Model Curriculum for UG Degree Course in

Computer Science and Engineering

Artificial Intelligence and Machine Learning (AIML)

2021

ALL INDIA COUNCIL FOR TECHNICAL EDUCATION

Nelson Mandela Marg, Vasant Kunj, New Delhi 110070

www.aicte-india.org

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MESSAGE

The quality of technical education depends on many factors but largely on- outcome based socially and industrially relevant curriculum, good quality motivated faculty, teaching learning process, effective industry internship and evaluation of students based on desired outcomes. Therefore, it was imperative that a Model Curriculum be prepared by best experts from academia and industry, keeping in view the latest industry trends and market requirements and be made available to all universities / board of technical education and engineering institutions in the country. AICTE constituted team of experts to prepare the model curriculum of UG Degree Course in Computer Science and Engineering Artificial Intelligence and Machine Learning (AIML) Engineering. Similar exercise is done for other UG, Diploma and PG level in engineering, MBA, PGDM, Architecture, etc.

It comprises of basic science and engineering courses, having focus on fundamentals, significant discipline level courses and ample electives both from the disciplines and cross disciplines including emerging areas all within a cumulative structure of 165 credits. Summer Internships have been embedded to make the student understand the industry requirements and have hands on experience. Virtual Labs has been introduced for few experiments. Also, most courses have been mapped to its equivalent SWAYAM/NPTEL Course to offer an alternative for learning that course online from SWAYAM. These features will allow students to develop a problem-solving approach to face the challenges in the future and develop outcome based learning approach.

As a major initiative by AICTE, a three-week mandatory induction program for students has also been designed and has to be given at the beginning of the course. The idea behind this is to make the students feel comfortable in their new environment, open them up, set a healthy daily routine, develop awareness, sensitivity and understanding of the self, people around them, society at large, and nature.

AICTE places on record, special thanks to Prof. Rajesh K. Bhatia from Punjab Engineering College, Prof. Ajay Mittal from Punjab University, Dr. Varun Dutt from IIT Mandi, Ms. Manisha from Education Infosys Ltd, and Dr. Manish Kumar Punjab Engineering College. We are sure that this Model Curriculum will help to enhance not just the employability skills but will also enable youngsters to become job creators.

We strongly urge the institutions / universities / boards of technical education in India to adopt this Model Curriculum at the earliest. This is a suggestive curriculum and the concerned university / institution / board should build on and exercise flexibility in readjustment of courses within the overall 165 credits.

(Prof. Anil D. Sahasrabudhe)
Chairman
All India Council for Technical Education

PREFACE

Taking cognizance of growing concern about quality of technical education in India, AICTE in its 49th council meeting held on 14.03.2017 approved a package of measures for improving quality of technical education - Revision of Curriculum, Mandatory Internship, and Student Induction Program were amongst the few.

AICTE constituted committee of academia industry experts to prepare model curriculum of UG Course in Computer Science and Engineering Artificial Intelligence and Machine Learning (AIML) Engineering. During the development of curriculum, the employability and employment opportunities for graduates, future ready workforce who will be skilled enough to handle the rapid growth in the field of Computer Science and Engineering specialization in Artificial Intelligence and Machine Learning (AIML) were kept in mind.

AICTE has introduced mandatory internship in the new curriculum which will equip the students with practical understanding and training about industry practices in a suitable industry or organization. In the course of development of model curriculum, the committee took feedback of industry experts on the draft curriculum and accordingly modified the draft before finalization. This exercise has ensured that essential emphasis on industry requirements and market trends, employability and problem solving approach is given.

After due deliberations, the scheme and syllabus have been formulated. Salient features of this model curriculum are enumerated as under:

- Reduced number of credits.
- Introduction of Student Induction Program.
- Well defined learning objectives & outcomes for each course.
- Inclusion of courses on socially relevant topics.
- Built-in flexibility to the students in terms of professional elective and open elective courses.
- Mandatory internship to equip the students with practical knowledge and provide them exposure to real time industrial environments.
- Virtual Labs.
- Mapping of Courses to its equivalent NPTEL/SWAYAM Course.
- Course on 'Entrepreneurship and Startups' to encourage entrepreneurial mindset.
- Introduction of Design Thinking and Universal Human Value course.

I gratefully acknowledge the time and efforts of the members of the working group Prof. Rajesh K. Bhatia from Punjab Engineering College, Prof. Ajay Mittal from Punjab University, Dr. Varun Dutt from IIT Mandi, Ms. Manisha from Education Infosys Ltd, and Dr. Manish Kumar Punjab Engineering College.

Special thanks to Prof. Anil D. Sahasrabudhe, Chairman; Prof. M.P. Poonia, Vice-Chairman; and Prof. Rajive Kumar, Member Secretary, AICTE who all have been instrumental and encouraging throughout the process of development of this model curriculum.

I appreciate the dedication put by the Col. A Shreenath, Director (P&AP), Dr. Pradeep C. Bhaskar, Assistant Director (P&AP); Mr. Rakesh Kumar Pandit, Young Professional (P&AP); and other office staff of AICTE.

(Dr. Ramesh Unnikrishnan)
Advisor – II
Policy and Academic Planning Bureau
All India Council for Technical Education

Committee for Model Curriculum

S.No	Name	Designation & Organization
1	Prof. Rajesh K Bhatia	Professor, Computer Science and Engineering Dept., Punjab Engineering College (Deemed University)
2	Prof. Ajay Mittal	Professor, Computer Science and Engineering Dept., University Institute of Engineering & Technology, Punjab University
3	Dr. Varun Dutt	Associate Professor, Computer Science and Engineering, IIT Mandi
4	Ms. Manisha	Lead Principal, Education Infosys Ltd.
5	Dr Manish Kumar	Assistant Professor, Computer Science and Engineering Dept. ,Punjab Engineering College (Deemed University)

Table of Contents

GENERAL COURSE STRUCTURE & CREDIT DISTRIBUTION

GENERAL COURSE STRUCTURE & THEME

A. Definition of Credit:

1 Hr. Lecture (L) per week	1 Credit
1 Hr. Tutorial (T) per week	1 Credit
1 Hr. Practical (P) per week	0.5 Credit
2 Hours Practical (P) per week	1 Credit

B. Range of Credits:

In the light of the fact that a typical Model Four-year Under Graduate degree program in Engineering has about 163 credits, the total number of credits proposed for the four-year B. Tech/B.E. in Computer Science and Engineering Artificial Intelligence and Machine Learning (AIML) is kept as 163.

C. Structure of UG Program in AIML:

The structure of UG program in Artificial Intelligence and Machine Learning shall have essentially the following categories of courses with the breakup of credits as given:

S. No.	Category	Breakup of Credits
1.	Humanities & Social Science Courses	10*
2.	Basic Science Courses	16*
3.	Engineering Science Courses	08*
4.	Program Core Courses (Branch specific)	71*
5.	Professional Elective Courses (Branch specific)	16*
6.	Open Elective Courses (from Humanities, Technical Emerging or other Subjects)	06*
7.	Project work, Seminar and Internship in Industry or elsewhere	38*
8.	Audit Courses [Environmental Sciences, Indian Constitution]	(non-credit)
	TOTAL	**165***

**Minor variation is allowed as per need of the respective disciplines.*

D. Course code and definition:

Course code	Definitions
L	Lecture
T	Tutorial
P	Practical
C	Credits
HS	Humanities & Social Science Courses
BS	Basic Science Courses
ES	Engineering Science Courses
PC	Program Core Courses
PE	Professional Elective Courses
OE	Open Elective Courses
AU	Audit Courses
EEC	Employment Enhancement Courses (Project/Summer Internship/Seminar)

- **Course level coding scheme:** Three-digit number (odd numbers are for the odd semester courses and even numbers are for even semester courses) used as suffix with the Course Code for identifying the level of the course. Digit at hundred's place signifies the year in which course is offered. e.g.

  101, 102 … etc. for first year.

  201, 202 …. Etc. for second year.

  301, 302 … for third year.

- **Category-wise Courses**

HUMANITIES & SOCIAL SCIENCES COURSES [HS]

(i) Number of Humanities & Social Science Courses: 4
(ii) Credits: 10

Sl. No	Course Code	Course Title	Hours per week			Total Credits	Semester
			Lecture	Tutorial	Practical		
1	HS101	Communication Skills	2	0	2	3	1
2	HS102	Design Thinking	0	0	2	1	1
3	HS401	Theory of computation Ecosystems	3	0	0	3	4
4	HSMC (H-102)	Universal Human Values-II: Understanding Harmony And Ethical Human Conduct	2	1	0	3	2
					Total Credits	**10**	

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BASIC SCIENCE COURSES [BS]

(i) Number of Basic Sciences Courses: 04
(ii) Credits: 16

Sl. No	Course Code	Course Title	Semester	Hours per week			Total Credits
				Lecture	Tutorial	Practical	
1	BS101	Physics	1	3	0	2	4
2	BS102	Mathematics-I	1	3	1	0	4
3	BS201	Mathematics-II	2	3	1	0	4
4	BS202	Chemistry	2	3	0	2	4
						Total Credits	**16**

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ENGINEERING SCIENCE COURSES [ES]

(i) Number of Engineering Sciences Courses: 02
(ii) Credits: 08

Sl. No	Course Code	Course Title	Semester	Hours per week			Total Credits
				Lecture	Tutorial	Practical	
1	ES101	Problem Solving and Programming	1	3	0	2	4
2	ES103	Mathematical Concepts for AI	1	3	1	0	4
						Total Credits	**8**

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PROGRAM CORE COURSES [PC]

(i) Number of Program Core Courses: 18
(ii) Credits: 71

Sl. No	Course Code	Course Title	Semester	Hours per week			Total Credits
				Lecture	Tutorial	Practical	
1	PC202	Object Oriented Programming	2	3	0	2	4
2	PC203	Data Structures	2	3	0	2	4
3	PC204	Discrete Mathematical Structures	2	3	1	0	4
4	PC205	Modern Computer Architecture	2	3	0	0	3
5	PC301	Algorithm Analysis and Design	3	3	0	2	4
6	PC302	Database Systems	3	3	0	2	4
7	PC303	Computer Networks	3	3	0	2	4

8	PC304	Introduction to Machine Learning	3	3	0	2	4
9	PC305	Artificial Intelligence	3	3	1	0	4
10	PC401	Theory of Computation	4	3	1	0	4
11	PC402	Software Engineering	4	3	0	2	4
12	PC403	Deep Learning	4	3	0	2	4
13	PC404	Operating System	4	3	0	2	4
14	PC501	Data and Visual analytics in AI	5	3	0	2	4
15	PC502	Optimization Techniques in Machine Leaning	5	3	1	0	4
16	PC503	Natural Language Processing	5	3	0	2	4
17	PC504	Advanced Machine Learning	5	3	0	2	4
18	PC701	Soft Computing	7	3	0	2	4
						Total Credits	**71**

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PROFESSIONAL ELECTIVE COURSES [PE]

(i) Number of Professional Elective Courses: 04
(ii) Credits: 16

Sl. No	**Course Code**	**Course Title**	**Semester**	**Hours per week**			**Total Credits**
				Lecture	**Tutorial**	**Practical**	
1	PE701	Professional Elective-I	**7**	3	0	2	4
2	PE702	Professional Elective-II	**7**	3	0	2	4
3	PE801	Professional Elective-III	8	3	0	2	4
4	PE802	Professional Elective-IV	8	3	0	2	4
						Total Credits	**16**

For detailed syllabus of Professional Elective Course, Refer Appendix II.

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OPEN ELECTIVE COURSES [OE]

(i) Number of Open Elective Courses: 2
(ii) Credits: 6

Sl. No	Course Code	Course Title	Semester	Hours per week			Total Credits
				Lecture	Tutorial	Practical	
1	OE301	Open Elective – I	3	3	0	0	3
2	OE701	Open Elective – II	7	3	0	0	3
Total Credits							**6**

For detailed syllabus of Open Elective Course, Refer Appendix I.

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PROJECT WORK, SEMINAR AND INTERNSHIP IN INDUSTRY OR ELSEWHERE

Sl. No	Course Code	Course Title	Semester	Hours per week			Total Credits
				Lecture	Tutorial	Practical	
1	EEC 401, 501	Minor Project	4,5	0	0	6+6	3+3
2	EEC 601	Internship	6	-	-	-	16
3	EEC 701,801	Capstone Project I & II	7,8	-	-	-	6+10
Total Credits							**38**

For some suggested internships, Refer Appendix IV.

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AUDIT COURSES [AU]

Note: These are mandatory non-credit courses.

S. No.	Course Code	Course Title	Semester	L	T	P	Credits
1	AU202	Environmental Science	4	3	0	0	0
2	AU301	Indian Constitution	5	3	0	0	0
Total Credits							**0**

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INDUCTION PROGRAM

The Essence and Details of Induction program can also be understood from the 'Detailed Guide on Student Induction program', as available on AICTE Portal, (Link:https://www.aicteindia.org/sites/default/files/Detailed%20Guide%20on%20Student%20Induction%20program.pdf). For more, Refer **Appendix III.**

Induction program (mandatory)	**Three-week duration**
Induction program for students to be offered right at the start of the first year.	• Physical activity • Creative Arts • Universal Human Values • Literary • Proficiency Modules • Lectures by Eminent People • Visits to local Areas • Familiarization to Dept./Branch & Innovations

E. Mandatory Visits/ Workshop/Expert Lectures:

a. It is mandatory to arrange one industrial visit every semester for the students of each branch.

b. It is mandatory to conduct a One-week workshop during the winter break after fifth semester on professional/ industry/ entrepreneurial orientation.

c. It is mandatory to organize at least one expert lecture per semester for each branch by inviting resource persons from domain specific industry.

F. Evaluation Scheme (Suggestive only):

a. **For Theory Courses:**
(The weightage of Internal assessment is 40% and for End Semester Exam is 60%)
The student has to obtain at least 40% marks individually both in internal assessment and end semester exams to pass.

b. **For Practical Courses:**
(The weightage of Internal assessment is 60% and for End Semester Exam is 40%)
The student has to obtain at least 40% marks individually both in internal assessment and end semester exams to pass.

c. For Summer Internship / Projects / Seminar etc.
Evaluation is based on work done, quality of report, performance in viva-voce, presentation etc.

Note: The internal assessment is based on the student's performance in mid semester tests (two best out of three), quizzes, assignments, class performance, attendance, viva-voce in practical, lab record etc.

G. Mapping of Marks to Grades

Each course (Theory/Practical) is to be assigned 100 marks, irrespective of the number of credits, and the mapping of marks to grades may be done as per the following table:

Range of Marks	**Assigned Grade**
91-100	AA/A^+
81-90	AB/A
71-80	BB/B^+
61-70	BC/B
51-60	CC/C^+
46-50	CD/C
40-45	DD/D
< 40	FF/F (Fail due to less marks)
-	F^R (Fail due to shortage of attendance and therefore, to repeat the course)

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Semester wise Structure and Curriculum for

Semester I						
3-Week Orientation Programme						
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1.	HS101	Communication Skills	2	0	2	3
2.	BS102	Mathematics-I	3	1	0	4
3.	BS101	Physics	3	0	2	4
4.	ES103	Mathematical Concepts for AI	3	1	0	4
5.	BS202	Chemistry	3	0	2	4
6.	ES101	Problem Solving and Programming	3	0	2	4
Total						**23**

Semester II						
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1.	BS201	Mathematics-II	3	1	0	4
2.	PC202	Object Oriented Programming	3	0	2	4
3.	PC203	Data Structures	3	0	2	4
4.	PC204	Discrete Mathematical Structures	3	1	0	4
5.	PC205	Modern Computer Architecture	3	0	0	3
6.	HS102	Design Thinking	0	0	2	1
7.	HSMC(H-102)	Universal Human Values-II: Understanding Harmony And Ethical Human Conduct	2	1	0	3
Total						**23**

Semester III						
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1.	PC301	Algorithm Analysis and Design	3	0	2	4
2.	PC302	Database Systems	3	0	2	4
3.	PC303	Computer Networks	3	0	2	4
4.	PC304	Introduction to Machine Learning	3	0	2	4
5.	PC305	Artificial Intelligence	3	1	0	4
6.	OE301	Open Elective-I	3	0	0	3
Total						**23**
Any one course from following options can be opted under "Open Elective-I' (Refer, Appendix –I) 1. Internet of Thing (IoT) -(OE001) 2. Robotics- (OE002)						

Semester IV						
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1.	PC401	Theory of Computation	3	1	0	4
2.	PC402	Software Engineering	3	0	2	4
3.	PC403	Deep Learning	3	0	2	4
4.	PC404	Operating System	3	0	1	4
5.	HS401	Theory of computation Ecosystems	3	0	0	3
6.	EEC401	Minor Project	3	0	0	3
7.	AU202^	Environmental Science	3	0	0	0
Total						**22**

Note: ^ Represents "Audit Course"

Semester V						
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1.	PC501	Data and Visual analytics in AI	3	0	2	4
2.	PC503	Natural Language Processing	3	0	2	4
3.	PC504	Advanced Machine Learning	3	0	2	4
4.	PC502	Optimization Techniques in Machine Leaning	3	1	0	4
5.	EEC501	Minor Project	--	--	--	3
6.	AU301^	Indian Constitution	3	0	0	0
Total						**19**

Note: ^ Represents "Audit Course"

Semester VI						
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1.	EEC601	Industry / Research Lab Internship	--	--	--	**16**
Internship option			**Alternate option**			
• Within India or Abroad (MITACS/DAAD/ Any other aligned with GOI schemes) • To enhance hands-on skills (As per NEP-2020) • Refer Appendix-IV for some suggested Internships.			• Alternatively, Courses can also be offered from Open Electives/Professional Electives • Two Course of 3 credits each and one Major project for 10 credits. • Students may opt for a virtual internship along with courses.			

Semester VII						
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1.	PC701	Soft Computing	3	0	2	4
2.	PE701	Professional Elective-I	3	0	2	4
3.	PE702	Professional Elective-II	3	0	2	4
4.	OE701	Open Elective-II	3	0	0	3
5.	EEC701	Capstone Project (Part-I)	----	----	----	6
Total						21
Any one course from following options can be opted under "Open Elective-II' (Refer, Appendix –I) 1. Machine Learning with Python-(OE003) 2. AI for Everyone- (OE004)						

Semester VIII						
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1.	PE801	Professional Elective-III	3	0	2	4
2.	PE802	Professional Elective-IV	3	0	2	4
3.	EEC801	Capstone Project (Part-II)	-	-	-	10
Total						**18**

- ***Main emphasis should be on Project Based Learning / Experiential Learning.***
- ***There should be an option to delay internship semester to $7^{th}/8^{th}$ Semester as per institute convenience and availability of internship slots for different group of students.***

SEMESTER – I

SEMESTER I

HS101	Communication Skills	2L:0T:2P	3 Credits

Course Objective:

The main aim of the course is to build competence in English grammar and vocabulary and to enhance effective communication by developing Reading, Writing, Listening and Speaking skills of students.

Detailed contents:

Module 1: Fundamentals of Communication Skills

Scope and Significance of Communication Skills, Listening, Speaking, Reading and Writing, Technical Communication, Tools of Effective Communication.

Module 2: Writing Skills

Basics of Grammar – Placing of Subject and Verb, Parts of Speech, Uses of Tenses, Active-Passive, Narration.

Module 3: Vocabulary Building and Writing

Word Formation & Synonyms, Antonyms, Words Often Confused, One-Word Substitutes, Idioms and Phrasal Verbs, Abbreviations of Scientific and Technical Words.

Module 4: Speaking Skills

Introduction to Phonetic Sounds & Articulation, Word Accent, Rhythm and Intonation, Interpersonal Communication, Oral Presentation, Body Language and Voice Modulation (Para linguistics and Non- Verbal), Negotiation and Persuasion, Group Discussion, Interview Techniques (Telephonic and Video Conferencing).

Module 5: Technical Writing

Job Application, CV Writing, Business Letters, Memos, Minutes, Notices, Report Writing & Structure, E-mail Etiquette, Blog Writing.

Laboratory/ Practicals:

1. Introducing Oneself, Exercise on Parts of Speech & Exercise on Tense.
2. Exercise on Agreement, Narration, Active Passive Voice & Dialogue Conversation.
3. Exercise on Writing Skills and Listening Comprehension (Audio CD).
4. Practice of Phonemes, Word Accent, Intonation, JAM Session.
5. Individual Presentation, Extempore and Picture Interpretation.
6. Vocabulary Building Exercises (One Word Substitute, Synonyms, Antonyms, Words Often Confused etc.) & Group Discussion.

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Communication Skills - Video course	Dr. T. Ravichandran	IIT Kanpur
2.	Communication Skills	Dr. Zuchamo Yanthan	Indira Gandhi National Open University

Text Books/Suggested References:

1. The Essence of Effective Communication", Ludlow R. and Panton F., Pubs: Prentice Hall, 1992
2. "Effective Communication Skills", Kulbhushan Kumar, Khanna Publishing House, 2019.
3. "A University Grammar of English", Quirk R. and Sidney G., 3rd Edition, Pubs: Pearson Education, 2008
4. "High School English Grammar", Wren and Martin, Pubs: S. Chand & Company Ltd, 2007
5. "Essentials of Business Communication", Guffrey M.E., 8th Edition, Pubs: South-Western College Publishing, 2009
6. "Technical Communication: Principles and Practice", Raman M. and Sharma S., 2nd Edition, Pubs: Oxford University Press, 2012
7. "Effective Business Communication", Rodrigues M.V., Pubs: Concept Publishing Company, Delhi, 2003
8. "English Vocabulary in Use", McCarthy M. and Felicity O' Dell, 2nd Edition, Pubs:2010

Course outcomes: After completion of course, students would be able to:

1. Understand various technical writing skills and
2. Apply the technical writing and communication skills in their academic and professional life.
3. Gain self-confidence with improved command over English.
4. Understand the technical aspects of communication for better performance in extra-curricular activities, recruitment process and prospective jobs.

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BS102	Mathematics I	3L:1T:0P	4 Credits

Course Objective:

To make the students well versed with the concepts of linear algebra. The students should also be able to solve calculus and vector calculus-based problems.

Detailed Contents:

Module 1: Linear Algebra

Vector spaces, Subspaces, basis and dimension, linear transformations, representation of transformations by Matrices, linear functionals, transpose of linear transformations, canonical forms. Linear functionals and adjoints, Bilinear forms, symmetric bilinear forms, skew symmetric bilinear forms

Module 2: Calculus

Continuity and differentiability of a function of single variable, statement of Rolle's Theorem, Lagrange's mean value theorem and applications. Double and Triple Integrals: Calculations, Areas, Volumes, change of variables

Module 3: Vector Calculus

Applications. Integrals of Vector Functions: Line integrals, Green's formula, path independence, Surface integral: definition, evaluation, Stoke's formula, Gauss-Ostrogradsky divergence theorem.

Module 4: Differential Equations

Ordinary Differential Equations: First order linear equations, Bernoulli's equations, Exact equations and integrating factor, Second order and Higher order linear differential equations with constant coefficients

Module 5: Multivariate Calculus

Integral Calculus: Definite Integrals as a limit of sums, Applications of integration to area, volume, surface area, Improper integrals. Functions of several variables: Continuity and differentiability, mixed partial derivatives, local maxima and minima for function of two variables, Lagrange multipliers.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Basic calculus for Engineers, Scientists and Economists	Prof. Joydeep Dutta	IIT Kanpur

Text Books/Suggested References:

1. G. B. Thomas, R. L. Finney. Calculus and Analytic Geometry, Ninth Edition, Pearson Education, 2010
2. Reena Garg, Advanced Engineering Mathematics, Khanna Book Publishing Co., Delhi.
3. B. V. Ramana. Higher Engineering Mathematics, Tata McGraw Hill, 2017
4. E. Kreyszig. Advanced Engineering Mathematics, Wiley, 2015
5. Calculus and Analytic Geometry, G. B. Thomas and R. L. Finney, Pearson Education, 2010

Course Outcomes: After completion of course, students would be able to:

1. Understand basic algebra
2. Understand and apply calculus
3. Understand and apply vector calculus
4. Understand and apply differential equations
5. Understand and apply multivariate calculus

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BS101	Physics	3L:0T:2P	4 Credits

Course Objective:
This course will help the students to familiarize with Ultrasonics, SHM, Oscillations, Wave motion, diffraction, polarization, laser, fiber optics and holography concepts.

Detailed Contents:

Module 1: Ultrasonics & SHM
Production, detection and uses of ultrasonics, reverberation, Sabine's formula (no derivation), Review of basic kinematics (displacement, velocity, acceleration, time period and phase of vibration) and dynamics (restoring force and energetics) of simple harmonic motion, differential equation of SHM, superposition of two SHM in one dimension, charge oscillations in LC circuits

Module 2: Oscillations
Damped Oscillations: Concept and cause of damping, differential equation of a damped oscillator and different kinds of damping, Methods of describing damping of an oscillator - logarithmic decrement, relaxation time, quality factor, band width. Series LCR circuit as a damped oscillator. Forced Oscillations: States of forced oscillations, differential equation of forced oscillator – its displacement, velocity and impedance, behavior of displacement and velocity with driver's frequency, Power, bandwidth, Quality factor and amplification of forced oscillator, resonance in forced oscillators, forced oscillations in series LCR circuit

Module 3: Wave Motion and interference
Wave equation and its solution, characteristic impedance of a string, reflection and transmission of waves on a string at a boundary, reflection and transmission of energy, the matching of impedances, Division of wave front and amplitude; Fresnel's biprism, Newton's rings, Michelson interferometer and its applications for determination of λ and $d\lambda$.

