B.S. Abdur Rahman ™
Crescent
Institute of Science & Technology
Deemed to be University u/s 3 of the UGC Act, 1956

Regulations 2021
Minor Degree Programmes

Curriculum and Syllabi

MINOR DEGREE PROGRAMME

REGULATIONS 2021

CURRICULUM AND SYLLABI

TABLE OF CONTENT

LIST OF MINOR DEGREE PROGRAMMES OFFERED UNDER REGULATIONS 2021

Sl. No.	Minor Degree	Eligible Major Degree Programmes	Offering School	Offering Department
1.	Artificial Intelligence and Machine Learning	Mechanical Engineering Aeronautical Engineering Polymer Engineering Automobile Engineering Civil Engineering Biotechnology Electrical and Electronics Engineering Electronics and Instrumentation Engineering	School of Computer, Information & Mathematical Sciences	Department of Computer Science & Engineering
2.	Block Chain			Department of Computer Science & Engineering
3.	Cyber Security			Department of Information Technology
4.	Data Science			Department of Computer Science & Engineering

Sl. No.	Minor Degree	Eligible Major Degree Programmes	Offering School	Offering Department
5.	Virtual and Augmented Reality	Mechanical Engineering Aeronautical Engineering Polymer Engineering Automobile Engineering Civil Engineering Biotechnology Electrical and Electronics Engineering Electronics and Instrumentation Engineering Electronics and Communication Engineering		Department of Computer Science & Engineering
6.	Sensor Technology	Mechanical Engineering Aeronautical Engineering Polymer Engineering Automobile Engineering Civil Engineering Biotechnology Electrical and Electronics Engineering		Department of Information Technology

Sl. No.	Minor Degree	Eligible Major Degree Programmes	Offering School	Offering Department
7.	Robotics	Artificial Intelligence and Data Science Computer Science and Engineering (Cyber Security) Computer Science and Engineering (IoT) Computer Science and Engineering Information and Technology Civil Engineering Biotechnology Electrical and Electronics Engineering Electronics and Instrumentation Engineering	School of Mechanical Sciences	Department of Mechanical Engineering
8.	3D Printing	Artificial Intelligence and Data Science Computer Science and Engineering (Cyber Security) Computer Science and Engineering (IoT) Computer Science and Engineering Information and Technology		Department of Mechanical Engineering

Sl. No.	Minor Degree	Eligible Major Degree Programmes	Offering School	Offering Department
		Biotechnology Electrical and Electronics Engineering Electronics and Instrumentation Engineering Electronics and Communication Engineering		
9.	Electric Vehicles	Artificial Intelligence and Data Science Computer Science and Engineering (Cyber Security) Computer Science and Engineering (IoT) Computer Science and Engineering Information and Technology Civil Engineering Biotechnology Electronics and Communication Engineering	School of Electrical & Communication Sciences	Department of Electrical & Electronics Engg.
10.	Internet of Things (IoT)	Mechanical Engineering Aeronautical Engineering Polymer Engineering		Department of Electronics & Communication

Sl. No.	Minor Degree	Eligible Major Degree Programmes	Offering School	Offering Department
		Automobile Engineering Civil Engineering Biotechnology Electrical and Electronics Engineering Electronics and Instrumentation Engineering		Engg.
11.	Industrial Automation	Artificial Intelligence and Data Science Computer Science and Engineering (Cyber Security) Computer Science and Engineering (IoT) Computer Science and Engineering Information and Technology Mechanical Engineering Aeronautical Engineering Polymer Engineering Automobile Engineering Civil Engineering Biotechnology Electronics and Communication		Department of Electrical & Instrumentation Engg.

Sl. No.	Minor Degree	Eligible Major Degree Programmes	Offering School	Offering Department
		Engineering		
12.	GIS and Remote Sensing	Artificial Intelligence and Data Science Computer Science and Engineering (Cyber Security) Computer Science and Engineering (IoT) Computer Science and Engineering Information and Technology Mechanical Engineering Aeronautical Engineering Polymer Engineering Automobile Engineering Biotechnology Electrical and Electronics Engineering Electronics and Instrumentation Engineering Electronics and Communication Engineering	School of Infrastructure	Department of Civil Engineering
13.	Computational Biology	Artificial Intelligence and Data Science	School of Life Sciences	School of Life Sciences

Sl. No.	Minor Degree	Eligible Major Degree Programmes	Offering School	Offering Department
		Computer Science and Engineering (Cyber Security) Computer Science and Engineering (IoT) Computer Science and Engineering Information and Technology Mechanical Engineering Aeronautical Engineering Polymer Engineering Automobile Engineering Civil Engineering Electrical and Electronics Engineering Electronics and Instrumentation Engineering Electronics and Communication Engineering		

SCHOOL OF COMPUTER, INFORMATION AND MATHEMATICAL SCIENCES

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

MINOR DEGREE - ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

CURRICULUM AND SYLLABUS

S. No	Semester	Course Code	Course Title	L	T	P	C
1	I	CSAI 3142	Artificial Neural Networks	3	0	0	3
2		CSAI 3145	Pattern Recognition	3	0	0	3
3		CSAI 3146	Machine Learning Techniques	3	0	0	3
							9
4	II	CSAI 1241	Introduction to Artificial Intelligence	3	0	0	3
5		CSAI 1242	Python Programming	3	0	1	4
6			Project	0	0	2	2
			* Value Added Course	-			
							9
			Total Credits				**18**

CSAI 3142 ARTIFICIAL NEURAL NETWORKS L T P C
3 0 0 3

OBJECTIVES:

This course aims

- To study Artificial Neural Networks and its Applications in Computer Field
- To understand the basics of ANN and comparison with Human brain
- To study about various methods of representing information in ANN
- To learn various architectures of building an ANN and its applications
- To understand the Pattern classification and Pattern Association techniques
- To learn the skills of applying ANN concepts to solve Real-time Optimization Problems

MODULE I INTRODUCTION 8

Definition of ANN - Biological Neural Networks - Applications of ANN – Typical Architectures - Setting the weights - Common Activation functions - Development of Neural Networks - McCulloch - Pitts Neuron

MODULE II SIMPLE NEURAL NETS FOR PATTERN CLASSIFICATION 7

General discussion - Hebb net - Perceptron - Adaline - Backpropagation neuralnet- Architecture - Delta Learning Rule Algorithm - Applications

MODULE III NEURAL NETS BASED PATTERN RECOGNITION 7

Introduction to Feedforward Neural networks - Feedforward Networks and training by Back Propagation - Content Addressable Memory Approaches and Unsupervised - Learning in Neural PR.

MODULE IV PATTERN ASSOCIATION 8

Training Algorithm for Pattern Association - Heteroassociative memory neural network applications - Autoassociative net - Iterative Autoassociative net - Bidirectional Associative Memory - Applications

MODULE V NEURAL NETS BASED ON COMPETITION 7

Fixed Weights Competitve Nets - Kohonen's Self - Organizing Map - Applications - Learning Vector Quantization - Applications - Counter Propagation Network - Applications.

