Model Curriculum for Minor Degree

for UG Degree Courses in Engineering & Technology

2020

ALL INDIA COUNCIL FOR TECHNICAL EDUCATION

Nelson Mandela Marg, Vasant Kunj, New Delhi 110070

www.aicte-india.org

MESSAGE

With a view to enhance the employability skills and impart deep knowledge in emerging areas which are usually not being covered in Undergraduate Degree credit framework, AICTE has come up with the concept of '**Minor Degree**' in emerging areas. The concept of Minor Degree is discussed in the Approval Process Handbook (APH) for the academic session 2020-21 issued by AICTE. Minor Degree will carry 18 to 20 credits in addition to the credits essential for obtaining the Under Graduate Degree in Major Discipline (i.e. 160 credits usually).

Keeping in mind the need of manpower in emerging areas, AICTE with the help of industry-academia experts, has framed the curriculum for seven Minor Degrees:

- Artificial Intelligence and Machine Learning
- Blockchain
- Cyber Security
- Data Science
- Internet of Things (IoT)
- Robotics
- Virtual and Augmented Reality

Courses have been designed after rigorous brainstorming and considering the inputs from the experts of corresponding domain. I am hopeful that knowledge of these emerging areas will help students in capturing the plethora of employment opportunities available in these domains.

I gratefully acknowledge the time and efforts of all those who were involved in preparation of this curriculum especially, the contributions 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, Dr. Shantipal S. Ohol from College of Engineering Pune, Dr. Pushparaj Pathak from IIT Delhi and Dr. S.K Saha from IIT Roorkee. I am very thankful to Prof. Uday. B. Desai, Director, IIT Hyderabad for helping in refining the draft.

The well timed initiative to have this model curriculum addressing the need by Prof. M.P Poonia, Vice Chairman, Prof. Rajive Kumar, Member Secretary, AICTE is highly appreciated. I also appreciate the continuous effort put in coordinating the complete process of development of this curriculum by members of the Policy and Academic Planning Bureau of AICTE namely, Dr. Dileep Malkhede, Adviser–I; Dr. Neeraj Saxena, Adviser-II; Dr. Pradeep Bhaskar, Assistant Director, Mr. Dharmesh Kumar Dewangan & Mr. Rakesh Kumar Pandit, Young Professionals and others.

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

Working Group for this Model Curriculum of Minor Degree for UG Degree Courses in Engineering & Technology

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.

Working Group for Robotics Model Curriculum:

S.No	Name	Designation & Organization
1	Dr. S.K Saha	Professor, IIT Delhi
2	Dr. Pushparaj Pathak	Professor, IIT Roorkee
3	Prof. S. Ohol	Professor ,College of Engineering Pune,

Table of Contents

S. No.	Subject	From	To
1	Artificial Intelligence and Machine Learning	1	12
2	Blockchain	13	24
3	Cyber Security	25	34
4	Data Science	35	46
5	Internet of Things (IoT)	47	58
6	Robotics	59	70
7	Virtual and Augmented Reality	71	82

Artificial Intelligence and Machine Learning

Minor Degree in "Artificial Intelligence and Machine Learning"

Course Structure						
S. No.	**Course Code**	**Title**	**L**	**T**	**P**	**Credits**
1	AIML-01	Introduction to AI & Machine Learning	3	0	2	4
2	AIML-02	Introduction to Data Analytics	3	0	2	4
3	AIML-03	Deep Learning and Neural Network	3	0	2	4
4	AIML-04	Special topics in Artificial Intelligence	3	0	0	3
5	AIML-05	Applications of AI	3	0	0	3
TOTAL			**15**	**0**	**6**	**18**

Course Coding Nomenclature:

- AIML denotes that minor degree in "Artificial Intelligence and Machine Learning".
- 01, 02, 03, 04, 05 are course in order they have to be taken, if taken in different semesters. Multiple course may also be taken in the same semester (if required).

Detailed Syllabus

Course Code	:	AIML-01
Course Title	:	Introduction to AI & Machine Learning
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	AIML

Course Objective:

- To review and strengthen important mathematical concepts required for AI & ML.
- Introduce the concept of learning patterns from data and develop a strong theoretical foundation for understanding state of the art Machine Learning algorithms.

Course Contents:

[Total Theory Duration: 42 Lectures]

Module 1: [Duration: 12 Lectures]
Defining Artificial Intelligence, Defining AI techniques, Using Predicate Logic and Representing Knowledge as Rules, Representing simple facts in logic, Computable functions and predicates, Procedural vs Declarative knowledge, Logic Programming, Mathematical foundations: Matrix Theory and Statistics for Machine Learning.

Module 2: [Duration: 8 Lectures]
Idea of Machines learning from data, Classification of problem –Regression and Classification, Supervised and Unsupervised learning.

Module 3: [Duration: 10 Lectures]
Linear Regression: Model representation for single variable, Single variable Cost Function, Gradient Decent for Linear Regression, Gradient Decent in practice.

Module 4: [Duration: 7 Lectures]
Logistic Regression: Classification, Hypothesis Representation, Decision Boundary, Cost function, Advanced Optimization, Multi-classification (One vs All), Problem of Overfitting.

Module 5: [Duration: 5 Lectures]
Discussion on clustering algorithms and use-cases cantered around clustering and classification.

Lab Work:

1. Implementation of logical rules in Python.
2. Using any data apply the concept of:
    a. Liner regression
    b. Gradient decent
    c. Logistic regression

3. To add the missing value in any data set.
4. Perform and plot under fitting and overfitting in a data set.
5. Implementation of clustering and classification algorithms.

Text Books/References:

1. Saroj Kaushik, Artificial Intelligence, Cengage Learning, 1st Edition 2011.
2. Anindita Das Bhattacharjee, "Practical Workbook Artificial Intelligence and Soft Computing for beginners, Shroff Publisher-X team Publisher.
3. M.C. Trivedi, A Classical Approach to Artificial Intelligence, Khanna Publishing House, Delhi.
4. Jeeva Jose, Introduction to Machine Learning, Khanna Publishing House, Delhi.
5. Yuxi (Hayden) Liu, "Python Machine Learning by Example", Packet Publishing Limited, 2017.
6. Tom Mitchell, Machine Learning, McGraw Hill, 2017.
7. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2011.
8. T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e, 2011.

Corresponding Online Resources:

1. Artificial Intelligence, https://swayam.gov.in/nd2_cec20_cs10/preview.

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

1. Design and implement machine learning solutions to classification, regression and clustering problems.
2. Evaluate and interpret the results of the different ML techniques.
3. Design and implement various machine learning algorithms in a range of Real-world applications.

*****

Course Code	:	AIML-02
Course Title	:	Introduction to Data Analytics
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	AIML

Course Objective:

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

Course Contents:

Module 1: [Duration: 7 Lectures]
Introduction to Data Science, Different Sectors using Data science, Purpose and Components of Python in Data Science.

Module 2: [Duration: 7 Lectures]
Data Analytics Process, Knowledge Check, Exploratory Data Analysis (EDA), EDA- Quantitative technique, EDA- Graphical Technique, Data Analytics Conclusion and Predictions.

Module 3: [Duration: 11 Lectures]
Feature Generation and Feature Selection (Extracting Meaning from Data)- Motivating application: user (customer) retention- Feature Generation (brainstorming, role of domain expertise, and place for imagination)- Feature Selection algorithms.

Module 4: [Duration: 10 Lectures]
Data Visualization- Basic principles, ideas and tools for data visualization, Examples of inspiring (industry) projects- Exercise: create your own visualization of a complex dataset.

Module 5: [Duration: 7 Lectures]
Applications of Data Science, Data Science and Ethical Issues- Discussions on privacy, security, ethics- A look back at Data Science- Next-generation data scientists.

Lab Work:

1. Python Environment setup and Essentials.
2. Mathematical computing with Python (NumPy).
3. Scientific Computing with Python (SciPy).
4. Data Manipulation with Pandas.
5. Prediction using Scikit-Learn
6. Data Visualization in python using matplotlib

Text Books/References:

1. Joel Grus, Data Science from Scratch, Shroff Publisher Publisher /O'Reilly Publisher Media
2. V.K. Jain, Big Data and Hadoop, Khanna Publishing House
3. V.K. Jain, Data Sciences & Analytics, Khanna Publishing House
4. Annalyn Ng, Kenneth Soo, Numsense! Data Science for the Layman, Shroff Publisher Publisher
5. Cathy O'Neil and Rachel Schutt. Doing Data Science, Straight Talk from The Frontline. O'Reilly Publisher Media.
6. Jure Leskovek, Anand Rajaraman and Jeffrey Ullman. Mining of Massive Datasets. v2.1, Cambridge University Press.
7. Jake VanderPlas, Python Data Science Handbook, Shroff Publisher Publisher /O'Reilly Publisher Media
8. Philipp Janert, Data Analysis with Open Source Tools, Shroff Publisher Publisher /O'Reilly Publisher Media.

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

1. Explain how data is collected, managed and stored for data science;
2. Understand the key concepts in data science, including their real-world applications and the toolkit used by data scientists;
3. Implement data collection and management scripts using MongoDB.

*****

Course Code	:	AIML-03
Course Title	:	Deep Learning and Neural Network
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	AIML

Course Objective:

- To strengthen important Mathematical concepts required for Deep learning and neural network.
- To get a detailed insight of advanced algorithms of ML.

Course Contents:

[Total Theory Duration: 42 Lectures]

Module 1: [Duration: 8 Lectures]
Information flow in a neural network, understanding basic structure and ANN.

Module 2: [Duration: 8 Lectures]
Training a Neural network, how to determine hidden layers, recurrent neural network.

Module 3: [Duration: 10 Lectures]
Convolutional neural networks, image classification and CNN.

Module 4: [Duration: 9 Lectures]
RNN and LSTMs. Applications of RNN in real world.

Module 5: [Duration: 7 Lectures]
Creating and deploying networks using tensor flow and keras.

Lab Work:

1. Introduction to Kaggle and how it can be used to enhance visibility.
2. Build general features to build a model for text analytics.
3. Build and deploy your own deep neural network on a website using tensor flow.

Text Books/References:

1. Rajiv Chopra, Deep Learning, Khanna Publishing House.
2. John Paul Mueller, Luca Massaron, Deep Learning for Dummies, John Wiley & Sons.
3. Adam Gibson, Josh Patterson, Deep Learning, A Practitioner's Approach, Shroff Publisher /O'Reilly Publisher Media.
4. Christopher M. Bishop, Neural Networks for Pattern Recognition, Oxford.

5. Russell Reed, Robert J MarksII, Neural Smithing: Supervised Learning in Feedforward Artificial Neural Networks, Bradford Book Publishers.

Corresponding Online Resources:

1. Fuzzy Logic and Neural Networks, https://swayam.gov.in/nd1_noc20_ge09/preview.

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

1. To design and implement Artificial Neural networks.
2. To decide when to use which type of NN.

*****

Course Code	:	AIML-04
Course Title	:	Special topics in Artificial Intelligence
Number of Credits	:	3 (L: 3; T: 0; P: 0)
Course Category	:	AIML

Course Objective: To give fundamental knowledge to the students so that they can understand what the AI is and study important topics related to the field.

Course Contents:

[Total Theory Duration: 42 Lectures]

Module 1: [Duration: 9 Lectures]
Bayesian Filtering; Recurrent Neural Networks, Deep Neural Networks, Deep Reinforcement Learning.

Module 2: [Duration: 7 Lectures]
Self-Play Networks, Generative Adversarial Networks, Learning from Concept-Drifting Data Streams.

Module 3: [Duration: 9 Lectures]
Audio Signal Processing Basics, mirtoolbox contains many useful audio processing library functions, VOICEBOX: Speech Processing Toolbox for MATLAB, Audio processing in Matlab.

Module 4: [Duration: 10 Lectures]
Architectures for second generation knowledge based systems, Distributed AI and its applications.

Module 5: [Duration: 7 Lectures]
An introduction to neurocomputing and its possible role in AI, The role of uncertainty measures and principles in AI.

Text Books/References:

1. Dr. Nilakshi Jain, Artificial Intelligence: Making a System Intelligent, John Wiley & Sons.
2. M.C. Trivedi, A Classical Approach to Artificial Intelligence, Khanna Publishing House, Delhi.
3. Artificial Intelligence & Soft Computing for Beginners, 3rd Edition-2018, by Anindita Das, Shroff Publisher Publisher.
4. Artificial Intelligence: A Modern Approach, 3rd Edition, by Stuart Russell and Peter Norvig, Pearson Publisher.
5. New Artificial Intelligence (Advanced), Takashi Maeda and Fumio Aoki, Ohmsha Publisher.