Module 4: Diffraction & Polarization
Fresnel and Fraunhofer diffraction, qualitative changes in diffraction pattern on moving from single slit to double slit, plane transmission grating, dispersive power & resolving power of a grating, Methods of polarization, analysis of polarized light, quarter and half wave plates, double refraction.

Module 5: Lasers, Fibre Optics and Holography
Elementary idea of LASER production, spontaneous emission, stimulated emission, Einstein's coefficients, Helium-Neon, Ruby and semiconductor lasers, applications of lasers. Basics of optical fibre - its numerical aperture, coherent bundle, step index and graded index fibre, material dispersion, fibre Optics sensors, applications of optical fibre in communication systems, Holography: Basic principle, theory and requirements.

Laboratory/ Practicals (if any):

1. To find the wavelength of sodium light using Fresnel's biprism.
2. To determine the wavelength of He-Ne laser using transmission grating.
3. To determine the slit width using the diffraction pattern.
4. To determine the wave length of sodium light by Newton's rings method.
5. To determine the wave length of sodium light using a diffraction grating.
6. To find the specific rotation of sugar solution using a Bi-quartz Polarimeter.

7. To design a hollow prism and used it find the refractive index of a given liquid

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Classical Physical	Prof. V. Balakrishnan	IIT Madras
2.	Modern Optics	Prof. Partha Roy Chaudhuri	IIT Kharagpur

Text Books/Suggested References:

1. Engineering Physics by A.B. Bhattacharya, Khanna Publishing House, 2020.
2. Physics for Engineers by N.K. Verma, Prentice Hall India, 2017.
3. Physics of Vibrations and Waves by H.J.Pain, 5th Edition, Wiley, 2006.
4. Optics by Ajoy Ghatak, McGraw Hill Education India, 2017.

Course outcomes: After completion of course, students would be able to:

1. Understand latest developments in certain areas of Physics which have important applications for societal needs.
2. Understand lasers and fibre optics which have important applications for societal needs.
3. Understand latest developments in certain areas of Physics which have important applications for societal needs.
4. Develop capability to tackle problems in general and in the various areas covered in the course.

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ES102	Mathematical Concepts for AI	3L:1T:0P	4 Credits

Course Objective:
This course should help the students understand the basic mathematical background of AI. Also, the students should be able to apply statistics and probability to analyse various datasets.

Detailed contents:

Module 1: Equations, Functions and Graphs
Introduction to linear equations, Intercepts and slopes, System of equations, Exponentials, radicals and logarithms, Polynomials, Polynomial operations, Factorizations, Introduction to quadratic equations, Functions

Module 2: Derivatives and Optimizations
Rate of change, Introduction to limits, Continuity, finding limits, Differentiability, Derivative rules and operations, using derivatives to analyse functions, Second order derivatives, Optimization functions, Multivariate differentiation

Module 3: Vectors and Matrices
Introduction to vectors, Vector addition, vector multiplication, Introduction to matrices, matric multiplication, properties of matrices, types of matrices, Matrix division, solving system of equations with matrices, Matrix transformations, Eigen values and eigen vectors, rank of matrix

Module 4: Probability
Basic rules and axioms events, sample space, dependent and independent events, conditional probability, Random variables- continuous and discrete, expectation, variance, distributions- joint and conditional, Bayes' Theorem, Popular distributions- binomial, Bernoulli, poisson, exponential, Gaussian

Module 5: Statistics
Fundamentals of Data: Collection, Summarization, and Visualization; Sampling and Sampling Distributions, Central Limit Theorem; Methods of Estimation, Unbiased estimators; Confidence Interval Estimation: Z-interval, t-interval; Hypothesis Testing, Types of Errors, Rejection Region Approach and p-value Approach.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Essential Mathematics for Machine Learning	Prof. Sanjeev Kumar Prof. S. K. Gupta	IIT Roorkee

Text Books/Suggested References:

1. Mathematics for Machine Learning, Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, Cambridge University Press., 2020
2. Advanced Engineering Mathematics, Reena Garg, Khanna Book Publishing Co., Delhi.
3. Machine Learning, Rajiv Chopra, Khanna Book Publishing Co., Delhi.
4. Introduction to Applied Linear Algebra: Vectors, Matrices, and Least Squares, Stephen Boyd, Lieven Vandenberghe, Cambridge University Press., 2018
5. Probability and statistics for Engineers and Scientists, Walpole, Myers, Myers and Ye, Pearson Education, 2012
6. Advanced Engineering Mathematics, Wylie and Barrett, McGraw Hill, 1995
7. https://www.udemy.com/course/mathematical-foundation-for-machine-learning-and-ai/

Course outcomes: After completion of course, students would be able to:

1. To understand the mathematical background of AI.
2. Use statistical methods to analyze and collect data.
3. Use probability and statistics to analyze data
4. Use and apply hypothesis testing on different datasets

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BS202	Chemistry	3L:0T:2P	4 Credits

Course Objective: The student with the knowledge of the basic chemistry, will understand and explain scientifically the various chemistry related problems in the industry/engineering field. The student will able to understand the new developments and breakthroughs efficiently in engineering and technology. The introduction of the latest (R&D oriented) topics will make the engineering student upgraded with the new technologies.

Course Content:

Module I: Atomic and Molecular Structure
Schrodinger equation. Particle in a box solutions and their applications for conjugated molecules and nanoparticles. Forms of the hydrogen atom wave functions and the plots of these functions to explore their spatial variations. Molecular orbitals of diatomic molecules and plots of the multicentre orbitals. Equations for atomic and molecular orbitals. Energy level diagrams of diatomic. Pi-molecular orbitals of butadiene and benzene and aromaticity. Crystal field theory and the energy level diagrams for transition metal ions and their magnetic properties. Band structure of solids and the role of doping on band structures.

Module II: Spectroscopic techniques and applications
Principles of spectroscopy and selection rules. Electronic spectroscopy. Fluorescence and its applications in medicine. Vibrational and rotational spectroscopy of diatomic molecules. Applications. Nuclear magnetic resonance and magnetic resonance imaging, surface characterization techniques. Diffraction and scattering.

Module III: Intermolecular forces and potential energy surfaces
Ionic, dipolar and van Der Waals interactions. Equations of state of real gases and critical phenomena. Potential energy surfaces of H3, H2F and HCN and trajectories on these surfaces.

Module IV: Use of free energy in chemical equilibria (6 lectures)
Thermodynamic functions: energy, entropy and free energy. Estimations of entropy and free energies. Free energy and emf. Cell potentials, the Nernst equation and applications. Acid base, oxidation reduction and solubility equilibria. Water chemistry. Corrosion. Use of free energy considerations in metallurgy through Ellingham diagrams.

Module V: Periodic properties
Effective nuclear charge, penetration of orbitals, variations of s, p, d and f orbital energies of atoms in the periodic table, electronic configurations, atomic and ionic sizes, ionization energies, electron affinity and electronegativity, polarizability, oxidation states, coordination numbers and geometries, hard soft acids and bases, molecular geometries.

Module VI: Stereochemistry
Representations of 3 dimensional structures, structural isomers and stereoisomers, configurations and symmetry and chirality, enantiomers, diastereomers, optical activity, absolute configurations and conformational analysis. Isomerism in transitional metal compounds.

Module VII: Organic reactions and synthesis of a drug molecule

Introduction to reactions involving substitution, addition, elimination, oxidation, reduction, cyclization and ring openings. Synthesis of a commonly used drug molecule.

LABORATORY

Choice of 10-12 experiments from the following:

1. Determination of surface tension and viscosity.
2. Thin layer chromatography.
3. Ion exchange column for removal of hardness of water.
4. Determination of chloride content of water.
5. Colligative properties using freezing point depression.
6. Determination of the rate constant of a reaction.
7. Determination of cell constant and conductance of solutions.
8. Potentiometry - determination of redox potentials and emfs.
9. Synthesis of a polymer/drug.
10. Saponification/acid value of an oil.
11. Chemical analysis of a salt.
12. Lattice structures and packing of spheres.
13. Models of potential energy surfaces.
14. Chemical oscillations- Iodine clock reaction.
15. Determination of the partition coefficient of a substance between two immiscible liquids.
16. Adsorption of acetic acid by charcoal.
17. Use of the capillary viscosimeters to the demonstrate of the isoelectric point as the pH of minimum viscosity for gelatin sols and/or coagulation of the white part of egg.

Text/Reference Books:

1. University chemistry, by B. H. Mahan
2. Chemistry: Principles and Applications, by M. J. Sienko and R. A. Plane
3. Fundamentals of Molecular Spectroscopy, by C. N. Banwell
4. Engineering Chemistry (NPTEL Web-book), by B. L. Tembe, Kamaluddin and M. S. Krishnan
5. Physical Chemistry, by P. W. Atkins
6. Organic Chemistry: Structure and Function by K. P. C. Volhardt and N. E. Schore, 5th Edition http://bcs.whfreeman.com/vollhardtschore5e/default.asp.

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	CHEMISTRY - I	PROF. MANGALA SUNDER KRISHNAN	IITM

EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

S. No.	Experiment Name	Experiment Link(s)
1	Determination of surface tension and viscosity.	http://pcv-au.vlabs.ac.in/physical-chemistry/Determination_of_Viscosity_of_Organic_Solvents/

2	Ion exchange column for removal of hardness of water.	http://icv-au.vlabs.ac.in/inorganic-chemistry/Water_Analysis_Determination_of_Chemical_Parameters/
3	Determination of chloride content of water.	http://vlabs.iitb.ac.in/vlabs-dev/labs/nitk_labs/Environmental_Engineering_1/experiments/determination-of-chloride-nitk/simulation.html
4	Colligative properties using freezing point depression.	http://pcv-au.vlabs.ac.in/physical-chemistry/Cryoscopy/
5	Determination of the rate constant of a reaction.	http://pcv-au.vlabs.ac.in/physical-chemistry/EMF_Measurement/
6	Determination of cell constant and conductance of solutions.	http://icv-au.vlabs.ac.in/inorganic-chemistry/Water_Analysis_Determination_of_Physical_Parameters/
7	Potentiometry - determination of redox potentials and emfs.	http://pcv-au.vlabs.ac.in/physical-chemistry/EMF_Measurement/
8	Saponification/acid value of an oil.	http://biotech01.vlabs.ac.in/bio-chemistry/Estimation_of_Saponification_Value_of_Fats_or_Oils/
9	Lattice structures and packing of spheres.	https://vlab.amrita.edu/?sub=1&brch=282&sim=370&cnt=1

Course Outcomes: The course will enable the students:

- To analyse microscopic chemistry in terms of atomic and molecular orbitals and intermolecular forces.
- To rationalise bulk properties and processes using thermodynamic considerations.
- To distinguish the ranges of the electromagnetic spectrum used for exciting different molecular energy levels in various spectroscopic techniques
- To rationalise periodic properties such as ionization potential, electronegativity, oxidation states and electronegativity.
- To list major chemical reactions that are used in the synthesis of molecules.

Laboratory Outcomes: The chemistry laboratory course will consist of experiments illustrating the principles of chemistry relevant to the study of science and engineering. The students will learn:

- To estimate rate constants of reactions from concentration of reactants/products as a function of time.
- To measure molecular/system properties such as surface tension, viscosity, conductance of solutions, redox potentials, chloride content of water, etc.
- To synthesize a small drug molecule and analyze a salt sample.

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ES101	Problem Solving and Programming	3L:0T:2P	4 Credits

Course Objective:

To develop logical skills and basic technical skills so that students should be able to solve basic computing problems. The students should be able to learn the basic of any computer programming language.

Detailed contents:

Module 1: Introduction to Programming

Evolution of languages: Machine languages, Assembly languages, High-level languages. Software requirements for programming: System softwares like operating system, compiler, linker, loader; Application programs like editor. Algorithm, specification of algorithm. Flowcharts.

Module 2: Data Types and Operators, Variables, Sequences and Iteration

Different types of Data types, Expressions, Precedence Rules, Operators- Operators: arithmetic operators, relational operators, logical operations, bitwise operators, miscellaneous operators, Local Variables, Global Variables, List, String, Tuples, Sequence Mutations and Accumulation Patterns.

Module 3: Conditional Statements, Loops, Arrays and Strings, User Defined Data Types

If-else statement, For loop, While Loop, Nested Iteration, Concept and use of arrays, declaration and usage of arrays, 2-dimensional arrays, different types of user defined data types

Module 4: Dictionaries and Dictionary Accumulation, Functions/Methods

Dictionary Basics, Operations, Methods, Accumulation, Advantage of modularizing program into functions, function definition and function invocation. Positional Parameter Passing, Passing arrays to functions, Recursion, Library functions.

Module 5: File Handling and Memory Management

Concepts of files and basic file operations, Writing/ Reading Data to/from a .csv File, Memory Management Operations

Laboratory/ Practicals:

1. Write a program that asks the user for their name and greets them with their name.
2. Write a program that asks the user for a number n and gives them the possibility to choose between computing the sum and computing the product of 1,…,n.
3. Write a function that checks whether an element occurs in a list.
4. Write three functions that compute the sum of the numbers in a list: using a for-loop, a while-loop and recursion.
5. Given two strings, write a program that efficiently finds the longest common subsequence.

Alternative NPTEL/SWAYAM Course:

S. No.	Course Name	Instructor	Host Institute
1.	Introduction to Problem Solving and Programming - Video course	Prof. D. Gupta	IIT Kanpur
2.	Problem solving Aspects and Python Programming	Dr.S.Malliga, Dr.R.Thangarajan, Dr.S.V.Kogilavani	Kongu Engineering College

Text Books/Suggested References:

1. Programming for Problem Solving, R.S. Salaria, Khanna Book Publishing Co., Delhi.
2. Taming Python by Programming, Jeeva Jose, Khanna Book Publishing Co., Delhi.
3. Learning Python, 5th Edition, by Mark Lutz, O'Reilly Media, Inc., ISBN: 9781449355739
4. Python Crash Course: A Hands-On, Project-Based Introduction to Programming by Eric Matthes, No Starch Press.
5. Programming in Python, R.S. Salaria, Khanna Book Publishing Co., Delhi.
6. https://www.coursera.org/learn/python-basics
7. https://www.coursera.org/specializations/python-3-programming

Course outcomes: After completion of course, students would be able to:

1. Understand real world problems and developing computer solutions for those.
2. Understand the basics of python.
3. Apply python for solving basic programming solutions.
4. Create algorithms using learnt programming skills.

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SEMESTER – II

SEMESTER II

BS201	Mathematics II	3L:1T:0P	4 Credits

Course Objective:

To make the students understand the behaviour of various series. They should also be able to calculate probabilities and statistics of different datasets.

Detailed contents:

Module 1: Sequences and Series

Limit of a sequence, monotone and Cauchy sequences and properties of convergent sequences, examples. Infinite series, positive series, tests for convergence and divergence, integral test, alternating series, Leibnitz test.

Module 2: Functional Series
Pointwise and uniform convergence, basic aspects of Power series, Fourier series

Module 3: Math Foundation
Statements, Quantifiers, Operation on sets and functions, Relations, Proofs.

Module 4: Number System
Countability of algebraic numbers, Transcendental numbers and construction of Liouville's number, Equivalence classes, construction of real numbers (using Cauchy sequences), Fermat's little theorem and using it for Miller-Rabin primality test, Wilson's theorem and Primitive root theorem.

Module 5: Probability
Sample space and events, definitions of probability, properties of probability, conditional probability. Random variables: distribution functions, discrete and continuous random variables, moments of random variables, conditional expectation, Chebyshev inequality, functions of random variables. Special Distributions: Bernoulli, Binomial, Geometric, Pascal, Poisson, Exponential, Uniform, Normal distributions, Limit Theorems: Law of large numbers

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Engineering Mathematics - I	Prof. Jitendra Kumar	IIT Kharagpur
2.	Probability and Statistics	Prof. Somesh Kumar	IIT Kharagpur

Text Books/Suggested References:

1. Probability and statistics for Engineers and Scientists, Walpole, Myers, Myers and Ye, Pearson Education, 2012

2. Advanced Engineering Mathematics, Reena Garg, Khanna Book Publishing Co., Delhi
3. Advanced Engineering Mathematics, Wylie and Barrett, McGraw Hill, 1995
4. Advanced Engineering Mathematics, M.D. Greenberg, Pearson Education Asia, 2002

Course Outcomes: After completion of course, students would be able to:

1. Understand the behavior of series and their applications.
2. Understand number system and its applications.
3. Understand the concept of probability and apply in real life.
4. Understand and apply the concept of statistics.

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PC202	Object Oriented Programming	3L:0T:2P	4 Credits

Course Objective:

The students should be able to understand the concept of object-oriented programming like classes, constructors, Polymorphism, inheritance, and file handling and open source libraries.

Detailed contents:

Module 1: Introduction to Object Oriented Programming Paradigms

Introduction to various programming paradigms, advantages of OOP, comparison of OOP with Procedural Paradigm, Classes and Objects: Prototyping, Referencing the variables in functions, Inline, static and friend functions. Memory allocation for classes and objects. Arrays of objects, Constructors

Module 2: Polymorphism & Inheritance

Overriding Methods, type conversions from basic data types to user defined and vice versa, Base classes and Derived classes, types of inheritance, various types of classes, Invocation of Constructors and Destructors in Inheritance, aggregation, composition, classification hierarchies, metaclass/abstract classes, Unit Testing and Exceptions.

Module 3: Python libraries:

Basics of open-source libraries for data prepressing, modelling and visualization.

Module 4: Using Python to Access Web Data

Regular Expressions, Extracting Data, Sockets, Using the Developer Console to Explore HTTP, Retrieving Web Page, Parsing Web Pages

Module 5: Using Databases with Python

Using Databases, Single Table CRUD, Designing and Representing a Data Model, Inserting Relational Data, Reconstructing Data with JOIN, Many to Many Relationships.

Laboratory/ Practicals:

1. Write a NumPy program to compute the cross product of two given vectors
2. Write a NumPy program to calculate the QR decomposition of a given matrix
3. Write a Pandas program to convert a Panda Module Series to Python list and it's type.
4. Write a Pandas program to convert a NumPy array to a Pandas series
5. Create a Python project to get the citation from Google scholar using title and year of publication, and volume and pages of journal.
6. Create a Python project to get total Covid-19 cases, total deaths due to Covid-19, total Covid-19 patients recovered in the world.

Alternative NPTEL/SWAYAM Course:

S. No.	Course Name	Instructor	Host Institute
1.	Python For Data Science	Prof. Raghunathan Rengasamy	IIT Madras
2.	The Joy of Computing Using Python	Prof. Sudarshan Prof. Yayati Guptaiyengar	IIT Ropar, IIIT Dharwad

Text Books/Suggested References:

1. How to Think Like a Computer Scientist: Learning with Python, by Allen Downey, Jeff Elkner and Chris Meyers, SoHo Books, 2009.
2. Mastering Object-Oriented Programming, R.S. Salaria, Khanna Book Publishing Co., Delhi
3. Introduction to Computing & Problem Solving with Python, Jeeva Jose, Khanna Book Publishing, 2019.
4. https://www.coursera.org/specializations/python-3-programming#courses
5. Head First Python by Paul Barry, O'Reilly, 2010.

Course outcomes: After completion of course, students would be able to:

1. Understand the basic concepts of OOPs.
2. Apply different Python library to solve programming problems.
3. Understand the advanced concepts of python and apply for accessing databases and web data.
4. Understand APIs and third-party libraries to be used with Python.

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PC203	Data Structures	3L:0T:0P	4 Credits

Course Objective:

The students should be able to describe and implement various data structures including lists, arrays, stacks, queues, binary search trees, graphs, hash tables, and matrices. The student will be able to analyse and apply various algorithms for shortest path calculation, sorting and searching applications.

Detailed contents:

Module 1: Introduction and Elementary Data Structures

Introduction: Introduction to Data Structures and data types, Efficient use of memory, Recursion, time and space complexity of algorithms, Big O Notation and theta notations.

Elementary Data Structures: Stacks, queues, Infix, Postfix & Prefix conversions, evaluations of expressions, multiple, stacks and queues, priority queues as heaps, double ended queue, implementation of stacks and queues

Module 2: Linked Lists

Singly linked lists, linked stacks and queues, polynomial addition, sparse matrices, doubly linked lists and dynamic storage management, circular linked list, Applications of Stacks, Queues and Linked lists, Garbage collection, Josephus Problem

Module 3: Trees

Basic terminology, binary trees, binary tree traversal, representations of binary tree, application of trees, decision tree, game trees, Threaded Trees, Binary Search Tree, AVL tree, B-tree

Module 4: Graph Theory

Graph representations, Graph Traversals, Dijkstra's algorithm for shortest path, Prim's and Kruskal's Algorithm for Minimal Spanning tree

Module 5: Sorting and Searching

Searching: Linear search, binary search and hash search. Sorting: Insertion sort, selection sort, bubble sort, quick sort, merge sort, heap sort, and Bucket sort

Laboratory/ Practicals:

1. Implement infix to postfix conversion using Stack
2. Write a program for swaping nodes in a linked list without swapping data.
3. Write a program to reverse a Linked List in groups of given size.
4. Write a program for finding the first circular tour that visits all petrol pumps.
5. Implement Inorder tree traversal without recursion.
6. Write a program to Check whether a given graph is Bipartite or not.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	Course Name	Instructor	Host Institute
1.	Data Structures and Algorithms - Video course	Prof. Naveen Garg	IIT Delhi
2.	Data Structures	Dr.S.Sasikala	University of Madras

Text Books/Suggested References:

1. Data Structures, R.S. Salaria, Khanna Book Publishing, 2019.
2. Data Structures and Program Design in C By Robert L. Kruse,C.L. Tondo, Bruce Leung, Pearson Education, 2007.
3. Expert Data Structures with C/ 3rd Edition, R.B. Patel, Khanna Book Publishing, 2020.
4. Expert Data Structures with C++/ 2nd Edition, R.B. Patel, Khanna Book Publishing, 2020.
5. Data Structures Using C & C++, By Langsam, Augenstein, Tanenbaum, Pearson Education, 1989.
6. Fundamentals of Data Structures, By Ellis Horowitz and Sartaj Sahni, Computer Science Press, 2011.
7. An introduction to data structures with applications, By J.P. Trembley & P.G. Sorensen, TMH, 2004.

Course outcomes: After completion of course, students would be able to:

1. Understand the different types of data structure to be implemented using any programming language.
2. Choose the data structures that effectively model the information in a problem and analyses the efficiency trade-offs (run time and memory usage) among alternative data structure implementations or combinations.
3. Design, implement, test, and debug programs using a variety of data structures including stacks, queues, hash tables, binary and general tree structures, search trees, and graphs.
4. Apply efficient data structure (linked lists, stacks and queues) to solve a particular problem.

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PC204	Discrete Mathematical Structures	3L:1T:0P	3 Credits

Course Objective:

Students should be able to understand Discrete Mathematical Structures (DMS) for the development of theoretical computer science, problem solving in programming language using Discrete Structure and importance of discrete structures towards simulation of a problem in computer science and engineering.

Detailed contents:

Module 1: Mathematical Reasoning

Mathematical reasoning, Propositions, Negation, disjunction and conjunction, Implication and Equivalence, Truth tables, Predicates, Quantifiers, Natural deduction, Rules of Inference, Methods of proofs, Resolution principle, Application to PROLOG.

Module 2: Set Theory

Paradoxes in set theory, Inductive definition of sets and proof by induction, Peano postulates, Relations, Properties of relations, Equivalence Relations and partitions, Partial orderings, Posets, Linear and well-ordered sets.

Module 3: Combinatorics and Functions

Elementary Combinatorics, counting techniques, Recurrence relation, Generating functions, Functions; mappings, Injection and Surjections, Composition of functions, Inverse functions, Special functions, Pigeonhole principle, Recursive function theory.

Module 4: Graph Theory

Elements of graph theory, Euler graph, Hamiltonian path, trees, Tree traversals, Spanning trees, Representation of relations by graphs.

