good as it could possibly be the first- time submission | 4 |

**Suggested Studies:**

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press

3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

## AUDIT 1 and 2: DISASTER MANAGEMENT

**Course Objectives: -**Students will be able to:

1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in

**Syllabus**

| Units | CONTENTS | Hours |
|---|---|---|
| 1 | **Introduction**<br>Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude. | 4 |
| 2 | **Repercussions Of Disasters And Hazards**: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.<br>Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts. | 4 |
| 3 | **Disaster Prone Areas In India**<br>Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics | 4 |
| 4 | **Disaster Preparedness And Management**<br>Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness. | 4 |
| 5 | **Risk Assessment**<br>Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival. | 4 |
| 6 | **Disaster Mitigation**<br>Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India. | 4 |

**SUGGESTED READINGS:**

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

## AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE

***Course Objectives***

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

***Syllabus***

| Unit | *Content* | *Hours* |
|---|---|---|
| 1 | • Alphabets in Sanskrit,<br>• Past/Present/Future Tense,<br>• Simple Sentences | 8 |
| 2 | • Order<br>• Introduction of roots<br>• Technical information about Sanskrit Literature | 8 |
| 3 | • Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics | 8 |

***Suggested reading***

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.

***Course Output***

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

## AUDIT 1 and 2: VALUE EDUCATION

***Course Objectives***

Students will be able to

1.Understand value of education and self- development

2. Imbibe good values in students

3. Let the should know about the importance of character

***Syllabus***

| Unit | *Content* | *Hours* |
|---|---|---|
| 1 | • Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism.<br>• Moral and non- moral valuation. Standards and principles. | 4 |

| | | |
|---|---|---|
| | • Value judgements | |
| 2 | • Importance of cultivation of values.<br>• Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness.<br>• Honesty, Humanity. Power of faith, National Unity.<br>• Patriotism.Love for nature ,Discipline | 6 |
| 3 | • Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline.<br>• Punctuality, Love and Kindness.<br>• Avoid fault Thinking.<br>• Free from anger, Dignity of labour.<br>• Universal brotherhood and religious tolerance.<br>• True friendship.<br>• Happiness Vs suffering, love for truth.<br>• Aware of self-destructive habits.<br>• Association and Cooperation.<br>• Doing best for saving nature | 6 |
| 4 | • Character and Competence –Holy books vs Blind faith.<br>• Self-management and Good health.<br>• Science of reincarnation.<br>• Equality, Nonviolence ,Humility, Role of Women.<br>• All religions and same message.<br>• Mind your Mind, Self-control.<br>• Honesty, Studying effectively | 6 |

***Suggested reading***

1 Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

***Course outcomes***

Students will be able to
1.Knowledge of self-development
2.Learn the importance of Human values
3.Developing the overall personality

## AUDIT 1 and 2: CONSTITUTION OF INDIA

**Course Objectives:**
Students will be able to:
1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

| Syllabus | | |
|---|---|---|
| **Units** | **Content** | **Hours** |
| **1** | • **History of Making of the Indian Constitution:**<br>History<br>Drafting Committee, ( Composition & Working) | 4 |
| **2** | • **Philosophy of the Indian Constitution:**<br>Preamble<br>Salient Features | 4 |
| **3** | • **Contours of Constitutional Rights & Duties:**<br>• Fundamental Rights<br>• Right to Equality<br>• Right to Freedom<br>• Right against Exploitation<br>• Right to Freedom of Religion<br>• Cultural and Educational Rights<br>• Right to Constitutional Remedies<br>• Directive Principles of State Policy<br>• Fundamental Duties. | 4 |
| **4** | • **Organs of Governance:**<br>• Parliament<br>• Composition<br>• Qualifications and Disqualifications<br>• Powers and Functions<br>• Executive<br>• President<br>• Governor<br>• Council of Ministers<br>• Judiciary, Appointment and Transfer of Judges, Qualifications<br>• Powers and Functions | 4 |
| **5** | • **Local Administration:**<br>• District's Administration head: Role and Importance,<br>• Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.<br>• Pachayati raj: Introduction, PRI: Zila Pachayat.<br>• Elected officials and their roles, CEO Zila Pachayat: Position and role.<br>• Block level: Organizational Hierarchy (Different departments),<br>• Village level: Role of Elected and Appointed officials,<br>• Importance of grass root democracy | 4 |
| **6** | • **Election Commission:**<br>• Election Commission: Role and Functioning.<br>• Chief Election Commissioner and Election Commissioners.<br>• State Election Commission: Role and Functioning.<br>• Institute and Bodies for the welfare of SC/ST/OBC and women. | 4 |