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

1. To understand various AI techniques.
2. To decide when to use which type of AI technique.

*****

Course Code	:	AIML-05
Course Title	:	Applications of AI
Number of Credits	:	3 (L: 3; T: 0; P: 0)
Course Category	:	AIML

Course Objective: To give deep knowledge of AI and how AI can be applied in various fields to make the life easy.

Course Contents: [Total Theory Duration: 42 Lectures]

Module 1: [Duration: 12 Lectures]
Linguistic aspects of natural language processing, A.I. And Quantum Computing, Applications of Artificial Intelligence (AI) in business.

Module 2: [Duration: 8 Lectures]
Emotion Recognition using human face and body language, AI based system to predict the diseases early, Smart Investment analysis, AI in Sales and Customer Support.

Module 3: [Duration: 7 Lectures]
Robotic Processes Automation for supply chain management.

Module 4: [Duration: 8 Lectures]
AI-Optimized Hardware, Digital Twin i.e. AI Modelling, Information Technology & Security using AI.

Module 5: [Duration: 7 Lectures]
Recent Topics in AI/ML: AI/ML in Smart solutions, AI/ML in Social Problems handling, Block chain and AI.

Text Books/References:

1. Sameer Dhanrajani, AI and Analytics, Accelerating Business Decisions, John Wiley & Sons.
2. Life 3.0: Being Human in the Age of Artificial Intelligence by Max Tegmark, published July 2018.
3. Homo Deus: A Brief History of Tomorrow by Yuval Noah Harari, published March 2017.
4. Artificial Intelligence in Practice: How 50 Successful Companies Used AI and Machine Learning to Solve Problems, Bernard Marr, Matt Ward, Wiley.

Course Outcomes: After completion of course, students would:

1. To correlate the AI and solutions to modern problem.
2. To decide when to use which type of AI technique.

*****

Blockchain

Minor Degree in "Blockchain"

Course Structure						
S. No.	**Course Code**	**Title**	**L**	**T**	**P**	**Credits**
1	BLC-01	Fundamentals of Blockchain	3	0	0	3
2	BLC-02	Smart Contracts and Solidity	3	0	2	4
3	BLC-03	Blockchain Platforms and Use cases	3	0	2	4
4	BLC-04	Blockchain Security and Performance	3	0	2	4
5	BLC-05	Blockchain and FinTech	3	0	0	3
TOTAL			**15**	**0**	**6**	**18**

Course Coding Nomenclature:

- BLC denotes that minor degree in "Blockchain".
- 01, 02, 03, 04, 05 are course in order they have to be taken, if taken in different semesters. Multiple course may also be taken in the same semester (if required).

Detailed Syllabus

Course Code	:	BLC-01
Course Title	:	Fundamentals of Blockchain
Number of Credits	:	3 (L: 3; T: 0; P: 0)
Course Category	:	BLC

Course Objective:

- The students should be able to understand a broad overview of the essential concepts of blockchain technology.
- To familiarize students with Bitcoin protocol followed by the Ethereum protocol – to lay the foundation necessary for developing applications and programming.
- Students should be able to learn about different types of blockchain and consensus algorithms.

Course Contents:

Module 1 [6 Lectures]
Basics: The Double-Spend Problem, Byzantine Generals' Computing Problems, Public-Key Cryptography, Hashing, Distributed Systems, Distributed Consensus.

Module 2 [10 Lectures]
Technology Stack: Blockchain, Protocol, Currency.
Bitcoin Blockchain: Structure, Operations, Features, Consensus Model, Incentive Model.

Module 3 [10 Lectures]
Ethereum Blockchain: Smart Contracts, Ethereum Structure, Operations, Consensus Model, Incentive Model.

Module 4 [6 Lectures]
Tiers of Blockchain Technology: Blockchain 1.0, Blockchain 2.0, Blockchain 3.0, Types of Blockchain: Public Blockchain, Private Blockchain, Semi-Private Blockchain, Sidechains.

Module 5 [10 Lectures]
Types of Consensus Algorithms: Proof of Stake, Proof of Work, Delegated Proof of Stake, Proof Elapsed Time, Deposite-Based Consensus, Proof of Importance, Federated Consensus or Federated Byzantine Consensus, Practical Byzantine Fault Tolerance. Blockchain Use Case: Supply Chain Management.

Text Books/References:

1. Kirankalyan Kulkarni, Essentials of Bitcoin and Blockchain, Packt Publishing.
2. Anshul Kaushik, Block Chain & Crypto Currencies, Khanna Publishing House.
3. Tiana Laurence, Blockchain for Dummies, 2nd Edition 2019, John Wiley & Sons.
4. Mastering Blockchain: Deeper insights into decentralization, cryptography, Bitcoin, and popular Blockchain frameworks by Imran Bashir, Packt Publishing (2017).

5. Blockchain: Blueprint for a New Economy by Melanie Swan, Shroff Publisher O'Reilly Publisher Media; 1st edition (2015).
6. Mastering Bitcoin: Programming the Open Blockchain by Andreas Antonopoulos.

Corresponding Online Resources:

1. https://www.coursera.org/specializations/blockchain.
2. https://nptel.ac.in/courses/106105184/
3. Introduction to Blockchain Technology and Applications, https://swayam.gov.in/nd1_noc20_cs01/preview

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

1. To explain the basic notion of distributed systems.
2. To use the working of an immutable distributed ledger and trust model that defines blockchain.
3. To illustrate the essential components of a blockchain platform.

*****

Course Code	:	BLC-02
Course Title	:	Smart Contracts and Solidity
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	BLC

Course Objective:

1. Students should be able to understand the concept of smart contracts related to blockchain.
2. Students should be able to understand the smart contract higher-level language Solidity and apply it to create smart contracts.
3. Students should be able to learn Truffle IDE for creating and deploying a DApp.

Course Contents:

Module 1

Smart Contracts: Definition and Need, Features of Smart Contracts, Life Cycle of a Smart Contract, Introduction to Ethereum Higher-Level Languages.

Module 2

Development Environment: Building A Simple Smart Contract with Solidity, Solc-Compiler, Ethereum Contract ABI, Remix-IDE for Smart Contract Development.

Module 3

Introduction to Solidity: Contracts, Constructors & Functions, Variables, Getters & Setters, Arrays, Memory vs Storage, Mappings in Solidity

Advanced Solidity: Structs, Error Handling & Restrictions, Libraries, Global Variables in Solidity, Abstract Contracts, Inheritance, And Interfaces, Events

Module 4

Truffle Framework & Ganache: Environment Setup for Truffle & Ganache, Truffle Project Creation, Truffle Compile, Migrate and Create Commands.

Module 5

Decentralized App Creation: Smart Contract Creation, Front-End Creation, Connecting Smart Contract with Front-End Application, Deploying Dapp, Validation, And Testing of Dapp.

Text Books/References:

1. Tiana Laurence, Blockchain for Dummies, 2nd Edition 2019, John Wiley & Sons.
2. Anshul Kaushik, Block Chain & Crypto Currencies, Khanna Publishing House.
3. Building Blockchain Projects, Narayan Prusty, Packt Publishing.
4. Mastering Ethereum: Building Smart Contracts and Dapps Book by Andreas Antonopoulos and Gavin Wood, Shroff Publisher/O'Reilly Publisher.

Corresponding Online Resources:

1. https://www.coursera.org/learn/smarter-contracts
2. https://www.udemy.com/course/solidity-smart-contracts-build-dapps-in-ethereum-blockchain/
3. Introduction to Blockchain Technology and Applications, https://swayam.gov.in/nd1_noc20_cs01/preview

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

1. To understand the working and importance of smart contracts.
2. To learn the solidity language required for coding Ethereum smart contracts.
3. To create and deploy a DApp on a Ethereum test network.

*****

Course Code	:	BLC-03
Course Title	:	Blockchain Platforms and Use cases
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	BLC

Course Objective:

- Students should be able to learn different types of blockchain platforms.
- Students should be able to understand different types of Decentralized applications developed using blockchain technology.
- Students should be able to understand several types of blockchain use cases.

Course Contents:

Module 1 [14 Lectures]

Permissioned Blockchains: Hyperledger Fabric Services, Model and Functions, Hyperledger Composer, Microsoft Azure Blockchain Platform and Services,
Other Platforms: IOTA, TRON, Ziliqa, Cosmos, Ripple.

Module 2 [5 Lectures]
Decentralized Application Platforms: Augur-Decentralised Prediction Market Platform, Grid+-Energy Ecosystem Platform.

Module 3 [5 Lectures]
Challenges and Solutions Related to Blockchain: Consensus, Scalability, Privacy and Confidentiality, Escrow, and Multi signature.

Module 4 [8 Lectures]
Alternative Decentralized Solutions: Interplanetary File System (IPFS) Working and Uses, Hashgrapgh- Working, Benefits, And Use-Cases.

Module 5 [10 Lectures]
Blockchain Use Cases: Financial Services Related Use Cases, Revolutionization of Global Trade, Digital Identity, Auditing Services, Supply Chain Management, Healthcare Related Services, Blockchain and IOT, Blockchain and AI.

Text Books/References:

1. Tiana Laurence, Blockchain for Dummies, 2nd Edition 2019, John Wiley & Sons.
2. Anshul Kaushik, Block Chain & Crypto Currencies, Khanna Publishing House.
3. Building Blockchain Projects, Narayan Prusty, Packt Publishing.
4. Mastering Blockchain: Deeper insights into decentralization, cryptography, Bitcoin, and popular Blockchain frameworks by Imran Bashir, Packt Publishing (March 17, 2017).
5. Blockchain: Blueprint for a New Economy by Melanie Swan, Shroff Publisher publisher/O'Reilly Publisher Media; 1st edition (2015).

Corresponding Online Resources:
1. https://nptel.ac.in/courses/106105184/
2. https://www.coursera.org/learn/blockchain-platforms.
3. Introduction to Blockchain Technology and Applications, https://swayam.gov.in/nd1_noc20_cs01/preview.

Course Outcomes: After completion of course, students would be able to:
1. To distinguish between different types of blockchain platforms.
2. To understand different types of uses of blockchain and apply it to some real-life scenarios accordingly.
3. To learn about the shortcomings of blockchain technology and their corresponding solutions.

******

Course Code	:	BLC-04
Course Title	:	Blockchain Security and Performance
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	BLC

Course Objective:

- Students should be able to understand the security and performance-related issues of blockchain.
- Students should be able to learn techniques and tools to tackle the security related issues of blockchain.
- Students should be able to learn new approaches required for enhancing blockchain performance.

Course Contents:

Module 1 [6 Lectures]
Security Issues: Blockchain Related Issues, Higher-Level Language (Solidity) Related Issues, EVM Bytecode Related Issues, Real-Life Attacks on Blockchain Applications/ Smart Contracts, Trusted Execution Environments.

Module 2 [12 Lectures]
Security Tools for Smart Contracts: Working, Advantages, And Disadvantages of Tools- Oyente, Securify, Maian, Manticore, Mythril, SmartCheck, Verx. Secure Key Management, Quantum Resilience Keys.

Module 3 [5 Lectures]
Performance Related Issues: Transaction Speed, Transaction Fees, Network Size, Complexity, Interoperability Problems, Lack of Standardization. Lack of Supportive Regulations Related to Blockchain Applications.

Module 4 [12 Lectures]
Performance Improvements: Off-Chain State Channels, Sidechains, Parallels Chains, Concurrent Smart Contract Transactions, Sharding Technique and Its Benefits, Atomic Swaps Between Smart Contracts.

Module 5 [7 Lectures]
Blockchain Applications: Decentralized Cryptocurrency, Distributed Cloud Storage, E-Voting, Insurance Claims, Cross-Border Payments, Asset Management, Smart Appliances.

Text Books/References:

1. Mastering Ethereum: Building Smart Contracts and Dapps Book by Andreas Antonopoulos and Gavin Wood, Shroff Publisher/O'Reilly Publisher.

Corresponding Online Resources:

1. https://www.edx.org/course/blockchain-and-fintech-basics-applications-and-limitations

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

1. To understand the security and performance perspective of blockchain technology.
2. To learn and apply security analysis and performance-enhancing techniques related to blockchain.
3. To understand the real-life applications of blockchain technology and apply it to provide solutions to some real-life problems.

*****

Course Code	:	BLC-05
Course Title	:	Blockchain in FinTech
Number of Credits	:	3 (L: 3; T: 0; P: 0)
Course Category	:	BLC

Course Objective:

- Students should be able to understand the benefits of using blockchain in financial sector.
- Students should understand how decentralized nature of blockchain is impacting banking and financial sector.
- Students should learn blockchain regulations and future trends related to blockchain to be used in financial sector.