Module 5: Groups, Rings, Fields, Discrete Probability

Definition and elementary properties of groups, Semigroups, Monoids, Rings, Fields, Vector spaces and lattices, Introduction, Discrete random variables, Applications to Binary Search Tree.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	Course Name	Instructor	Host Institute
1.	Discrete Mathematical Structures - Video course	Prof. Kamala Krithivasan	IIT Madras
2.	Discrete Mathematics	Prof. Sudarshan Iyengar, Prof. Neeldhara	IIT Ropar, IIT Gandhinagar

Text Books/Suggested References:

1. K. H. Rosen, Discrete Mathematics and applications, 6th Edition, Tata McGraw Hill 2007.
2. S.B. Singh, Discrete Structures/ 3rd Edition, Khanna Book Publishing, 2019.
3. S.B. Singh, Combinatorics and Graph Theory/ 3rd Edition, Khanna Book Publishing, 2018.
4. C. L. Liu, Elements of Discrete Mathematics, 2nd Edn., Tata McGraw-Hill 2000.
5. J .L. Mott, A. Kandel, T.P .Baker, Discrete Mathematics for Computer Scientists and Mathematicians, Second edition, Prentice Hall of India 1986.
   W. K. Grassmann and J. P. Trembnlay, Logic and Discrete Mathematics, A Computer Science Perspective, Prentice Hall Inc 1996

Course outcomes: After completion of course, students would be able to:

1. Understand the basics of various discrete structures.
2. Apply applications of discrete structures in Computer Science and Engineering.

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PC205	Modern Computer Architecture	3L:1T:0P	4 Credits

Course Objective:

Students should be able to understand basic principles of Computer Systems. They should be able to understand various logic design techniques and their applications. They should be capable of using high performance computing architecture.

Detailed contents:

Module 1: Basics

Designing combinational and sequential logic, computers registers and instructions, timing, and control, instructions cycle, memory reference instruction, I/O interruption, Adder and Subtractor circuits, Booth Multiplication Algorithm, Pipelining Review, control hazards and the motivation for caches, cache characteristics and basic superscalar architecture basics,

Module 2: Multi-core Architecture

Memory technologies, hierarchical memory systems, the locality principle and caching, direct-mapped caches, block size, cache conflicts, associative caches, write strategies, advanced optimisations, performance improvement techniques, DRAM – organisation, access techniques, scheduling algorithms and signal systems. Tiled Chip Multicore Processors (TCMP), Network on Chips (NoC), NoC router – architecture, design, routing algorithms and flow control techniques, Advanced topics in NoC and storage – compression, prefetching, QoS.

Module 3: Distributed Computing Systems and Concurrency

Relation to Parallel Multiprocessors/multicomputer Systems, Distributed and Concurrent Programs, Message Passing vs. Shared Memory Systems, Synchronous vs. Asynchronous Executions, Design Issues and Challenges, Distributed Computing Technologies, Clocks and Synchronization, Coordination and Agreement Algorithms, Global State and Distributed Transactions.

Module 4: High Performance Computing (HPC)

HPC Architecture, Parallel Processing, Parallel Memory Models, Data vs. Task Parallelism, High Throughput Computing, Vectorization, Multithreading.

Module 5: High Performance Computing with CUDA

CUDA programming model, Basic principles of CUDA programming, Concepts of threads and blocks, GPU and CPU data exchange

Alternative NPTEL/SWAYAM Course:

S. No.	Course Name	Instructor	Host Institute
1.	COMPUTER ARCHITECTURE	PROF. SMRUTI RANJAN SARANGI	IIT Delhi
2.	ADVANCED COMPUTER ARCHITECTURE	PROF.JOHN JOSE	IIT Guwahati

Text Books/Suggested References:

1. M. Morris Mano, Computer System & Architecture, Prentice Hall of India, 2002.
2. John L. Hennessy and David A Patterson, Computer Architecture-A quantitative approach, Morgan Kaufmann/ Elsevier, 4th Edition, 2007.
3. Hayes. J.P, Computer architecture and organization by McGraw-Hill Companies, 1998
4. Parallel Computer Architecture: A Hardware/Software Approach David Culler and J.P. Singh with Anoop Gupta, Morgan Kaufmann, 1998.
5. https://onlinecourses.nptel.ac.in/noc20_cs41/preview
6. https://www.coursera.org/learn/introduction-high-performance-computing#syllabus

Course outcomes: After completion of course, students would be able to:

1. Understand the organization of the Control unit, Arithmetic and Logical unit, Memory unit and the I/O unit.
2. Analyse different computer architectures and their applications.
3. Understand modern design structures of Pipelined and Multiprocessors systems.
4. Understand distributed computing architecture and high-performance computing.

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HS102	Design Thinking	0L:0T:2P	1 Credits

COURSE OBJECTIVE(S):

The objective of this Course is to provide the new ways of creative thinking and Learn the innovation cycle of Design Thinking process for developing innovative products which useful for a student in preparing for an engineering career.

COURSE CONTENTS:

Unit 1: An Insight to Learning

Understanding the Learning Process, Kolb's Learning Styles, Assessing and Interpreting

Unit 2: Remembering Memory

Understanding the Memory process, Problems in retention, Memory enhancement techniques

Unit 3: Emotions: Experience & Expression

Understanding Emotions: Experience & Expression, Assessing Empathy, Application with Peers

Unit 4: Basics of Design Thinking

Definition of Design Thinking, Need for Design Thinking, Objective of Design Thinking, Concepts & Brainstorming, Stages of Design Thinking Process (explain with examples) – **Empathize, Define, Ideate, Prototype, Test**

Unit 5: Being Ingenious & Fixing Problem

Understanding Creative thinking process, Understanding Problem Solving, Testing Creative Problem Solving

Unit 6: Process of Product Design

Process of Engineering Product Design, Design Thinking Approach, Stages of Product Design, Examples of best product designs and functions, **Assignment – Engineering Product Design**

Unit 7: Prototyping & Testing

What is Prototype? Why Prototype? Rapid Prototype Development process, Testing, **Sample Example**, Test Group Marketing

Unit 8: Celebrating the Difference

Understanding Individual differences & Uniqueness, Group Discussion and Activities to encourage the understanding, acceptance and appreciation of Individual differences

Unit 9: Design Thinking & Customer Centricity

Practical Examples of Customer Challenges, Use of Design Thinking to Enhance Customer Experience, Parameters of Product experience, Alignment of Customer Expectations with Product Design

Unit 10: Feedback, Re-Design & Re-Create

Feedback loop, Focus on User Experience, Address "ergonomic challenges, User focused design, rapid prototyping & testing, final product, Final Presentation – **"Solving Practical Engineering Problem through Innovative Product Design & Creative Solution".**

Course Outcomes (CO):

Student will able to

1. Compare and classify the various learning styles and memory techniques and Apply them in their engineering education
2. Analyze emotional experience and Inspect emotional expressions to better understand users while designing innovative products
3. Develop new ways of creative thinking and Learn the innovation cycle of Design Thinking process for developing innovative products
4. Propose real-time innovative engineering product designs and Choose appropriate frameworks, strategies, techniques during prototype development
5. Perceive individual differences and its impact on everyday decisions and further Create a better customer experience

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HSMC (H-102)	**Universal Human Values-II: Understanding Harmony And Ethical Human Conduct**	**2L:1T:0P**	**3 Credits**

Pre-requisites: None. Universal Human Values 1 (Desirable)

1-COURSES ON HUMAN VALUES

During the Induction Program, students would get an initial exposure to human values through Universal Human Values-I. This exposure is to be augmented by this compulsory full semester foundation course.

Objectives of UHV-II Course

This introductory course input is intended:

1. To help the students appreciate the essential complementarily between 'VALUES' and 'SKILLS' to ensure sustained happiness and prosperity which are the core aspirations of all human beings.
2. To facilitate the development of a Holistic perspective among students towards life and profession as well as towards happiness and prosperity based on a correct understanding of the Human reality and the rest of existence. Such a holistic perspective forms the basis of Universal Human Values and movement towards value-based living in a natural way.
3. To highlight plausible implications of such a Holistic understanding in terms of ethical human conduct, trustful and mutually fulfilling human behavior and mutually enriching interaction with Nature.

Thus, this course is intended to provide a much-needed orientational input in value education to the young enquiring minds.

Salient Features of the Course

The salient features of this course are:

1. It presents a universal approach to value education by developing the right understanding of reality (i.e. a worldview of the reality “as it is”) through the process of self-exploration.
2. The whole course is presented in the form of a dialogue whereby a set of proposals about various aspects of the reality are presented and the students are encouraged to self-explore the proposals by verifying them on the basis of their natural acceptance within oneself and validate experientially in living.
3. The prime focus throughout the course is toward affecting a qualitative transformation in the life of the student rather than just a transfer of information.
4. While introducing the holistic worldview and its implications, a critical appraisal of the prevailing notions is also made to enable the students discern the difference on their own right.

Course Methodology

1. The methodology of this course is explorational and thus universally adaptable. It involves a systematic and rational study of the human being vis-à-vis the rest of existence.

2. The course is in the form of 28 lectures (discussions) and 14 practice sessions.
3. It is free from any dogma or value prescriptions.
4. It is a process of self-investigation and self-exploration, and not of giving sermons. Whatever is found as truth or reality is stated as a proposal and the students are facilitated to verify it in their own right, based on their Natural Acceptance and subsequent Experiential Validation – the whole existence is the lab and every activity is a source of reflection.
5. This process of self-exploration takes the form of a dialogue between the teacher and the students to begin with, and then to continue within the student in every activity, leading to continuous self-evolution.
6. This self-exploration also enables them to critically evaluate their pre-conditionings and present beliefs.

2-COURSE TOPICS

The course has 28 lectures and 14 tutorials in 5 modules. The lectures and tutorials are of 01-hour duration. Tutorial sessions are to be used to explore and practice what has been proposed during the lecture sessions.

The Teacher's Manual provides the outline for lectures as well as practice sessions. The teacher is expected to present the issues to be discussed as propositions and encourage the students to have a dialogue.

The syllabus for the lectures and practice sessions is given below:

Module 1 – Introduction to Value Education (6 lectures and 3 tutorials for practice session)

Lecture 1: Right Understanding, Relationship and Physical Facility (Holistic Development and the Role of Education)
Lecture 2: Understanding Value Education
Tutorial 1: **Practice Session PS1** Sharing about Oneself
Lecture 3: Self-exploration as the Process for Value Education
Lecture 4: Continuous Happiness and Prosperity – the Basic Human Aspirations
Tutorial 2: Practice Session PS2 Exploring Human Consciousness
Lecture 5: Happiness and Prosperity – Current Scenario
Lecture 6: Method to Fulfill the Basic Human Aspirations
Tutorial 3: Practice Session PS3 Exploring Natural Acceptance

Expected outcome:

The students start exploring themselves: get comfortable with each other and with the teacher; they start appreciating the need and relevance for the course.

The students start finding that technical education without study of human values can generate more problems than solutions. They also start feeling that lack of understanding of human values is the root cause of most of the present-day problems; and a sustained solution could emerge only through understanding of value-based living. Any solution brought out through fear, temptation of dogma will not be sustainable.

The students are able to see that verification on the basic of natural acceptance and experiential validation through living is the only way to verify right or wrong, and referring to any external source like text or instrument or any other person cannot enable them to verify with authenticity; it will only develop assumptions.
The students are able to see that their practice in living is not in harmony with their natural acceptance most of the time, and all they need to do is to refer to their natural acceptance to overcome this disharmony.
The students are able to see that lack of right understanding leading to lack of relationship is the major cause of problems in their family and not the lack of physical facility in most of the cases, while they have given higher priority to earning of physical facility in their life giving less value to or even ignoring relationships and not being aware that right understanding is the most important requirement for any human being.

Module 2 – Harmony in the Human Being (6 lectures and 3 tutorials for practice session)

Lecture 7: Understanding Human being as the Co-existence of the Self and the Body
Lecture 8: Distinguishing between the Needs of the Self and the Body
Tutorial 4: Practice Session PS4 Exploring the difference of Needs of Self and Body
Lecture 9: The Body as an Instrument of the Self
Lecture 10: Understanding Harmony in the Self
Tutorial 5: Practice Session PS5 Exploring Sources of Imagination in the Self
Lecture 11: Harmony of the Self with the Body
Lecture 12: Programme to ensure self-regulation and Health
Tutorial 6: Practice Session PS6 Exploring Harmony of Self with the Body

Expected outcome:

The students are able to see that they can enlist their desires and the desires are not vague. Also they are able to relate their desires to 'I' and 'Body' distinctly. If any desire appears related to both, they are able to see that the feeling is related to I while the physical facility is related to the body. They are also able to see that 'I' and Body are two realities, and most of their desires are related to 'I' and not body, while their efforts are mostly centered on the fulfilment of the needs of the body assuming that it will meet the needs of 'I' too.
The students are able to see that all physical facility they are required for a limited time in a limited quantity. Also, they are able to see that in case of feelings, they want continuity of the naturally acceptable feelings and they do not want feelings which are not naturally acceptable even for a single moment.
The students are able to see that activities like understanding, desire, though and selection are the activities of 'I' only the activities like breathing, palpitation of different parts of the body are fully the activities of the body with the acceptance of 'I' while the activities they do with their sense organs like hearing through ears, seeing through eyes, sensing through touch, tasting through tongue and smelling through nose or the activities they do with their work organs like hands, legs etc. are such activities that require the participation of both 'I' and body.

The students become aware of their activities of 'I' and start finding their focus of attention at different moments. Also they are able to see that most of their desires are coming from outside (through preconditioning or sensation) and are not based on their natural acceptance The students are able to list down activities related to proper upkeep of the body and practice them in their daily routine. They are also able to appreciate the plants wildly growing in and around the campus which can be beneficial in curing different diseases.

Module 3 – Harmony in the Family and Society (6 lectures and 3 tutorials for practice session)

Lecture 13: Harmony in the Family – the Basic Unit of Human Interaction
Lecture 14: 'Trust' – the Foundational Value in Relationship
Tutorial 7: Practice Session PS7 Exploring the Feeling of Trust
Lecture 15: 'Respect' – as the Right Evaluation
Tutorial 8: Practice Session PS8 Exploring the Feeling of Respect
Lecture 16: Other Feelings, Justice in Human-to-Human Relationship
Lecture 17: Understanding Harmony in the Society
Lecture 18: Vision for the Universal Human Order
Tutorial 9: Practice Session PS9 Exploring Systems to fulfil Human Goal

Expected outcome:

The students are able to note that the natural acceptance (intention) is always for living in harmony, only competence is lacking! We generally evaluate ourselves on the basis of our intention and others on the basis of their competence! We seldom look at our competence and others' intention as a result we conclude that I am a good person and other is a bad person.
The students are able to see that respect is right evaluation, and only right evaluation leads to fulfilment in relationship. Many present problems in the society are an outcome of differentiation (lack of understanding of respect), like gender biasness, generation gap, caste conflicts, class struggle, dominations through power play, communal violence, clash of isms and so on so forth. All these problems can be solved by realizing that the other is like me as he has the same natural acceptance, potential and program to ensure a happy and prosperous life for them and for others through he may have different body, physical facility or beliefs.
The students are able to use their creativity for education children. The students are able to see that they can play a role in providing value education for children. They are able to put in simple words the issues that are essential to understand for children and comprehensible to them. The students are able to develop an outline of holistic model for social science and compare it with the existing model.

Module 4 – Harmony in the Nature/Existence (4 lectures and 2 tutorials for practice session)

Lecture 19: Understanding Harmony in the Nature
Lecture 20: Interconnectedness, self-regulation and Mutual Fulfilment among the Four Orders of Nature
Tutorial 10: Practice Session PS10 Exploring the Four Orders of Nature

Lecture 21: Realizing Existence as Co-existence at All Levels
Lecture 22: The Holistic Perception of Harmony in Existence
Tutorial 11: Practice Session PS11 Exploring Co-existence in Existence

Expected outcome:

The students are able to differentiate between the characteristics and activities of different orders and study the mutual fulfilment among them. They are also able to see that human being s are not fulfilling to other orders today and need to take appropriate steps to ensure right participation (in terms of nurturing, protection and right utilization) in the nature.
The students feel confident that they can understand the whole existence; nothing is a mystery in this existence. They are also able to see the interconnectedness in the nature, and point out how different courses of study relate to the different units and levels. Also, they are able to make out how these courses can be made appropriate and holistic.

Module 5 – Implications of the Holistic Understanding – a Look at Professional Ethics (6 lectures and 3 tutorials for practice session)

Lecture 23: Natural Acceptance of Human Values
Lecture 24: Definitiveness of (Ethical) Human Conduct
Tutorial 12: Practice Session PS12 Exploring Ethical Human Conduct
Lecture 25: A Basis for Humanistic Education, Humanistic Constitution and Universal Human Order
Lecture 26: Competence in Professional Ethics
Tutorial 13: Practice Session PS13 Exploring Humanistic Models in Education
Lecture 27: Holistic Technologies, Production Systems and Management Models-Typical Case Studies
Lecture 28: Strategies for Transition towards Value-based Life and Profession
Tutorial 14: Practice Session PS14 Exploring Steps of Transition towards Universal Human Order

Expected outcome:
The students are able to present sustainable solutions to the problems in society and nature. They are also able to see that these solutions are practicable and draw roadmaps to achieve them.
The students are able to grasp the right utilization of their knowledge in their streams of Technology/Engineering/Management/any other area of study to ensure mutual fulfilment. E.g. mutually enriching production system with rest of nature.
The students are able to sincerely evaluate the course and share with their friends. They are also able to suggest measures to make the course more effective and relevant. They are also able to make use of their understanding in the course for the happy and prosperous family and society.

Guidelines and Content for Practice Sessions (Tutorials)

In order to connect the content of the proposals with practice (living), 14 practice sessions have been designed. The full set of practice sessions is available in the Teacher's Manual as well as the website.

Practice Sessions for Module 1 – Introduction to Value Education
PS1 Sharing about Oneself
PS2 Exploring Human Consciousness
PS3 Exploring Natural Acceptance

Practice Sessions for Module 2 – Harmony in the Human Being
PS4 Exploring the difference of Needs of Self and Body
PS5 Exploring Sources of Imagination in the Self
PS6 Exploring Harmony of Self with the Body

Practice Sessions for Module 3 – Harmony in the Family and Society
PS7 Exploring the Feeling of Trust
PS8 Exploring the Feeling of Respect
PS9 Exploring Systems to fulfil Human Goal

Practice Sessions for Module 4 – Harmony in the Nature (Existence)
PS10 Exploring the Four Orders of Nature
PS11 Exploring Co-existence in Existence

Practice Sessions for Module 5 – Implications of the Holistic Understanding – a Look at Professional Ethics
PS12 Exploring Ethical Human Conduct
PS13 Exploring Humanistic Models in Education
PS14 Exploring Steps of Transition towards Universal Human Order

As an example, PS 7 is a practice session in module 3 regarding trust. It is explained below:

PS 7: Form small groups in the class and in that group initiate dialogue and ask the eight questions related to trust. The eight questions are:

1a. Do I want to make myself happy?	1b. Am I able to make myself always happy?
2a. Do I want to make the other happy?	2b. Am I able to make the other always happy?
3a. Does the other want to make him happy?	3b. Is the other able to make him always happy?
4a. Does the other want to make me happy?	4b. Is the other able to make me always happy?
Intention (Natural Acceptance)	Competence
What is the answer?	What is the answer?

Let each student answer the questions for himself/herself and everyone else. Discuss the difference between intention and competence. Observe whether you evaluate your intention and competence as well as the others' intention and competence.

Expected outcome of PS 7: The students are able to see that the first four questions are related to our Natural Acceptance i.e. intention and the next four to our Competence. They are able to note that the intention is always correct, only competence is lacking! We generally evaluate ourselves on the basis of our intention and others on the basis of their competence! We seldom look at our competence and others' intention, as a result we conclude that I am a good person and other is a bad person.

3-READINGS:

3-1-Text Book and Teachers Manual

a. The Textbook

A Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-47-1

b. The Teacher's Manual

Teachers' Manual for A Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-53-

3-2-Reference Books

1. JeevanVidya: EkParichaya, A Nagaraj, JeevanVidyaPrakashan, Amarkantak, 1999.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3. The Story of Stuff (Book).
4. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
5. Small is Beautiful - E. F Schumacher.
6. Slow is Beautiful - Cecile Andrews
7. Economy of Permanence - J C Kumarappa
8. Bharat Mein Angreji Raj – Pandit Sunderlal
9. Rediscovering India - by Dharampal
10. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
11. India Wins Freedom - Maulana Abdul Kalam Azad
12. Vivekananda - Romain Rolland (English)
13. Gandhi - Romain Rolland (English)

4-MODE OF CONDUCT (L-T-P-C 2-1-0-3)

Lecture hours are to be used for interactive discussion, placing the proposals about the topics at hand and motivating students to reflect, explore and verify them.
Tutorial hours are to be used for practice sessions.

While analysing and discussing the topic, the faculty mentor's role is in pointing to essential elements to help in sorting them out from the surface elements. In other words, help the students explore the important or critical elements.

In the discussions, particularly during practice sessions (tutorials), the mentor encourages the student to connect with one's own self and do self-observation, self-reflection and self-exploration.

Scenarios may be used to initiate discussion. The student is encouraged to take up" ordinary" situations rather than" extra-ordinary" situations. Such observations and their analyses are shared and discussed with other students and faculty mentor, in a group sitting.

Tutorials (experiments or practical) are important for the course. The difference is that the laboratory is everyday life, and practical are how you behave and work in real life. Depending on the nature of topics, worksheets, home assignment and/or activity are included. The practice sessions (tutorials) would also provide support to a student in performing actions commensurate to his/her beliefs. It is intended that this would lead to development of commitment, namely behaving and working based on basic human values.

It is recommended that this content be placed before the student as it is, in the form of a basic foundation course, without including anything else or excluding any part of this content. Additional content may be offered in separate, higher courses.

This course is to be taught by faculty from every teaching department.

Teacher preparation with a minimum exposure to at least one 8-day Faculty Development Program on Universal Human Values is deemed essential.

5-SUGGESTED ASSESSMENT:

This is a compulsory credit course. The assessment is to provide a fair state of development of the student, so participation in classroom discussions, self-assessment, peer assessment etc. will be used in evaluation.

Example:

Assessment by faculty mentor: 10 marks
Self-assessment: 10 marks
Assessment by peers: 10 marks
Socially relevant project/Group Activities/Assignments: 20 marks
Semester End Examination: 50 marks
The overall pass percentage is 40%. In case the student fails, he/she must repeat the course.

6-OUTCOME OF THE COURSE:

By the end of the course, students are expected to become more aware of themselves, and their surroundings (family, society, nature); they would become more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind.

They would have better critical ability. They would also become sensitive to their commitment towards what they have understood (human values, human relationship and

human society). It is hoped that they would be able to apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.

Therefore, the course and further follow up is expected to positively impact common graduate attributes like:

1. Holistic vision of life
2. Socially responsible behaviour
3. Environmentally responsible work
4. Ethical human conduct
5. Having Competence and Capabilities for Maintaining Health and Hygiene
6. Appreciation and aspiration for excellence (merit) and gratitude for all

This is only an introductory foundational input. It would be desirable to follow it up by

a) Faculty-student or mentor-mentee programs throughout their time with the institution

b) Higher level courses on human values in every aspect of living.

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SEMESTER – III

SEMESTER III

PC301	Algorithm Analysis and Design	3L:0T:2P	4 Credits

Course Objective:

The students should be able to analyse various algorithms mainly for time and space complexity. They should be able to develop algorithm for solving various computational problems by applying various algorithm design strategies. They should be able to understand the effect of choice of data structures on the complexity of algorithm.

Detailed contents:

Module 1: Basic Concepts of Algorithms

Notion of Algorithm, Fundamentals of Algorithmic Solving, Important problem types, Fundamentals of the Analysis Framework, Asymptotic Notations and Basic Efficiency Classes, Mathematical analysis of non-recursive algorithms. Mathematical analysis of recursive algorithm: recurrence relations, solution of recurrence relations using substitution method

Module 2: Brute Force, Divide and Conquer Strategy

Selection sort, Bubble sort, Sequential searching (Linear Search), Brute force string matching, General method, Merge sort, Quick Sort, Binary Search, Strassen's matrix multiplication

Module 3: Greedy Approach and Dynamic Programming

Fractional Knapsack problem, Minimum cost spanning tree: Prim's and Kruskal's algorithm, Single source shortest path problem, Principle of optimality, Multi-stage graph problem, all pair shortest path problem, 0/1 Knapsack problem, Traveling salesperson problem

Module 4: Backtracking and Branch and Bound

General method backtracking**,** N-Queen problem, 0/1 Knapsack problem, General method of branch & bound, 0/1 Knapsack problem, Traveling sales person problem

Module 5: Lower Bound Theory and Complexity Classes

Lower bounds, Decision trees, P, NP and NP Complete problems

Laboratory/ Practicals:

1. Write a program to implement different sorting techniques.
2. Write a program to find minimum cost spanning tress.
3. Write a program to implement travelling sales person problem.
4. Write a program to find Longest Path in a Directed Acyclic Graph.
5. Write a program for Shortest path with exactly k edges in a directed and weighted graph.
6. Write a program find maximum number of edge disjoint paths between two vertices

Alternative NPTEL/SWAYAM Course (if any):

S. No.	Course Name	Instructor	Host Institute
1.	Design and analysis of algorithms	Prof. Madhavan Mukund	Chennai Mathematical Institute
2.	Design and analysis of algorithms	Prof. Abhiram Ranade	IIT Bombay

Text Books/Suggested References:

1. Algorithm Design, Jon Kelinberg and Eva Tardos, 1st Edition, Pearson Education 2014.
2. Design & Analysis of Algorithms, Gajendra Sharma, Khanna Book Publishing 2018.
3. Fundamentals of algorithms, Horowitz E, Sahini S, Rajasekaran S., University Press 2008.
4. Introduction to algorithms, Cormen, Leiserson, Rivest, Stein, 3rd Edition, PHI. 2012
5. An introduction to analysis of algorithms, R. Sedgewick, 1st edition, Pearson Education 1996.
6. Data Structures and Program Design in C By Robert L. Kruse, C.L. Tondo, Bruce Leung, Pearson Education. 2007.