MODULE VI ADAPTIVE RESONANCE THEORY AND NEOCOGNITRON 8

Motivation - Basic Architecture - Basic Operation - ART1 - ART2 - Architecture - Algorithm - Applications - Analysis Probabilistic Neural Net - Cascade Correlation Neocognitron: Architecture - Algorithm - Applications.

L = 45; T = 0; TOTAL HOURS = 45

TEXT BOOKS

1. Samarasinghe, Sandhya. Neural networks for applied sciences and engineering: from fundamentals to complex pattern recognition. Crc Press, 2016.

REFERENCES

1. Patterson, Josh, and Adam Gibson. Deep learning: A practitioner's approach. " O'Reilly Media, Inc.", 2017.
2. Heaton, Jeff. AIFH, Volume 3: Deep Learning and Neural Networks. 2015.
3. http://www.cs.stir.ac.uk/~lss/NNIntro/InvSlides.html
4. http://www.willamette.edu/~gorr/classes/cs449/intro.html
5. http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-867-machine-learning

OUTCOMES:

Upon the completion of this course, the students will be able to meet the following outcomes:

- Understand the important concepts of Neural networks.
- Understand different ANN techniques like Feedforward Neural Networks, Probabilistic Neural networks and their combination.
- Implement algorithms based on ANN.
- Apply neural network techniques to solve engineering or real life problems.
- Understand the various architectures of building an ANN and its applications
- Implement various methods of data interpretation using ANN

CSAI 3145	PATTERN RECOGNITION	L	T	P	C
		3	0	0	3

OBJECTIVES:

This course aims:

- To learn the basics of Pattern Classifier
- To learn Feature extraction, Classification and Recognition techniques
- To learn recent advances in pattern classification
- To introduce the concepts of statistical and syntactic pattern recognition
- To understand the fundamentals of fuzzy sets and fuzzy logic
- To know aboutthe recent applications and real-time case studies in pattern recognition

MODULE I PATTERN RECOGNITION OVERVIEW 8

Pattern recognition, Classification and Description - Patterns and feature Extraction with Examples - Training and Learning in PR systems - Pattern Recognition Approaches - Statistical pattern recognition - Syntactic pattern recognition - Neural pattern recognition - other approaches to PR

MODULE II STATISTICAL PATTERN RECOGNITION 8

Introduction to statistical Pattern Recognition - supervised Learning using Parametric and Non Parametric Approaches. Linear Discriminant Functions Introduction - Discrete and binary Classification problems - Techniques to directly Obtain Linear Classifiers

MODULE III SYNTACTIC PATTERN RECOGNITION 7

Overview of Syntactic Pattern Recognition - Syntactic recognition via parsing and Other Grammars - Graphical Approaches to syntactic pattern recognition – learning via grammatical Inference.

MODULE IV NEURAL PATTERN RECOGNITION 8

Introduction to Neural networks - Feedforward Networks and training by Back Propagation - Content Addressable Memory Approaches and Unsupervised Learning in Neural PR.

MODULE V APPLICATIONS AND CASE STUDIES 7

Web Applications - Audio and Video Analysis - Medical Applications – Image processing - Financial Applications - Related case studies

MODULE VI APPLICATIONS AND CASE STUDIES 7

Web Applications - Audio and Video Analysis - Medical Applications – Image processing - Financial Applications - Related case studies

L = 45; T = 0; TOTAL HOURS = 45

TEXT BOOKS

1. Nyström, Ingela, Yanio Hernández Heredia, and Vladimir MiliánNúñez, eds. Progress in Pattern Recognition, Image Analysis, Computer Vision, and Applications: 24th Iberoamerican Congress, CIARP 2019, Havana, Cuba, October 28-31, 2019, Proceedings. Vol. 11896. Springer Nature, 2019.

REFERENCES

1. Gopi, E. S. Pattern Recognition and Computational Intelligence Techniques Using Matlab. Springer Nature, 2019.
2. Chollet, Francois. Deep Learningmit Python und Keras: Das Praxis-HandbuchvomEntwickler der Keras-Bibliothek. MITP-Verlags GmbH & Co. KG, 2018.

OUTCOMES:

Upon completion of the course, the students will be able to perform all the following outcomes:

- Understand the basic concepts in pattern recognition
- Formulate and describe various applications in pattern recognition
- Gain knowledge about state-of-the-art algorithms used in pattern recognition research
- Understand pattern recognition theories, such as Bayes classifier, linear discriminant analysis, principle component analysis.
- Demonstrate successful applications to process and analyse images, and to make automatic decisions based on extracted feature information
- Applying different pattern recognition techniques for providing solution to a specific problem domain.

CSAI 3146 MACHINE LEARNING TECHNIQUES L T P C
3 0 0 3

OBJECTIVES:

This course aims

- To understand the need for machine learning based on the scenario of application.
- To study the various supervised, semi-supervised and unsupervised learning algorithms in machine learning
- To study the innovative methods in machine learning
- To strategy suitable machine learning algorithms for problem solving.
- To generate graphical models from the data for better learning.
- To analysis various algorithms that learn massive quantities of data within less time and resources to train it properly.

MODULE I INTRODUCTION TO MACHINE LEARNING 8

Learning – Examples of Machine Learning Applications– Supervised Learning – Vapnik-Chervonenkis (VC) Dimension -Probably Approximately Correct (PAC) Learning- Noise - Learning Multiple Classes - Regression - Model Selection and Generalization

MODULE II NEURONS, NEURAL NETWORKS, AND LINEAR DISCRIMINANTS 7

The Brain and The Neuron - Neural Networks -The Perceptron - Linear Separability - Linear Regression - The Multi-Layer Perceptron- Back-Propagation of Error- Multi-Layer Perceptron

MODULE III LEARNING FUNCTIONS USING OPTIMIZATION 8

Radial Basis Functions and Splines- Dimensionality Reduction- Probabilistic Learning- Support Vector Machines- Optimization and Search

MODULE IV EVOLUTIONARY MODEL 7

The genetic algorithm - reinforcement learning-Markova decision processes-learning with trees-decision trees-classification and regression trees (cart)- boosting – bagging

MODULE V PROBABILISTIC MODELS 7

Unsupervised Learning – K means Algorithms –Vector Quantization – Self Organizing Feature Map-Markov Chain Monte Carlo (MCMC) Methods

MODULE VI GRAPHICAL MODELS 8

Bayesian Networks – Markov Random Fields – Hidden Markov Models – Tracking Methods-Energetic Learning: The Hopfield Network- Stochastic Neurons — The Boltzmann Machine-Deep Learning

L – 45; T – 0; Total Hours - 45

TEXT BOOKS

1. AurélienGéron -Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts. SecondEdition,O'reilly,2019.
2. Stephen Marsland, —Machine Learning – An Algorithmic Perspectivell, Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2018.
3. EthemAlpaydin, —Introduction to Machine Learning 3e (Adaptive Computation and Machine Learning Series)ll, Third Edition, MIT Press, 2019
4. Jason Bell, —Machine learning – Hands on for Developers and Technical Professionalsll, First Edition, Wiley, 2014
5. Peter Flach, —Machine Learning: The Art and Science of Algorithms that Make Sense of Datall, First Edition, Cambridge University Press, 2012.
6. Tom M Mitchell, —Machine Learningll, First Edition, McGraw Hill Education, 2013.