Course Contents:

Module 1 [12 Lectures]

Cryptocurrencies: Concept**,** Cryptocurrency Mining**,** Uses of Cryptocurrencies**,** Tokens, Token vs Crypto Coin, Concept of ICOs (Initial Coin Offerings), Benefits of Using ICOs, STOs (Security token offerings), ICO vs STO, Cryptocurrency wallets.

Module 2 [5 Lectures]

Decentralized Finance (DeFi): Concept, Benefits and Risks Associated with DeFi, Centralized vs Decentralized finance, DeFi Projects, DeFi future trends.

Module 3 [11 Lectures]

Decentralized Markets: Concept of Decentralized markets**,** impact of decentralization on financial market**,** Decentralized Exchanges (DEX)**,** Security, control and privacy concerns related to DEX, Liquidity and Usability of DEX, best DEXs for trading, Fund Management and Trading logic of DEX, Concept of Decentralized Web.

Module 4 [7 Lectures]

Blockchain & Cryptocurrency Regulations: Introduction, History Stance of the Government, Judicial Approach to Cryptocurrency, Possible Reasons for Ban, Virtual

Currency Regulations, Global Perspective of Regulations on Blockchain, Future needs for Regulations.

Module 5 [7 Lectures]

Blockchain in Banking Sector: Cross-Border Payments Using Blockchain and Its Benefits, Study of blockchain platforms used for cross-border payments, Impact of Blockchain on Banking Services.

Stable Coin: Concept, Uses and Types of Stable Coins

Case-Study: Tether and Libra Coins

Text Books/References:

1. Melanie Swan, Blockchain: Blueprint for a new economy, Shroff Publisher/O'Reilly Publisher.
2. Ron Quaranta, Blockchain in Financial Markets and Beyond: Challenges and Applications, Risk Books Publisher.
3. Richard Hayen, Blockchain & FinTech: A Comprehensive Blueprint to Understanding Blockchain & Financial Technology. - Bitcoin, FinTech, Smart Contracts, Cryptocurrency, Risk Books Publisher.

Corresponding Online Resources:

1. https://www.accenture.com/in-en/insight-blockchain-technology-how-banks-building-real-time
2. https://medium.com/search?q=decentralized%20exchange
3. Emerging Technology Projection: The Total Economic Impact™ Of IBM Blockchain https://www.ibm.com/downloads/cas/QJ4XA0MD
4. https://www.globallegalinsights.com/practice-areas/blockchain-laws-and-regulations/india#chaptercontent1
5. https://www.eduonix.com/blockchain-and-cryptocurrencies-for-beginners
6. https://www.coursera.org/learn/cryptocurrency

Course Outcomes: After completion of course, students would:

1. To understand difference between different types of coins and tokens related to blockchain technology.
2. To understand the benefits of blockchain in banking sector.
3. To understand the concept of decentralized markets.

*****

Cyber Security

Minor Degree in "Cyber Security"

Course Structure						
S. No.	**Course Code**	**Title**	**L**	**T**	**P**	**Credits**
1	CBS-01	Information Theory for Cyber Security	3	0	2	4
2	CBS-02	Data Encryption	3	0	2	4
3	CBS-03	Steganography and Digital Watermarking	3	0	0	3
4	CBS-04	Security Assessment and Risk Analysis	3	0	0	3
5	CBS-05	Database Security and Access Control	3	0	2	4
TOTAL			**15**	**0**	**6**	**18**

Course Coding Nomenclature:

- CBS denotes that minor degree in "Cyber Security".
- 01, 02, 03, 04, 05 are course in order they have to be taken, if taken in different semesters. Multiple course may also be taken in the same semester (if required).

Detailed Syllabus

Course Code	:	CBS-01
Course Title	:	Information Theory for Cyber Security
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	CBS
Pre-requisites	:	Probability Theory, Computer Networks

Course Objective: The objective of this course is to provide an insight to information coding techniques, error correction mechanism for cyber security.

Course Contents:

Module 1 [8 Lectures]

Shannon's foundation of Information theory, Random variables, Probability distribution factors, Uncertainty/entropy information measures, Leakage, Quantifying Leakage and Partitions, Lower bounds on key size: secrecy, authentication and secret sharing. provable security, computationally-secure, symmetric cipher.

Module 2 [8 Lectures]

Secrecy, Authentication, Secret sharing, Optimistic results on perfect secrecy, Secret key agreement, Unconditional Security, Quantum Cryptography, Randomized Ciphers, Types of codes**:** block codes, Hamming and Lee metrics, description of linear block codes, parity check Codes, cyclic code, Masking techniques.

Module 3 [8 Lectures]

Information-theoretic security and cryptograph, basic introduction to Diffie-Hellman, AES, and side-channel attacks.

Module 4 [10 Lectures]

Secrecy metrics: strong, weak, semantic security, partial secrecy, Secure source coding: rate-distortion theory for secrecy systems, side information at receivers, Differential privacy, Distributed channel synthesis.

Module 5 [8 Lectures]

Digital and network forensics, Public Key Infrastructure, Light weight cryptography, Elliptic Curve Cryptography and applications.

Text Books/References:

1. Information Theory and Coding, Muralidhar Kulkarni, K S Shivaprakasha, John Wiley & Sons.
2. Communication Systems: Analog and digital, Singh and Sapre, Tata McGraw Hill.
3. Fundamentals in information theory and coding, Monica Borda, Springer.
4. Information Theory, Coding and Cryptography R Bose.
5. Information Security & Cyber Laws, Gupta & Gupta, Khanna Publishing House.
6. Multi-media System Design, Prabhat K Andleigh and Kiran Thakrar.

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

1. To introduce the principles and applications of information theory.
2. To justify how information is measured in terms of probability and entropy.

3. To learn coding schemes, including error correcting codes.

*****

Course Code	:	CBS-02
Course Title	:	Data Encryption and Compression
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	CBS
Pre-requisites	:	Linear Algebra, Cryptography

Course Objective: This course will cover the concept of security, types of attack experienced, encryption and authentication for deal with attacks, what is data compression, need and techniques of data compression.

Course Contents:

Module 1 [8 Lectures]
Introduction to Security: Need for security, Security approaches, Principles of security, Types of attacks.
Encryption Techniques: Plaintext, Cipher text, Substitution & Transposition techniques, Encryption & Decryption, Types of attacks, Key range & Size.

Module 2 [6 Lectures]
Symmetric & Asymmetric Key Cryptography: Algorithm types & Modes, DES, IDEA, Differential & Linear Cryptanalysis, RSA, Symmetric & Asymmetric key together, Digital signature, Knapsack algorithm.

Module 3 [9 Lectures]
Case Studies of Cryptography: Denial of service attacks, IP spoofing attacks, Conventional Encryption and Message Confidentiality, Conventional Encryption Algorithms, Key Distribution.
Public Key Cryptography and Message Authentication: Approaches to Message Authentication, SHA-1, MD5, Public-Key Cryptography Principles, RSA, Digital, Signatures, Key Management, Firewall.

Module 4 [7 Lectures]
Introduction: Need for data compression, Fundamental concept of data compression & coding, Communication model, Compression ratio, Requirements of data compression, Classification.
Methods of Data Compression: Data compression-- Loss less & Lossy.

Module 5 [8 Lectures]
Entropy encoding-- Repetitive character encoding, Run length encoding, Zero/Blank encoding; Statistical encoding-- Huffman, Arithmetic & Lempel-Ziv coding; Source encoding-- Vector quantization (Simple vector quantization & with error term).

Module 6 [4 Lectures]
Recent trends in encryption and data compression techniques.

Text Books/References:

1. Cryptography and Network Security, Mohammad Amjad, John Wiley & Sons.

2. Cryptography & Network Security by Atul Kahate, TMH.
3. Information Theory and Coding, Muralidhar Kulkarni, K S Shivaprakasha, John Wiley & Sons.
4. Cryptography and Network Security by B. Forouzan, McGraw-Hill.
5. The Data Compression Book by Nelson, BPB.
6. Cryptography & Network Security, V.K. Jain, Khanna Publishing House.

Course Outcomes: At the end of this course the student will have the knowledge of plain text, cipher text, RSA and other cryptographic algorithm, Key Distribution, communication model, Various models for data compression.

*****

Course Code	:	CBS-03
Course Title	:	Steganography and Digital Watermarking
Number of Credits	:	3 (L: 3; T: 0; P: 0)
Course Category	:	CBS
Pre-requisites	:	Image and Video Processing, Linear Algebra

Course Objective: The objective of course is to provide an insight to steganography techniques. Watermarking techniques along with attacks on data hiding and integrity of data is included in this course.

Course Contents:

Module 1 [8 Lectures]
Steganography: Overview, History, Methods for hiding (text, images, audio, video, speech etc.).
Steganalysis: Active and Malicious Attackers, Active and passive Steganalysis.

Module 2 [8 Lectures]
Frameworks for secret communication (pure steganography, secret key, public key steganography), Steganography algorithms (adaptive and non-adaptive).

Module 3 [6 Lectures]
Steganography techniques: Substitution systems, Spatial Domain, transform domain techniques, Spread spectrum, Statistical steganography.

Module 4 [6 Lectures]
Detection, Distortion, Techniques: LSB Embedding, LSB Steganalysis using primary sets.

Module 5 [9 Lectures]
Digital Watermarking: Introduction, Difference between Watermarking and Steganography, Classification (Characteristics and Applications),
types and techniques (Spatial-domain, Frequency-domain, and Vector quantization-based watermarking), Watermark security & authentication.

Module 6 [5 Lectures]
Recent trends in Steganography and digital watermarking techniques. Case study of LSB Embedding, LSB Steganalysis using primary sets.

Text Books/References:

1. Peter Wayner, "Disappearing Cryptography – Information Hiding: Steganography & Watermarking", Morgan Kaufmann Publishers, New York, 2002.
2. Ingemar J. Cox, Matthew L. Miller, Jeffrey A. Bloom, Jessica Fridrich, TonKalker, "Digital Watermarking and Steganography", Margan Kaufmann Publishers, New York, 2008.
3. Information Hiding: Steganography and Watermarking-Attacks and Countermeasures by Neil F. Johnson, Zoran Duric, Sushil Jajodia.
4. Information Hiding Techniques for Steganography and Digital Watermarking by Stefan Katzenbeisser, Fabien A. P. Petitcolas.

Corresponding Online Resources:

1. Cyber Security, https://swayam.gov.in/nd2_cec20_cs09/preview.
2. Introduction to Cyber Security, https://swayam.gov.in/nd2_nou20_cs01/preview

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

1. Learn the concept of information hiding.
2. Survey of current techniques of steganography and learn how to detect and extract hidden information.
3. Learn watermarking techniques and through examples understand the concept.

*****

Course Code	:	CBS-04
Course Title	:	Security Assessment and Risk Analysis
Number of Credits	:	3 (L: 3; T: 0; P: 0)
Course Category	:	CBS
Pre-requisites	:	Computer and Network Security

Course Objective: Describe the concepts of risk management in information security. Define and differentiate various Contingency Planning components. Define and be able to discuss incident response options, and design an Incident Response Plan for sustained organizational operations.

Course Contents:

Module 1 [8 Lectures]

SECURITY BASICS: Information Security (INFOSEC) Overview: critical information characteristics – availability information states – processing security countermeasures-education, training and awareness, critical information characteristics – confidentiality critical information characteristics – integrity, information states – storage, information states – transmission, security countermeasures-policy, procedures and practices, threats, vulnerabilities.

Module 2 [9 Lectures]

Threats to and Vulnerabilities of Systems: Threats, major categories of threats (e.g., fraud, Hostile Intelligence Service (HOIS).
Countermeasures: assessments (e.g., surveys, inspections).
Concepts of Risk Management: consequences (e.g., corrective action, risk assessment), cost/benefit analysis and implementation of controls, monitoring the efficiency and effectiveness of controls (e.g., unauthorized or inadvertent disclosure of information).

Module 3 [7 Lectures]
Security Planning: directives and procedures for policy mechanism.
Contingency Planning/Disaster Recovery: agency response procedures and continuity of operations, contingency plan components, determination of backup requirements, development of plans for recovery actions after a disruptive event.

Module 4 [8 Lectures]
Personnel Security Practices and Procedures: access authorization/verification (need-to-know), contractors, employee clearances, position sensitivity, security training and awareness, systems maintenance personnel.
Auditing and Monitoring: conducting security reviews, effectiveness of security programs, investigation of security breaches, privacy review of accountability controls, review of audit trails and logs.

Module 5 [7 Lectures]
Operations Security (OPSEC): OPSEC surveys/OPSEC planning INFOSEC: computer security – audit, cryptography-encryption (e.g., point-to-point, network, link).

Module 6 [3 Lectures]
Case study of threat and vulnerability assessment.