## Suggested reading


1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

**Course Outcomes:**

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

## AUDIT 1 and 2: PEDAGOGY STUDIES

**Course Objectives:**

Students will be able to:

4. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
5. Identify critical evidence gaps to guide the development.

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| 1 | • **Introduction and Methodology:**<br>• Aims and rationale, Policy background, Conceptual framework and terminology<br>• Theories of learning, Curriculum, Teacher education.<br>• Conceptual framework, Research questions.<br>• Overview of methodology and Searching. | 4 |
| 2 | • Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.<br>• Curriculum, Teacher education. | 2 |
| 3 | • Evidence on the effectiveness of pedagogical practices<br>• Methodology for the in depth stage: quality assessment of included studies.<br>• How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?<br>• Theory of change.<br>• Strength and nature of the body of evidence for effective pedagogical practices.<br>• Pedagogic theory and pedagogical approaches.<br>• Teachers' attitudes and beliefs and Pedagogic strategies. | 4 |
| 4 | • Professional development: alignment with classroom practices and follow-up support<br>• Peer support<br>• Support from the head teacher and the community.<br>• Curriculum and assessment<br>• Barriers to learning: limited resources and large class sizes | 4 |
| 5 | • **Research gaps and future directions**<br>• Research design<br>• Contexts<br>• Pedagogy<br>• Teacher education<br>• Curriculum and assessment<br>• Dissemination and research impact. | 2 |

## Suggested reading


1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.


**Course Outcomes:**

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

## AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

***Course Objectives***

1. To achieve overall health of body and mind
2. To overcome stress

***Syllabus***

| **Unit** | ***Content*** | ***Hours*** |
|---|---|---|
| 1 | • Definitions of Eight parts of yog. ( Ashtanga ) | 8 |
| 2 | • Yam and Niyam.<br>Do`s and Don't's in life.<br>i) Ahinsa, satya, astheya, bramhacharya and aparigraha<br>ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan | 8 |
| 3 | • Asan and Pranayam<br>i) Various yog poses and their benefits for mind & body<br>ii)Regularization of breathing techniques and its effects-Types of pranayam | 8 |

***Suggested reading***


1. 'Yogic Asanas for Group Tarining-Part-I" : Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata


**Course Outcomes:**

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

## AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS

***Course Objectives***

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

***Syllabus***

| Unit | Content | Hours |
|---|---|---|
| 1 | Neetisatakam-Holistic development of personality<br>• Verses- 19,20,21,22 (wisdom)<br>• Verses- 29,31,32 (pride & heroism)<br>• Verses- 26,28,63,65 (virtue)<br>• Verses- 52,53,59 (dont's)<br>• Verses- 71,73,75,78 (do's) | 8 |
| 2 | • Approach to day to day work and duties.<br>• Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48,<br>• Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,<br>• Chapter 18-Verses 45, 46, 48. | 8 |
| 3 | • Statements of basic knowledge.<br>• Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68<br>• Chapter 12 -Verses 13, 14, 15, 16,17, 18<br>• Personality of Role model. Shrimad Bhagwad Geeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42,<br>• Chapter 4-Verses 18, 38,39<br>• Chapter18 – Verses 37,38,63 | 8 |

***Suggested reading***

1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

***Course Outcomes***

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

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