REFERENCES

1. Müller A , Guido S. Introduction to Machine Learning With Python. 1st ed. Schanafelt D, editor. Sebastopol: O'Reilly Media; 2016.

2. Coelho LP, Richert W. Building Machine Learning Systems with Python. 2nd Revised Edition. Birmingham: edPackt Publishing, 2015.

OUTCOMES:

Upon the completion of this course, the students will be able to meets the following outcomes:

- Analyze and distinguish between different learning methods.
- Differentiateamid the data for different learning such as supervised, unsupervised and

semi-supervised learning

- Apply the suitable machine learning algorithms for any given problem
- Proposeasuitable algorithm algorithm for any specified problem
- Enterprise systems that uses the suitable graph models of machine learning
- Modify existing machine learning algorithms to improve classification efficiency

CSAI 1241 INTRODUCTION TO ARTIFICIAL INTELLIGENCE L T P C
3 0 0 3

OBJECTIVES:

This course aims

- To impart concepts of the concepts of Artificial Intelligence.
- To learn the methods of solving problems using Artificial Intelligence.
- To introduce the fundamental concepts of Expert Systems
- To study about problem solving techniques using various AI based algorithms
- To understand various knowledge representation techniques.
- To provide knowledge of AI systems and its variants

MODULE I INTRODUCTION 8

Introduction - Foundation and history of AI. AI Problems and techniques - AI programming languages –Introduction to LISP and PROLOG – Problem spaces and searches -Blind search strategies; Breadth first -Depth first –Heuristic search techniques Hill climbing - Best first – A* algorithm AO* algorithm – game trees-Minimax algorithm – Game playing – Alpha beta pruning.

MODULE II KNOWLEDGE REPRESENTATION 8

Knowledge representation issues – Predicate logic – logic programming – Sematic nets - Frames and inheritance - constraint propagation –Representing Knowledge using rules – Rules based deduction system.

MODULE III REASONING UNDER UNCERTAINTY 8

Introduction to uncertain knowledge review of probability – Baye's Probabilistic inferences and Dempster Shafer theory –Heuristic methods – Symbolic reasoning under uncertainty- Statistical reasoning – Fuzzy reasoning – Temporal reasoning- Non monotonic reasoning.

MODULE IV PLANNING AND LEARNING 7

Planning - Introduction, Planning in situational calculus - Representation for planning – Partial order planning algorithm- Learning from examples- Discovery as learning – Learning by analogy – Explanation based learning –Introduction to Neural nets – Genetic Algorithms

MODULE V EXPERT SYSTEMS 7

Expert systems - Architecture of expert systems, Roles of expert systems - Knowledge Acquisition - Meta knowledge, Heuristics. Typical expert systems - MYCIN, DART, XOON, Expert systems shells.

MODULE VI APPLICATIONS 7

Principles of Natural Language Processing Rule Based Systems Architecture - AI application to robotics - Current trends in Intelligent Systems

L – 45; T – 0; Total Hours - 45

TEXT BOOKS

1. Daugherty, Paul R., and H. James Wilson. Human+ machine: reimagining work in the age of AI. Harvard Business Press, 2018.
2. Prateek, J.: Artificial Intelligence with Python, pp. 14–16. Packt Publishing, Birmingham (2017)

REFERENCES

1. Husain, Amir. The sentient machine: The coming age of artificial intelligence. Simon and Schuster, 2017.
2. Kaplan, Jerry. Artificial intelligence: What everyone needs to know. Oxford University Press, 2016.

OUTCOMES:

Upon the completion of this course, the students will be able to meets the following outcomes:

- An ability to analyze a problem, identify and define the computing requirements appropriate to its solution.
- An ability to design, implement and evaluate a system / computer based system process, component or program to meet desired needs
- An ability to identify, formulate and solve engineering problems using the concepts of Artificial Intelligence.
- Design and conduct experiments as well as analyze and interpret data using Machine Learning Algorithms
- An ability to use current techniques and skills necessary for computing andengineering practice
- Get familiarized with the tools mandatory for handling problem solving techniques

CSAI 1242	PYTHON PROGRAMMING	L	T	P	C
		3	0	0	3

OBJECTIVES:

This course aims:

- To understand why Python is a useful scripting language for developers.
- To learn how to write loops and decision statements in Python.
- To learn how to design object-oriented programs with Python classes.
- To learn how to use exception handling in Python applications for error handling.
- To define the structure and components of a Python program.
- To learn how to build and package Python modules for reusability.

MODULE I INTRODUCTION TO PYTHON 8

Introduction to python - Applications of Python - Comments and Literals - Running Python scripts in Cloud Lab - Variables - Data types and Operators - Conditional Statements, Loops - Reading from and Writing to a file - Sequences in Python - Standard Libraries - Built-in Functions - Distinct types of Function Arguments - Lambda Functions - Scope of Variables

MODULE II PYTHON OOPS 8

Built-in Modules - Regular Expressions - User Defined Modules – Packages Object-oriented Programming - Classes and Objects - Public, Private and Protected Attributes - Constructors and Destructors - Encapsulation - Abstraction - Inheritance - Polymorphism - Exception Handling - User Defined Exceptions

MODULE III PYTHON NUMPY AND PANDAS 7

Introduction to Data Analysis - Why use Python for Data Analysis - Introduction to NumPy - Creating NumPy Array - Indexing of NumPy Array - NumPy Array Attributes - Introduction to Pandas - Importing and Exporting data - Creating Series and DataFrames

MODULE IV DATA PRE-PROCESSING 7

Data Pre-processing - Data Acquisition - Handling Null Values - Handling the Categorical Values - Label Encoder - One Hot Encoder Scaling - Standard Scaler - Min-Max Scaler - Robust Scaler - Normalization - Sampling

MODULE V DATA MANIPULATION AND DATA VISUALIZATION 9

Introduction to Data Manipulation - Basic Functionalities of pandas Series - Basic Functionalities of pandas DataFrames - Grouping and Aggregating DataFrames - Concatenating, Merging and Joining DataFrames - Extracting Insights from a Dataset, Introduction to Data Visualization - Libraries available for Visualization - Basics of plotting graphs in Matplotlib - Distinct types of plots in Matplotlib - Distinct types of plots in Seaborn

MODULE VI DATA VISUALIZATION 6

Introduction to Data Visualization - Libraries available for Visualization - Basics of plotting graphs in Matplotlib - Distinct types of plots in Matplotlib - Distinct types of plots in Seaborn

L = 45; T = 0; TOTAL HOURS = 45

TEXT BOOKS

1. Matthes, E. Python crash course: a hands-on, “Project-based introduction to programming”, 2015
2. Fuhrer, C., Solem, J. E., &Verdier, O. Scientific computing with Python 3: Packet Publishing Ltd, 2016.