Course outcomes: After completion of course, students would be able to:

1. Apply the best data structure for designing an algorithm to solve a given problem.
2. Evaluate different algorithms with respect to time and space complexity.
3. Create algorithms to solve various computational problems.
4. Understand different complexity classes.

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PC302	Database Systems	3L:0T:2P	4 Credits

Course objective: Students should be able to understand various basics of DBMS and query languages. They should learn different types of database systems and their applications in different scenarios.

Detailed contents:

Module 1: Introduction

Characteristics and fundamental concepts of Databases, Types of Data Models and Data Modelling, Elements of Database Systems, Classification and comparison of Database Management Systems (Regular and NoSQL Page), concurrency control, Lock based concurrency control, Time stamping methods.

Module 2: Structured and semi-structured data management

Structured data, relational databases, Relational model, Functional Dependencies, normal forms, algorithms for query optimization, Semi-structured data, document-databases, semi-structured data abstraction, representation, and search.

Module 3: Transaction Management

Transaction concept, transaction state, ACID properties, serializability, Recoverability, Implementation of Isolation, Testing for serializability.

Module 4: Unstructured Data Management

Unstructured text, Information retrieval systems, document retrieval and ranking.

Module 5: Big Data Management

Platforms for Big Data, algorithms for Map-Reduce & Hadoop, Platforms for Big Graphs, algorithms for large graphs.

Laboratory/ Practicals:

1. Implement normal forms in a database.
2. Implement basic SQL commands on a database.
3. Implement information and raking using any language.
4. Implement document retrieval and ranking using any algorithm.
5. Implement Map-reduce algorithm on any big data task.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Data Base Management System	Prof. Partha Pratim Das, Prof. Samiran Chattopadhyay	IIT Kharagpur
2.	Introduction To Database Systems	Prof. Sreenivasa Kumar	IIT Madras

Text Books/Suggested References:

1. Database System Concepts, Abraham Silberschatz, Henry F. Korth, S. Sudharshan, Tata McGraw Hill, 2006
2. Fundamentals of Database Systems, Elmsari and Navathe, Pearson Education 2013
3. Database Management Systems, Ramakrishnan and Gehrke, McGrawHill 2003
4. "An Introduction to Database Systems", C.J.Date, A.Kannan, S.Swamynathan, Pearson Education, 2006
5. Database Management Systems, R.P. Mahapatra, Khanna Book Publishing 2016.
6. J. D. Ullman, "Principles of Database Systems", 2nd Ed., Galgotia Publications
7. Learning Spark: Lightning-Fast Big Data Analysis / Holden Karau, Andy Konwinski, Patrick Wendell, Matei Zaharia / O'Reilly Media; 1st edition / ISBN-13: 978-1449358624 / ISBN-10: 1449358624
8. Data on the Web: From Relations to Semistructured Data and XML / Serge Abiteboul, Peter Buneman, Dan Suciu / 1st Edition / ISBN-13: 978-1558606227 /
9. ISBN-10: 155860622X
10. Introduction to Information Retrieval / Christopher Manning, Prabhakar Raghavan, Hinrich Schütze / book and slides available online

Course outcomes: After completion of course, students would be able to:

1. Understand the basics of databases and data management.
2. Understand various theoretical and practical principles involved in the design and use of databases systems with the help of database
3. Design and implement databases for various scenarios.
4. Design a database scenario for handling big data.

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PC303	Computer Networks	3L:0T:2P	4 Credits

Course Objective:

Students should be able to have an understanding of the fundamental concepts of computer networking and have a basic knowledge of the various network models and their uses. They should be able to analyse simple protocols and independently study literature concerning computer networks.

Detailed contents:

Module 1: Computer Networks and The Internet

What is the Internet; network edge; network core; Delay, Loss and throughput in Packet-Switched Networks; Protocol Layers and their Service Models.

Module 2: Application Layer

Principles of Network Applications; The Web and HTTP; File Transfer: FTP;Electronic Mail in the Internet; DNS - The Internet's Directory Service; Peer-to-Peer applications; Socket Programming – Creating network applications.

Module 3: Transport Layer

Introduction and Transport-Layer Services; Multiplexing and Demultiplexing; Connectionless Transport: UDP; Principles of Reliable of Data Transfer; Connection-Oriented Transport: TCP; Principles of Congestion Control, TCP Congestion Control.

Module 4: Network Layer

Introduction; Virtual circuit and datagram networks; What is inside a router; Internet Protocol (IP): Forwarding and Addressing in the Internet; Routing Algorithms; Routing in the Internet; Broadcast and Multicast Routing.

Module 5: Data Link Layer

Introduction to the link layer; Error Detection and Correction Techniques; Multiple Access links and Protocols; Switched local area networks.

Laboratory/ Practicals:

1. Write a program for using TCP and UDP Sockets.
2. Write a simulation of sliding window protocols.
3. Write a simulation of Routing Protocols.
4. Configure given network topologies using any network simulator software.
5. Write a programs for error detecting codes.
6. Write a program for Client Server Communication.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	Course Name	Instructor	Host Institute
1.	Computer Networks - Video course	Prof. Sujoy Ghosh	IIT Kharagpur
2.	Computer Networks and Internet Protocol	Prof. Soumya Kanti Ghosh, Prof. Sandip Chakraborty	IIT Kharagpur,

Text Books/Suggested References:

1. James F. Kurose and Keith W. Ross, "Computer Networking: A top-down approach", Pearson Education, 6th edition. 2012
2. A.S. Tanenbaum, "Computer Networks", 5th Edition, PHI 2010
3. Bhavneet Sidhu, "An Integrated Approach to Computer Networks", Khanna Book Publishing House 2019.
4. G. Keiser, "Local Area Networks", 2nd Edition, TMH 2002
5. D. Bertesekas and R. Gallager, "Data Networks", 2nd Edition, PHI 2000
6. William Stallings, "Data & Computer Communication", PHI, 10th Edition 2013
7. B.A. Forouzan, "Data communications and networking", TMH, 5th Edition2012
8. B.A. Forouzan, "Local Area Networks", TMH. 2002
9. B.A. Forouzan, "TCP/IP Protocol Suite", TMH.2004

Course outcomes: After completion of course, students would be able to:

1. Understand basic computer network technology.
2. Understand the different types of network topologies and protocols.
3. Analyze the different types of network devices and their functions within a network.
4. Analyze the architecture and principles of today's computer networks.
5. Understand the requirements for the future Internet and its impact on the computer network architecture.

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PC304	Introduction to Machine Learning	3L:0T:2P	4 Credits

Course Objective:
The students will understand the basics of Machine Learning. They will also learn and will be able to apply different machine learning models to various datasets.

Detailed Contents:

Module 1: Introduction
What Is Machine Learning?, How Do We Define Learning?, How Do We Evaluate Our Networks?, How Do We Learn Our Network?, What are datasets and how to handle them?, Feature sets, Dataset division: test, train and validation sets, cross validation.

Module 2: Basics of machine learning
Applications of Machine Learning, processes involved in Machine Learning, Introduction to Machine Learning Techniques: Supervised Learning, Unsupervised Learning and Reinforcement Learning, Real life examples of Machine Learning.

Module 3: Supervised learning
Classification and Regression: K-Nearest Neighbor, Linear Regression, Logistic Regression, Support Vector Machine (SVM), Evaluation Measures: SSE, MME, R2, confusion matrix, precision, recall, F-Score, ROC-Curve.

Module 4: Unsupervised learning
Introduction to clustering, Types of Clustering: Hierarchical, Agglomerative Clustering and Divisive clustering; Partitional Clustering - K-means clustering.

Module 5: Miscellaneous
Dimensionality reduction techniques: PCA, LDA, ICA. Introduction to Deep Learning, Gaussian Mixture Models, Natural Language Processing, Computer Vision.

Laboratory/ Practicals:

1. Python Introduction:
2. Loops and Conditions and other preliminary stuff,
3. Functions, Classes and Modules,
4. Exceptions, Database access,
5. Mathematical computing with Python packages like: numpy, Mat- plotLib, pandas Tensor Flow, Keras
6. Implement basic ML models like SVM, KNN, K-Means, Logistic Regression, Linear Regression

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Introduction to Machine Learning	Prof. Balaraman Ravindran	IIT Madras

2.	Machine Learning	Prof. Carl Gustaf Jansson	KTH, The Royal Institute of Technology

Text Books/Suggested References:

1. Introduction to Machine Learning, By Jeeva Jose, Khanna Book Publishing Co., 2020.
2. Machine Learning for Dummies, By John Paul Mueller and Luca Massaron, For Dummies, 2016.
3. Machine Learning, By Rajeev Chopra, Khanna Book Publishing Co., 2021.
4. Machine Learning: The New AI, By Ethem Alpaydin, The MIT Press, 2016.
5. Machine Learning, Tom M. Mitchell, McGraw Hill Education, 2017.
6. https://www.udacity.com/course/intro-to-machine-learning--ud120
7. https://www.coursera.org/learn/machine-learning-duke

Course Outcomes: After completion of course, students would be able to:

1. Understand basic applications and issues of Machine Learning
2. Understand the different types of datasets
3. Analyze and work with different datasets
4. Analyze various Machine Learning techniques and algorithms
5. Apply various algorithms to different datasets.

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PC305	Artificial Intelligence	3L:1T:0P	4 Credits

Course Objective:
Students will learn the basic concepts and techniques of Artificial Intelligence. They should be able to develop AI algorithms for solving practical problems.

Detailed Contents:

Module 1: Introduction
Artificial Intelligence and its applications, Artificial Intelligence Techniques, Level of models, criteria of success, Intelligent Agents, Nature of Agents, Learning Agents. AI Techniques, advantages, and limitations of AI, Impact and Examples of AI, Application domains of AI. The AI Ladder - The Journey for Adopting AI Successfully, Advice for a career in AI, Hotbeds of AI Innovation.

Module 2: Problem solving techniques
State space search, control strategies, heuristic search, problem characteristics, production system characteristics., Generate and test, Hill climbing, best first search, A* search, Constraint satisfaction problem, Mean-end analysis, Min-Max Search, Alpha-Beta Pruning, Additional refinements, Iterative Deepening.

Module 3: Logic
Propositional logic, predicate logic, Resolution, Resolution in proportional logic and predicate logic, Clause form, unification algorithm,

Module 4: Knowledge Representation schemes and reasoning
Mapping between facts and representations, Approaches to knowledge representation, procedural vs declarative knowledge, Forward vs. Backward reasoning, Matching, conflict resolution, Non-monotonic reasoning, Default reasoning, statistical reasoning, fuzzy logic Weak and Strong filler structures, semantic nets, frame, conceptual dependency, scripts

Module 5: Planning
The Planning problem, planning with state space search, partial order planning, planning graphs, planning with propositional logic, Analysis of planning approaches, Hierarchical planning, conditional planning, Continuous and Multi Agent planning.

Tutorial List:

1. Numerical type questions on CNN-
    a. Parameters tuning
    b. Convolution function
    c. Different types of filters
2. Fuzzy Logic and Neural Networks

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	An Introduction to Artificial Intelligence	Prof. Mausam	IIT Delhi

2.	Artificial Intelligence	Prof. Sudeshna Sarkar	IIT Kharagpur

Text Books/Suggested References:

1. A Classical Approach to Artificial Intelligence, M.C. Trivedi, Khanna Book Publishing, 2019.
2. Artificial Intelligence: A modern approach by Stuart Russel, Pearson Education, 2010.
3. Artificial Intelligence by Rich and Knight, The McGraw Hill, 2017.
4. Artificial Intelligence: A new synthesis by Nils and Nilson, Elsevier, 1997.
5. Artificial Intelligence by Luger, Pearson Education, 2002.
6. Artificial Intelligence by Padhy, Oxford Press, 2005.
7. https://www.edx.org/course/artificial-intelligence-ai
8. https://www.udemy.com/course/artificial-intelligence-az/

Course outcomes: After completion of course, students would be able to:

1. Understand the basic concepts and techniques of Artificial Intelligence.
2. Apply AI algorithms for solving practical problems
3. Describe human intelligence and AI
4. Explain how intelligent system works.
5. Apply basics of Fuzzy logic and neural networks.
6. Explain Expert System and implementation

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OE301	**Open Elective - I**	**2L:0T:2P**	**3 Credits**

Any one course from following options can be opted under 'Open Elective I':

1. IOT (OE001)
2. Robotics (OE002)

For syllabus, Refer Appendix - I on Open Electives.

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SEMESTER – IV

SEMESTER IV

AU 2020	Environmental Science	3L:0T:0P	0 Credits

Course Objective: People working in industries or elsewhere essentially require the knowledge of environmental science so as to enable them to work and produce most efficient, economical and eco-friendly finished products.

- Solve various engineering problems applying ecosystem to produce eco – friendly products.
- Use relevant air and noise control method to solve domestic and industrial problems.
- Use relevant water and soil control method to solve domestic and industrial problems.
- To recognize relevant energy sources required for domestic and industrial applications.
- Solve local solid and e-waste problems.

Course Content:

Unit-1: Ecosystem

- Structure of ecosystem, Biotic & Abiotic components.
- Food chain and food web.
- Aquatic (Lentic and Lotic) and terrestrial ecosystem.
- Carbon, Nitrogen, Sulphur, Phosphorus cycle.
- Global warming -Causes, effects, process, Green House Effect, Ozone depletion.

Unit–2: Air and, Noise Pollution

- Definition of pollution and pollutant, Natural and manmade sources of air pollution (Refrigerants, I.C., Boiler).
- Air Pollutants: Types, Particulate Pollutants: Effects and control (Bag filter, Cyclone separator, Electrostatic Precipitator).
- Gaseous Pollution Control: Absorber, Catalytic Converter, Effects of air pollution due to Refrigerants, I.C., Boiler.
- Noise pollution: sources of pollution, measurement of pollution level, Effects of Noise pollution, Noise pollution (Regulation and Control) Rules, 2000.

Unit-3: Water and Soil Pollution

- Sources of water pollution, Types of water pollutants, Characteristics of water pollutants Turbidity, pH, total suspended solids, total solids BOD and COD: Definition, calculation.
- Waste Water Treatment: Primary methods: sedimentation, froth floatation, Secondary methods: Activated sludge treatment, Trickling filter, Bioreactor, Tertiary Method: Membrane separation technology, RO (reverse osmosis).
- Causes, Effects and Preventive measures of Soil Pollution: Causes-Excessive use of Fertilizers, Pesticides and Insecticides, Irrigation, E-Waste.

Unit– 4: Renewable sources of Energy

- Solar Energy: Basics of Solar energy. Flat plate collector (Liquid & Air). Theory of flat plate collector. Importance of coating. Advanced collector. Solar pond. Solar water heater, solar dryer. Solar stills.
- Biomass: Overview of biomass as energy source. Thermal characteristics of biomass as fuel. Anaerobic digestion. Biogas production mechanism. Utilization and storage of biogas.
- Wind energy: Current status and future prospects of wind energy. Wind energy in India. Environmental benefits and problem of wind energy.
- New Energy Sources: Need of new sources. Different types new energy sources. Applications of (Hydrogen energy, Ocean energy resources, Tidal energy conversion.) Concept, origin and power plants of geothermal energy.

Unit-5: Solid Waste Management, ISO 14000 & Environmental Management

- Solid waste generation- Sources and characteristics of: Municipal solid waste, E- waste, biomedical waste.
- Metallic wastes and Non-Metallic wastes (lubricants, plastics, rubber) from industries. Collection and disposal: MSW (3R, principles, energy recovery, sanitary landfill), Hazardous waste.
- Air quality act 2004, air pollution control act 1981 and water pollution and control act1996. Structure and role of Central and state pollution control board.
- Concept of Carbon Credit, Carbon Footprint.
- Environmental management in fabrication industry.
- ISO14000: Implementation in industries, Benefits.

Text Books/References:

1. S.C. Sharma & M.P. Poonia, Environmental Studies, Khanna Publishing House, New Delhi.
2. C.N. R. Rao, Understanding Chemistry, Universities Press (India) Pvt. Ltd., 2011.
3. Arceivala, Soli Asolekar, Shyam, Waste Water Treatment for Pollution Control and
4. Reuse, Mc-Graw Hill Education India Pvt. Ltd., New York, 2007, ISBN:978-07-062099-
5. Nazaroff, William, Cohen, Lisa, Environmental Engineering Science, Willy, New York, 2000, ISBN 10: 0471144940.
6. O.P. Gupta, Elements of Environmental Pollution Control, Khanna Publishing House, New Delhi
7. Rao, C. S., Environmental Pollution Control and Engineering, New Age International Publication, 2007, ISBN: 81-224-1835-X.
8. Rao, M. N.Rao, H.V.N, Air Pollution, Tata Mc-Graw Hill Publication, New delhi, 1988, ISBN: 0-07- 451871-8.
9. Frank Kreith, Jan F Kreider, Principles of Solar Engineering, McGraw-Hill, New York; 1978, ISBN: 9780070354760.
10. Aldo Vieira, Da Rosa, Fundamentals of renewable energy processes, Academic Press Oxford, UK; 2013. ISBN: 9780123978257.
11. Patvardhan, A.D, Industrial Solid Waste, Teri Press, New Delhi, 2013, ISBN:978-81-7993-502-6
12. Metcalf & Eddy, Waste Water Engineering, Mc-Graw Hill, New York, 2013, ISBN: 077441206.
13. Keshav Kant, Air Pollution & Control, Khanna Publishing House, New Delhi (Edition 2018)

Open source software and website address:

1. www.eco-prayer.org
2. www.teriin.org
3. www.cpcp.nic.in
4. www.cpcp.gov.in
5. www.indiaenvironmentportal.org.in
6. www.whatis.techtarget.com
7. www.sustainabledevelopment.un.org
8. www.conserve-energy-future.com

Teachers should use the following strategies to achieve the various outcomes of the course.

- Different methods of teaching and media to be used to attain classroom attention.
- Massive open online courses (MOOCs) may be used to teach various topics/sub topics.
- 15-20% of the topics which are relatively simpler of descriptive in nature should be given to the students for self-learning and assess the development of competency through classroom presentations.
- Micro-projects may be given to group of students for hand-on experiences.
- Encouraging students to visit to sites such as Railway station and research establishment around the institution.

Course Outcomes: At the end of the course student will be able to

1. Understand the ecosystem and terminology and solve various engineering problems applying ecosystem knowledge to produce eco – friendly products.
2. Understand the suitable air, extent of noise pollution, and control measures and acts.
3. Understand the water and soil pollution, and control measures and acts.
4. Understand different renewable energy resources and efficient process of harvesting.
5. Understand solid Waste Management, ISO 14000 & Environmental Management.

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PC401	Theory of Computation	3L:1T:0P	4 Credits

Course Objective:

Students should be able to understand fundamental mathematical and computational principles that are foundations of computer science. They should learn about abstract models of computation, finite representations for languages and gain formal understanding of algorithms and procedures.

Detailed contents:

Module 1: Automata

Introduction to formal proof, Additional forms of proof, Inductive proofs, Finite Automata (FA), Deterministic Finite Automata (DFA), Non-deterministic Finite Automata (NFA), Finite Automata with Epsilon transitions.

Module 2: Regular Expressions and Languages

Regular Expression, FA and Regular Expressions, proving languages not to be regular, Closure properties of regular languages, Equivalence and minimization of Automata.

Module 3: Context-Free Grammars and Languages

Context-Free Grammar (CFG), Parse Trees, Ambiguity in grammars and languages, Definition of the Pushdown automata, Languages of a Pushdown Automata, Equivalence of Pushdown automata and CFG Deterministic Pushdown Automata.

Module 4: Properties of Context-Free Languages

Normal forms for CFG, Pumping Lemma for CFL, Closure Properties of CFL, Turing Machines, Programming Techniques for TM, Variations of TM, Non-Universal TM, Universal TM.

Module 5: Undecidability

A language that is not Recursively Enumerable (RE), An undecidable problem that is RE Undecidable problems about Turing Machine, Post's Correspondence Problem, The classes P and NP.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	Course Name	Instructor	Host Institute
1.	Theory of Computation - Video course	Prof. Somenath Biswas	IIT Kanpur
2.	Theory of Computation	Prof. Ragunath Tewari	IIT Kanpur

Text Books/Suggested References:

1. J.E. Hopcroft, R. Motwani and J.D. Ullman, "Introduction to Automata Theory, Languages and Computations", second Edition, Pearson Education 2007
2. H.R. Lewis and C.H. Papadimitriou, "Elements of the theory of Computation", Second Edition, Pearson Education 2003
3. R.B. Patel, "Theory of Computation (with Formal Languages)/ 2nd Edition", Khanna Book Publishing 2020.
4. Thomas A. Sudkamp," An Introduction to the Theory of Computer Science, Languages and Machines", Third Edition, Pearson Education. 2007
5. J. Martin, "Introduction to Languages and the Theory of computation" Third Edition, Tata Mc Graw Hill. 2007

Course outcomes: After completion of course, students would be able to:

1. Evaluate computer science problems as mathematical statements and to formulate proofs.
2. Understand properties of the corresponding language classes defined by various computation models and the relations between them.
3. Understand the general properties of computation and learn how to increase efficiency at which computers solve problems.
4. Understand how to model different computations problem using state machines.

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PC402	Software Engineering	3L:0T:2P	4 Credits

Course Objective:

Students should learn the concept and importance of Software Engineering. They should be able to construct software that is reasonably easy to understand, modify, maintain and reliable. They should learn strengths and weaknesses of various Software Engineering Techniques used in industrial applications.

Detailed contents:

Module 1: Introduction and Software Process Models

Software, Software Engineering, Myths, Software Process, Work Products, Importance of Software Engineering, Standard for Software Process, Waterfall Model, Prototyping Model, Iterative Enhancement Model, Spiral Model, RAD model, 4th Generation models, Formal Methods, Agile Development

Module 2: Requirement Engineering and Software Project Management

Software Requirements, Types of Requirements, Requirement Engineering Cycle, Requirements Specification document, Characteristics of Requirements, Requirement verification and validation, Role of Management in Software Development, Project Estimation Techniques, Staffing, Scheduling, Earned Value Analysis, Software Risks, Software Configuration Management, Software Process and Project metrics.

Module 3: Software Design and Coding

Process, Data and Behavioural Modelling, Design Concepts, Modularity, Architectural design, Coupling and Cohesion, Top-down and bottom-up design, Object-oriented Analysis, Function-oriented and Object-Oriented Design approach, Software Design Document, Coding styles and documentation,

Module 4: Testing and Software Quality

Testing principles, testing strategies, Black-box and White-box Testing Techniques, Levels of testing -unit, integration, system, regression, Test Plan, Test Cases Specification, Software debugging, Software Maintenance, Software Quality Assurance (SQA), SQA tasks, Software amplification and removal, Formal Technical Reviews, Software Quality Factors, ISO 9126, SEI CMM, CMMI, Software Reliability. Software Availability.

Module 5: Computer Aided Software Engineering and Advanced Topics

Computer Aided Software Engineering (CASE) and its Scope, CASE support in Software Life Cycle, Architecture of CASE Environment, Upper CASE and Lower CASE, Exposure to CASE

tools. Software Process Improvement, Component Based Software Engineering, Web Engineering, Reverse Engineering, Software Engineering challenges of Big Data, Mobile Applications.

Laboratory/ Practicals:

1. Programming Exercises for software design concepts.
2. Programming Exercises for software testing concepts.
3. Programming Exercises for Project Management concepts.
4. Design and Develop UML diagrams for any Software Project.
5. Project Development with Software Engineering practices.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	Course Name	Instructor	Host Institute
1.	Software Engineering	Prof. Rajib Mall	IIT Kharagpur
2.	Software Engineering - Video course	Prof. N.L. Sarda, Prof. Rushikesh K Joshi, Prof. Umesh Bellur	IIT Bombay

Text Books/Suggested References:

1. Software Engineering-A Practitioners Approach, By R. Pressman, McGraw Hill International edition, 2004
2. Software Engineering, N.S. Gill, Khanna Publishing Co., Delhi 2018.
3. Software Engineering, Ian Sommerville, Addison-Wesley, 2010
4. An Integrated Approach to Software Engineering, Pankaj Jalote, Narosa, 2014
5. Fundamentals of Software Engineering, By Rajib Mall, PHI Learning Pvt. Ltd, 2014
6. Software Engineering (3rd ed.), By K.K Aggarwal & Yogesh Singh, New Age International Publishers, 2007

Course outcomes: After completion of course, students would be able to:

1. Understand the process of designing, creating and maintaining software.
2. Create softwares for various application domains.
3. Understand the challenges of large scale software development.
4. Understand the importance of software design and development practices.