Text Books/References:
1. Information Systems Security, 2ed: Security Management, Metrics, Frameworks and Best Practices, Nina Godbole, John Wiley & Sons.
2. Principles of Incident Response and Disaster Recovery, Whitman & Mattord, Course Technology ISBN: 141883663X.

Corresponding Online Resources:
1. Introduction to Cyber Security, https://swayam.gov.in/nd2_nou20_cs01/preview
2. (Web Link) http://www.cnss.gov/Assets/pdf/nstissi_4011.pdf

Course Outcomes: After completion of course, students would be able:
1. To apply contingency strategies including data backup and recovery and alternate site selection for business resumption planning
2. To Skilled to be able to describe the escalation process from incident to disaster in case of security disaster.
3. To Design a Disaster Recovery Plan for sustained organizational operations.

*****

Course Code	:	CBS-05
Course Title	:	Database Security and Access Control
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	CBS
Pre-requisites	:	Database Management

Course Objective: The objective of the course is to provide fundamentals of database security. Various access control techniques mechanisms were introduced along with application areas of access control techniques.

Course Contents:

Module 1 [7 Lectures]
Introduction to Access Control, Purpose and fundamentals of access control.

Module 2 [8 Lectures]
Policies of Access Control, Models of Access Control, and Mechanisms, Discretionary Access Control (DAC), Non- Discretionary Access Control, Mandatory Access Control (MAC). Capabilities and Limitations of Access Control Mechanisms: Access Control List (ACL) and Limitations, Capability List and Limitations.

Module 3 [10 Lectures]
Role-Based Access Control (RBAC) and Limitations, Core RBAC, Hierarchical RBAC, Statically Constrained RBAC, Dynamically Constrained RBAC, Limitations of RBAC. Comparing RBAC to DAC and MAC Access Control policy, Integrating RBAC with enterprise IT infrastructures: RBAC for WFMSs, RBAC for UNIX and JAVA environments.

Module 5 [8 Lectures]
Smart Card based Information Security, Smart card operating system-fundamentals, design and implantation principles, memory organization, smart card files, file management. PPS Security techniques- user identification, smart card security, quality assurance and testing, smart card life cycle-5 phases, smart card terminals.

Module 6 [9 Lectures]
Cloud Data Security: Recent trends in Database security and access control mechanisms. Cloud Data Audit: Intro, Audit, Best Practice, Key management, Cloud Key Management Audit.

Text Books/References:

1. Role Based Access Control: David F. Ferraiolo, D. Richard Kuhn, Ramaswamy Chandramouli.

Corresponding Online Resources:

1. http://www.smartcard.co.uk/tutorials/sct-itsc.pdf : Smart Card Tutorial.
2. Advanced System Security Topics, https://www.coursera.org/lecture/advanced-system-security-topics/role-based-access-control-rbac-bYvzS.

Course Outcomes:

After completion of this course, the students will be enable:

1. To understand and implement classical models and algorithms.
2. To analyze the data, identify the problems, and choose the relevant models and algorithms to apply.
3. To assess the strengths and weaknesses of various access control models and to analyze their behaviour.

*****

Data Science

Minor Degree in "Data Science"

Course Structure						
S. No.	**Course Code**	**Title**	**L**	**T**	**P**	**Credits**
1	DAS-01	Introduction to Data Science	3	0	2	4
2	DAS-02	Introduction to AI and ML	3	0	2	4
3	DAS-03	Computational Data analytics	3	0	2	4
4	DAS-04	Web Data Mining	3	0	0	3
5	DAS-05	Analysing, Visualizing and Applying data science with python	3	0	2	4
TOTAL			**15**	**0**	**8**	**19**

Course Coding Nomenclature:

- DAS denotes that minor degree in "Data Science".
- 01, 02, 03, 04, 05 are course in order they have to be taken, if taken in different semesters. Multiple course may also be taken in the same semester (if required).

Detailed Syllabus

Course Code	:	DAS-01
Course Title	:	Introduction to Data Science
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	DAS

Course Objective:

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

Course Contents:

Module 1: [7 Lectures]
Introduction to Data Science, Different Sectors using Data science, Purpose and Components of Python in Data Science.

Module 2: [7 Lectures]
Data Analytics Process, Knowledge Check, Exploratory Data Analysis (EDA), EDA- Quantitative technique, EDA- Graphical Technique, Data Analytics Conclusion and Predictions.

Module 3: [11 Lectures]
Feature Generation and Feature Selection (Extracting Meaning from Data)- Motivating application: user (customer) retention- Feature Generation (brainstorming, role of domain expertise, and place for imagination)- Feature Selection algorithms.

Module 4: [10 Lectures]
Data Visualization- Basic principles, ideas and tools for data visualization, Examples of inspiring (industry) projects- Exercise: create your own visualization of a complex dataset.

Module 5: [7 Lectures]
Applications of Data Science, Data Science and Ethical Issues- Discussions on privacy, security, ethics- A look back at Data Science- Next-generation data scientists.

Lab Work:
1. Python Environment setup and Essentials.
2. Mathematical computing with Python (NumPy).
3. Scientific Computing with Python (SciPy).
4. Data Manipulation with Pandas.
5. Prediction using Scikit-Learn
6. Data Visualization in python using matplotlib

Text Books/References:

1. Data Sciences & Analytics, V.K. Jain, Khanna Publishing House.
2. Business Analytics: The Science of Data - Driven Decision Making, U Dinesh Kumar, John Wiley & Sons.
3. Introducing Data Science: Big Data, Machine Learning, and More, Using Python Tools, Davy Cielen, John Wiley & Sons.
4. Joel Grus, Data Science from Scratch, Shroff Publisher/O'Reilly Publisher Media
5. Annalyn Ng, Kenneth Soo, Numsense! Data Science for the Layman, Shroff Publisher Publisher
6. Cathy O'Neil and Rachel Schutt. Doing Data Science, Straight Talk from The Frontline. O'Reilly Publisher.
7. Jure Leskovek, Anand Rajaraman and Jeffrey Ullman. Mining of Massive Datasets. v2.1, Cambridge University Press.
8. Jake VanderPlas, Python Data Science Handbook, Shroff Publisher/O'Reilly Publisher Media.
9. Philipp Janert, Data Analysis with Open Source Tools, Shroff Publisher/O'Reilly Publisher Media.

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

1. To explain how data is collected, managed and stored for data science;
2. To understand the key concepts in data science, including their real-world applications and the toolkit used by data scientists;
3. To implement data collection and management scripts using MongoDB.

*****

Course Code	:	DAS-02
Course Title	:	Introduction to AI and ML
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	DAS

Course Objective:

- To understand basics of machine learning in data science.
- To understand various basic machine learning algorithm that can be used with various type of data.

Course Contents:

Module 1: [6 Lectures]

Linear Regression: Basic facts of linear regression, implementation of linear regression, case studies of linear regression using data set

Module 2: [8 Lectures]

Logistic Regression: Basic facts and implementation of logistic regression, solve a case study to predict output using existing data set

Module 3: [11 Lectures]

Clustering and Principle Component Analysis: K means and hierarchical clustering, how to make market strategies using clustering, recommendation and PCA

Module 4: [9 Lectures]
Support Vector Machine: basics of SVM and use it to detect the spam emails and recognize alphabets

Module 5: [8 Lectures]
Model Selection and advanced regression: use of Lasso and Ridge

Lab Work:
1. Use python to predict employee attrition in a firm and help them plan their manpower. (take data set from kaggle).
2. Create customer clusters using different market strategies on a data set.
3. Make a movie recommendation system.
4. Develop a prediction mechanism to predict which employee can go on leave in a company in near future.
5. Recognizing alphabets using SVM.

Text Books/References:

1. Machine Learning using Python , U Dinesh Kumar and Manaranjan Pradhan, John Wiley & Sons.
2. A Classical Approach to Artificial Intelligence, M.C. Trivedi, Khanna Publishing House.
3. Machine Learning, V.K. Jain, Khanna Publishing House.
4. Advanced Data Analytics Using Python: With Machine Learning, Deep Learning by By Sayan Mukhopadhyay, Apress.
5. Practical Data Mining" by Monte F. Hancock, Auerbach Publication.
6. "Machine Learning for Absolute Beginners: A Plain English Introduction (Second Edition)" by Oliver Theobald.
7. Practical Data Science with R, Nina Zumel, John Wiley & Sons.
8. Python for Data Science for Dummies, John Paul Mueller, Luca Massaron, John Wiley & Sons.
9. Big Data and Analytics, Seema Acharya and Subhashini Chellappan, Wiley Publication.
10. Introduction to Machine Learning, Jeeva Jose, Khanna Publishing House.

Course Outcomes: After completion of course, students would be able:
1. To explain how data is collected, managed and stored for data science;
2. To use various type of Machine learning model
3. To implement various ML algorithms on data models

*****

Course Code	:	DAS-03
Course Title	:	Computational Data Analytics
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	DAS

Course Objective:

- To learn how to think about your study system and research question of interest in a systematic way in order to design an efficient sampling and experimental research program.
- To understand how to analyze collected data to derive the most information possible about your research questions.

Course Contents:

Module 1: [6 Lectures]
Introduction to R Computing language. Best practices in executing Reproducible Research in data science, Sampling and Simulation. Descriptive statistics, and the creation of good observational sampling designs.

Module 2: [8 Lectures]
Data visualization, Data import and visualization, Introduction to various plots

Module 3: [10 Lectures]
Frequentist Hypothesis Testing, Z-Tests, Power Analysis

Module 4: [10 Lectures]
Linear regression, diagnostics, visualization, Likelihoodist Inference, Fitting a line with Likelihood, Model Selection with one predictor

Module 5: [8 Lectures]
Bayesian Inference, Fitting a line with Bayesian techniques, Multiple Regression and Interaction Effects, Information Theoretic Approaches

Lab Work:
1. To give a basic insight of R and its various libraries.
2. Libraries in R. R as a Data Importing Tool, Dplyr. Forcats.
3. Simulation and Frequentist Hypothesis testing, Simulation and Power.
4. Bayesian computation in R, Fitting a line with Bayesian techniques.

Text Books/References:

1. Beginner's Guide for Data Analysis using R Programming, Khanna Publishing House
2. Practical Data Science with R, Nina Zumel, John Wiley & Sons.
3. Big Data & Hadoop, V.K. Jain, Khanna Publishing House.
4. N. C. Das, Experimental Designs in Data Science with Least Resources, Shroff Publisher Publisher.

5. Hadley Wickham, Garret Grolemund, *R for Data Science*, Shroff Publisher/O'Reilly Publisher Publisher
6. Benjamin M. Bolker. *Ecological Models and Data in R*. Princeton University Press, 2008. ISBN 978-0-691-12522-0.
7. John Fox and Sanford Weisberg. *An R Companion to Applied Regression*. Sage Publications, Thousand Oaks, CA, USA, second edition, 2011. ISBN 978-1-4129-7514-8.

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

1. Explain how data is collected, managed and stored for data science;
2. When to use which type of Machine learning model.
3. Implement various ML algorithms on data models.

*****

Course Code	:	DAS-04
Course Title	:	Web Data Mining
Number of Credits	:	3 (L: 3; T: 0; P: 0)
Course Category	:	DAS

Course Objective:

- To learn how to extract data from the Web.
- To understand how to analyze collected data to derive the most information

Course Contents:

Module 1: [6 Lectures]

Introduction to internet and WWW, Data Mining Foundations, Association Rules and Sequential Patterns, Basic Concepts of Association Rules, Apriori Algorithm, Frequent Itemset Generation, Association Rule Generation, Data Formats for Association Rule Mining, Mining with multiple minimum supports, Extended Model, Mining Algorithm, Rule Generation

Module 2: [8 Lectures]

Mining Class Association Rules, Basic Concepts of Sequential Patterns, Mining Sequential Patterns on GSP, Mining Sequential Patterns on Prefix Span, Generating Rules from Sequential Patterns

Module 3: [10 Lectures]

Concepts of Information Retrieval, IR Methods, Boolean Model, Vector Space Model and Statistical Language Model, Relevance Feedback, Evaluation Measures, Text and Web Page Pre-processing, Stopword Removal, Stemming, Web Page Preprocessing, Duplicate Detection, Inverted Index and Its Compression, Inverted Index, Search using Inverted Index, Index Construction, Index Compression, Latent Semantic Indexing, Singular Value Decomposition, Query and Retrieval, Web Search, Meta Search, Web Spamming.

Module 4: [10 Lectures]

Link Analysis, Social Network Analysis, Co-Citation and Bibliographic Coupling, Page Rank Algorithm, HITS Algorithm, CommModuley Discovery, Problem Definition, Bipartite Core CommModuleies, Maximum Flow CommModuleies, Email CommModuleies, Web Crawling, A Basic Crawler Algorithm – Breadth First Crawlers, Preferential Crawlers, Implementation Issues – Fetching, Parsing, Stopword Removal, Link Extraction, Spider Traps, Page Repository, Universal Crawlers, Focused Crawlers, Topical Crawlers, Crawler Ethics and Conflicts.