REFERENCES

1. Guzdial, M., & Ericson, B. Introduction to computing and programming in python: Pearson, 2016

OUTCOMES:

Upon completion of the course, the students will be able to perform all the following outcomes:

- Understand the basic concepts in Python Programming
- Familiarize with object-oriented concepts and Implement exception handling
- Create arrays using NumPy and understand Pandas and how to employ it for data manipulation
- Implement different techniques of Data Pre-processing and handling data cleaning techniques
- Perform function manipulations on Data objects, perform Concatenation, Merge and Join on DataFrames
- Create simple visualizations like scatter plot, histogram, bar graph, pie chart using Matplotlib

CSAI 1244	PYTHON PROGRAMMING LAB	L	T	P	C
		0	0	2	1

OBJECTIVES:

This course aims to learn about:

- Basics of Python programming
- Decision Making and Functions in Python
- Object Oriented Programming using Python
- Files Handling in Python
- GUI Programming and Databases operations in Python
- Network Programming in Python

LIST OF PROGRAMS

1. Write a Python program to make a simple calculator
2. Write a Python program to manipulate various data types - Lists, Tuples, Sets, Dictionaries
3. Write a Python program to handle exception in Python.
4. Write a Python program to perform indexing and slicing operations in Python
5. Write a Python program to perform various operations on dataframe and numpy array.
6. Write a Python program to handle categorical values - Label Encoding, OneHot Encoding
7. Write a Python program to perform scaling the Data - StandardScaler, MinMaxScaler, RobustScaler.
8. Write a Python program to perform groupby operations.
9. Write a program to perform merging and joining operations on dataframe
10. Write a program to create various plots like histogram, bar plot, scatterplot heatmap, countplot, boxplot.

TOTAL HOURS = 15

OUTCOMES:

Upon completion of the course, the students will be able to perform all the following outcomes:

- Describe the Numbers, Math functions, Strings, List, Tuples and Dictionaries in Python.
- Express different Decision Making statements and Functions
- Interpret Object oriented programming in Python
- Understand and summarize different File handling operations
- Explain how to design GUI Applications in Python and evaluate different database operations
- Design and develop Client Server network applications using Python

SCHOOL OF COMPUTER, INFORMATION AND MATHEMATICAL SCIENCES

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

MINOR DEGREE - BLOCKCHAIN

CURRICULUM AND SYLLABUS

Sl.no	Course Code	Course Title	L	T	P	C
1		Information Security and Cryptography	3	0	2	4
2		Introduction to Blockchain	3	0	0	3
3		Python Programming in Blockchain	3	0	2	4
4		Distributed Computing & Ledger Technologies	3	0	0	3
5		Blockchain Development with Corda	3	0	2	4
6		Project	0	0	3	3
					Total Credits	21

INFORMATION SECURITY AND CRYPTOGRAPHY

L	T	P	C
3	0	2	4

OBJECTIVES:

- To provide knowledge on fundamental concepts of network, data structures & security attacks.
- To elucidatevarious Cryptography Theories, Algorithms and Systems.
- To provide knowledgeabout concept of confidentaility and modular arithmatics.
- To make them understand necessary Approaches and Techniques to build protectionmechanisms.
- To familarize with variouscryptographic techniques and algorithm.
- To exert an analyzing capabilityto define the arithmetic techniques for securing a system, network or information.

MODULE I FUNDAMENTAL CONCEPTS 7

Introduction to Networks - Networks model and topology, Network elements, network protocols & routing,**Introduction to Data Structures** - Concept of data, Data object, Data structure, Abstract Data Types, Concept of Primitive and non-primitive, linear and Non-linear, static and dynamic, persistent and transient data structures.Introduction to security attacks, introduction to cryptography - Classical Encryptiontechniques - substitution ciphers and transposition ciphers – cryptanalysis, stream and blockciphers.

MODULE II BLOCK CIPHERS 6

Block Ciphers: Block ciphers principals - Shannon's theory of confusion anddiffusion - fiestal structure - data encryption standard(DES) - strength of DES - differential and linearcrypt analysis of DES - block cipher modes of operations - triple DES – AES.

MODULE III CONFIDENTIALITY AND MODULAR ARITHMETIC 8

Confidentiality using conventional encryption - traffic confidentiality - key distribution - random number generation - Introduction to graph - ring and field - prime and relative prime numbers - modular arithmetic - Fermat's and Euler's theorem - primality testing - Euclid's Algorithm - Chinese Remainder theorem - discrete algorithms.

MODULE IVPUBLIC KEY CRYPTOGRAPHY 8

Principles of public key crypto systems - RSA algorithm - security of RSA - key management – Diffle-Hellman key exchange algorithm - introductory idea of Elliptic curve cryptography – Elgamel encryption - Message Authentication and Hash Function: Authentication requirements - authentication functions - message

authentication code - hash functions - birthday attacks – security of hash functions and MACS.

MODULE V AUTHENTICATION ALGORITHMS 8

MD5 message digest algorithm - Secure hash algorithm (SHA) Digital Signatures: Digital Signatures - authentication protocols - digital signature standards (DSS) - proof of digital signature algorithm - Authentication Applications: Kerberos and X.509 - directory authentication service - electronic mail security-pretty good privacy (PGP) - S/MIME.

MODULE VIWEB, SYSTEM AND CYBER SECURITY 8

IP Security: Architecture - Authentication header - Encapsulating security payloads - combining security associations - key management. Web Security: Secure socket layer and transport layer security - secure electronic transaction (SET) - System Security: Intruders - Viruses and related threads - firewall design principals – trusted systems. Cyber Security: Footprinting & System Hacking, Network Scanning, Firewall, Cyber Threats and Attacks: Malware, Denial-of-service attacks, Man-in-the-middle attack, Social engineering attacks, Spoofing, Phishing.

Total Hours: 45

REFERENCES:

1. William Stallings, Cryptography and Network Security: Principles and Practice, PHI 3rd Edition, 2006.
2. C K Shyamala, N Harini and Dr. T R Padmanabhan: Cryptography and Network Security, Wiley India Pvt.Ltd.
3. BehrouzA.Foruzan, Cryptography and Network Security, Tata McGraw Hill 2007.
4. Charlie Kaufman, Radia Perlman, and Mike Speciner, Network Security: PRIVATECommunication in a PUBLIC World, Prentice Hall, ISBN 0-13-046019-2.