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PC403	Deep Learning	3L:0T:2P	4 Credits

Course Objective:
To introduce the fundamentals of deep learning and the main research activities in this field. To learn architectures and optimization methods for deep neural network training

Detailed Contents:
Module 1: Introduction
History of Deep Learning, McCulloch Pitts Neuron, Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Feed Forward Neural Networks, Back propagation

Module 2: Activation functions and parameters
Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, Principal Component Analysis and its interpretations, Singular Value Decomposition, Parameters v/s Hyper-parameters

Module 3: Auto-encoders & Regularization
Auto encoders and relation to PCA, Regularization in auto encoders, Denoising auto encoders, Sparse auto encoders, Regularization: Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Encoder Decoder Models, Attention Mechanism, Attention over images, Batch Normalization

Module 4: Deep Learning Models
Introduction to CNNs, Architecture, Convolution/pooling layers, CNN Applications, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet. Introduction to RNNs, Back propagation through time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT, GRU, LSTMs

Module 5: Deep Learning Applications
Image Processing, Natural Language Processing, Speech recognition, Video Analytics

Laboratory/ Practicals (if any): Mention list of Practicals

1. Implementation of following deep learning algorithms in Python using TensorFlow:Convolution Neural Network
2. Implementation of following deep learning algorithms in Python using TensorFlow:Recurrent Neural Network
3. Project work involving application of Deep Learning

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Deep Learning	Prof. Mitesh M. Khapra	IIT Ropar
2.	Deep Learning	Prof. Prabir Kumar Biswas	IIT Kharagpur

Text Books/Suggested References:

1. Ian Goodfellow, YoshuaBengio, Aaron Courville. Deep Learning, the MIT press, 2016

2. Bengio, Yoshua. " Learning deep architectures for AI." Foundations and trends in Machine Learning 2.1, Now Publishers, 2009
3. Deep Learning, Rajiv Chopra, Khanna Book Publishing, Delhi 2020.
4. https://nptel.ac.in/courses/106/106/106106184/
5. https://www.coursera.org/specializations/deep-learning

Course Outcomes: After completion of course, students would be able to:

1. Understand the fundamentals of deep learning and the main research activities in this field
2. Remember architectures and optimization methods for deep neural network training
3. Implement, apply and test relevant learning algorithms in TensorFlow
4. Critically evaluate the method's applicability in new contexts and construct new applications

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PC404	Operating System	3L:0T:2P	4 Credits

Objectives of the Course:

Students should be able to describe the services provided by and the design of an operating system. They should be able to understand the structure and organization of the file system, processes synchronization, process scheduling, system calls and different approaches to memory management.

Detailed contents:

Module 1: Concepts of Operating Systems

Computer system overview, concept of an operating system, batch system, multiprogramming, multiprocessing, multi user, time sharing, personal system, parallel system, real time system, simple monitors, general system architecture, System components, operating system services, system calls, system programs, system structure, Approaches to OS design and implementation: Microkernel, Layered, Kernel Approach

Module 2: Processes and Threads

Concept of process, process states, process state transitions, process control block, operations on processes, threads, concurrent processes, mutual exclusion and synchronization, principles of deadlocks, integrated deadlocks strategy, scheduling levels, scheduling criteria, Inter process synchronization, Inter process communication, Linux, IPC Mechanism, Remote procedure calls, RPC exception handling, security issues

Module 3: Memory Management and Data Management

Logical and physical address space, storage allocation and management techniques, swapping concepts of multi programming, paging, segmentation, virtual storage management strategies, demand paging, page replacement algorithm, thrashing, File organization, record blocking, access

method, directory structure, protection file system structure, allocation methods, free space management, directory implementation, disk structure, disk scheduling, disk management, buffering, swap space management, RAID levels

Module 4: OS Security

Types of Threats in OS, Basic OS Security Mechanisms, Understanding the Threats: Malware Taxonomy: Viruses, Worms, Rootkits, Defence: An Overview, Logging, Auditing, and Recovery, OS-level Memory Protection

Module 5: Case Studies and OS Abstractions

Linux/Unix OS design and architecture, Unix shell, Unix operating system services, user perspective, representation of files in Unix system processes and their structure, input-output system, memory management in Unix, Processes: fork, wait, exec, exit, kill, getpid, brk, nice, sleep, trace, Files: open, close, read, write, lseek, stat, sync, Directories: mkdir, rmdir, link, unlink, mount, umount users +, Security: chown, chmod, getuid, setuid, Inter process communication: signals, pipe, Networking: socket, accept, snd, recv, connect

Laboratory/ Practicals:

1. To perform shell programming.
2. Implement memory management techniques like paging or segmentation.
3. Implement any file allocation technique (Linked, Indexed or Contiguous).
4. Use the following system calls of UNIX operating system: mkdir, rmdir, link, unlink, mount, umount users +, chown, chmod, getuid, setuid.
5. Use the following system calls of UNIX operating system: fork, wait, exec, exit, kill, getpid, brk, nice, sleep, trace, open, close, read, write, lseek, stat, sync
6. Use the following system calls of UNIX operating system: signals, pipe, socket, accept, snd, recv, connect.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	Course Name	Instructor	Host Institute
1.	Operating System Fundamentals	Prof.Santanu Chattopadhyay	IIT Kharagpur
2.	Operating System	Prof. Sorav Bansal	IIT Delhi

Text Books/Suggested References:

1. Operating system, Galvin & Silberschatz, 7th Edition, John Willey 2004
2. Operating Systems-A Concept Based Approach, Dhamdhare, TMH 2006
3. Operating System Concepts, Ekta Walia, Khanna Book Publishing 2020.
4. Operating systems Internals and design principles By William Stallings, Pearson Education, 2012
5. Operating Systems –A Design Oriented Approach, Crowley, TMH, 2001

6. Operating systems Design and Implementation, Andrew S. Tanenbaum, Pearson Education 2009

Course outcomes: After completion of course, students would be able to:

1. Understand the basics of an operating systems and its major components.
2. Understand and implement shell programing.
3. Create and/or modify concurrent programs.
4. Apply security as well as recovery features in the design of algorithm.

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HS401	**Theory of computation Ecosystems**	**3L:0T:0P**	**3 Credits**

Objectives of the Course:

The students should study the development of start-up projects in the realm of globalisation, crowdsourcing and the emergence of "open-source" innovations. They should be able to search for the governmental means of support for open innovation projects, private investment resources, and assess the level of maturity of the project.

Detailed contents:

Module 1: Introduction

Introduction to Entrepreneurship Strategy: from Ideation to Exit, identifying the trade-offs, Intellectual activity & knowledge economy, sharing economy – approach to construct social-economic models, Business as construction of value creation chain in the context of open knowledge,

Module 2: Digital technologies as an open innovation's environment

Transaction costs: trust and reviewing system (personification), Hard & software - Robotics and Intelligence: Computing Recognition and Decision Making, Infrastructure Building, Cyberphysical systems as a product and as an infrastructure.

Module 3: The organization and management of open innovation projects

History the emergence of open innovation, Analysis of elements of open innovation in the traditional management, Agile – flexible project management. Methodologies within agile approach, from project to product: steps of converting ideas into goods, Stakeholders of open innovation project: customers, investors, employees etc. Indicators of effectiveness for the various groups of stakeholders.

Module 4: Start-up environment: institutions that support and finance innovative projects

Types of financing, Infrastructure supporting small innovative enterprises and start-ups, Programs to support innovative projects at the federal and regional level.

Module 5: Operational and Strategy Management

Introduction to Operations Management*:*
Operations Analysis, Coordination and Planning, Quality Management, Project Management, and Logistics and Supply Chain Management, strategy management, technological strategy.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	SWAYAM Course Name	Instructor	Host Institute
1.	Innovation and Start-up Policy	Prof. Rahul K. Mishra	IILM Institute for Higher Education

Text Books:

1. Innovation and Entrepreneurship by Peter F. Drucker (Classic Drucker Collection, 2007)
2. Joseph A. Schumpeter's views on entrepreneurship and innovation by Perihan Hazel.

Suggested References:

1. https://www.coursera.org/learn/startups-in-open-innovation.
2. https://www.coursera.org/learn/entrepreneurship-strategy.
3. https://ocw.mit.edu/courses/entrepreneurship/topic-list/

Course outcomes: After completion of course, students would be able to:
1. Understand economic models in the digital environment and types of monetisation used for open innovations.
2. Create a business model of value in the open-knowledge environment**.**

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SEMESTER – V

SEMESTER V

Course Code	:	AU301
Course Title	:	Indian Constitution
Number of Credits	:	0 (L: 3, T: 0, P: 0)
Course Category	:	AU

Course Content

Unit 1: **The Constitution - Introduction**

- The History of the Making of the Indian Constitution
- Preamble and the Basic Structure, and its interpretation
- Fundamental Rights and Duties and their interpretation
- State Policy Principles

Unit 2 – Union Government

- Structure of the Indian Union
- President – Role and Power
- Prime Minister and Council of Ministers
- Lok Sabha and Rajya Sabha

Unit 3 – State Government

- Governor – Role and Power
- Chief Minister and Council of Ministers
- State Secretariat

Unit 4 – Local Administration

- District Administration
- Municipal Corporation
- Zila Panchayat

Unit 5 – Election Commission

a. Role and Functioning
b. Chief Election Commissioner
c. State Election Commission

Suggested Learning Resources:

S. No.	Title of Book	Author	Publication
1	Ethics and Politics of the Indian Constitution	Rajeev Bhargava	Oxford University Press, New Delhi, 2008
2	The Constitution of India	B.L. Fadia	Sahitya Bhawan; New edition (2017)
3	Introduction to the Constitution of India	DD Basu	Lexis Nexis; Twenty-Third 2018 edition

Suggested Software/Learning Websites:

a. https://www.constitution.org/cons/india/const.html
b. http://www.legislative.gov.in/constitution-of-india
c. https://www.sci.gov.in/constitution
d. https://www.toppr.com/guides/civics/the-indian-constitution/the-constitution-of-india/

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PC501	Data and Visual Analytics in AI	3L:0T:2P	4 Credits

Course Objective:
The student will be able to understand techniques and algorithms for creating effective visualizations based on principles from graphic design. They will also be introduced to several industry-standard software tools to create a compelling and interactive visualization of various types of data.

Detailed contents:
Module 1: Introduction
Data for Graphics, Design principles, Value for visualization, Categorical, time series, and statistical data graphics, Introduction to Visualization Tools

Module 2: Graphics Pipeline and Aesthetics and Perception
Introduction, Primitives: vertices, edges, triangles, Model transforms: translations, rotations, scaling, View transform, Perspective transform, window transform, Graphical Perception Theory, Experimentation, and the Application, Graphical Integrity, Layering and Separation, Color and Information, Using Space

Module 3: Visualization Design
Visual Display of Quantitative Information, Data-Ink Maximization, Graphical Design, Exploratory Data Analysis, Heat Map

Module 4: Multidimensional Data and Interaction
Query, Analysis and Visualization of Multi-Dimensional Relational Databases, Interactive Exploration, tSNE, Interactive Dynamics for Visual Analysis, Visual Queries, Finding Patterns in Time Series Data, Trend visualization, Animation, Dashboard, Visual Storytelling

Module 5: Collaboration
Graph Visualization and Navigation, Online Social Networks, Social Data Analysis, Collaborative Visual Analytics, Text, Map, Geospatial data

Laboratory/ Practicals:

1. Understand the meaning of big data and its application.
2. using NOSQL to get data from unstructured database.
3. explore differed open source technologies available for big data.
4. Project involving yarn, Pig, grant etc.

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Introduction to Data Analytics	Prof. Nandan Sudarasanam Prof. B. Ravidran	IIT Madras
2.	Deep Learning for Visual Computing	Prof. Debdoot Sheet	IIT Kharagpur

Text Books/Suggested References:

1. The Visual Display of Quantitative Information by E. Tufte, Graphics Press, 2nd Edition, 2001
2. Beginner's Guide for Data Analysis using R Programming, Jeeva Jose, Khanna Publishing 2019.
3. Data Visualization Handbook by J. Koponen, J. Hildén, CRC Press, 2019
4. The Book of Trees: Visualizing Branches of Knowledge by M. Lima, Princeton Architectural Press, 2014
5. Handbook of Graph Drawing and Visualization by R. Tamassia, CRC Press, 2013
6. Interactive Data Visualization for the Web by S. Murray O'Reilly Press, 2nd Edition, 2017

Course Outcomes: After completion of course, students would be able to:

1. Understand the key techniques and theory used in visualization, including data models, graphical perception, and techniques for visual encoding and interaction.
2. Apply knowledge to a number of common data domains and corresponding analysis tasks, including multivariate data, networks, text, and cartography.
3. Describe big data and use cases from selected business domains.
4. Explain NoSQL big data management and other technologies such as Hadoop and HDFS

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PC503	Natural Language Processing	3L:0T:2P	4 Credits

Course Objective:
The students should be able to study language and the tools that are available to efficiently study and analyze large collections of text. They should learn about and discuss the effects of electronic communication on our language.

Detailed Contents:

Module 1: Introduction
A computational framework for natural language, description of English or an Indian language in the frame work, lexicon, algorithms and data structures for implementation of the framework, Finite state automata, the different analysis levels used for NLP (morphological, syntactic, semantic, pragmatic, Recursive and augmented transition networks. Applications like machine translations.

Module 2: Word level and syntactic analysis
Word Level Analysis: Regular Expressions, Finite-State Automata, Morphological Parsing, Spelling Error Detection and correction, Words and Word classes, Part-of Speech Tagging. Syntactic Analysis: Context-free Grammar, Constituency, Parsing-Probabilistic Parsing. Machine-readable dictionaries and lexical databases, RTN, ATN.

Module 3: Semantic analysis
Semantic Analysis: Meaning Representation, Lexical Semantics, Ambiguity, Word Sense Disambiguation. Discourse Processing: cohesion, Reference Resolution, Discourse Coherence and Structure. Knowledge Representation, reasoning.

Module 4: Natural language generation
Natural Language Generation (NLG): Architecture of NLG Systems, Generation Tasks and Representations, Application of NLG. Machine Translation: Problems in Machine Translation, Characteristics of Indian Languages, Machine Translation Approaches, Translation involving Indian Languages.

Module 5: Information retrieval and lexical resources
Information Retrieval: Design features of Information Retrieval Systems, Classical, Non-classical, Alternative Models of Information Retrieval, valuation Lexical Resources: World Net, Frame Net, Stemmers, POS Tagger.

Laboratory/ Practicals:

1. Implement program to perform automatic word analysis.
2. Implement program to perform word generation.
3. Implement programs related to morphology, N-Grams, N-Grams Smoothing.
4. Implementation of Hidden Markov Models.
5. Program to build POS Tagger, Chunker.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Natural Language Processing	Prof. Pawan Goyal	IIT Kharagpur

2.	Natural Language Processing	Prof. Pushpak Bhattacharya	IIT Bombay

Text Books/Suggested References:

1. Natural Language understanding by James Allen, Pearson Education, 2002.
2. NLP: A Paninian Perspective by Akshar Bharati, Vineet Chaitanya, and Rajeev Sangal, Prentice Hall, 2016.
3. Meaning and Grammar by G. Chirchia and S. McConnell Ginet, MIT Press, 1990.
4. An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition by Daniel Jurafsky and James H. Martin, Pearson Education, 2006.
5. Natural language processing in Prolog by Gazdar, & Mellish, Addison-Wesley
6. https://www.coursera.org/specializations/natural-language-processing

Course Outcomes: After completion of course, students would be able to:

1. Understand language and the tools that are available to efficiently study and analyse large collections of text.
2. Analyze and discuss the effects of electronic communication on our language
3. Learn natural language processing with manual and automated approaches.
4. Learn computational frameworks for natural language processing.

******

PC504	Advanced Machine Learning	3L:0T:2P	4 Credits

Course Objective:
To introduce advanced concepts and methods of machine learning and to develop an understanding of the role of machine learning in massive scale automation. To design and implement various machine learning algorithms in a range of real-world applications.

Detailed Contents:
Module 1: Artificial Neural Network
Introduction to ANN, Perceptron, Cost Function, Gradient Checking, multi-layer perceptron and backpropagation algorithm that is used to help learn parameters for a neural network, Random Initialization

Module 2: Bayesian Learning
Probability theory and Bayes rule, Naive Bayes learning algorithm, Bayes nets.

Module 3: Decision Trees
Representing concepts as decision trees, Recursive induction of decision trees, best splitting attribute: entropy and information gain. Searching for simple trees and computational complexity, Overfitting, noisy data, and pruning.

Module 4: Reinforcement Learning
Reinforcement earning through feedback network, function approximation.

Module 5: Ensemble Methods
Bagging, boosting, stacking and learning with ensembles. Random Forest

Laboratory/ Practicals:

Implementation of following machine learning algorithms in various projects using Python:
1. Classification and regression algorithms.
2. K-Means Clustering.
3. Artificial Neural Network (with back-propagation).
4. Decision Trees.
5. Random Forest.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Machine Learning for Engineering and Science Applications	Dr. Balaji Srinivasan	IIT Madras

Text Books/Suggested References:

1. Tom Mitchell, Machine Learning, McGraw Hill, 1997.
2. Jeeva Jose, Introduction to Machine Learning, Khanna Book Publishing 2020.
3. Rajiv Chopra, Machine Learning, Khanna Book Publishing 2021
4. Ethem Apaydin, Introduction to Machine Learning, 2e. The MIT Press, 2010.
5. Kevin P. Murphy, Machine Learning: a Probabilistic Perspective, The MIT Press, 2012.
6. https://www.coursera.org/learn/bayesian-methods-in-machine-learning?specialization=aml

7. https://www.coursera.org/learn/practical-rl?specialization=aml

Course Outcomes: After completion of course, students would be able to:

1. Understand advanced concepts and methods of machine learning and to develop an understanding of the role of machine learning in massive scale automation.
2. Apply various machine learning algorithms in a range of real-world applications.
3. Integrate and apply their expertise to produce solutions for real-world problems.
4. Interpret and Analyze results with reasoning using different ML techniques.

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PC502	Optimization Techniques in Machine Learning	3L:1T:0P	4 Credits

Course Objective:

The students will be able to understand and analyze how to deal with changing data. They will also be able to identify and interpret potential unintended effects in your project. They will understand and define procedures to operationalize and maintain your applied machine learning model.

Detailed Contents:

Module 1: Introduction

What is optimization, Formulation of LPP, Solution of LPP: Simplex method, Basic Calculus for optimization: Limits and multivariate functions, Derivatives and linear approximations: Singlevariate functions and multivariate functions.

Module 2: Machine Learning Strategy

ML readiness, Risk mitigation, Experimental mindset, Build/buy/partner, setting up a team, Understanding and communicating change.

Module 3: Responsible Machine Learning

AI for good and all, Positive feedback loops and negative feedback loops, Metric design and observing behaviours, Secondary effects of optimization, Regulatory concerns.

Module 4: Machine Learning in production and planning

Integrating info systems, users break things, time and space complexity in production, when to retain the model? Logging ML model versioning, Knowledge transfer, Reporting performance to stakeholders.

Module 5: Care and feeding of your machine learning model

MLPL Recap, Post deployment challenges, QUAM monitoring and logging, QUAM Testing, QUAM maintenance, QUAM updating, Separating Datastack from Production, Dashboard Essentials and Metrics monitoring.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Applied Optimization for Wireless, Machine Learning and Big Data	Prof. Aditya Jagannath	IIT Kanpur

Text Books/Suggested References:

1. Jeeva Jose, Introduction to Machine Learning, Khanna Book Publishing 2020.
2. Rajiv Chopra, Machine Learning, Khanna Book Publishing 2021
3. Optimization for Machine Learning, Suvrit Sra, Sebastian Nowozin and Stephen J. Wright, MIT Press, 2011.
4. Optimization in Machine Learning and Applications, Suresh Chandra Satapathy, Anand J. Kulkarni, Springer, 2019.

5. Algorithms for Optimization by Mykel J. Kochenderfer and Tim A. Wheeler, MIT Press, 2019.
6. Accelerated Optimization for Machine Learning: First-Order Algorithms by Cong Fang, Huan Li, and Zhouchen Lin, Springer, 2020.
7. https://www.coursera.org/learn/optimize-machine-learning-model-performance

Course Outcomes: After completion of course, students would be able to:

1. Understand and analyze how to deal with changing data.
2. Understand and interpret potential unintended effects in their project.
3. Understand and define procedures to operationalize and maintain the applied machine learning model.
4. Understand how to optimize the use of Machine Learning in real-life problems.

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SEMESTER – VI

SEMESTER VI

EEC601	Industry/Research Lab Internship	16 Credits

Internship can be done in an industry, Start-up, Social Internship, Work from Home Internship etc. For various available internships, student may visit **Appendix IV**.

For more guidance regarding internship, refer AICTE Internship Policy and AICTE Internship Portal (www.internship.aicte-india.org).

Or

Alternatively, courses can also be offered from Open Electives/Professional Electives. Two courses of 03 Credits each and one major project for 10 credits. Also, students may opt for a virtual internship along with course.

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SEMESTER – VII

SEMESTER VII

PC701	Soft Computing	3L:0T:2P	4 Credits

Course Objective:
Students should be able to understand soft computing concepts and techniques and foster their abilities in designing and implementing soft computing-based solutions for real-world problems.

Detailed Contents:

Module 1: Introduction to neural networks
Structure and working of Biological Neural Network, Fundamentals of Artificial Neural Networks & Applications, Characteristics of Artificial Neural Networks, History of neural network research, characteristics of neural networks terminology.

Module 2: Neural networks models and Learning Methods
Models of neuron McCulloch – Pitts model, Perceptron, Adaline model, Basic learning laws, Topology of neural network architecture, Multilayer Neural Networks, Learning Methods, Backpropagation, Counter propagation, ART, BAM, Associative memories.

Module 3: Introduction of Fuzzy logic and Neuro Fuzzy Systems
Introduction, Fuzzy sets, Fuzzy model, Fuzzy rule generation Fuzzy inference system, Defuzzification, Architecture of a Neuro-Fuzzy system and its applications.

Module 4: Machine Learning
Supervised learning: Primitive algorithms, Generative algorithms, Support Vector Machine, Ensemble methods. Unsupervised learning: K-means, Principal component analysis, Independent component analysis. Reinforcement learning and control.

Module 5: Applications
Applications of GA & GP, Hybrid systems.

Laboratory/ Practicals:

1. Setting up MATLAB.
2. Experiments with neural network toolbox.
3. Experiments with fuzzy logic toolbox.
4. Implementing fuzzy logic.
5. Implementing artificial neural network.
6. Implementing genetic algorithms.

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Introduction to Soft Computing	Prof. Debasis Samanta	IIT Kharagpur
2.	Fuzzy Logic and Neural Netwroks	Prof. Dilip Kumar Pratihar	IIT Kharagpur

Text Books/Suggested References:

1. Neuro fuzzy and soft computing by Jang, Pearson Education, 1996
2. Learning and Soft Computing by Kecman, Pearson Education, 2001
3. Fuzzy Sets and Fuzzy Logic - Klir and Yuan, PHI, 1995
4. Neural Network in computer Intelligence by Fu, TMH, 2003
5. Bio-Inspired Artificial Intelligence – Dario Floreano, PHI, 2008
6. Soft Computing – Ikvinderpal Singh, Khanna Book Publishing 2015.

Course Outcomes: After completion of course, students would be able to:

1. Understand, Identify and describe soft computing techniques and their roles in building intelligent machines.
2. Apply a soft computing methodology for a particular problem.
3. Analyze and compare solutions by various soft computing approaches for a given problem.
4. Apply genetic algorithms to combinatorial optimization problems.
5. Evaluate and compare solutions by various soft computing approaches for a given problem.

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PE701	**Professional Elective - I**	**3L:0T:2P**	**4 Credits**

Important Note: For Professional Elective Courses, A Student can opt for any one subject out of available subjects defined in **Appendix II**.

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PE702	**Professional Elective - II**	**3L:0T:2P**	**4 Credits**

Important Note: A Student can opt for any one subject out of available subjects defined in **Appendix II** on Professional Elective Courses provided he/she has not taken that particular subject in Professional Elective - I

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OE701	**Open Elective - II**	**2L:0T:2P**	**3 Credits**

Any one course from following options can be opted under 'Open Elective - II':

3. Machine Learning with Python (OE003)
4. AI for everyone (OE004)

For syllabus, Refer Appendix - I on Open Electives.