Module 5: [8 Lectures]

Opinion Mining, Sentiment Classification, Classification based on Sentiment Phrases, Classification Using Text Classification Methods, Feature based Opinion Mining and Summarization, Problem Definition, Object feature extraction, Comparative Sentence and Relation Mining, Opinion Search and Opinion Spam. Web Usage Mining, Data Collection and Preprocessing, Sources and Types of Data, Key Elements of Web Usage Data Preprocessing, Data Modeling for Web Usage Mining, Discovery and Analysis of Web

Usage Patterns, Session and Visitor Analysis, Cluster Analysis and Visitor Segmentation, Association and Correlation Analysis, Analysis of Sequential and Navigation Patterns.

Text Books/References:

1. Mining the Web: Discovering Knowledge from Hypertext Data, Soumen Chakrabarti, Morgan Kaufmann Publishers.
2. Bing Liu, Web Data Mining: Exploring Hyperlinks, Contents, and Usage Data, Springer Publications, 2011.
3. Jiawei Han, Micheline Kamber, Data Mining: Concepts and Techniques, Second Edition, Elsevier Publications 2010.
4. Anthony Scime, Web Mining: Applications and Techniques, 2005.
5. Kowalski, Gerald, Mark T Maybury: Information Retrieval Systems: Theory and Implementation, Kluwer Academic Press, 1997.
6. Mathew Russell, Mining the Social Web 2nd Edition, Shroff Publisher/O'Reilly Publisher Publication.
7. Data Mining and Data Warehousing Principles and Practical Techniques, Parteek Bhatia, Cambridge University Press.
8. Data Mining & Business Intelligence, Balram Krishan, Khanna Publishing House

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

1. To explain how data is can be collected from the Web.
2. To extract data and information from the webpages.
3. To make decision based on the data collected.

*****

Course Code	:	DAS-05
Course Title	:	Analysing, Visualizing and Applying data science with python
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	DAS

Course Objective:

- To learn how to use python for data science.
- To understand and use all the tools and libraries of python for data science.

Course Contents:

Module 1: [6 Lectures]
Data Analysis libraries: will learn to use Pandas DataFrames, Numpy multi-dimentional arrays, and SciPy libraries to work with a various dataset.

Module 2: [8 Lectures]
Pandas, an open-source library, and we will use it to load, manipulate, analyze, and visualize various datasets.

Module 3: [10 Lectures]
Scikit-learn, and we will use some of its machine learning algorithms to build smart models and make predictions, various parameters that can be used to compare various parameters.

Module 4: [10 Lectures]
Descriptive Statistics, Basic of Grouping, ANOVA, Correlation, Polynomial Regression and Pipelines, R-squared and MSE for In-Sample Evaluation, Prediction and Decision Making

Module 5: [10 Lectures]
Grid Search, Model Refinement, Binning, Indicator variables

Lab Work:
1. Demonstrate knowledge of Data Science and Machine Learning.
2. Apply Data Science process to a real life scenario.
3. Explore New York City - 311 Complaints and Housing datasets.
4. Analyze and Visualize data using Python.
5. Perform feature engineering exercise using Python.
6. Build and validate predictive machine learning model using Python.
7. Create and share Actionable Insights to real life data problems.

Text Books/References:
1. Taming Python by Programming, Jeeva Jose, Khanna Publishing House.
2. Data Visualization with Python and JavaScript, Kyran Dale, Shroff Publisher/O'Reilly Publisher Publication.
3. Data Science Using Python and R by Chantal D. Larose and Daniel T. Larose, Wiley Publication.
4. Data Science & Analytics (with Python, R, SPSS Programming), V.K. Jain, Khanna Publishing House.
5. Python for Data Science and Visualization -Beginners to Pro, Udemy.

Course Outcomes: After completion of course, students would:
1. To explain how data is can be collected from the Web.
2. To extract data and information from the webpages.
3. To make decision based on the data collected.

*****

Internet of Things (IoT)

Minor Degree in "Internet of Things"

Course Structure						
S. No.	**Course Code**	**Title**	**L**	**T**	**P**	**Credits**
1	IoT-01	Introduction to Internet of Things	3	0	2	4
2	IoT-02	Introduction to Security of Cyber-Physical Systems	3	0	2	4
3	IoT-03	Ubiquitous Sensing, Computing and Communication	3	0	2	4
4	IoT-04	Embedded Systems for IoT	3	0	0	3
5	IoT-05	IoT with Arduino, ESP, and Raspberry Pi	3	0	2	4
TOTAL			**15**	**0**	**8**	**19**

Course Coding Nomenclature:

- IoT denotes that minor degree in "Internet of Things".
- 01, 02, 03, 04, 05 are course in order they have to be taken, if taken in different semesters. Multiple course may also be taken in the same semester (if required).

Detailed Syllabus

Course Code	:	IoT-01
Course Title	:	Introduction to Internet of Things
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	IoT

Course Objective:

- To make students know the IoT ecosystem.
- To provide an understanding of the technologies and the standards relating to the Internet of Things.
- To develop skills on IoT technical planning.

Course Contents:

Module 1 [8 Lectures]
IoT & Web Technology: The Internet of Things Today, Time for Convergence, Towards the IoT Universe, Internet of Things Vision, IoT Strategic Research and Innovation Directions, IoT Applications, Future Internet Technologies, Infrastructure, Networks and Communication, Processes, Data Management, Security, Privacy & Trust, Device Level Energy Issues, IoT Related Standardization, Recommendations on Research Topics.

Module 2 [9 Lectures]
M2M to IoT – A Basic Perspective– Introduction, Some Definitions, M2M Value Chains, IoT Value Chains, an emerging industrial structure for IoT, the international driven global value chain and global information monopolies. M2M to IoT-An Architectural Overview– Building an architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations.

Module 3 [9 Lectures]
IoT Architecture -State of the Art – Introduction, State of the art, Architecture Reference Model- Introduction, Reference Model and architecture, IoT reference Model, IoT Reference Architecture- Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views.

Module 4 [8 Lectures]
IoT Applications for Value Creations Introduction, IoT applications for industry: Future Factory Concepts, Brownfield IoT, Smart Objects, Smart Applications, Four Aspects in your Business to Master IoT, Value Creation from Big Data and Serialization, IoT for Retailing Industry, IoT for Oil and Gas Industry, Opinions on IoT Application and Value for Industry, Home Management, eHealth.

Module 5 [8 Lectures]
Internet of Things Privacy, Security and Governance Introduction, Overview of Governance, Privacy and Security Issues, Contribution from FP7 Projects, Security, Privacy and Trust in IoT-Data-Platforms for Smart Cities, First Steps Towards a Secure Platform, Smart Approach. Data Aggregation for the IoT in Smart Cities, Security.

Text Books/References:

1. Dr. Jeeva Jose, Internet of Things, Khanna Publishing House.
2. Nitesh Dhanjani, Abusing the Internet of Things, Shroff Publisher/O'Reilly Publisher.
3. Internet of Things, RMD Sundaram Shriram K Vasudevan, Abhishek S Nagarajan, John Wiley and Sons.
4. Internet of Things, Shriram K Vasudevan, Abhishek S Nagarajan, RMD Sundaram, John Wiley & Sons.
5. Cuno Pfister, "Getting Started with the Internet of Things", Shroff Publisher/Maker Media.
6. Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1 st Edition, Apress Publications.
7. Massimo Banzi, Michael Shiloh Make: Getting Started with the Arduino, Shroff Publisher/Maker Media Publishers.

Corresponding Online Resources:

1. https://www.coursera.org/specializations/internet-of-things

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

1. To understand the technology and standards relating to IoTs.
2. To understand the critical ecosystem required to mainstream IoTs.
3. To Acquire skills on developing their own national and enterprise level technical strategies.

*****

Course Code	:	IoT-02
Course Title	:	Introduction to Security of Cyber-Physical Systems
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	IoT

Course Objective:

- To learn the basics of security and various types of security issues.
- To study different cryptography techniques available and various security attacks.
- Explore network security and how they are implemented in real world.
- To get an insight of various issues of Web security and biometric authentication.

Course Contents:

Module 1 [6 Lectures]
Overview of Security and Privacy in Information System.

Module 2 [10 Lectures]
Applied Cryptography & Intrusion Detection, Architecture of Applied Cryptography, One Way Hash Function and Integrity, Encryption Algorithms and Confidentiality, Digital Signature and Authentication (DH, RSA, 2 class), Intrusion Detection and Information Theory.

Module 3 [10 Lectures]
Internet of Things Security, Security and Privacy for IoT Case Study: Smart Home, Smart Grid Network, Modern Vehicle, Wearable Computing & BYOD, Mobile HealthCare.

Module 4 [8 Lectures]
Software-Defined Networks, Introduction of Software-Defined Networks, Security for Software-Defined Networks, Privacy Leakages for Software-Defined Networks, Case Studies: How to Attack Software-Defined Networks.

Module 5 [8 Lectures]
Cyber-Physical Systems (CPS), CPS - Platform components, CPS implementation issues, Intelligent CPS, Secure Deployment of CPS.

Text Books/References:

1. Cyber Security, Nina Godbole, John Wiley & Sons.
2. Li Da Xu, Shancang Li, "Securing the Internet of Things", Syngress.
3. Alasdair Gilchrist, "IoT Security Issues", De Gruyter
4. Sean Smith, "The Internet of Risky Things", Sean Smith, Shroff Publisher/O'Reilly Publisher
5. Dr. Jeeva Jose, Internet of Things, Khanna Publishing House.

Course Outcomes: After completion of course, students would be able:
1. To Apply basics of security and issues related to it.
2. To use biometric techniques available and how they are used in today's world.
3. To investigate Security issues in web and how to tackle them.
4. To Learn mechanisms for transport and network security

*****

Course Code	:	IoT-03
Course Title	:	Ubiquitous Sensing, Computing and Communication
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	IoT

Course Objective:

- Basic introduction of all the elements of IoT-Mechanical, Electronics/sensor platform, Wireless and wireline protocols, Mobile to Electronics integration, Mobile to enterprise integration.
- To have an understanding of basics of open source/commercial electronics platform for IoT.
- To have an understanding of basics of open source /commercial enterprise cloud platform for IoT.

Course Contents:

Module 1
Introduction, Overview, Challenges in IoT, Networking Basics of IoT, NFC, Wireless LAN.

Module 2

Location in ubiquitous computing: Personal assistants, Location aware computing, Location tracking, Architecture, Location based service and applications, Location based social networks (LBSN), LBSN Recommendation.

Context-aware computing: Context and Context-aware Computing, Issues and Challenges, Developing Context-aware Applications, System Architecture.

Module 3

Privacy and security in ubiquitous computing, Energy constraints in ubiquitous computing.

Wearable computing, Glass and Augmented Reality, Eye-Tracking, Digital Pen and Paper, Mobile social networking & crowd sensing, Event based social network.

Module 4

Mobile affective computing: Human Activity and Emotion Sensing, Health Apps, Mobile p2p computing, Smart Homes and Intelligent Buildings, Mobile HCI, Cloud centric IoT, Open challenges, Architecture, Energy Efficiency, Participatory sensing, Protocols, QoS, QoE.

Module 5

IoT and data analytics IoT and Data Management, Data cleaning and processing, Data storage models.

Search techniques, Deep Web, Semantic sensor web, Semantic Web Data Management, Searching in IoT.

Real-time and Big Data Analytics for The Internet of Things, Heterogeneous Data Processing, High-dimensional Data Processing, Parallel and Distributed Data Processing.

Text Books/References:

1. N. Jeyanthi, Ajith Abraham, Hamid Mcheick, "Ubiquitous Computing and Computing Security of IoT".
2. John Krumm, Ubiquitous Computing Fundamentals, CRC Press.
3. Dirk Slama, "Enterprise IoT", Shroff Publisher/O'Reilly Publisher
4. Dr. Jeeva Jose, Internet of Things, Khanna Publishing House.

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

1. To understand merging technological options, platforms and case studies of IoT implementation in home & city automation.
2. To determine the Market perspective of IoT.

*****

Course Code	:	IoT-04
Course Title	:	Embedded Systems for IoT
Number of Credits	:	3 (L: 3; T: 0; P: 0)
Course Category	:	IoT

Course Objective:

- To make students know the basic concept and architecture of embedded systems.
- Different design platforms used for an embedded system for IoT applications.
- To have knowledge about the IoT enabled technology.