OUTCOMES:

On completion of this course, students will be able to

- Understand the fundamental concepts of network, data structures & security attacks.
- understand and applyvarious Cryptography Theories, Algorithms and Systems.
- Attain knowledge about confidentaility and modular arithmatics.
- understand necessary Approaches and Techniques to build protectionmechanisms.
- familarize with various cryptographic techniques and algorithm.
- analyze& define the arithmetic techniques for securing a system, network or information.

INTRODUCTION TO BLOCKCHAIN

L	T	P	C
3	0	0	3

OBJECTIVES:

- Acquire knowledge on fundamental concept of blockchain, Components and their interconnections.
- To acquire in depth knowledge of various techniquesofblockchain.
- To understand the concept of decetralization and its platforms.
- Familarize with diverse applications of blockchain in real world domains.
- To understand the process of mining and its applicability in real domain.
- Analyze and derive the applicability of smart contract, Proofs ofconcept, and mining.

MODULE I FUNDAMENTAL CONCEPTS 8

Blockchain:- Definition & Characteristics,Electronic Cash, Peer-to-peer network, ledger, Generic elements of blockchain,Benefits and Limitations of Blockchain, evolution of blockchain technology, Features of blockchain, **Types of blockchain**– Distributed Ledgers, Distributed Ledger Technology, Public and Private Blockchain, Shared Ledger, Fully Private and Propriety blockchains, Tokenised & Tokenless Blockchains, **Consensus** – Mechanism, Types of Consensus mechanism, consensus in blockchain, CAP theorem.

MODULE II BLOCKCHAIN ARCHITECTURE 7

Node, Distributed State Machine, Transactions – Transaction State, Transaction Format, Linked Transactions, Blocks – Block Header, Types of Blocks, Block Validity, Blockchains, Mining – Hashing, Mining Incentive, Consensus - 51-attack, proof of work protocols.

MODULE III DECENTRALIZATION 8

Network Basics – Centralised, decentralised and distributed networks.Methods of decentralization - disintermediation and competition. Decentralization Framework, Blockchain and full ecosystem decentralization–Storage, Communication and Processing Power, Smart contracts, Decentralized Organization - Types of decentralized organisations, Requirements, Platforms for decentralization.

MODULE IV CONSENSUS 8

Introduction- Need for Consensus, Uses of Consensus, Fault Types, Properties of Distributed Consensus. Consensus in Open System – Problems in open system, Consensus Mechanism – Proof of Work (PoW), Proof of Storage, Proof of Stake

(PoS), Proof of coinage, Proof of Deposit (PoD), Proof of Burn, Proof of Activity (PoA), Retargeting Algorithms.

MODULE V CRYPTOCURRENCY 8

History, Distributed Ledger, Bitcoin protocols - Mining strategy and rewards, Ethereum- Construction, DAO, Smart Contract, GHOST, Vulnerability, Attacks, Sidechain, Namecoin, Stakeholders.

MODULE VIAPPLICATIONS Of BLOCKCHAIN 6

Applications- Financial Transactions, Internet of Things, Medical Record Management System, Domain Name Service and future of Blockchain.

Total Hours: 45

REFERENCES:

1. Bashir, Imran. Mastering Blockchain: Distributed ledger technology, decentralization, and smart contracts explained. Packt Publishing Ltd, 2018.
2. Antonopoulos, Andreas M. Mastering bitcoin: Programming the open blockchain. " O'Reilly Media, Inc.", 2017.
3. Sze, Keizer. "Blockchain: Mastering Blockchain (Volume 2)." (2017).

OUTCOMES:

On completion of this course, students will be able to

- apply various blockchain techniques in real world applications.
- perform variousconsensus algorithms for authentication purposes.
- perform different mining techniques for transaction audit.
- choose the appropriate algorithms for implementing real time problems.
- validate consensus or cryptocurrency algorithms.
- perform case study on blockchain applications.

PYTHON PROGRAMMING IN BLOCKCHAIN **L T P C**
3 0 2 4

OBJECTIVES:

- Introduce the basic concepts of python programming with values and variables.
- Know the basic arithmetic operators syntax in program.
- Understand the conditional branching of programming flow.
- Understand the function parameters and their passing values.
- Apply the data structures and features in sorting and searching.
- Use the NumPy for performing complex numerical analysis tasks.

MODULE I INTRODUCTION **7**

Introduction to Python Programming, development tools, values and variables, integer values, variables and assignment, identifiers, floating point types, control codes with strings, user input, Eval function, print function

MODULE II ARITHMETIC EXPRESSION **6**

Expression and arithmetic, operator precedence and associatively, comments and errors, syntax errors, run time errors, logic errors, arithmetic operators

MODULE III CONDITION STAEMENTS **8**

Conditional execution, Boolean expressions, simple if statement, if/else, compound Boolean expressions, nested conditions, decision statements, conditional expressions. Iterations, while statement, definite vs indefinite loops, nested loops, abnormal loop termination

MODULE IV FUNCTIONS **8**

Functions, standard mathematics functions, time function, random function, importing function, writing own functions, parameter passing, custom function vs standard functions. Global variables, default variables, recursion, reusable functions, functions as data.

MODULE V LINEAR SEARCH **8**

Lists, List assignment, list bounds, slicing, list and functions, prime generation with list, sorting, flexible sorting, search, linear search, binary search, list permutation, random permutation, objects, string objects, list objects, Custom types - geometric, handling exceptions.

MODULE VI DATA PROCESSING USING NUMPY **8**

Understanding Data Types - The Basics of NumPy Arrays - Computation on NumPy Arrays - Universal Functions – Aggregations - Min, Max, Computation on Arrays- Sorting Arrays.

TOTALHOURS : 45

REFERENCES:

1. Jake VanderPlas, "Python Data Science Handbook", Jake. Published by O'Reilly Media,Inc., 1005 Gravenstein Highway North, Sebastopol, Copyright © 2019, ISBN-13:978-1491912050.
2. Jesus Rogel-Salazar "Data Science and Analytics with Python", CRC Press, ISBN:0367240416, 9780367240417, 2019.
3. Learning to Program with Python by Richard L. Halter man. (2011).
4. Guttag, John. Introduction to Computation and Programming Using Python. Spring2013 edition. MIT Press, 2013.

OUTCOMES:

On completion of this course, students will be able to

- Write code with basic data types and variable declarations.
- Performs calculations using arithmetic expressions.
- Performs control flow with conditional branching in program.
- Writes customised and standard function in a program.
- Stores data and performs sorting and searching operations.
- Perform installation of packages and apply various data manipulation techniques in python.