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EEC701	**Capstone Project (Part-I)**	**06 Credits**

- ***Main emphasis should be on Project Based Learning / Experiential Learning.***

SEMESTER – VIII

SEMESTER VIII

PE801	**Professional Elective - III**	**3L:0T:2P**	**4 Credits**

Important Note: A Student can opt for any one subject out of available subjects defined in **Appendix II** on Professional Elective Courses provided he/she has not taken that particular subject in Professional Elective – I/II/IV

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PE802	**Professional Elective - IV**	**3L:0T:2P**	**4 Credits**

Important Note: A Student can opt for any one subject out of available subjects defined in **Appendix II** on Professional Elective Courses provided he/she has not taken that particular subject in Professional Elective – I/II/III

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EEC801	**Capstone Project (Part-II)**	**10 Credits**

- ***Main emphasis should be on Project Based Learning / Experiential Learning.***

Appendix – I

Appendix – I

Open Electives (3 Credits)

S.No	Course Code	Course	Credits	L	T	P
1.	OE001	IOT	3	2	0	2
2.	OE002	Robotics	3	2	0	2
3.	OE003	Machine Learning with Python	3	2	0	2
4.	OE004	AI for Everyone	3	2	0	2

OE001	IOT	2L:0T:2P	03 Credits

Course objectives:

Understanding core technology, applications, sensors used and IOT architecture along with the industry perspective. Principles and operations of different types of sensors commonly used on mobile platform will be taught in a manner that by the end of the course the students will be able to design and implement real time solutions using IOT.

Detailed Contents:

Module 1:
Introduction to IoT: What is IoT, how does it work? Difference between Embedded device and IoT device, Properties of IoT device, IoT Ecosystem, IoT Decision Framework, IoT Solution Architecture Models, Major IoT Boards in Market

Module 2:
Setting Up Raspberry/Arduino to Create Solutions: Explore Raspberry Pi, setting up Raspberry Pi, showing working of Raspberry Pi using SSH Client and Team Viewer, Understand Sensing actions, Understand Actuators and MEMS

Module 3:
Communication Protocols used in IoT: Types of wireless communication, Major wireless Short-range communication devices, properties, comparison of these devices (Bluetooth, WIFI, ZigBee, 6LoWPAN), Major wireless Long-range communication devices, properties, comparison of these devices (Cellular IoT, LPWAN)

Module 4:

IoT Applications: Industrial Internet 4.0, Applications such as: Smart home, wearables, smart city, smart grid, connected car, connected health (digital health, telehealth, telemedicine), smart retail

Module 5:

Sensors: Applications of various sensors: Google Maps, Waze, WhatsApp, Ola Positioning sensors: encoders and accelerometers, Image sensors: cameras, Global positioning sensors: GPS, GLONASS, IRNSS, Galileo and indoor localization systems, Motion & Orientation Sensors: Accelerometer, Magnetometer, Proximity Sensor, Gyroscope Calibration, noise modeling and characterization and noise filtering and sensor data processing. Privacy &Security

Suggested References:

1. Vijay Madisetti and Arshdeep Bahga, Internet of Things (A Hands-on Approach), 1st Edition, VPT, 2014
2. Francis da Costa, Rethinking the Internet of Things: A Scalable Approach to Connecting Everything, 1stEdition, Apress Publications, 2014
3. CunoPfister, Getting Started with the Internet of Things, O Reilly Media, 2011
4. Kyung, C.-M., Yasuura, H., Liu, Y., Lin, Y.-L., Smart Sensors and Systems, Springer International Publishing, 2015

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Introduction to Internet of Things	Prof. Sudip Misra	IIT Kharagpur
2.	Introduction to Industry 4.0 and Industrial Internet of Things	Prof. Sudip Misra	IIT Kharagpur

Course Outcomes: After completion of course, students would be able to:

1. Understand core technology, applications, sensors used and IOT architecture along with the industry perspective.
2. Understand Raspberry's working and implementation.
3. Understand various communication protocols used in IoT.
4. Apply various IOT technologies in real-life applications.

****

OE002	Robotics	2L:0T:2P	03 Credits

Course Objective:
The students will be able to understand the basic concepts and fundamentals of robotics. They will also be able to use AI in the field of robotics.

Detailed Contents:
Module 1:
Introduction: Introduction to Robotics Fundamentals of Robotics, Robot Kinematics: Position Analysis, Dynamic Analysis and Forces, Robot Programming languages & systems: Introduction, the three levels of robot programming, requirements of a robot programming language, problems peculiar to robot programming languages.

Module 2:
Need of AI in Robotics: History, state of the art, Need for AI in Robotics. Thinking and acting humanly, intelligent agents, structure of agents.

Module 3:
Game Playing: AI and game playing, plausible move generator, static evaluation move generator, game playing strategies, problems in game playing.

Module 4:
Robotics fundamentals: Robot Classification, Robot Specification, notation, kinematic representations and transformations, dynamics techniques; trajectory planning and control.

Module 5:
Robotics and Its applications: DDD concept, Intelligent robots, Robot anatomy-Definition, law of robotics, History and Terminology of Robotics-Accuracy and repeatability of Robotics-Simple problems-Specifications of Robot-Speed of Robot, Robot joints and links-Robot classifications-Architecture of robotic systems-Robot Drive systems-Hydraulic, Pneumatic and Electric system

Suggested References:
1. Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Peter Corke, Springer, 2011.
2. Robotics: Everything You Need to Know About Robotics from Beginner to Expert, Peter McKinnon, Createspace Independent Publishing Platform, 2016.
3. Introduction to AI Robotics, Second Edition, By Robin R. Murphy, MIT press, 2001.
4. Artificial Intelligence for Robotics: Build intelligent robots that perform human tasks using AI techniques, Francis X. Govers, Packt Publishers, 2018.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Introduction to Robotics	Prof. Asokan T, Prof. Balaraman Ravindran, Prof. Krishna Vasudevan	IIT Madras
2.	Robotics	Prof. Dilip Kumar Pratihar	IIT Kharagpur

Course outcomes: After completion of course, students would be able to:

1. Understand the basics of robotics
2. Understand game playing concepts involving robotics and AI.
3. Apply robotics to create robot driven systems.
4. Analyze and co-relate robotics with AI and use in real-world applications.

****

OE003	Machine Learning with Python	2L:0T:2P	03 Credits

Course Objective:
The students will be able to handle various datatypes and datasets in python. They will also be able to implement various machine learning model sin python.

Detailed Contents:
Module 1:
Introduction to Python: Data Types, Operators, Expression, Indexing & Slicing, Strings, Conditionals, Functions, Control Flow, Nested Loops, Sets & Dictionaries

Module 2:
Introduction to Machine Learning: Machine Learning Vs Statistical Modelling, Supervised vs Unsupervised Learning, Supervised Learning Classification, Unsupervised Learning, Reinforcement Learning, Applications, Python libraries suitable for Machine Learning: Pandas, Numpy, Scikit-learn, visualization libraries: matplotlib etc.

Module 3:
Regression: Simple Linear Regression, Multiple Linear Regression, Non-linear Regression, Model Evaluation in Regression Models, Evaluation Metrics in Regression Models

Module 4:
Classification: Introduction to Classification, K-Nearest Neighbour, Decision Trees, Logistic Regression, Support Vector Machines, Logistic regression vs Linear regression, Evaluation Metrics in Classification

Module 5:
Unsupervised Learning: Intro to Clustering, K-Means Clustering, Hierarchical Clustering, Density-Based Clustering, Content-based recommender systems, Collaborative Filtering

Laboratory/ Practicals:
Implementation of following machine learning algorithms in various projects using Python:

1. Classification and regression algorithms.
2. Artificial Neural Network (with back-propagation).
3. Mathematical computing with Python packages like: numpy, Mat- plotLib, pandas Tensor Flow, Keras
4. Implement basic ML models like SVM, KNN, K-Means, Logistic Regression, Linear Regression

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Introduction to Machine Learning	Prof. Balaraman Ravindran	IIT Madras
2.	Machine Learning	Prof. Carl Gustaf Jansson	KTH, The Royal Institute of Technology

Suggested References:

1. Hands–On Machine Learning with Scikit–Learn and TensorFlow 2e: Concepts, Tools, and Techniques to Build Intelligent Systems, Aurelien Geron, O'Reilly, 2017
2. Python Machine Learning - Third Edition, Sebastian Raschka , Vahid Mirjalili, Packt Publishers, 2019
3. Introduction to Machine Learning with Python: A Guide for Data Scientists 1st Edition by Andreas C. Müller, Sarah Guido, O'Reilly, 2016
4. https://www.coursera.org/learn/machine-learning-with-python
5. https://www.edx.org/course/machine-learning-with-python-a-practical-introduct

Course Outcomes: After completion of course, students would be able to:

1. Understand python and be able to handle various datasets in python.
2. Understand basic machine learning algorithms.
3. Apply different classification and clustering algorithms for problem solving.
4. Create basic machine learning algorithms in python.

****

OE004	AI for Everyone	2L:0T:2P	03 Credits

Course Objective: The students should be able to understand what is AI, its applications and use cases and how it is transforming our lives.

Detailed contents:

Module 1:

Introduction

Machine Learning, What is data, The terminology of AI, What makes an AI company, What machine learning can and cannot do, Non-technical explanation of deep learning, basics of neural networks, Examples of AI, Application domains of AI.

Module 2:

Building AI projects

Workflow of a machine learning project, Workflow of a data science project, how to use data, How to choose an AI project, Working with an AI team, How to process and visualize data, Technical tools for AI teams, use of python in AI related projects.

Module 3:

Building AI in Your Company
Case study: Smart speaker, Case study: Self-driving car, Example roles of an AI team, AI pitfalls to avoid, Survey of major AI application areas

Module 4:

AI and Society
A realistic view of AI, Discrimination / Bias, Adversarial attacks on AI, Adverse uses of AI, AI and developing economies, AI and jobs

Module 5:

AI case studies related to a specific domain.

Laboratory/ Practicals:

1. Numerical type questions on CNN-
   a. Parameters tuning
   b. Convolution function
   c. Different types of filters

2. Fuzzy Logic and Neural Networks

3. Implement self-driving vehicle algorithm.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Artificial Intelligence	Prof. Sudeshna Sarkar	IIT Kharagpur
2	An Introduction to Artificial Intelligence	Prof. Mausam	IIT Delhi

Suggested References:

1. https://www.coursera.org/learn/ai-for-everyone#syllabus
2. https://www.edx.org/course/artificial-intelligence-for-everyone
3. Artificial Intelligence: A Modern Approach, by Stuart Russell, Peter Norvig, Prentice Hall, 2010
4. Artificial Intelligence: The Basics by Kevin Warwick, Routledge, 2011

5. Artificial Intelligence for Humans by Jeff Heaton, CreateSpace Independent Publishing, 2015

Course outcomes: After completion of course, students would be able to:

1. Understand the basic concepts of AI and machine learning.
2. Understand the working of self-driving systems.
3. Understand how to build different AI projects.
4. Apply AI techniques to any application domain.

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Appendix – II

Appendix – II

Professional Electives (4 Credits)

S.No	Course Code	Courses	Credits
1	PE001	Statistical Thinking for Data Science	4
2	PE002	Machine Learning for Data Science	4
3	PE003	Data Visualization	4
4	PE004	Big Data Analytics	4
5	PE005	Solve Business Problems with AI	4
6	PE006	Pattern Recognition & Visual Recognition	4
7	PE007	Image and Video Processing	4
8	PE008	Deep Learning for Computer Vision	4
9	PE009	Autonomous Systems	4
10	PE010	Bioinformatics	4
11	PE011	Genome Sequencing	4
12	PE012	Algorithms for DNA Sequencing	4
13	PE013	Computational Neuroscience	4
14	PE014	AI in Gaming	4
15	PE015	AI in Healthcare	4
16	PE016	AI in Finance	4
17	PE017	Predictive Analytics	4

Appendix – II

PE001	Statistical Thinking for Data Science	3L:0T:2P	4 Credits

Course Objective:

This course will provide the students a statistical foundation for data science. They will be able to exercise statistical thinking in collecting, modelling and analyzing data.

Detailed Contents:

Module 1: Introduction to Data Science

Data acquisition, cleaning, and aggregation, Exploratory data analysis and visualization, Feature engineering, Model creation and validation

Module 2: Statistical Thinking

Examples of Statistical Thinking, Numerical Data, Summary Statistics, From Population to Sampled Data, Different Types of Biases, Introduction to Probability, Introduction to Statistical Inference

Module 3: Statistical Thinking 2

Association and Dependence, Association and Causation, Conditional Probability and Bayes Rule, Simpsons Paradox, Confounding, Introduction to Linear Regression, Special Regression Models

Module 4: Exploratory Data Analysis and Visualization

Goals of statistical graphics and data visualization, Graphs of Data, Graphs of Fitted Models, Graphs to Check Fitted Models, What makes a good graph?, Principles of graphics

Module 5: Introduction to Bayesian Modeling

Bayesian inference: combining models and data in a forecasting problem, Bayesian hierarchical modeling for studying public opinion, Bayesian modeling for Big Data

Laboratory/ Practicals:

1. Installing R and R studio.
2. Understanding R fundamentals.
3. Data cleaning and manipulation using R.
4. Data Visualisation using R.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	SWAYAM Course Name	Instructor	Host Institute
1.	Essentials of Data Science With R Software - 1: Probability and Statistical Inference	Prof. Shalabh	IIT Kanpur

Text Books/Suggested References:

1. Tamhane, Ajit C., and Dorothy D. Dunlop. Statistics and Data Analysis: From Elementary to Intermediate. Prentice Hall, 1999.

2. Jeeva Jose, Beginner's Guide for Data Analysis using R Programming, Khanna Book Publishing House 2019.
3. V.K. Jain, Data Sciences & Analytics, Khanna Book Publishing House 2021.
4. Practical Statistics for Data Scientists by Peter Bruce and Andrew Bruce, O'Reilly, 2017
5. Statistics in Plain English by Timothy C. Urdan, Routledge, 2010
6. https://www.mooc-list.com/course/statistical-thinking-data-science-and-analytics-edx

Course Outcomes: After completion of course, students would be able to:

- Understand the statistical foundation for data science
- Apply statistical thinking in collecting, modelling and analyzing data
- Ability to visualize all types of data
- Understand how to use R for different types of data

******

PE002	Machine Learning for Data Science	3L:0T:2P	4 Credits

Course Objective:
The students will be able to derive practical solutions using predictive analytics. They will also understand the importance of various algorithms in Data Science.

Detailed Contents:

Module 1: Introduction
Algorithms and Machine Learning, Introduction to algorithms, Tools to analyze algorithms, Algorithmic techniques: Divide and Conquer, examples, Randomization, Applications

Module 2: Algorithms
Graphs, maps, Map searching, Application of algorithms: stable marriages example, Dictionaries and hashing, search trees, Dynamic programming

Module 3: Application to Personal Genomics
Linear Programming, NP completeness, Introduction to personal Genomics, Massive Raw data in Genomics, Data science on Personal Genomes, Interconnectedness on Personal Genomes, Case studies

Module 4: Machine Learning
Introduction, Classification, Linear Classification, Ensemble Classifiers, Model Selection, Cross Validation, Holdout

Module 5: Machine Learning Applications
Probabilistic modelling, Topic modelling, Probabilistic Inference, Application: prediction of preterm birth, Data description and preparation, Relationship between machine learning and statistics

Laboratory/ Practicals (if any): Mention list of Practicals

1. Case Studies in Data Science: Eve, the Pharmaceutical Robot Scientist: Data Science for Drug Discovery
2. Case Studies in Data Science: Data science for sports analytics
3. Case Studies in Data Science: Data science for sensor data (Introduction to challenge)

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Introduction to Machine Learning	Prof. Sudeshna Sarkar	IIT Kharagpur
2.	Introduction to Data Analytics	Prof. Nandan Sudarsanam Prof. B. Ravindran	IIT Madras

Text Books/Suggested References:

1. Introduction to Machine Learning, Jeeva Jose, Khanna Book Publishing House.
2. Machine Learning, Rajiv Chopra, Khanna Book Publishing House.
3. Data Science and Machine Learning: Mathematical and Statistical Methods Machine Learning & Pattern Recognition, by Dirk P. Kroese, Zdravko Botev, Thomas Taimre, Radislav Vaisman, Chapman & Hall/Crc, 2019.
4. Hands-On Data Science and Python Machine Learning, Frank Kane, Packt Publishers, 2017.
5. https://www.edx.org/course/machine-learning-for-data-science-and-analytics

Course Outcomes: After completion of course, students would be able to:

1. Apply practical solutions using predictive analytics.
2. Understand the importance of various algorithms in Data Science.
3. Create competitive advantage from both structured and unstructured data.
4. Predict outcomes with supervised machine learning techniques.
5. Unearth patterns in customer behavior with unsupervised techniques.

******

PE003	Data Visualization	3L:0T:2P	4 Credits

Course Objective:
The students will be able to represent any type of dataset in visual form. They will also be able to draw insights from the data. They will also learn about different python visualization libraries.

Detailed contents:

Module 1: The Computer and the Human
Overview of Visualization, 2-D Graphics, SVG example, 2-D Drawing, 3-D Graphics, Photorealism, Non-Photorealism, the human retina: Perceiving Two Dimensions, Perceiving Perspective

Module 2: Visualization tools
Line plots, area plots, histogram, bar charts, pie charts, scatter plots, bubble plots, waffle charts, word clouds,

Module 3: Visualization of numerical data
Introduction, Data, Mapping, Charts, Glyphs, parallel coordinates, Parallel coordinates, Stacked graphs, Tufte's Design Rules, Using Color

Module 4: Visualization of non-numerical data
Graphs and Networks, Embedding Planar Graphs, Graph Visualization, Tree Maps, Principal Component Analysis, Multidimensional Scaling

Module 5: Python visualization libraries
matplotlib, pandas, seaborn, ggplot, plotly

Laboratory/ Practicals:

1. Understanding the basic python visualization tools
2. Implement different types of charts anad graphs
3. Implement visualization of numerical data
4. Implement visualization of non-numerical data
5. Implement basic functions of matplotlib, pandas, seaborn, ggplot, pyplot

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Data Science for Engineers	Prof. Raghunathan Rengaswamy Prof. Shankar Narsimhan	IIT Madras

Text Books/Suggested References:

1. Taming Python by Programming, Jeeva Jose, Khanna Book Publishing House.
2. Data Visualization with Python and JavaScript: Scrape, Clean, Explore & Transform Your Data, Kyran Dale, O'Reilly, 2016
3. Introduction to Computing & Problem Solving with Python, Jeeva Jose, Khanna Publishing House.
4. Data Visualization with Python: Create an impact with meaningful data insights using interactive and engaging visuals, Mario Döbler , Packt Publishers, 2019
5. Mastering Python Data Visualization, Kirthi Raman, Packt Publishers, 2015
6. https://www.coursera.org/learn/python-for-data-visualization

Course Outcomes: After completion of course, students would be able to:

1. Apply data visualizations in order to derive more meaning out of data.
2. Understand python visualization libraries.
3. Apply data visualization on different types of data.
4. Perceive hidden meanings from data using data visualization.

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PE004	Big Data Analytics	3L:0T:2P	4 Credits

Course Objective:
The students should be able to understand and apply big data flow to actual projects as well as apply data analytics life cycle to big data projects. The student should identify and successfully apply appropriate techniques and tools to solve big data problems.

Detailed Contents:
Module 1: Introduction to big data
Introduction to BigData Platform, Traits of Big data, Challenges of Conventional Systems, Web Data, Evolution of Analytic Scalability, Analysis vs Reporting, Statistical Concepts: Sampling Distributions, Re-Sampling, Statistical Inference, Prediction Error.

Module 2: Basic data analysis and data analytic methods using R
Regression Modelling, Multivariate Analysis, Bayesian Modelling, Inference and Bayesian Networks, Support Vector and Kernel Methods, Analysis of Time Series: Linear Systems Analysis, Nonlinear Dynamics, Rule Induction, Neural Networks: Learning and Generalization, Competitive Learning, Principal Component Analysis and Neural Networks, Fuzzy Logic: Extracting Fuzzy Models from Data Fuzzy Decision Trees, Stochastic Search Methods.
Introduction to R, Statistics for Model Building and Evaluation

Module 3: Frequent item sets and clustering
Mining Frequent item sets: Market Based Model, Apriori Algorithm, Handling Large Data Sets in Main Memory, Limited Pass Algorithm, Counting Frequent item sets in a Stream, Clustering Techniques: Hierarchical, K-Means, Frequent Pattern based Clustering Methods.

Module 4: Mining data streams
Introduction to Streams Concepts: Stream Data Model and Architecture, Stream Computing, Sampling Data in a Stream: Filtering Streams, Counting Distinct Elements in a Stream, Estimating Moments, Counting Oneness in a Window, Decaying Window, Real time Analytics Platform (RTAP) Applications, Case Studies, Real Time Sentiment Analysis, Stock Market Predictions.

Module 5: Framework, technologies, tools and visualization
Map Reduce: Hadoop, Hive, MapR, Sharding, NoSQL Databases: S3, Hadoop Distributed File Systems, Visualizations: Visual Data Analysis Techniques, Interaction Techniques; Systems and Analytics Applications, Analytics using Statistical packages, Industry challenges and application of Analytics

Laboratory/ Practicals:

1. Describe big data and use cases from selected business domains.
2. Explain NoSQL big data management.
3. Install, configure, and run Hadoop and HDFS.
4. Perform map-reduce analytics using Hadoop.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Big Data Computing	Prof. Rajiv Misra	IIT Patna

2.	Introduction to Data Analytics	Prof. Nandan Sudarsanam Prof. Balaram Ravindran	IIT Madras

Text Books/Suggested References:

1. Bart Baesens, "Analytics in a Big Data World: The Essential Guide to data Science and its Applications", Wiley publications, 2014.
2. V.K. Jain, Big Data & Hadoop, Khanna Book Publishing Co., Delhi. (ISBN 978-93-82609-131)
3. Michael Berthold, David J. Hand, "Intelligent Data Analysis", Springer, 2003.
4. Anand Rajaraman and Jeffrey David Ullman, "Mining of Massive Datasets", Cambridge University Press, 2020.
5. Jeeva Jose, Beginner's Guide for Data Analysis using R Programming, Khanna Book Publishing House, 2019.
6. Bill Franks, "Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics", Wiley, 2012.
7. Glenn J. Myatt, "Making Sense of Data", Wiley, 2006.

Course Outcomes: After completion of course, students would be able to:

1. Understand and apply big data flow to actual projects as well as apply data analytics life cycle to big data projects.
2. Apply appropriate techniques and tools to solve big data problems
3. Describe big data and use cases from selected business domains
4. Explain NoSQL big data management
5. Use Hadoop related tools such as HBase, Cassandra, Pig, and Hive for big data analytics

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PE005	Solve Business Problems with AI	3L:0T:2P	4 Credits

Course objective:
The students will be able to relate with the practical uses of AI in day-to-day businesses. They will be able to understand the cautions need to be observed while working with AI. They will also be able to apply AI to boost business productivity.

Detailed Contents:

Module 1: Introduction
AI for businesses, optimizing business processes, Minimizing costs, AI solutions: Deep Q-learning, Action selection policies

Module 2: Apply AI and ML to business problems
Solve Business Problems with AI and Machine Learning Course Introduction, Identify Data-Driven Emerging Technologies Module Introduction, The Data Hierarchy, Big Data, Data Mining, Applied AI and ML in Business, Appropriate Business Problems, Challenges of AI/ML, Machine Learning Model, Machine Learning Workflow, Concept Drift and Transfer Learning, Problem Formulation, Differences Between Traditional Programming and Machine Learning, Differences Between Supervised and Unsupervised Learning, Randomness and Uncertainty, Machine Learning Outcomes

Module 3: How to choose the right tool?
importance of choosing the right tools, Hardware requirements: Parallel processors, GPUs, GPU platforms; Cloud Platforms: cloud hosting services: Amazon Web Services, Microsoft Azure, Google TPUs; Open-source AI tools, Proprietary AI tools

Module 4: Data privacy and Ethical Practices
Introduction, Data Protection, Data Privacy Laws, Privacy by Design, Data Privacy Principles at Odds with Machine Learning, Compliance with Data Privacy Laws and Standards, Data Sharing and Privacy, The Big Data Challenge, Preconceived Notions, The Black Box Challenge, Bias, Prejudice, and Discrimination, Ethics in NLP, Use of Data for Unintended Purposes, Intellectual Property, Humanitarian Principles, Asilomar AI Principles

Module 5: Case Studies
Real world case study

Laboratory/ Practicals:

1. Basics of python programming
2. Basics of ML-supervised models
3. Basics of ML-Unsupervised models
4. Data privacy
5. Overview of various cloud platforms
6. Case Studies

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Artificial Intelligence Search Methods for Problem Solving	Prof. Deepak Khemani	IIT Madras
2.	Business analytics and data mining Modeling using R	Prof. Gaurav Dixit	IIT Roorkee

Text Books/Suggested References:

1. A Classical Approach to Artificial Intelligence, M.C. Trivedi, Khanna Book Publishing.
2. Artificial Intelligence in Practice by Bernard Marr, Matt Ward, O'Reilly, 2019.
3. Artificial Intelligence and Machine Learning for Business: A No-Nonsense Guide to Data-Driven Technologies by Steven Finlay, Relativistic publishers, 2017.
4. https://www.coursera.org/learn/solve-problems-ai-machine-learning

Course Outcomes: After completion of course, students would be able to:

1. Analyze practical uses of AI in day-to-day businesses.
2. Understand the cautions need to be observed while working with AI
3. Apply AI to boost business productivity.
4. Use various cloud platforms.
5. Understand data privacy.