Course Contents:

Module 1 [7 Lectures]
Purpose and requirement specification, IoT level specification, Functional view specification, Operational view specification, Device and component integration, Pillars of Embedded IoT and Physical Devices: The internet of devices.

Module 2 [8 Lectures]
Design of Embedded Systems: Common Sensors, Actuators, Embedded Processors, Memory Architectures, Software architecture.

Module 3 [7 Lectures]
Inputs and Outputs: Digital Inputs and Outputs, Digital Inputs, Digital Outputs, BusIn, BusOut, and BusInOut, Analog Inputs and Outputs, Analog Inputs, Analog Outputs, Pulse Width Modulation (PWM), Accelerometer and Magnetometer, SD Card, Local File System (LPC1768).

Module 4 [10 Lectures]
IoT Enabling Technologies: Communications, RFID and NFC (Near-Field Communication), Bluetooth Low Energy (BLE), LiFi, 6LowPAN, ZigBee, Z-Wave, LoRa, Protocols, HTTP, WebSocket, MQTT, CoAP, XMPP, Node-RED, Platforms, IBM Watson IoT—Bluemix, Eclipse IoT, AWS IoT, Microsoft Azure IoT Suite, Google Cloud IoT, ThingWorx, GE Predix, Xively, macchina.io, Carriots.

Module 5 [10 Lectures]
Web of Things and Cloud of Things: Web of Things versus Internet of Things, Two Pillars of the Web, Architecture Standardization for WoT, Platform Middleware for WoT, Cloud of Things. IoT Physical Servers,

Cloud Offerings and IoT Case Studies: Introduction to Cloud Storage Models, Communication API.

Text Books/References:

1. Dr. Jeeva Jose, Internet of Things, Khanna Publishing House.
2. RMD Sundaram Shriram K Vasudevan, Abhishek S Nagarajan, Internet of Things, John Wiley and Sons.
3. Klaus Elk, “Embedded Software for the IoT”.

4. Perry Xiao, “Designing Embedded Systems and the Internet of Things (IoT) with the ARM Mbed”.
5. Elizabeth Gootman et. al, “Designing Connected Products”, Shroff Publisher/O’Reilly Publisher.

Corresponding Online Resources:

1. Introduction to the Internet of Things and Embedded Systems, https://www.coursera.org/learn/iot

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

1. Understand the embedded system concepts and architecture of embedded systems.
2. Understand the different hardware/software co-design techniques for microcontroller-based embedded systems, apply techniques in IoT applications.
3. To be able to design web/cloud based IoT applications.

*****

Course Code	:	IoT-05
Course Title	:	IoT with Arduino, ESP, and Raspberry Pi
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	IoT

Course Objective:

- To give students hands-on experience using different IoT architectures.
- To provide skills for interfacing sensors and actuators with different IoT architectures.
- To develop skills on data collection and logging in the cloud.

Course Contents:

Module 1 [5 Lectures]

IoT- introduction and its components, IoT building blocks, Sensors and Actuators, IoT Devices, IoT boards (Arduino Uno, ESP 8266-12E Node MCU, and Raspberry Pi 3).

Module 2 [10 Lectures]

Arduino Uno – getting started with the Uno boards, blink program, connection of sensors to the Uno board, reading values of sensors from the Uno board, interrupts. Case study: Temperature/Humidity Control; Case Study: Sending values Temperature/Humidity values to the Internet via GSM module.

Module 3 [10 Lectures]

ESP 8266-12E Node MCU – getting started with the ESP board, Micropython and Esplorer IDE, Flushing the ESP8266 board with micropython, connecting sensors to the ESP board, Connecting ESP board to WiFi, Interfacing ESP with the Cloud (REST API-GET, POST, MQTT), interrupts, comparison of ESP 32 board with the ESP 8266 board. Case Study: Switching light on /off remotely. Case Study: Voice-based Home

Automation for switching lights on/off (Android phone – Google Assistant (Assistant <-> IFTTT), MQTT (ESP <-> IFTTT), ESP 8266 <-> Lights).

Module 4 [8 Lectures]

Raspberry Pi 3 - Rpi3 introduction and installing the Raspbian Stretch OS, Headless - Computer and Rpi3 configuration to connect through SSH via Ethernet, Headless - connecting Rpi3 remotely without Ethernet cable via SSH, IP address, Rpi 3 - Testing the GPIO pins through Scripts.

Module 5 [9 Lectures]

Raspberry pi3 interfacing with Sensor DHT11, Raspberry pi3 python library install and reading sensor feed, 'Plug and play ' type cloud platform overview for integration to IOT devices, 'Plug and play' cloud platform for integration to IOT device - actuator (LED), Plug and play platform - Custom widget (DHT11-Sensor) integration through Python. New - Raspeberry Pi 4 Vs Raspberry Pi3 Mobel B Comparison, LoRawan /LPWAN – Overview.

Text Books/References:

1. Dr. Jeeva Jose, Internet of Things, Khanna Publishing House.
2. Rao, M. (2018). Internet of Things with Raspberry Pi 3: Leverage the power of Raspberry Pi 3 and JavaScript to build exciting IoT projects. Packt Publishing Ltd
3. Baichtal, J. (2013). *Arduino for beginners: essential skills every maker needs*. Pearson Education.
4. Schwartz, M. (2016). *Internet of Things with ESP8266*. Packt Publishing Ltd.
5. Richardson, M., & Wallace, S. (2012). *Getting started with raspberry PI*. " O'Reilly Publisher Media, Inc."

Software/Hardware Requirements:

Python, IOT boards - Arduino UNO, NODEMCU ESP 8266, Raspberry PI 3, Few resistors, potentiometer (5K~10K OHM), breadboard, LEDs, DHT 11 sensor.

Course Outcomes: After completion of course, students would:

1. To understand Arduino Uno, NODE MCU 8266 and Raspberry PI along with critical protocols and its communication to cloud.
2. To apply commonly used IOT protocols such as REST API, MQTT through IOT based demonstration.
3. To solve analog sensor and digital sensor Interfacing with IOT devices.

*****

Robotics

Minor Degree in "Robotics"

Course Structure						
S. No.	**Course Code**	**Title**	**L**	**T**	**P**	**Credits**
1	ROB-01	Introduction to Robotics	3	1	0	4
2	ROB-02	Mechanics of Robots	3	0	0	3
3	ROB-03	Microprocessor & Embedded Systems	3	0	2	4
4	ROB-04	Control of Robotic Systems	3	0	0	3
5	ROB-05	Project in Robotics	1	0	6	4
TOTAL			**13**	**1**	**8**	**18**

Course Coding Nomenclature:

- ROB denotes that minor degree in "Robotics".
- 01, 02, 03, 04, 05 are course in order they have to be taken, if taken in different semesters. Multiple course may also be taken in the same semester (if required).
- It is preferable to take ROB-05 after completing all previous courses or at least after completing ROB-01, ROB-02, ROB-03, in parallel with ROB-04.

Detailed Syllabus

Course Code	:	ROB-01
Course Title	:	Introduction to Robotics
Number of Credits	:	4 (L: 3; T: 1; P: 0)
Course Category	:	ROB

Course Objective: This course aims to familiarise students with basic terminologies of the robotics sciences and essential knowledge required to get started in the field of Robotics.

Course Contents:

Module 1 : Introduction to robotics : Brief History, Basic Concepts of Robotics such as Definition , Three laws, Elements of Robotic Systems i.e. Robot anatomy, DOF, Misunderstood devices etc., Classification of Robotic systems on the basis of various parameters such as work volume, type of drive, etc., Associated parameters i.e. resolution, accuracy, repeatability, dexterity, compliance, RCC device etc., Introduction to Principles & Strategies of Automation, Types & Levels of Automations, Need of automation, Industrial applications of robot.

Module 2: Grippers and Sensors for Robotics: Grippers for Robotics - Types of Grippers, Guidelines for design for robotic gripper, Force analysis for various basic gripper system.
Sensors for Robots - Types of Sensors used in Robotics, Classification and applications of sensors, Characteristics of sensing devices, Selections of sensors. Need for sensors and vision system in the working and control of a robot.

Module 3: Drives and Control for Robotics: Drive - Types of Drives, Types of transmission systems, Actuators and its selection while designing a robot system. Control Systems: Types of Controllers, Introduction to closed loop control

Module 4: Programming and Languages for Robotics: Robot Programming: Methods of robot programming, WAIT, SIGNAL and DELAY commands, subroutines, Programming Languages: Generations of Robotic Languages, Introduction to various types such as VAL, RAIL, AML, Python, ROS etc., Development of languages since WAVE till ROS.

Module 5: Related Topics in Robotics: Socio-Economic aspect of robotisation. Economical aspects for robot design, Safety for robot and standards, Introduction to Artificial Intelligence, AI techniques, Need and application of AI, New trends & recent updates in robotics.

Text Books/References:

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014)
2. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press (2006)
3. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, (2019)

4. R. K. Mittal, I. J. Nagrath, Robotics and Control, TATA McGraw Hill Publishing Co Ltd, New Delhi (2003)
5. S. B. Niku, Introduction to Robotics – Analysis, Contro, Applications, 3rd edition, John Wiley & Sons Ltd., (2020)
6. J. Angeles, Fundamentals of Robotic Mechanical Systems Theory Methods and Algorithms, Springer (1997)
7. Mikell Groover, Mitchell Weiss, Roger N. Nagel, Nicholas Odrey, Ashish Dutta, Industrial Robotics 2nd edition, SIE, McGraw Hill Education (India) Pvt Ltd (2012)
8. R. D. Klafter, Thomas A. Chmielewski, and Mechael Negin, Robotic Engineering – An Integrated Approach, EEE, Prentice Hall India, Pearson Education Inc. (2009)

Alternative SWAYAM/NPTEL Course:

NPTEL Course Name	Instructor	Host Institute
Introduction to robotics	Dr. Krishna Vasudevan, Dr. Balaraman Ravindran, Dr. T Asokan	IIT Madras
Sensors and Actuators	Prof. Hardik Jeetendra Pandya	IISc Bangalore

Course Outcomes: After completion of course, students would be able:
1. To express his views as per terminologies related to Robotics technology.
2. To apply logic for selection of robotic sub systems and systems.
3. To analyse basics of principals of robot system integration.
4. To understand ways to update knowledge in the required area of robotic technology.

*****

Course Code	:	ROB-02
Course Title	:	Mechanics of Robots
Number of Credits	:	3 (L: 3; T: 0; P: 0)
Course Category	:	ROB

Course Objective: This course aims to inculcate thorough understanding about basic knowledge of mathematics, kinematics and dynamics required for understanding motion programming and operational / control functionality in robotics.

Course Contents:

Module 1: Mathematical Preliminaries of Robotics: Spatial Descriptions: positions, orientations, and frame, mappings: changing description from frame to frame, Operators: translations, rotations and transformations, transformation arithmetic, compound Transformations, inverting a transform, transform equations, Euler Angles, Fixed Angles, Euler Parameters.

Module 2: Robot Kinematics: Manipulator Kinematics, Link Description, Link to reference frame connections, Denavit-Hartenberg Approach, D-H Parameters, Position Representations, Homogeneous Transformation Matrix, Forward Kinematics. Inverse Kinematics, Geometric and analytical approach.

Module 3: Velocities & Statics: Cross Product Operator for kinematics, Jacobians - Direct Differentiation, Basic Jacobian, , Jacobian Jv / Jw, Jacobian in a Frame, Jacobian in Frame {0}, Kinematic Singularity, Kinematics redundancy, Force balance equation, Forces, Velocity/Force Duality, Virtual Work, Force ellipsoid, Jacobian, Kinematic Singularity, Kinematics redundancy, Mechanical Design of robot linkages,

Module 4: Robot Dynamics: Introduction to Dynamics, Velocity Kinematics, Acceleration of rigid body, mass distribution Newton's equation, Euler's equation, Iterative Newton –Euler's dynamic formulation, closed dynamic, Lagrangian formulation of manipulator dynamics, dynamic simulation, computational consideration.

Text Books/References:

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014).
2. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, (2019)
3. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press (2006)
4. M. Spong, M. Vidyasagar, S. Hutchinson, Robot Modeling and Control, Wiley & Sons, (2005).
5. J. J. Craig, "Introduction to Robotics: Mechanics and Control", 3rd edition, Addison-Wesley (2003).

Alternative SWAYAM/NPTEL Course:

NPTEL Course Name	Instructor	Host Institute
Robotics	Prof. Dilip Kumar Pratihar	IIT Kharagpur
Robotics	Prof. P. Seshu, Prof. P.S. Gandhi, Prof. K. Kurien Issac, Prof. B. Seth, Prof. C. Amarnath	IIT Bombay

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

1. To understand terminologies related to Kinematics and Dynamics of Robotics.
2. To apply mathematics for manipulator positioning and motion planning.
3. To analyse basics of motion programming as per kinematics.
4. To estimate the force/torque required to drive a robot.