DISTRIBUTED COMPUTING & LEDGER TECHNOLOGIES	L	T	P	C
	3	1	0	4

OBJECTIVES:

- To provide knowledge about distributed computing paradigm.
- To gain insight on the core concepts of distributed systems.
- To dessiminate the mechanisms of inter process communication in distributed systems.
- To provide in depth knowledge about the Structure, Components and working of BitCoin Network.
- To elucidate the ecosystem of Ethereum Network.
- To provide knowledge about HyperLedger Fabric technology.

MODULE I INTRODUCTION TO DISTRIBUTED COMPUTING& LEDGER TECHNOLOGY 8

System models, issues, Distributed- computing environment web based distributed model, Inter process Communication – Message Passing, Synchronization, Buffering, Process Addressing, Remote Procedure Calls (RPC), Distributed Shared Memory – Granularity, Structure of Shared memory Space, Consistency Models, Synchronization - Clock Synchronization, Event Ordering, Mutual Exclusion, Election Algorithms. Introduction to Smart Contracts, Decentralized blockchain application.

MODULE II DISTRIBUTED LEDGER TECHNOLOGY 7

DLT–Definition, DLT Constructs, DLT designs – Bitcoin, Ripple, Ethereum, Corda, Microsoft Azure,Application of DLTs, Challenges in implementation of DLTs.

MODULE III SECURITY & APPLICATIONS OF DLT 6

Privacy and confidentiality of data, Security of DLTs,Fragmentation, Policy, regulatory, and legal issues relating to DLTs, Application of DLT technology to financial inclusion, healthcare, etc.

MODULE IV BITCOIN 8

Bitcoin – definition, payments, Digital keys – Private and public keys, addresses - Base58Check encoding, Vanity addresses, Transactions – life cycle, data Structure, Transaction types, verification. Blockchain – structure of block, bitcoin block header, genesis block, Mining – Tasks, rewards, Proof of Work (PoW), mining algorithm, The hash rate, Mining systems, Mining pools,Bitcoin network, Wallet, Alternative Coins

MODULE V ETHUREUM 8

Ethereum network– Mainnet, Testnet, Private Net, Components of the Ethereum ecosystem – Keys and addresses, Accounts, Transactions, Messages, Ether cryptocurrency, Ethereum Virtual Machine (EVM),Runtime bytecode, Blocks and blockchain, Fee schedule, Ethereum development environment.

MODULE VI HYPERLEDGER **8**

Hyperledger – definition, protocol, architecture, Fabric – Types of services, Distributed ledger - peer to peer protocol, Ledger storage, Chaincode services, Components of the fabric, Peers, World state database, Transactions, Smart contracts, Crypto service provider, The application model, Consensus in Hyperledger Fabric, Transaction Life Cycle.

Total Hours: 45

REFERENCES:

1. Mohanty, Debajani. R3 Corda for Architects and Developers: With Case Studies in Finance, Insurance, Healthcare, Travel, Telecom, and Agriculture. Apress, 2019.
2. Hill, Brenn, et al. Blockchain Developer's Guide: Develop smart applications with Blockchain technologies-Ethereum, JavaScript, Hyperledger Fabric, and Corda. Packt Publishing Ltd, 2018.
3. George Coulouris, Jean Dollimore and Tim Kindberg, Distributed Systems: Concepts and Design, Fifth Edition , Pearson Education, 2011
4. Pradeep K Sinha, Distributed Operating Systems: Concepts and Design, Prentice Hall of India.

OUTCOMES:

On completion of this course, students will be able to

- Distinguish distributed computing paradigm from other computing paradigms
- Identify the core concepts of distributed systems
- Illustrate the mechanisms of inter process communication in distributed system.
- Identify the Structure, Components and working of BitCoin Network.
- Identify the ecosystem of Ethereum Network.
- Identify and contrast the different DLT technologies with HyperLedger Fabric.

BLOCKCHAIN DEVELOPMENT WITH CORDA

L	T	P	C
3	0	2	4

OBJECTIVES:

- Introduce the basic concepts of Corda Environment.
- To provide the knowledge offundamentaloperations in Corda.
- To demostrate various Node Operationsin Corda.
- To Understand the structure and architecture of Cordapps.
- To develop the knowledge about various transactional flows in corda environment.
- To provide knowledge about advance operations in Corda development environment.

MODULE I INTRODUCTION 8

Introduction to Blockchain – Money Systems, Bussiness Models, Benefits, DLT vs Blockchain, Possible Attacks, development tools, DAGs, Fork in Blockchain, Visibilities in Blockchain Networks, Blockchain and DLT Protocols, Traditional blockchain architecture for GDPR Compliance, Tools Installation.

MODULE II CORDA ARCHITECTURE 6

Doorman Network Service, Node, Corda Ledger, Identity, State Objects, Contracts, Contract Code,Legal Prose,Transaction, Flow, Consensus, Notary, Time Window, Oracles, Vaults, Corda's Compliance with GDPR, Salient features of Corda.

MODULE III NODE OPERATIONS 8

Node folder structure, Node identity, Node configuration, Node command-line options, Node administration, Deploying a node to a server, Node database, Database tables, Upgrading CorDapps on a node, Node shell, Interacting with a node, Creating nodes locally, Running nodes locally, Flow Hospital, Node Services, Networking and Messaging..

MODULE IV CorDapps 8

Definition, Initial setup for CorDapp development, CorDapp Structure, Building and installing, Debugging, Secure coding guidelines, Configuring Responder Flows, Flow cookbook.

MODULE V TRANSACTIONS 7

Building transaction – life cycle of transactions, gathering inputs, generating commands, Generating outputs, Completing transaction, writing flows.

MODULE VIADVANCE OPERATIONS 8

Components of smart contract, Contract class, interface, abstract contract, State– class, methods andContractState interface, Commands, verify function, state groups, contract testing, upgrading contracts workflow.

Total Hours: 45

REFERENCES:

1. Mohanty, Debajani. R3 Corda for Architects and Developers: With Case Studies in Finance, Insurance, Healthcare, Travel, Telecom, and Agriculture. Apress, 2019.
2. Hill, Brenn, et al. Blockchain Developer's Guide: Develop smart applications with Blockchain technologies-Ethereum, JavaScript, Hyperledger Fabric, and Corda. Packt Publishing Ltd, 2018.
3. Brown, Richard Gendal, et al. "Corda: an introduction." R3 CEV, August 1 (2016): 15.

OUTCOMES:

On completion of this course, students will be able to

- Write code with basic operation declarations.
- Design and Apply Corda architecture in various application domains.
- Design and develop Cordapp for variousapplication flows.
- Writes customised and standard function in a program.
- Stores data and performs various node operations.
- Design and Perform various advance level concept in block chain development.

PROJECT	L	T	P	C
	0	0	3	3

GUIDELINES

The students undertake individual application project based on their interest level. The projects must be approved by the project coordinators.

REPORT AND DOCUMENTATION

- Students must maintain a lab record and update the project progress on a weekly basis.
- Must demonstrate during lab hours and update the project progress on a weekly basis.
- Must submit a detailed project report as per the common template for a Project Viva-voce examination.
- Monthly review will be conducted and evaluated by the coordinators.