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PE006	**Pattern Recognition & Visual Recognition**	**3L:0T:2P**	**4 Credits**

Course Objective:
To help students understand basic mathematical and statistical techniques commonly used in pattern recognition. To introduce students to a variety of pattern recognition algorithms.

Detailed Contents:

Module 1: Introduction and mathematical Preliminaries
Principles of pattern recognition: Uses, mathematics, Classification and Bayesian rules, Clustering vs classification, Basics of linear algebra and vector spaces, Eigen values and eigen vectors, Rank of matrix and SVD

Module 2: Pattern Recognition basics
Bayesian decision theory, Classifiers, Discriminant functions, Decision surfaces, Parameter estimation methods, Hidden Markov models, dimension reduction methods, Fisher discriminant analysis, Principal component analysis, non-parametric techniques for density estimation, non-metric methods for pattern classification, unsupervised learning, algorithms for clustering: K-means, Hierarchical and other methods

Module 3: Feature Selection and extraction
Problem statement and uses, Branch and bound algorithm, Sequential forward and backward selection, Cauchy Schwartz inequality, Feature selection criteria function: Probabilistic separability based and Interclass distance based, Feature Extraction: principles

Module 4: Visual Recognition
Human visual recognition system, Recognition methods: Low-level modelling (e.g. features), Mid-level abstraction (e.g. segmentation), High-level reasoning (e.g. scene understanding); Detection/Segmentation methods; Context and scenes, Importance and saliency, Large-scale search and recognition, Egocentric vision, systems, Human-in-the-loop interactive systems, 3D scene understanding.

Module 5: Recent advancements in Pattern Recognition
Comparison between performance of classifiers, Basics of statistics, covariance and their properties, Data condensation, feature clustering, Data visualization, Probability density estimation, Visualization and Aggregation, FCM and soft-computing techniques, Examples of real-life datasets.

Laboratory/ Practicals:

1. Data extraction
2. Pre-processing of images
3. Image segmentation
4. Image classification

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Pattern Recognition and Application	Prof. P.K Biswas	IIT Kharagpur
2.	Pattern Recognition	Prof. C.A. Murthy	IIT Madras

Text Books/Suggested References:

1. Pattern Recognition and Machine Learning by Christopher M. Bishop, Springer, 2006.
2. Pattern Classification by Richard O. Duda , Peter E. Hart, David G. Stork, Wiley, 1973.
3. https://nptel.ac.in/courses/106/106/106106046/

Course Outcomes: After completion of course, students would be able to:

1. Understand basic mathematical and statistical techniques commonly used in pattern recognition.
2. Apply a variety of pattern recognition algorithms.
3. Understand and apply various pre-processing algorithms.
4. Apply various algorithms for image classification.

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PE007	Image and Video processing	3L:0T:2P	4 Credits

Course Objective:
The students will be able to work with images and videos in several ways. These methods can be used as pre-processing steps for complex models.

Detailed Contents:

Module 1: Image representation and analysis
Introduction to computer Vision, Numerical representation of images, Image augmentation, enhancement, processing, color transforms, geometric transforms, feature recognition and extraction

Module 2: Image Segmentation
Object detection, breaking image into parts, finding contours and edges of various objects in image, Background subtraction for video.

Module 3: Object Motion and tracking
Tracking a single point over time, motion models to define object movement over time, analyze videos as sequences of individual image frames, methods to track a set of features over time, matching features from image frame to other, tracking a moving car using optical flow

Module 4: Robotic localization
Bayesian statistics to locate a robot in space, sensor measurements to safely navigate an environment, Gaussian uncertainty, histogram filter for robot localization in python.

Module 5: Image Restoration
Degradation model, noise models, estimation of degradation function by modeling, restoration using Weiner filters and Inverse filters

Laboratory/ Practicals (if any): Mention list of Practicals

1. Various forms of image representation
2. Apply various image segmentation algorithms
3. Apply object motion and tracking
4. Apply object localization
5. Apply image restoration

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Digital Image Processing	Prof. P.K. Biswas	IIT Kharagpur
2.	Image Signal Processing	Prof. A.N. Rajagopalan	IIT Madras

Text Books/Suggested References:

1. Audio Video Systems, Bali & Bali, Khanna Book Publishing 2020.
2. Handbook of Image and Video Processing by Alan C. Bovik, Academic Press, 2000.
3. Python 3 Image Processing, Ashwin Pajankar, BPB Publication, 2019.
4. https://www.coursera.org/learn/image-processing

Course Outcomes: After completion of course, students would be able to:

1. Understand images and videos representation in a detailed manner.
2. Apply ML techniques for image processing in different scenarios.
3. Apply various object detection and image segmentation algorithms
4. Apply various image restoration techniques and algorithms

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PE008	Deep Learning for Computer Vision	3L:0T:2P	4 Credits

Course Objective:
To help students understand advanced deep learning models for handling images. This course also helps students to generate synthetic dataset with the help of GANs.

Detailed Contents:
Module 1: Convolutional Neural Networks
Introduction to Computer Vision, CNN architecture, Convolution function, CNN layers: Convolution, pooling and fully connected layers, activation functions, batch normalization, parameters and hyperparameters

Module 2: Advanced CNN
Advances in CNN architecture, region-based CNN, faster CNN, standard CNN architectures: VGG, ResNet, Xception YOLO etc., transfer learning, Efficient CNN architecture: SqueezeNet

Module 3: Recurrent Neural Network
RNN architecture, how RNN learns from ordered data sequences, RNN for sequential text generation, memory incorporation into deep learning models, applications of RNNs

Module 4: Attention Mechanisms and Image Captioning
how attention allows models to focus on a specific piece of input data, where attention is useful in natural language and computer vision applications, Combine CNN and RNN to build a complex captioning model, LSTM for caption generation.

Module 5: Generative Adversial Networks (GANs)
Introduction, Discriminator, Generator, Activation, Common activation functions for GANs, BCE loss, Conditional GANs, Controllable generation, real life GANs

Laboratory/ Practicals (if any): Mention list of Practicals

1. Apply basic CNN for image classification
2. Apply transfer learning with the help of advanced CNN for image classification
3. Apply Recurrent Neural Networks
4. LSTM for image captioning
5. Use of GANs for generating synthetic datasets\

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Deep Learning for Computer Vision	Prof. Vineeth N Balasubramaniam	IIT Hyderabad

Text Books/Suggested References:

1. Programming Computer Vision with Python: Techniques and Libraries for Imaging and Retrieving Information by Jan Erik Solem, O'Reilly, 2012
2. Deep Learning, Rajiv Chopra, Khanna Book Publishing, Delhi.

3. Hands-On Computer Vision with TensorFlow 2: Leverage deep learning to create powerful image processing apps with TensorFlow by Benjamin Planche, Eliot Andres, Packt Publishers, 2019
4. Learning Generative Adversarial Networks: Next-generation deep learning simplified by Kuntal Ganguly, Packt, 2017
5. https://www.coursera.org/learn/deep-learning-in-computer-vision

Course Outcomes: After completion of course, students would be able to:

1. Understand basic Computer Vision concepts.
2. Apply complex deep learning models to real-life problems and datasets
3. Create synthetic datasets with the help of GANs.
4. Use of transfer learning for image classification.
5. Use of LSTM for image captioning.

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PE009	Autonomous Systems	3L:0T:2P	4 Credits

Course Objective:
This course helps the students with a complete understanding of autonomous systems. They will be able to create a model of basic autonomous vehicle. The students will also be able to design and implement an autonomous robot.

Detailed Contents:
Module 1: Introduction
What are autonomous systems? AI in autonomous systems, Autonomous systems vs robots

Module 2: Functional architecture
Major functions in an autonomous vehicle system, Motion Modelling - Coordinate frames and transforms, point mass model

Module 3: Modelling in autonomous systems
Vehicle modelling (kinematic and dynamic bicycle model - two-track models), Sensor Modelling - encoders, inertial sensors, GPS.

Module 4: SLAM
Localization and mapping fundamentals, LIDAR and visual SLAM, Navigation - Global path planning, Local path planning, Vehicle control - Control structures, PID control, Linear quadratic regulator, Sample controllers.

Module 5: Drones
overview, definition, applications, components platforms, propulsion, on-board flight control, payloads, communications, concepts of flight, regulatory norms and regulations, Machine learning and deep learning for autonomous driving, Case study.

Laboratory/ Practicals:

1. Design and build systems that will use sensors, communication protocol and actuators.
2. Design and implement basic algorithms for autonomous vehicles.
3. Design and implement basic algorithms for autonomous robots.
4. Design and implement basic algorithms for drones.

Text Books/Suggested References:

1. Intelligent Autonomous Systems Foundations and Applications by Pratihar, Dilip Kumar, Springer, 2010
2. The Autonomous System: A Foundational Synthesis of the Sciences of the Mind Szabolcs Michael de Gyurky, Mark A. Tarbell, Wiley, 2013
3. Creating Autonomous Vehicle Systems by Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu, Jean-Luc Gaudiot, Morgan & Claypool Publishers , 2018

Course Outcomes: After completion of course, students would be able to:

1. Complete understanding of autonomous systems.
2. Create a model of basic autonomous vehicle.
3. Understand, design and implement an autonomous robot.
4. Understand, design and implement an autonomous drone.

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PE010	Bioinformatics	3L:0T:2P	4 Credits

Course Objective:

The students should be able to understand the scope of Bioinformatics. They should know about popular bioinformatics databases and sequence alignment algorithms.

Detailed contents:

Module 1: Introduction

History, scope and important contributions, aims and tasks of Bioinformatics, applications of Bioinformatics, challenges and opportunities, introduction to NCBI data model, various file formats for biological sequences.

Module 2: Biological Databases and Data Search Methods

Importance of databases, biological databases, primary sequence databases, composite sequence databases, secondary databases, nucleic and sequence databases, protein sequence databases, structure databases, bibliographic databases, specialized genomic resources, analysis packages
Methods for searching sequence databases like FASTA and BLAST algorithms, Statistical analysis and evaluation of BLAST results.

Module 3: Sequence Comparison Methods

Methods for comparison of two sequences, Needleman Wush and Smith Waterman algorithms. Analysis of computational complexities, merits and demerits of these algorithms, theory of scoring matrices and their use for sequence comparison.

Module 4: Sequence Alignment Methods

Sequence analysis of biological data, significance of sequence alignment, pair wise sequence alignment methods, use of scoring matrices and gap penalties in sequence alignments, multiple sequence alignment methods, tools and applications of multiple sequence alignment.

Module 5: Predictive Methods Using DNA and Protein Sequences

Gene prediction strategies, protein prediction strategies, molecular visualization tools, phylogenetic analysis: concept of trees, phylogenetic trees and multiple alignments.

Laboratory/ Practicals:

1. Hands-on with Nucleic acid databases (NCBI, DDBJ, EMBL), Protein databases (Primary, Composite and Secondary).
2. Hands-on with Specialized Genome databases (SGD, TIGR, ACeDB), Structure databases (CATH, SCOP, PDBsum).
3. Hands-on with methods for searching sequence databases.
4. Hands-on with sequence comparison and sequence alignment methods.
5. Hands-on with predictive methods.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Bio-Informatics: Algorithms And Applications	Prof. Michael Gromiha	IIT Madras

Suggested reference books:

1. Andreas D Baxevanis & B F Francis, "Bioinformatics-A practical guide to analysis of Genes and Proteins", John Wiley, 2010
2. T K Attwood, D J Parry-Smith, "Introduction to Bioinformatics", Pearson Education, 2005
3. Neil C. Jones, Pavel A. Pevzner, "An introduction to Bioinformatics Algorithms", MIT Press, 2005
4. Gary Benson Roderic, "Algorithms in Bioinformatics", Springer, 2004
5. Foundations of Bioinformatics, Manoj Darbari, Khanna Book Publishing Co., 2013.

Course outcomes: After completion of course, students would be able to:

1. Understand the various challenges and applications of bioinformatics.
2. Analyze various biological sequence databases
3. Perform sequence comparison and sequence alignment
4. Apply predictive methods on DNA and protein sequences.

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PE011	Genome sequencing	3L:0T:2P	4 Credits

Course Objective:

The students should be able to understand the basic biology of modern genomics and the experimental tools those can be used to measure it.

Detailed contents:

Module 1: Introduction

Genomics**,** Genomic Data Science, Molecular Biology Structures, From Genes to Phenotypes, Polymerase Chain Reaction, Next Generation Sequencing, Applications of Sequencing, The String Reconstruction Problem, String Reconstruction as a Hamiltonian Path Problem, String Reconstruction as a Eulerian Path Problem.

Module 2: Genomic data science with galaxy

Challenges of Reproducibility, Introduction to the Galaxy Platform, Genomic Intervals, Workflows, Sequence Data Quality Control, ChIP-Sequence Analysis with MACS, RNA-seq Analysis: Mapping, RNA Sequence Analysis: Assembly Quantitation, and Differential Expression.

Module 3: Sequencing Antibiotics

Discovery of Antibiotics, How Do Bacteria Make Antibiotics, Sequencing Antibiotics by Shattering them into Pieces, A Brute Force Algorithm for Cyclopeptide Sequencing, Cyclopeptide Sequencing with Branch and Bound.

Module 4: Ideal to Real Spectra for Antibiotics Sequencing

Adapting Sequencing for Spectra with Errors, from 20 to More than 100 Amino Acids, The Spectral Convolution, apply genome assembly tools to sequencing data from a dangerous pathogenic bacterium.

Module 5: Proteomics

Protein structure, proteomics, and protein-protein interaction networks.

Laboratory/ Practicals:

1. Write a program for sequence similarity search.
2. Write a program to count non-DNA bases in a sequence using Python.
3. Given a protein sequence, determine if it contains this highly redundant protein domain motif.
4. Hands on with RNA sequence Analysis.
5. Hands on with antibiotic sequence.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	Course Name	Instructor	Host Institute
1.	Introduction to Proteogenomics	Prof. Sanjeeva Srivastava	IIT Bombay
2.	Bio-Informatics: Algorithms And Applications	Prof. Michael Gromiha	IIT Madras

Text Books/Suggested References:

1. https://www.coursera.org/learn/genome-sequencing#syllabus
2. https://www.coursera.org/learn/galaxy-project?specialization=genomic-data-science#syllabus
3. Bioinformatics with Python Cookbook, Packt Publishing, 2015
4. Python for Bioinformatics, Sebastian Bassi, Chapman and Hall/CRC.

Course outcomes: After completion of course, students would be able to:

1. Understand how data from next-generation sequencing experiments are generated and analyzed.
2. Understand Galaxy framework and apply for different types of analysis.
3. Analyze RNA sequences using Galaxy framework.
4. Analyze antibiotic sequence using genomic assembly tools.

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PE012	Algorithms for DNA Sequencing	3L:0T:2P	4 Credits

Course Objective:

The students should be able to understand computational methods, algorithms and data structures for analyzing DNA sequencing data.

Detailed contents:

Module 1: DNA sequencing, strings and matching

DNA sequencing past and present, Genomes as strings, reads as substrings, String definitions and Python examples, How DNA gets copied, Sequencing reads in FASTQ format, Sequencers give pieces to genomic puzzles, Read alignment and why it's hard, Naive exact matching

Module 2: Pre-processing, indexing and approximate matching

Boyer-Moore basics, Diversion: Repetitive elements, Pre-processing, Indexing and the k-mer index, ordered structures for indexing, hash tables for indexing, Variations on k-mer indexes, Genome indexes used in research, Approximate matching, Hamming and edit distance, Pigeonhole principle.

Module 3: Edit distance, assembly, overlaps

Solving the edit distance problem, using dynamic programming for edit distance, a new solution to approximate matching, Meet the family: global and local alignment, read alignment in the field, Assembly: working from scratch, First and second laws of assembly, Overlap graphs.

Module 4: Algorithms for assembly

The shortest common superstring problem, Greedy shortest common superstring, Third law of assembly: repeats are bad, De Bruijn graphs and Eulerian walks, When Eulerian walks go wrong,

Module 5: Assemblers in practice

Assemble a genome from small pieces of DNA, comparing genomes of different species, gene finding, gene regulation, Cancer Sequencing, Fragment Assembly, Human Population Genomics

Laboratory/ Practicals:

1. Convert a given sequence of DNA into its Protein equivalent.
2. De-Coding a Human DNA Sequence using Python.
3. Implement DNA alignment using Python.
4. Implement assembly algorithms for DNA.
5. Write a program for comparing genomes of different species.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	Course Name	Instructor	Host Institute
1.	Bio-Informatics: Algorithms And Applications	Prof. Michael Gromiha	IIT Madras

Suggested reference books:

1. https://www.coursera.org/specializations/genomic-data-science
2. Python for Bioinformatics, Sebastian Bassi, Chapman and Hall/CRC.
3. Bioinformatics with Python Cookbook, Packt Publishing, 2015

Course outcomes: After completion of course, students would be able to:

1. Understand DNA sequences, genomics, and how DNA sequencing is used.
2. Apply python to implement key algorithms and data structures to analyze real genomes and DNA sequencing datasets.
3. Understand human population genomics.
4. Analyze genome sequence of different species.

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PE013	Computational Neuroscience	3L:0T:2P	4 Credits

Course Objective:

The students should be able to explore the computational principles governing various aspects of vision, sensory-motor control, learning, and memory. They should learn representation of information by spiking neurons, processing of information in neural networks, and algorithms for adaptation and learning.

Detailed contents:

Module 1: Introduction & Basic Neurobiology

Computational Neuroscience: Descriptive Models, Computational Neuroscience: Mechanistic and Interpretive Models, The Electrical Personality of Neurons, Making Connections: Synapses, Time to Network: Brain Areas and their Function.

Module 2: Neural Encoding Models

Neural Encoding: Simple Models, Feature Selection, Variability, Vectors and Functions, Convolutions and Linear Systems, Change of Basis and PCA.

Module 3: Extracting Information from Neurons & Neural coding

Neural Decoding and Signal Detection Theory, Population Coding and Bayesian Estimation, Reading Minds: Stimulus Reconstruction, Information and Entropy, Calculating Information in Spike Trains, Coding Principles.

Module 4: Computing in Carbon and Computing with Networks

Modelling Neurons, Spikes, Simplified Model Neurons, A Forest of Dendrites, modelling Connections Between Neurons, Introduction to Network Models, The Fascinating World of Recurrent Networks.

Module 5: Plasticity in the Brain & Learning

Synaptic Plasticity, Hebb's Rule, and Statistical Learning, Introduction to Unsupervised Learning, Sparse Coding and Predictive Coding

Learning from Supervision and Rewards

Neurons as Classifiers and Supervised Learning, Reinforcement Learning: Predicting Rewards, Reinforcement Learning: Time for Action

Laboratory/ Practicals:
1. Implement Neural encoding methods using Python.
2. Implement information extraction from neurons using Bayesian estimation.
3. Implement synaptic plasticity using Artificial Neural Networks (ANN).
4. Implement Neuron classification using Supervised learning algorithms.
5. Implement Neuron classification using Reinforcement learning algorithms.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	Course Name	Instructor	Host Institute
1.	Introduction to Computational Neuroscience – Web course	Dr. V Srinivasa Chakravarthy	IIT Madras
2.	Demystifying the Brain	Prof. Srinivas Chakravarthy	IIT Madras

Text Books/Suggested References:

1. https://www.coursera.org/learn/computational-neuroscience#syllabus
2. https://www.edx.org/course/computational-neuroscience-neuronal-dynamics-of-co
3. Fundamentals of Computational Neuroscience, Thomas Trappenberg, OUP Oxford; 2nd edition, 2009.
4. An Introductory Course in Computational Neuroscience, Paul Miller, The MIT Press; 1st edition, 2018.

Course outcomes: After completion of course, students would be able to:

1. Understand how the brain processes information.
2. Understand the mathematical and computational models used in neuroscience.
3. Analyze different neural encoding models using python.
4. Apply supervised leaning to neurons classifiers.

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PE014	AI in Gaming	3L:0T:2P	4 Credits

Course Objective:

The students should be able to understand and use AI techniques for generating efficient, intelligent behaviour in games. Additional attention is to be given to AI algorithms for improving game play experience.

Detailed contents:

Module 1: Introduction

Introduction to Game AI, kind of AI used in game development, model of game AI, AI engine structure.

Module 2: Movement Algorithms and Steering Behaviour

kinematic movement algorithms, problems related to the steering behaviour of objects and Solutions.

Coordinated Movement and Motor Control

This unit discusses the concepts related to coordinated movements and motor control.

Module 3: Pathfinding

Basic Path finding Algorithms in game development, Path finding for complex solutions

Module 4: Decision-Making and Uncertainty

decision trees and state machines for game development, models for implementing knowledge uncertainty, such as fuzzy logic and Markov systems.

Module 5: Introduction to Learning Mechanisms

Board game theory and discusses the implementation of some key algorithms, such as minimax and negamax,

Random Number Generation and Minimaxing, algorithms for implementing action prediction, decision learning and reinforcement learning.

Laboratory/ Practicals:

1. Implement kinematic movement algorithms.
2. Implement coordinated movement algorithms.
3. Implement path finding algorithms for AI agents.
4. Implement a state machine for any game development.
5. Implement minimax and negmax algorithms.

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Artificial Intelligence: Search Methods For Problem Solving	Prof. Deepak Khemani	IIT Madras

Suggested Reference:

1. https://www.athabascau.ca/syllabi/comp/comp452.php
2. https://www.udemy.com/course/artificial-intelligence-for-simple-games/
3. Artificial Intelligence for Games, Ian Millington and John Funge, CRC Press; 2nd edition, 2009.
4. Artificial Intelligence and Games, Georgios N. Yannakakis and Julian Togelius, Springer International Publishing, 2018.

Course outcomes: After completion of course, students would be able to:

1. Understand identify tasks that can be tackled using AI techniques.
2. Apply appropriate AI technique for the problem under investigation.
3. Create efficient and robust AI algorithms for game tasks.
4. Apply learning mechanisms to gaming problems.

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PE015	AI in Healthcare	3L:0T:2P	4 Credits

Course Objective:

The students should be able to understand how AI is transforming the practice of medicine. The students should learn the practical experience in applying machine learning to concrete problems in medicine.

Detailed contents:

Module 1: Disease detection with computer vision
Medical Image Diagnosis, Eye Disease and Cancer Diagnosis, Building and Training a Model for Medical Diagnosis, Training, prediction, and loss, Image Classification and Class Imbalance, Generating More Samples, Model Testing

Module 2: Evaluating models
Sensitivity, Specificity, and Evaluation Metrics, Accuracy in terms of conditional probability, Confusion matrix, ROC curve and Threshold

Image segmentation on MRI images
Medical Image Segmentation, MRI Data and Image Registration, Segmentation, 2D U-Net and 3D U-Net Data augmentation and loss function for segmentation, Different Populations and Diagnostic Technology, External validation

Module 3: Linear prognostic models
Medical Prognosis, Atrial fibrillation, Liver Disease Mortality, Risk of heart disease, Evaluating Prognostic Models, Concordant Pairs, Risk Ties, Permissible Pairs.

Prognosis with Tree-based models
Decision trees for prognosis, fix overfitting, Different distributions, Missing Data example, Imputation.

Module 4: Survival Models and Time
Survival Model, Survival function, collecting time data, Estimating the survival function.

Build a risk model using linear and tree-based models
Hazard Functions, Relative risk, Individual vs. baseline hazard, Survival Trees, Nelson Aalen estimator.

Module 5: Medical Treatment Effect Estimation
Analyze data from a randomized control trial, Average treatment effect, Conditional average treatment effect, T-Learner, S-Learner, C-for-benefit.

Laboratory/ Practicals:

1. Hands on with building and training a model for medical image diagnosis.
2. Hands on with medical image segmentation (2D U-Net and 3D U-Net Data augmentation)
3. Hands on with linear prognosis models for liver and heart diseases.
4. Hands on with tree-based prognosis models and computing accuracy.
5. Hands on building a risk model based on prognosis models.

Text Books/Suggested References:

1. https://www.coursera.org/learn/ai-for-medical-diagnosis
2. https://www.coursera.org/learn/ai-for-medical-prognosis#syllabus
3. https://www.coursera.org/learn/ai-for-medical-treatment#syllabus
4. Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again, Eric Topol, Basic Books, 1st edition 2019.
5. Machine Learning and AI for Healthcare: Big Data for Improved Health Outcomes, Arjun Panesar, Apress, 1st ed. Edition, 2019.
6. Artificial Intelligence in Healthcare, 2020, ISBN 978-0-12-818438-7, Elsevier Inc.