*****

Course Code	:	ROB-03
Course Title	:	Microprocessor and Embedded Systems
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	ROB

Course Objective: This course aims to teach the detailed functioning of microprocessors and the role of embedded systems in a robotic system.

Course Contents:

Module 1: Introduction to Embedded Systems and microcomputers: Introduction to Embedded Systems, Embedded System Applications, Block diagram of embedded systems, Trends in Embedded Industry, Basic Embedded System Models, Embedded System development cycle, Challenges for Embedded System Design, Evolution of computing systems and applications. Basic Computer architecture: Von-Neumann and Harvard Architecture. Basics on Computer organizations. Computing performance, Throughput and Latency, Basic high performance CPU architectures, Microcomputer applications to Embedded systems and Mechatronics.

Module 2: Microprocessor: 8086 Microprocessor and its Internal Architecture, Pin Configuration and their functions, Mode of Operation, Introduction to I/O and Memory, Timing Diagrams, Introduction to Interrupts. Introduction to C language, Instruction format, C language programming format, Addressing mode, Instruction Sets, Programming 8086 microprocessor.

Module 3: Microprocessor Interfacing: Introduction to interfacing, Memory Interfacing, Programmable Peripheral Interfacing, Programmable I/O, Programmable Interrupt Controller, Programmable Timers, Programmable DMA Controller, Programmable Key Board Controller, Data acquisition Interfacing: ADC, DAC, Serial and parallel data Communication interfacing. Microcontroller: Introduction to Microcontroller and its families, Criteria for Choosing Microcontroller. Microcontroller Architecture, Programming model, addressing modes, Instruction sets, Assembly and C programming for Microcontroller, I/O programming using assembly and C language, Interrupt Controller, I/O interfacing, Timers, Real Time Clock, Serial and parallel Communication protocols, SPI Controllers. LCD Controller.

Module 4: Microcontroller Interfacing: Introduction to Microcontroller Interfacing and applications: case studies: Display Devices, controllers and Drivers for DC, Servo and Stepper Motor.

Module 5: Introduction to Advanced Embedded Processor and Software: ARM Processor, Unified Model Language (UML), Embedded OS, Real Time Operating System (RTOS), Embedded C.

Module 6: Microprocessor and Embedded System Laboratories: Basic C language programming implementation on Microprocessor and Microcontroller. Interfacing Displays, Key boards and sensors with Microprocessors and Microcontrollers, Data Acquisition using Microprocessor and Microcontroller, Implementation of Controlling schemes for DC, Servo, Stepper motor using C programming in microprocessors and Microcontrollers.

Text Books/References:

1. K. V. Shibu, Introduction to Embedded Systems, McGRAW Hill Publications (2009).
2. Raj Kamal, Embedded Systems, TATA McGRAW Hill Publications (2003).
3. M. Morris Mano, Computer System Architecture, 3ed, Pearson Publication, (2007).
4. D. V. Hall, 8086 Microprocessors and Interfacings, TATA McGRAW Hill, (2005).
5. B. B. Brey, The Intel Microprocessors, Prentice Hall Publications, 8th ed, (2018).
6. M. A. Mazidi, R.D. Mckinlay and D. Casey, PIC Microcontrollers and Embedded Systems, Pearson Publications, (2008).
7. M. Predko, Programming and Customizing the PIC Microcontroller, McGRAW Hill Publications. 3ed, (2017).
8. R. Barnett, L. O'Cull and S. Cox, Embedded C Programming and Microchip PIC, Cengage Learning, (2003).

Alternative SWAYAM/NPTEL Course:

NPTEL Course Name	Instructor	Host Institute
Embedded Systems	Prof. Santanu Chaudhary	IIT Delhi

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

1. To prepare block diagrams for any robotic control-hardware design,
2. To choose appropriate flow of embedded systems for a specific application.
3. To Write code for micro controller devices.
4. To use advanced embedded processor and software.

*****

Course Code	:	ROB-04
Course Title	:	Control of Robotic Systems
Number of Credits	:	3 (L: 3; T: 0; P: 0)
Course Category	:	ROB

Course Objective: This course aims to develop the understanding of control systems, its designing and application.

Course Contents:

Module 1: Basics of Control: Differential Equation, Transfer function, Frequency response, Routh-Hurwitz test, relative stability, Root locus design, construction of root loci, phase lead and phase-lag design, lag-lead design, Bode, polar, Nyquist plot.

Module 2: Linear Control: Concept of states, state space model, different form, controllability, observability; pole placement by state feedback, observer design, P, PI & PID Controller, control law partitioning, modelling and control of a single joint.

Module 3: Non-Linear Control System: Common physical non-linear system, phase plane method, system analysis by phase plane method, stability of non-linear system, stability analysis by describing function method, Liapunov's stability criterion, the control problems for manipulators.

Module 4: Motion Control: Point to Point Control, trajectory generation, Continuous Path Control, Joint based control, Cartesian Control, Force Control, hybrid position/force control system.

Text Books/References:

1. M. Gopal, Control Systems, McGraw-Hill (2012)
2. K. Ogata, "Modern Control Engineering", Prentice Hall India (2009).
3. M. Spong, M. Vidyasagar, S. Hutchinson, Robot Modeling and Control, Wiley & Sons, (2005).
4. J. J. Craig, "Introduction to Robotics: Mechanics and Control", 3rd edition, Addison-Wesley (2003).
5. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014).
6. Thomas Kailath, "Linear Systems", Prentice Hall (1980).
7. Alok Sinha, "Linear Systems: Optimal and Robust Control", Taylor & Francis (2007).

Alternative SWAYAM/NPTEL Course:

NPTEL Course Name	Instructor	Host Institute
Robotics and Control : Theory and Practice	Prof. N. Sukavanam, Prof. M. Felix Orlando	IIT Roorkee
Control systems	Prof. C.S.Shankar Ram	IIT Madras

Course Outcomes: After completion of course, students would have thorough understanding of linear, non-linear control systems and Motion Control.

*****

Course Code	:	ROB-05
Course Title	:	Project in Robotics
Number of Credits	:	4 (L: 1; T: 0; P: 6)
Course Category	:	ROB

Course Objective:

To assimilate the theoretical knowledge gained in the lecture courses (ROB-1 to 4) for real-life practical applications in order have effective learning and skill-development, mainly, from the point of view of the employability in industries.

Course Contents:

This course is a project type. The plan of conducting this course is given below:

1. Participants will be divided into teams of two/four members within first week of the starting of the course by the course coordinators/managers depending on the number of participants registered in the course. The benefits of such team-based projects are listed in the Course Outcomes below.

2. The teams will have a team coordinator or leader, which will be identified by the coordinators/managers of the course (may be the first name in the list of a student team).

3. The projects could be of the following types:

    a. Literature search (LS) type: Studying about an aspect of robotics, say, vision, robot kinematics, dynamic, controls, etc.

    b. Algorithm development (AD) type: Analyse, say, a robot kinematics using RoboAnalyzer or Matlab/Octave/Freemat/Scilab or similar software or write an algorithm using any programming language (Python, etc.). For example, writing forward kinematics of a robot or image processing in Vision.

    c. Design/synthesis (DS) type: Proposing a new type of system/device for performing certain task. For example, a mobile robot for Covid-19 isolation wards.

4. The teams will be asked to contact their team members within a week and decide their topic with two weeks, i.e., within first 3 weeks of the starting of the course.

5. Students MUST spend about 6 hours in a week to discuss their progress together, study together or individually, write programmes, fabricate circuits, etc.

6. During the one lecture hour the coordinators will explain how to do literature survey, how to find the sources of hardware, which software to use for a particular purpose, how to select an electric motor, etc., present case studies, etc.

7. At the end of the course duration, each team will submit no more than 10 slides in .pdf file and/or not more than a video of one min to showcase their project hardware/software/plots, etc. generated during the project to a cloud (say, Google Drive).

8. Evaluation: It will be done in two parts
    a. Peer Evaluations (20%): Presentations in .pdf will be evaluated (online) by two other teams and grade them out of 10 marks.
    b. Expert evaluation (80%): Coordinators will take a presentation of 3 mins. plus, Q&A in a common online session to give marks out of 80.

Text Books/References:

Since it is a project type, some experience sharing books and links to similar activities are listed.

1. Chuhan, M., and Saha, S.K., 2010, Robotics Competition Knowledge Based Eduation in Engineering, Pothi.com
2. Baun, M., and Chaffe, J., 2018, Engineering and Building Robots for Competitions, Amazon.com

Corresponding Online Resources:

1. http://www.ddrobocon.in/
2. http://courses.csail.mit.edu/iap/6.095/

Course Outcomes:

The outcomes are envisaged as follows:

1. Each participant will know students from other colleges/states and their work ethics/culture.
2. To Practice how to work together in a team. An essential skill in an industry.
3. To apply the theoretical knowledge learnt from other courses, which is required by an industry.
4. To learn how to make presentation in a team. A soft skill needed in research and industry.
5. Peer learning from the evaluation of other teams' work. A skill which is essential when one is in a workforce.
6. To examine different hardware components and their working/control using software.

*****

Virtual and Augmented Reality

Minor Degree in "Virtual and Augmented Reality"

Course Structure						
S. No.	**Course Code**	**Title**	**L**	**T**	**P**	**Credits**
1	VAR-01	Computer Graphics for Virtual Reality	3	0	2	4
2	VAR-02	Concepts of Virtual and Augmented Reality	3	0	2	4
3	VAR-03	Scientific and Engineering Data Visualisation	3	0	2	4
4	VAR-04	Mathematical Modelling and Computer Aided Engineering	3	0	0	3
5	VAR-05	Mobile VR and AI in Moduley	3	0	2	4
TOTAL			**15**	**0**	**8**	**19**

Course Coding Nomenclature:

- VAR denotes that Minor Degree related to "Virtual and Augmented Reality".
- 01, 02, 03, 04, 05 are course in order they have to be taken, if taken in different semesters. Multiple course may also be taken in the same semester (if required).

Detailed Syllabus

Course Code	:	VAR-01
Course Title	:	Computer Graphics for Virtual Reality
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	VAR

Course Objective:

- To introduce the use of the components of a graphics system and become familiar with building approach of graphics system components and algorithms related with them.
- To learn the basic principles of 3-dimensional computer graphics.
- Provide an understanding of mapping from a world coordinates to device coordinates, clipping, and projections.

Course Contents:

Module 1 [4 Lectures]
Graphics system and models: applications of computer graphics, graphics system, physical and synthetic images, imaging systems, graphics architectures.

Module 2 [10 Lectures]
Geometric objects and transformations: scalars, points and vectors, three-dimensional primitives, coordinate systems and frames, frames in OpenGL, matrix and vector classes, modelling a colored cube, affine transformations - translation, rotation and scaling, transformations in homogeneous coordinates, concatenation of transformations, transformation matrices in OpenGL, interfaces to 3D applications, quaternion.

Vertices to fragments: basic implementation strategies, four major tasks, clipping - line clipping, polygon clipping, clipping of other primitives, clipping in three dimensions, polygon rasterization, hidden-surface removal, antialiasing, display considerations.

Module 3 [9 Lectures]
Lighting and shading: light and matter, light sources, the Phong reflection model, computation of vectors, polygonal shading, approximation of a sphere by recursive subdivision, specifying lighting parameters, implementing a lighting model, shading of the sphere model, per-fragment lighting, global illumination.

Hierarchical modelling: symbols and instances, hierarchical models, a robot arm, trees and traversal, use of tree data structures, other tree structures, scene graphs, open scene graph.

Module 4 [10 Lectures]
Discrete techniques: buffers - digital images - writing into buffers - mapping methods - texture mapping - texture mapping in OpenGL - texture generation - environment maps - reflection map - bump mapping - compositing techniques - sampling and aliasing.

Advanced rendering: going beyond pipeline rendering - ray tracing - building a simple ray tracer - the rendering equation - radiosity - Renderman - parallel rendering -

volume rendering - Isosurfaces and marching cubes - mesh simplification - direct volume rendering - image-based rendering.

Module 5 [9 Lectures]

Fractals: modelling - Sierpinski Gasket - coastline problem - fractal geometry - fractal dimension - recursively defined curves - Koch curves - c curves - dragons - space filling curves - turtle graphics - grammar based models - Graftals - volumetric examples - k-midpoint subdivision - fractal Brownian motion - fractal mountains - iteration in the complex plane - Mandelbrot set.