PROJECT EVALUATION CRITERIA

The Project coordinators verify and validate the information presented in the project report.

The split-up of marks is as follows:

1. Internal Assessment
2. External Examination
3. Viva Voce

INTERNAL ASSESSMENT

Internal Evaluator must evaluate Internal Project work based on the following criteria:

- Project Scope, Objectives and Deliverables
- Software Requirement analysis, design, coding and testing skills
- Report writing and presentation skill

EXTERNAL EXAMINATION

The examiners make individual assessment based on the following criteria.

- Software Requirement Specifications
- Project Demonstration
- Project Report
- Viva Voce

VIVA VOCE

Confidence level, Programming knowledge, Professional approach and Communication Skill

TOTAL MARKS

1**.** Internal Evaluation: 75 %

2. External Evaluation: 25 %

INTERNAL EVALUATION FOR 75 MARKS

- Review1: 15 marks
- Review2: 15 marks
- Project Novelty: 5 marks
- SRS : 10 marks
- Design : 10 marks
- Coding : 10 Marks
- Testing : 5 marks

External Evaluation 25 marks

- Demonstration 5 marks
- Project Report: 10 marks
- Viva-Voce 10 marks

The Project evaluator(s) verifies and validates the information presented in the project report.

SCHOOL OF COMPUTER, INFORMATION AND MATHEMATICAL SCIENCES

DEPARTMENT OF INFORMATON TECHNOLOGY

MINOR DEGREE – CYBER SECURITY

CURRICULUM AND SYLLABUS

S. No.	Semester	Course Code	Course Title	L	T	P	C
1			Programming in Python	3	0	2	4
2			Security in Computing	3	0	0	3
3			Foundation to Cyber Security	3	0	0	3
4			Linux Programming Lab	0	0	2	1
5			Cyber Forensics	3	0	0	3
6			Ethical Hacking	2	0	2	3
7			Project	0	0	6	3
			* Value Added Course	-			
			Total Credits				**20**

PROGRAMMING IN PYTHON **L T P C**
3 0 2 4

OBJECTIVES:

- To understand the fundamentals of python programming.
- To develop python programs with conditional loops.
- To define and declare functions and call them.
- To explore file I/O and GUI using python programming.
- To acquire knowledge about networking and client-server using python programming.
- To learn the security packages and setup the hacking environment using python.

Pre-requisites: Computer Fundamentals, Programming in 'C' or 'C++'.

MODULE I PYTHON BASICS **8**

Overview and fundamentals of python, executing simple programs, exploring python variables, operators and comprehend python blocks.

MODULE II DATA TYPES AND PROGRAM FLOW CONTROLS **7**

Basic data types, numeric data types, string and string operations, list data types and slicing, tuples and its types, conditional blocks, control statements, looping statements, break statements, for loop, while loop using strings and dictionaries.

MODULE III FUNCTIONS , PACKAGES AND MODULES **8**

Organize functions using python code, import libraries and methods internally and externally, usage of external packages, powerful functions in python, understanding packages.

MODULE IV BULIDING BLOCKS OF PYTHON – METHODS **7**

String and dictionary manipulations, list manipulation using in build methods, programming using string, list and inbuilt functions, Exception handling and programs.

MODULE V DESIGN WITH CLASSES & GUI **8**

Objects and Classes – Case Study, Data Modeling – Case Study, Inheritance, Polymorphism, Terminal-Based Programs and GUI-Based programs – Simple GUI-based progams, Case Study: A GUI-Based ATM

MODULE VI NETWORKS AND CLIENT-SERVER **7**

Threads and Processes, Networks, Clients and Servers, Case Study: A Multi-Client Chat Room

Theory : 45 Hrs

Laboratory Practice

1. Implementation of simple python program by installing and exploring python IDE.
2. Programs to implement basic data types, tuples, strings, numeric data types and list data types.
3. Implement control statements and conditional blocks.
4. Implement looping statements – for, while and do-while.
5. Implement strings and dictionaries.
6. Programming using functions in python
7. Programming powerful functions in python.
8. Import basic packages and libraries and execute programs
9. Build methods using list and basic data structures.
10. Implement exception handling using python programs.
11. GUI development using Python.
12. Client-server programs
13. Use of python packages in the computer security environment.
14. Analyze systems for vulnerabilities and security flaws using python.

Lab : 30 Hrs

Total Hours : 75

Text Books

1. Kenneth A. Lambert, “Fundamentals of Python: First Programs”, Cengage Learning, 2012.
2. Charles Dierbach, “Introduction to Computer Science using Python: A Computational Problem-Solving Focus, Wiley India Edition, 2013.
3. Sanjib Sinha, “Beginning Ethical Hacking with Python”, Apress, 2017.

References

1. John V Guttag, “Introduction to Computation and Programming Using Python’’, Revised and expanded Edition, MIT Press , 2013
2. Robert Sedgewick, Kevin Wayne, Robert Dondero, “Introduction to Programming in Python: An Inter-disciplinary Approach, Pearson India Education Services Pvt. Ltd., 2016.
3. Timothy A. Budd, “Exploring Python”, Mc-Graw Hill Education (India) Private Ltd., 2015.

OUTCOMES:

Upon Completion of course the students will be able to :

- Write and execute python programs.
- Develop simple python programs to solve problems.
- Explore libraries in python and modular programs to functions.
- Develop data structures based on python programs.

- Use the python packages and analyze security threats using python.
- Develop client-server environment using python.

SECURITY IN COMPUTING

L	T	P	C
3	0	0	3

OBJECTIVES:

- To understand the basics of cryptography techniques.
- To know the techniques and motivations used by hackers.
- To explore the technological aspects of program and web security.
- To know the security mechanism given by operating system.
- To discover the network level security.
- To study the critical need for ensuring Information Security in database.

MODULE I CRYPTOGRAPHY **9**

Introduction - Computer Security – Threats - Harm – Vulnerabilities – Controls - Authentication - Access Control – Cryptography – Symmetric key & Asymmetric key encryption – Digital signatures.

MODULE II CYBER ATTACKER TECHNIQUES AND MOTIVATIONS **7**

Hackers Covering Their Tracks, Proxies, Tunnelling, Fraud Techniques, Phishing, Smishing, Vishing, Mobile Malicious Code, Rogue Antivirus, Click Fraud, Threat Infrastructure, Botnets, Honeypots

MODULE III PROGRAM & WEB SECURITY **7**

Unintentional (Nonmalicious) Programming errors – Malicious code – Malware - Viruses, Trojan Horses, and Worms – Countermeasures - The Web - Browser Attacks - Web Attacks Targeting Users - Email Attacks.