Course outcomes: After completion of course, students would be able to:

1. Understand and apply on tree-based machine learning to estimate patient survival rates
2. Analyze convolutional neural network image classification and segmentation models to make diagnoses of lung and brain disorders.
3. Apply natural language processing to extract information from unstructured medical data.
4. Understand different types of prognosis models related to different diseases.

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PE016	AI in Finance	3L:0T:2P	4 Credits

Course Objective:

The students should be able to understand the evolution of AI-driven online wealth management platforms, robo-advisors, and learn how they work and why they're successful.

Detailed contents:

Module 1: Introduction

Fintech Innovations: Series Map and Learning Goals, Introduction to InsurTech, Investment & Market Size of the InsurTech Industry, Real Estate Tech, Residential Real Estate Tech Startups, Commercial Real Estate Tech

Module 2: Robo Advising

Expected Returns, Standard Deviations, and Correlation, Building an Efficient Portfolio, Diversified Investments, Exchange Traded Funds, Robo-Advisors, Pure Advisors vs Robo-Advisors, Customer support using robo advisors.

Module 3: Stock Selection & Asset Management

Fundamental Analysis: The Passive Benchmark, Manager Performance, Stock Selection Screening: Discovering Signals and Data Issue, Neural Networks, Smart Beta, Wealth Management: Automated Portfolio Optimization, Portfolio Rebalancing Recommendations

Module 4: Compliance and Fraud Detection

Behavioural Profiling Analytics in Fraud Detection, Distinguishing Specialized from Generic Behaviour Analytics,

Module 5: Case Studies

Fetch.ai, platforms or apps using AI for financial aspects.

Text Books/Suggested References:

1. https://www.coursera.org/learn/invest-tech#syllabus
2. https://www.coursera.org/learn/wharton-ai-application-insurtech-real-estate-technology#syllabus
3. https://www.coursera.org/learn/innovation-strategy-fintech
4. https://my.cfte.education/courses/AI-in-Finance-Specialisation
5. Artificial Intelligence in Finance, Yves Hilpisch, O'Reilly Media, Inc., 2020.
6. Machine Learning for Finance: Principles and Practice for Financial Insiders, Jannes Klaas, Packt Publishing Limited, 2019.

Course outcomes: After completion of course, students would be able to:

1. Understand the strengths and weaknesses of human financial advisors and investors.
2. Understand the business model of robo/AI-advisors.
3. Understand how InsurTech is redefining the insurance industry using AI techniques.
4. Understand stock selection and asset management related to financial world.

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PE017	Predictive Analytics	3L:0T:2P	4 Credits

Course Objective:

The students should be able to understand how to transform data and make it suitable for data-driven predictive tasks. Understand how to compute basic statistics using real-world datasets of consumer activities, like product reviews.

Detailed contents:

Module 1: Introduction

Data Product, Data Product Examples in Enterprise, Developing a Data Product Strategy,

Module 2: Reading Data in Python

Reading CSV & JSON Files, Processing Structured Data in Python, Live-Coding: JSON, Extracting Simple Statistics from Datasets

Data Processing in Python

Data Filtering and Cleaning, Processing Text and Strings in Python, Processing Times and Dates in Python

Module 3: Python Libraries and Toolkits

Matrix Processing and Numpy, Introduction to Data Visualization, Introduction to Matplotlib, urllib and BeautifulSoup

Module 4: Gradient Descent

Classification in Python, Introduction to Training and Testing, Gradient Descent in Python, Gradient Descent in TensorFlow

Module 5: Diagnostics for Data

Meaningful Predictive modelling, Regression Diagnostic, Over- and Under-Fitting, Classification Diagnostics: Accuracy and Error, Classification Diagnostics: Precision and Recall. Codebase for Evaluation and Validation, Model Complexity and Regularization, Evaluating Classifiers for Ranking.

Laboratory/ Practicals:

1. Hands on with data processing (dates, time, strings) in Python.
2. Hands on with different python libraries used for data visualization.
3. Hands on with TensorFlow for understand deep neural networks.
4. Hands on with regression diagnostic using python.
5. Hands on with classification diagnostic using python.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	Course Name	Instructor	Host Institute
1.	Predictive Analytics	Prof. Dinesh Kumar	Indian Institute of Management Bangalore (IIMB)
2.	NOC: Introduction to Data analytics - Video course	Dr. Balaraman Ravindran	IIT Madras

Text Books/Suggested References:

1. https://www.coursera.org/learn/basic-data-processing-visualization-python
2. https://www.coursera.org/learn/design-thinking-predictive-analytics-data-products
3. https://www.coursera.org/learn/meaningful-predictive-modeling
4. Applied Predictive Analytics: Principles and Techniques for the Professional Data Analyst, Dean Abbott, 2014, Wiley.
5. Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking, Tom Fawcett, O′Reilly, 1st edition, 2013.

Course outcomes: After completion of course, students would be able to:

1. Apply Python to create interactive data visualizations to make meaningful predictions and build simple demo systems.
2. Apply simple regressions and classifications on datasets using machine learning libraries.
3. Understand the usage of different python libraries.

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Appendix – III

A Guide to Induction Program

Appendix – III: A Guide to Induction Program

Introduction

In its 49th meeting, held on 14th March 2017, AICTE approved a package of measures for further improving the quality of technical education in the country. This 3-week mandatory Student Induction Program (SIP) based on Universal Human Values (UHV) is one of these key measures.

The SIP is intended to prepare newly admitted undergraduate students for the new stage in their life by facilitating a smooth transition from their home and school environment into the college and university environment.

The present form of the Student Induction Program (SIP) has taken inspiration from and gratefully acknowledges the many efforts in this direction. In particular the Foundation Program at IIT Gandhinagar[1] (July 2011) and the course in Universal Human Values and Professional Ethics[2] (IIIT Hyderabad, 2005; AKTU Lucknow, 2009 and PTU Jalandhar, 2011; overall about 35 universities); and also, the mentorship, internship and apprenticeship programs[3] of several institutions. The SIP amalgamates all the three into an integrated whole, which leads to its high effectiveness in terms of building a healthy lifestyle, creativity, bonding and character. It develops sensitivity towards self and one's relationships, builds awareness about others and society beyond the individual, and also in bonding with their own batch-mates and senior students as well as faculty members.

The purpose of this document along with accompanying details are to help institutions / colleges in understanding the spirit of the Induction Program and implementing it.

It is in line with the thoughts expressed in the NEP 2020:

"*Education is fundamental for achieving* ***full human potential****, developing an* ***equitable and just society****, and promoting* ***National development***".

"The purpose of the education system is to develop good human beings capable of rational thought and action, possessing compassion and empathy, courage and resilience, scientific temper and creative imagination, with sound ethical moorings and values".

[1] IIT Gandhinagar places great emphasis on not only educating successful engineers of the future, but also creating well-rounded personalities, who contribute to society, are respectful of and can adapt to their surroundings, and prove themselves to be great thinkers and problem solvers in all avenues of life. In 2011, in line with this vision, It took the bold step to introduce a five week Foundation Program for incoming 1st year UG students. It involved activities such as games, art, etc.; also science and other creative workshops as well as lectures by eminent resource persons. To enable undivided attention on this, normal classes were scheduled only after this program was over.

[2] The foundation course was started in 2005 at IIIT Hyderabad. In 2009, UP Technical University (now AKTU) introduced it in all academic programs across their 550 colleges. From there on, it has been included in the curriculum of many universities, particularly in technical universities, in quite a natural manner, filling a long-felt need. After AKTU, it was IKG-Punjab Technical University in 2011, then Royal University of Bhutan in 2012 and so on. By 2020, more than 40 universities in India and both universities of Bhutan have been offering this foundation course. Since 2017, it has been a compulsory credit course in AICTE's model curriculum for all UG courses. Faculty from all departments are involved in conducting the course. The content is universal, rational, verifiable and leading to harmony. The mode is a self-exploration (and not sermonising or lecturing). Faculty are to be prepared beforehand. The results have been quite encouraging.

[3] Many institutes setup mentor-mentee network under which 1st year students are divided into small groups, each assigned to a senior student as a Student Buddy, and to a faculty member as a Faculty Mentor. Thus, a new student has their guidance through regular interactions. They can discuss their aims and aspirations as well as concerns whether social, psychological, financial, academic, or otherwise.

"It aims at producing engaged, productive, and contributing citizens for building an equitable, inclusive, and plural society as envisaged by our Constitution".

"Education must build character, enable learners to be ethical, rational, compassionate, and caring, while at the same time prepare them for gainful, fulfilling employment".

"The curriculum must include basic arts, crafts, humanities, games, sports and fitness, languages, literature, culture, and values, in addition to science and mathematics, to develop all aspects and capabilities of learners; and make education more well-rounded, useful, and fulfilling to the learner".

So, when new students join an institution, they are to be welcomed and oriented to the institute, its vision, people, purpose, culture and values, policies, programs, rules and regulations etc. through a well-planned 3-week interaction before regular classes start.

Education aims at developing the students to their full potential, so that they are able to participate meaningfully not only in their profession, but also in their family, society and their natural environment. That requires the development of their values as well as skills.

Engineering colleges were established to train graduates in their respective branch/ department of study, be ready for the job market, but also have a holistic outlook towards life and have a desire and competence to work for national needs and beyond. The graduating student must have the knowledge and skills in the area of his study. However, s(he) must also have a broad understanding of society and relationships. Besides the above, several meta-skills and underlying values are needed. Character needs to be nurtured as an essential quality by which s(he) would understand and fulfil his/her responsibility as an engineer, a family member, a citizen etc.

The same applies to all other branches of study – be it professional, vocational or any other area of academic. The graduating student must be a good human being and have the skills in their area of study.

Each family, institution, region, community etc. have evolved their way of life, their cultures over a period of time. The new students are going from one culture to another. Today, a major issue is that one culture tends to be opposed to other cultures. This is because their basic assumptions, and therefore thoughts, are different. Even though there are commonalities at the core value level, the conflict is at the level of expression and details.

With this situation, it is imperative to

- Articulate the essence or core aspects of human culture and civilization, i.e. understand universal human values like trust and respect, love and compassion
- Appreciate the various expressions, different approaches taken in different regions

Our effort is in the context of the whole humanity. However, when it comes to exemplifying these essential concepts, we will have to take to local or national expressions.

In SIP, we want to provide an exposure to essence in the context of the whole humanity first. Then we can take a representative cross-section of all cultures as expressions of this essence. A yardstick to evaluate these various options is provided to guide the student towards a humanistic culture founded on the truth and universal human values like love and compassion.

For example: We want to live with fulfilment as a society. This part is common, universal.
To exemplify this, we may expose students to traditional Indian culture and philosophy as well as contemporary western culture and thought.

The intent is:

- Connecting the basic principles through specific examples
- To see and appreciate various cultures, to see the commonality amongst them, in the light of clarity about human culture and civilisation.
- To evaluate any specific example, system or culture, with a view to fill the gaps, rather than to criticise or reject it. Further, we can also be mutually enriching for other cultures.

Student Induction Program (SIP)

With this background, the SIP has been formulated with specific goals to help students to:

- Become familiar with the ethos and culture of the institution (based on institutional culture and practices)
- Set a healthy daily routine, create bonding in batch as well as between faculty members and students
- Get an exposure to a holistic vision of life, develop awareness, sensitivity and understanding of the
  Self---family---Society---Nation---International---Entire Nature
- Facilitate them in creating new bonds with peers and seniors who accompany them through their college life and beyond
- Overcome weaknesses in some essential professional skills – only for those who need it (e.g. Mathematics, Language proficiency modules)

The SIP consists of different activities which includes meeting new students, socializing with teachers and other people in the university. Secondly associating with the Local area or city, knowing different departments, associating with the department heads, local stores and necessary shops for the survival at new place. Basically, getting information about the rules and regulations of the university which includes do's and don'ts. Other activities which may involve students in several creative, cultural and co- curricular activities through which they can explore themselves and get idea about their intrinsic desires and interests which may help them in the long run. In order to make it worth, at the initial level of joining of student various seminars, lectures by eminent personalities, sessions by the appointed mentor for the student is being done to make them more familiar with the university environment. It has been seen that student after schooling when moves towards further studies for either under graduation or post-graduation has got so many confusions and false knowledge about the college and the curriculum. They should know the basic idea about the fruits and prospects of the particular course and the university or institute in which they are entering. To have faith about their choices and to know that after completion, they will be well equipped with the values and skills which may aid to their future goals and let them work for their personal motives, society and the Nation's development.

The various modules or core areas recommended for the 3-week SIP are:

SIP Module 1: Universal Human Values I (UHV I) 22 hours

The purpose is to help develop a holistic perspective about life. A self-reflective methodology of teaching is adopted. It opens the space for the student to explore

his/her role (value) in all aspects of living – as an individual, as a member of a family, as a part of the society and as a unit in nature. Through this process of self-exploration, students are able to discover the values intrinsic in them. The session-wise topics are given below:

Session No.	Topic Title	Aspirations and Issues	Basic Realities (underlying harmony)
1	Welcome and Introductions	Getting to know each other	Self-exploration
2 and 3	Aspirations and Concerns	Individual academic, career… Expectations of family, peers, society, nation… Fixing one's goals	Basic human aspirations Need for a holistic perspective Role of UHV
4 and 5	Self-Management	Self-confidence, peer pressure, time management, anger, stress… Personality development, self-improvement…	Harmony in the human being
6 and 7	Health	Health issues, healthy diet, healthy lifestyle Hostel life	Harmony of the Self and Body Mental and physical health
8, 9, 10 and 11	Relationships	Home sickness, gratitude towards parents, teachers and others Ragging and interaction Competition and cooperation Peer pressure	Harmony in relationship Feelings of trust, respect… gratitude, glory, love
12	Society	Participation in society	Harmony in the society
13	Natural Environment	Participation in nature	Harmony in nature/existence
14	Sum Up	Review role of education Need for a holistic perspective	Information about UHV-II course, mentor and buddy
15	Self-evaluation and Closure	Sharing and feedback	

SIP Module 2: Physical Health and Related Activities 51 hours

This module is intended to help understand the basic principles to remain healthy and fit and practice them through a healthy routine which includes exercise, games etc.

SIP Module 3: Familiarization of Department/ Branch and Innovation 06 hours
This module is for introducing and relating the student to the institution/department/branch; how it plays a role in the development of the society, the state, region, nation and the world at large and how students can participate in it.

SIP Module 4: Visit to a Local Area 10 hours
To relate to the social environment of the educational institution as well as the area in which it is situated through interaction with the people, place, history, politics…

SIP Module 5: Lectures by Eminent People 06 hours
Listening to the life and times of eminent people from various fields like academics, industry etc. about careers, art, self-management and so on enriches the student's perspective and provides a holistic learning experience.

SIP Module 6: Proficiency Modules 06 hours
This module is to help fill the gaps in basic competency required for further inputs to be absorbed. It includes effort to make student proficient in interpersonal communication and expression as well as awareness about linguistic and thereafter NLP.

SIP Module 7: Literature / Literary Activities 30 hours
Through the exposure of local, national and international literature, this module is aimed at helping the student learn about traditional as well as contemporary values and thought.

SIP Module 8: Creative Practices 49 hours
This module is to help develop the clarity of humanistic culture and its creative, joyful expression through practice of art forms like dance, drama, music, painting, pottery, sculpture etc.

SIP Module 9: Extra Curricular Activities 06 hours
This is a category under which things that are not placed in any of the above may be placed. Some clubs and hobby group may be made for each of the above categories, so that students may pursue them even after SIP.

The recommended hours to be allocated are given above. Depending on the available faculty, staff, infrastructure, playgrounds, class timings, hostellers and day scholars etc., the timetable for these activities may be drawn up. Of course, colleges may conduct an inaugural function at the beginning of the SIP; and they may also conduct a celebratory closing ceremony at the end of the SIP.

In particular, during the lockdown phase, appropriate care may be taken and some or all activities may be planned in distance-learning or on-line mode.

Sample 3-week Activity List

Week 1	Inaugural Function Regular SIP Activities (See Hours Plan)
Week 2	Regular SIP Activities (See Hours Plan)

Week 3	Regular SIP Activities (See Hours Plan) Valedictory and Closing Ceremony (Celebration)

Implementation

Every institution/college is expected to conduct the 3-week SIP under the guidance of the Director/Principal or Dean Students or a senior faculty member. For this, the institution is expected to make an SIP Cell / team, which will be responsible for planning, and then implementation of the SIP.

A UHV Cell is expected to be set up at each college and university. At the college, it will be managed by the UHV Convener / Coordinator under the chairpersonship of the director/principal. Faculty members and some students will be the members. They will coordinate the UHV activities like UHV-I during SIP, UHV-II, the faculty mentoring program and student buddy program throughout the student's association with the institute/college. The UHV Cell will work to incorporate human values in every aspect of education at the institute/college. Preparing UHV Faculty (Mentors) is one of its important activities.

Follow up

The SIP is only the beginning of the interaction with newly joined students.

An important part of the SIP is to associate one faculty mentor to every small groups of about 20 students; and also associate one senior student buddy to an even smaller groups of about 5 students for the guidance required for holistic development of the newly joined student throughout his/her time in the institution/college.

These activities are to be continued in the ongoing academic program along with other cultural activities through various student clubs which are largely be managed by students with the help of one or more faculty mentors. One of the main responsibilities of the faculty mentors would be helping the clubs to review their activities in alignment with human values.

Assessing the Implementation and Impact

The institution / college is expected to take feedback and prepare appropriate reports for assessing the impact and for further improvement of SIP. The basic feedback forms are included with the SIP Teaching Materials.

The SIP and its further follow up is expected to positively impact common graduate attributes like:
Holistic vision of life
Socially responsible behaviour
Environmentally responsible work
Ethical human conduct
Having Competence and Capabilities for Maintaining Health and Hygiene
Appreciation and aspiration for excellence (merit) and gratitude for all

AICTE will conduct periodic assessment to ascertain the implementation efforts and impact of the SIP and related activities.

Faculty Development

To ensure the implementation of SIP, and in particular to prepare the faculty, the National Coordination Committee for Student Induction (NCC-IP) has been formed. It offers various faculty development programs (FDPs) with the support from AICTE HQ and Regional Offices.

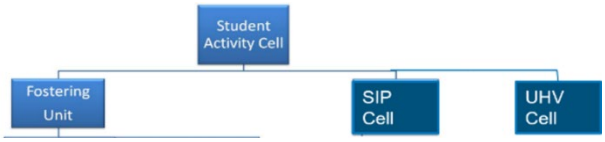
UHV Faculty (Mentors): Every institution is expected to prepare UHV Faculty in the ratio of 1:20 (1 faculty per 20 newly admitted students). Faculty from every teaching department are to be prepared. The basic preparation is participation in an 8-day FDP-SI (UHV).

Faculty for other Modules: Institutions/colleges generally have faculty, coaches, student clubs, alumni for these areas. FDP and comprehensive material will also be made available.

Student Activity Cell (SAC) – SIP Cell, UHV Cell and Fostering Unit

Student Activity Cell will have three cells or units:

- Fostering Unit – for coordinating various student clubs and activities in alignment with human values and IKS through various student clubs
- SIP Cell – for coordinating the annual SIP
- UHV Cell – for coordinating regular UHV activities, including UHV-I during SIP and UHV-II during future semesters, faculty mentoring and student buddy programs etc.



Each cell / unit will have some axis. E.g. the Fostering Unit will have 3 axis:

- UHV Axis – for UHV inputs and activities after the SIP
- Health Axis – for health oriented inputs and activities after SIP
- Career Axis – for career related inputs

Each axis will have one or more dimensions. E.g. the UHV Axis will have two dimensions:

- UHV Dimension
- Social Work Dimension

- Details of the clubs will be based on local conditions.

- Director or Principal or Dean of Student affairs will be the Chairman of Student Activity Cell

- SIP Cell (or Induction Unit) will be managed by faculty members with the help of student volunteers. 5 to 7 faculty members will be the members. The SIP Cell will be responsible for planning, organization, coordination and reporting of the annual Student Induction Program with the help of other faculty members and student volunteers

- UHV Cell will be managed by the UHV Convener / Coordinator under the chairpersonship of the director/principal. Faculty members and some students will be the members. They will coordinate the UHV activities like UHV-I during SIP, UHV-II 3rd/4th semester, faculty mentoring program and student buddy program throughout the student's association with the institute/college. UHV Cell will work to incorporate human values in every aspect of education at the institute/college. Preparing UHV Faculty (Mentors) is one of its activities

- Fostering unit will largely be managed by students with the help of one fostering unit faculty mentor. Student will be coordinators for axis, dimensions and clubs. Fostering unit will take support from induction unit as and when required. It will be responsible for coordinating various student clubs and activities in alignment with human values and Indian Knowledge System

SIP Teaching Material and More Details

The SIP Handbook as well as detailed guides and material for each of the modules is available on the AICTE website (http://www.fdp-si.aicte-india.org/download.php).

Details and Reference Documents:

- G012 SIP Handbook v2
- Teaching Material for UHV-I v2.1
- Teaching Material for SIP modules 2 to 9 v1
- G008 Facilitator (Mentor) Manual Version 2.1
- G911 UHV Cell, Nodal and Resource Centres
- G009 RP Development Process v2

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Appendix – IV

Appendix – IV: Internship

Appendix – IV: Internship

Please note the following points pertaining to internship semester:
1. Internship semester is kept as 6th Semester, there is a reason for it. All **International internships** (List of few such internships provided below), there is a necessary condition that **at least one semester study should be left to complete the degree** after undertaking that internship. They want students to come back to India and bring cross culture back.

2. For students opting for industry internships also, 6th Semester is a good option, as most of the Industries visit for campus placements in 7th Semester. At PEC 6th Semester for all students of all branches there is compulsory internship, industry OR research. Benefit of these internships in 6th Semester is that our 60% students get Pre Placement Offers (PPO) to join the companies where they have undertaken internships. Then they do not appear for Campus Placement interviews, and it becomes a win-win situation for all stakeholders, because companies also do not waste their time and efforts on students who may not join them. Here I want to mention that all types of companies namely a few: Microsoft, Amazon, Deshaw, JP Morgan, Goldman Sach, Maruti, BCG, PWC, TVS, Simens and many more follow the same procedure.

3. But yes, the other side of the coin is, sometimes students get employment offers if the internship is in the 8th (Last) Semester, it is applicable to small and medium level industries.

Keeping all these in mind and looking at **flexibility mentioned in NEP-2020, we should give flexibility to institutes to decide Internship Semester (Any of 6th, 7th OR 8th) as per local needs.**

1. A small list of International Fully Funded Internship Programmes (Few of them are especially for Indian Students), Like with MITACS, AICTE has tie-up, with other programmes also collaborations can be explored**.**

   [To explore tie-ups/collaborations AICTE/MHRD may explore with Indian Origin Academicians working in foreign universities. We have prepared a database of about 25000 Indian Origin Academicians working in US, UK, Australia and Canada as outcome of an on-going DST research project (available on http://ioa-dst.pec.ac.in/)].

   It is not an exhaustive list:

   - USC Summer Internships
   - UNIL Summer Undergraduate Research Program
   - World Bank Internship
   - Petro Jacyk Visiting Scholars Program
   - Charles Wallace India Trust Visiting Fellowship
   - Google Summer of Code Internship
   - RTC Summer Research Program for Undergraduates
   - Mitacs Globalink Research Internship
   - Charpak – Research Internship Program
   - CNIO Summer Training Programme
   - Vienna Biocenter Summer School
   - Global Challenges Fellowship Program
   - Google Site Reliability Engineering Internship

- Balmoral Residential Fellowships
- Nestle Sales Division Internship In USA
- William J. Clinton Fellowship for Indian Students
- American Foreign Service Association (AFSA) Communication Internship
- IST Summer Internship in Austria – Fully Funded Internship in Europe
- DESY Summer Student Program 2020 in Germany
- Japan Summer Internship 2020 in Kashiwa
- CRG Summer Internship 2020 in Barcelona, Spain
- The World Bank Summer Internship Program
- EPFL Summer Research Program 2020 in Switzerland
- Curatorial Internship Program 2020-2021 | Fully Funded Internship in Canada
- CERN Short Term Internship 2020 in Switzerland
- Taiwan International Internship 2020
- RIPS 2020 Summer Internship in the USA
- Echidna Global Scholars Program 2021 in the USA
- Netherlands Government Scholarship 2021 | Fully Funded | Orange Knowledge Programme
- UNIST Undergraduate Scholarship 2021 in South Korea
- Global Intern Program in South Korea 2021 | Fully Funded
- Max Planck Summer Internship in Germany 2021
- CERN Administrative Student Programme 2021 Switzerland – Fully Funded
- Commonwealth Foundation Internship 2021 in the UK
- WHO Internship Program 2021
- University of Tokyo Summer Internship

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ALL INDIA COUNCIL FOR TECHNICAL EDUCATION

Nelson Mandela Marg, Vasant Kunj, New Delhi 110070

www.aicte-india.org