Virtual reality modelling language: introduction, exploring and building a world, building object, lighting, sound and complex shapes, animation and user interaction, colors, normals and textures, nodes references. Special applications: stereo display programming, multiport display systems, multi-screen display system, fly mode navigation, walk through navigation, virtual track ball navigation.

Text Books/References:

1. Rajesh K. Maurya, Computer Graphics with Virtual Reality System, John Wiley & Sons.
2. Edward Angel, "Interactive Computer Graphics: A Top-Down Approach Using OpenGL", Addison-Wesley.
3. Foley James D, Van Dam, Feiner and Hughes, "Computer Graphics: Principles and Practice", Pearson Education.
4. Donald Hearn and Pauline Baker, "Computer Graphics C Version", Pearson Education.

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

1. To list the basic concepts used in computer graphics.
2. To implement various algorithms to scan, convert the basic geometrical primitives, transformations, Area filling, clipping.
3. To define the fundamentals of animation, virtual reality and its related technologies.
4. To design an application with the principles of virtual reality.

*****

Course Code	:	VAR-02
Course Title	:	Concepts of Virtual and Augmented Reality
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	VAR

Course Objective:

- To make students know the basic concept and framework of virtual reality.
- To teach students the principles and multidisciplinary features of virtual reality.
- To teach students the technology for multimodal user interaction and perception in VR, in particular the visual, audial and haptic interface and behaviour.
- To teach students the technology for managing large scale VR environment in real time.

- To provide students with an introduction to the VR system framework and development tools.

Course Contents:

Module 1 [9 Lectures]
Virtual reality and virtual environments: the historical development of VR, scientific landmarks computer graphics, real-time computer graphics, virtual environments, requirements for VR, benefits of virtual reality.
Hardware technologies for 3D user interfaces: visual displays, auditory displays, haptic displays, choosing output devices for 3D user interfaces.

Module 2 [14 Lectures]
3D user interface input hardware: input device characteristics, desktop input devices, tracking devices, 3d mice, special purpose input devices, direct human input, home - brewed input devices, choosing input devices for 3D interfaces.
Software technologies: database - world space, world coordinate, world environment, objects - geometry, position / orientation, hierarchy, bounding volume, scripts and other attributes, VR environment - VR database, tessellated data, LODs, Cullers and Occluders, lights and cameras, scripts, interaction - simple, feedback, graphical user interface, control panel, 2D controls, hardware controls, room / stage / area descriptions, world authoring and playback, VR toolkits, available software in the market.

Module 3 [8 Lectures]
3D interaction techniques: 3D manipulation tasks, manipulation techniques and input devices, interaction techniques for 3D manipulation, design guidelines – 3D travel tasks, travel techniques, design guidelines - theoretical foundations of wayfinding, user centered wayfinding support, environment centered wayfinding support, evaluating wayfinding aids, design guidelines - system control, classification, graphical menus, voice commands, Gestrual commands, tools, mutimodal system control techniques, design guidelines, case study: mixing system control methods, symbolic input tasks, symbolic input techniques, design guidelines, beyond text and number entry.

Module 4 [7 Lectures]
Designing and developing 3D user interfaces: strategies for designing and developing guidelines and evaluation.
Advances in 3D user interfaces: 3D user interfaces for the real world, AR interfaces as 3D data browsers, 3D augmented reality interfaces, augmented surfaces and tangible interfaces, agents in AR, transitional AR-VR interfaces - the future of 3D user interfaces, questions of 3D UI technology, 3d interaction techniques, 3d UI design and development, 3D UI evaluation and other issues.

Module 5 [4 Lectures]
Virtual reality applications: engineering, architecture, education, medicine, entertainment, science, training.

Text Books/References:

1. Paul Mealy, Virtual & Augmented Reality for Dummies, John Wiley & Sons.
2. Alan B Craig, William R Sherman and Jeffrey D Will, "Developing Virtual Reality Applications: Foundations of Effective Design", Morgan Kaufmann.
3. Jan Erik Solem, Programming Computer Vision with Python, Shroff Publisher/O'Reilly Publisher
4. Gerard Jounghyun Kim, "Designing Virtual Systems: The Structured Approach".
5. Doug A Bowman, Ernest Kuijff, Joseph J LaViola, Jr and Ivan Poupyrev, "3D User Interfaces, Theory and Practice", Addison Wesley, USA

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

1. To analyse the hardware and software requirements.
2. To use the different intersection techniques.
3. To design 3D interfaces.

*****

Course Code	:	VAR-03
Course Title	:	Scientific and Engineering Data Visualisation
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	VAR

Course Objective:

- The student should be able to design principles and techniques for visualizing data.
- Practical experience building and evaluating visualization systems.
- Allow for project-based opportModuleies to identify, understand, analyze, prepare, and present effective visualizations on a variety of topics.

Course Contents:

Module 1 [7 Lectures]

Visualisation - Scientific and engineering perspective - Impact of Visualisation in product design, an overview of computer graphics for visualization –Types of data for visualisation, Introduction to tensors. role of pre-processor, solver and post processor in solving engineering problems.

Overview of massive data visualization: Simplification methods, Multi-resolution methods, External memory methods, Visual scalability.

Module 2 [9 Lectures]

Scalar visualisation techniques: Visualisation Goals, Representation of mesh and results data, mapping analysis results to Visualisations, one dimensional, two dimensional and 3D Scalar fields - Element face colour coding - contour display - Isosurface techniques - Marching Cubes algorithm - Particle sampling.

Module 3 [9 Lectures]

Visualization of flow data: Visualization mappings of flow data, Vector mapping - elementary icons - particle traces - streaklines, streamlines - streamribbons and streamtubes - global icons - Tensor mappings - elementary icons - global icons.

Module 4 [7 Lectures]
Continuum volume display: Volume rendering Terminology, Surface and Volume rendering techniques, Optimisation.

Module 5 [10 Lectures]
Applications of engineering visualisation: Case studies created in the laboratory.
FUTURE TRENDS: Trends in Computing Hardware, Animation, Video and multi-media, software trends in Visualisation.

Text Books/References:

1. Torsten Möller and Bernd Hamann Robert D Russell, "Mathematical Foundations of Scientific Visualization, Computer Graphics and Massive Data Exploration", Springer-Verlag Berlin Heidelberg
2. Helen Wright, "Introduction to Scientific Visualization", Springer.
3. Richard S Gallagher, "Computer Visualization: Graphics Techniques for Engineering and Scientific Analysis", CRC Press, CRC Press LLC.

Course Outcomes: After completion of course, students would be able:
1. To design processes to develop visualization methods and visualization systems, and methods for their evaluation.
2. To complete preparation and processing of data, visual mapping and the visualization.
3. To analyze large-scale abstract data.

*****

Course Code	:	VAR-04
Course Title	:	Mathematical Modelling and Computer Aided Engineering
Number of Credits	:	3 (L: 3; T: 0; P: 0)
Course Category	:	VAR

Course Objective:
- Students should be able to formulate, analyze and apply mathematical models.
- Students should be able to understand the necessary mathematical abstraction to solve problems.

Course Contents:

Module 1 [12 Lectures]
Introduction: problems in engineering-structural - fluid flow and heat transfer with their relevance in product development - examples - need for computer aided engineering.
Partial differential equations: elliptic, parabolic and hyperbolic - physical significance - solution techniques.
Numerical methods to solve PDEs: central differences, Crank-Nicolson and ADI methods - examples - stability and error of numerical schemes.

Module 2 [6 Lectures]
Variational calculus: introduction, solutions selected differential equations by Variational methods, Rayleigh - Ritz method - introduction to finite element method.

Module 3 [8 Lectures]
Finite element method: concepts, nodes, elements, connectivity, coordinate systems, shape functions, stiffness matrix, global stiffness matrix, Isoparametri elements solution methods – examples- use of software.

Module 4 [6 Lectures]
Fluid flow: introduction to computational fluid dynamics (finite difference, finite element techniques) - formulation of fluid flow problems (simple cases only) - Navier-Stokes equation - solution techniques - examples, solution of fluid flow problems using software.

Module 5 [10 Lectures]
Heat transfer: derivation of energy equation in general form - solutions using numerical methods (finite difference and finite element techniques), solutions using FEA and CFD techniques for conductive and convective heat transfer problems.
Introduction to multi-physics problems: electrophoresis, electro-osmosis, lab-on – chip used in biotechnology use of software.

Text Books/References:

1. Reddy J N, "An Introduction to the Finite Element Method", Tata McGraw Hill.
2. Singerasu S Rao, "The Finite Element Method in Engineering", Butterworth Heinemann.
3. Curtis F Gerald Patrick O Wheatley, "Applied Numerical Analysis", Pearson.
4. Muralidhar K and Sundararajan T, "Computational Fluid Flow and Heat Transfer", Narosa Publications.

Course Outcomes: After completion of course, students would be able:
1. To describe the basics of partial differential equations and numerical methods.
2. To understand the methods of finite element methods.
3. To understand the methods fluid flow techniques.

*****

Course Code	:	VAR-05
Course Title	:	Mobile VR and AI in Moduley
Number of Credits	:	4 (L: 3; T: 0; P: 2)
Course Category	:	VAR

Course Objective:
- To give students hands-on exposure to mobile virtual reality in Moduley.
- To give students experience with basic AI algorithms in virtual reality.
- To provide students with fundamentals of game designs in virtual reality.

Course Contents:

Module 1 [12 Lectures]
Introduction to Moduley, Moduley Editor, Moving a Cube, Lights, Particle Systems, Applying Physics, and Moduley Asset Store, C# Coding Introduction, Variables, Methods, If Blocks, Loops, Hello Mammoth, User Interaction in Moduley, Inputs Introduction Preview, Key Presses, Moving a Player, Jumping, Moving Forward, Cycling Cameras, Prefabs Introduction, What are Prefabs?, Instantiating Objects, Random Angles, Destroying Objects, Explosion Effects, Adding Explosion Effects.

Module 2 [6 Lectures]

Developing a Pathfinding Game, How to Set Up a Project, Node, String Map, A* Algorithm Setup, A* Algorithm Loop, Auxiliary Methods, Finishing the Algorithm, Importing 2D Assets, Building a Level, From Console to Visual, Adding Tanks, Identifying Nodes, Moving the Tank, Visually Moving Tank, Smooth Movement, Smooth Rotation, Ordering Tank to Move, Speeding up Player, Spawning Logic, Crate Visuals, Adding Crates to Valid Positions, Collecting Crates, Score Counting, Game Interface, Starting the Game, Game Over Screen, Scoring, Sounds.

Module 3 [8 Lectures]
VR Introduction - Moduley, Activating VR, Building a Castle, Camera Changing Position, Lowering Castle Doors, Triggering Events Interface, Blender, Download and Install Blender, Introduction & Customizing Settings, Controlling Blender Camera, Emulate Numpad Camera, Manipulating Objects, Common Tools, Mirroring 1 Side of Object. Case Study: Flappy bird Moduley game, First person shooter game, Kart Moduley game.

Module 4 [6 Lectures]
Introduction to Moduley-ML, Why Machine Learning, different kinds of learnings, Neural Networks (NNs), Training a NN, Optimizer, Convolutional layers, Transfer learning, Imitation learning in Moduley, Training the kart in kart game via IL, Testing the drive.

Module 5 [10 Lectures]
Introduction to Reinforcement Learning in Moduley-ML, Reinforcement Learning, Initial state, training a policy, The PPO algorithm, Evolutional Strategies, Reward, training a kart in the kart game with RL, Tensor board analysis, Testing results.

Text Books/References:

1. Linowes, J., & Schoen, M. (2016). Cardboard VR Projects for Android. Packt Publishing Ltd.
2. Lanham, M. (2019). Hands-On Deep Learning for Games: Leverage the power of neural networks and reinforcement learning to build intelligent games. Packt Publishing Ltd.
3. Aversa, D., Kyaw, A. S., & Peters, C. (2018). Moduley Artificial Intelligence Programming: Add powerful, believable, and fun AI entities in your game with the power of Moduley 2018! Packt Publishing Ltd.

Software/Hardware Requirements: Moduley 2017 and 5.4.3f1; Moduley ML; Google cardboard or a compatible headset; A smart phone with 2-3 GB RAM, 16 GB of storage space, Qualcomm® Snapdragon™ 675 or higher.

Course Outcomes: After completion of course, students would:

1. To learn to code for game development in Moduley C#
2. To understand the fundamentals of game design.
3. To learn to use AI algorithms (A*, IL, and RL) in Moduley-ML.

******

Artificial Intelligence and Machine Learning

Blockchain

Cyber Security

Data Science

Internet of Things (IoT)

Robotics

Virtual and Augmented Reality

ALL INDIA COUNCIL FOR TECHNICAL EDUCATION

Nelson Mandela Marg, Vasant Kunj, New Delhi 110070

www.aicte-india.org