MODULE IV OPERATING SYSTEM SECURITY **7**

Memory and Address Protection - File Protection Mechanisms - User Authentication - Trusted Operating Systems - Designing Trusted Operating Systems- Assurance in Trusted Operating Systems

MODULE V NETWORK SECURITY **8**

Network Security Attacks - Threats to Network Communications - Wireless Network Security - Denial of Service - Security Countermeasures - Cryptography in Network Security – Firewalls - Intrusion Detection and Prevention Systems

MODULE VI DATABASE SECURITY **7**

Introduction - Security Requirements of Databases - Reliability and Integrity - Database Disclosure - Data Mining and Big Data

Total Hours : 45

REFERENCES:

1. Charles B. Pfleeger, Shari Lawrence Pfleeger, "Security in Computing", 5th Edition, Pearson Education, 2015.
2. William Stallings, "Cryptography and Network Security - Principles and Practices", 3rd Edition, Pearson Education, 2003.
3. Atul Kahate, "Cryptography and Network Security", Tata McGraw Hill, 2003.
4. James Graham, “Cyber Security Essentials”, CRC Press, 2011.

OUTCOMES:

Upon completion of this course, students will be able to

- Analyze the various cryptographic techniques in Information Security.
- Detect the techniques and motivations of attackers.
- Identify program level malicious code and provide control measures.
- Discuss operating system level security to assess trusted operating systems.
- Explain threats in network level scenarios.
- Outline database security requirements in multilevel databases.

FOUNDATION TO CYBER SECURITY

L	T	P	C
3	0	0	3

OBJECTIVES:

- To know the impact of various cybercrimes and cyber offenses.
- To understand cybercrimes in mobile devices.
- To know the tools and techniques used to secure from cybercrimes.
- To understand the basics of cyber security standards and policies.
- To learn about the basics of cyber forensics.
- To understand the basics of cyber laws.

MODULE I CYBERCRIME AND CYBEROFFENSES 7

Cybercrime and Information Security – Cybercriminals – Classifications of Cybercrimes – Email Spoofing – Spamming – Cyber defamation – Internet Time Theft – Forgery – Web jacking – Hacking – Online Frauds – Software Piracy – Mail Bombs – Password Sniffing – Cyberoffenses – Categories – Planning the attacks – Cyberstalking – Cybercafe and Cybercrimes.

MODULE II CYBERCRIME: MOBILE AND WIRELESS DEVICES 8

Proliferation of Mobile and Wireless Devices – Trends in Mobility – Credit card frauds in Mobile and Wireless Computing – Security Challenges – Authentication Service Security – Attacks on Mobile Phones – Android OS - iOS.

MODULE III TOOLS AND METHODS USED IN CYBERCRIME 8

Proxy Servers and Anonymizers – Phishing – Password Cracking – Keyloggers and Spywares – Virus and Worms – Trojan Horses and Backdoors – Steganography – DoS and DDoS Attacks.

MODULE IV SECURITY POLICIES 7

Introduction - Defining User Policies – Passwords – Internet Use – Email Usage – Installing/ Uninstalling Software – Instant Messaging – Defining System Administrative Policies – Defining Access Control – Developmental Policies – Standards, Guidelines and Procedures – Basics of Assessing a System - Firewalls.

MODULE V COMPUTER FORENSICS 7

General Guidelines – Finding Evidence on the PC - Finding Evidence in System Logs – Windows Logs – Linux Logs – Getting Back Deleted Files – Operating System Utilities – The Windows Registry.

MODULE VI CYBER LAWS 8

Basics of Law, Understanding Cyber Space, Defining Cyber Laws, Scope and

Jurisprudence, Concept of Jurisdiction, Cyber Jurisdiction, Overview of Indian Legal System, Introduction to IT Act 2000, Amendments in IT Act, Cyber Laws of EU – USA – Australia - Britain, other specific Cyber laws.

Total Hours : 45

TEXT BOOK:

1. Nina Godbole, Sunit Belapure, “Cyber Security: Understanding Cyber Crimes, Computer Forensics and Legal Perspectives”, Wiley, 2011.
2. Chuck Easttom, “Computer Security Fundamentals”, 2nd Edition, Pearson Education, 2012.
3. Vivek sood, “Cyber Law Simplified”, McGraw Hill, 2001.
4. James Graham, Richard Howard, Ryan Olson, "Cyber Security Essentials", CRC Press, 2011

OUTCOMES:

Upon completion of this course, students will be able to

- Know various cybercrimes and offenses.
- Identify cybercrime in mobile and wireless environment.
- Use relevant tools and methods in cybercrime.
- Apply security policies in cyber forensics.
- Outline the strategies adopted in computer forensics.
- Able to identify the cyber law against the attacks.

LINUX PROGRAMMING LAB

L	T	P	C
0	0	2	1

OBJECTIVES:

- To write shell scripts to solve problems.
- To understand Linux directories.
- To implement some standard Linux utilities such as Is,cp etc using system calls.
- To learn the security using Linux OS.
- To develop network-based applications using C.
- To understand the communication between client and server.

Laboratory Practice (Sample problems)

Note: Use Bash for Shell scripts.

1. Write a shell script that accepts a file name, starting and ending line numbers as arguments and displays all the lines between the given line numbers.
2. Write a shell script that deletes all lines containing a specified word in one or more files supplied as arguments to it.
3. Write a shell script that displays a list of all the files in the current directory to which the user has read, write and execute permissions.
4. Write a shell script that receives any number of file names as arguments checks if every argument supplied is a file or a directory and reports accordingly. Whenever the argument is a file, the number of lines on it is also reported.
5. Write a shell script that accepts a list of file names as its arguments, counts and reports the occurrence of each word that is present in the first argument file on other argument files.
6. Write a shell script to list all of the directory files in a directory.
7. Write an awk script to count the number of lines in a file that do not Contain vowels.
8. Write an awk script to find the number of characters, words and lines in a file.
9. Write a C program that makes a copy of a file using standard I/O and system calls.
10. Implement in C the following Linux commands using System calls a). cat b) my
11. Write a C program to list files in a directory.
12. Write a C program to emulate the Unix Is —I command.
13. Write a C program to list for every file in a directory, its mode number and file name.
14. Write a C program that redirects standard output to a file.Ex: Is > f 1.
15. Write a C program to create a child process and allow the parent to display “parent” and the child to display “child” on the screen.
16. Write a C program to create a Zombie process.
17. Write a C program that illustrates how an orphan is created.
18. Write a C program that illustrates how to execute two commands concurrently with a command pipe. Ex:- Is —l I sort
19. Write C programs that illustrate communication between two unrelated processes using

named pipe (FIFO FUe).

20. Write a C program in which a parent writes a message to a pipe and the child reads the message.
21. Write a C program (sender.c) to create a message queue with read and write permissions to write 3 messages to it with different priority numbers.
22. Write a C program (receiver.c) that receives the messages (from the above message queue as specified in (22)) and displays them.
23. Write a C program that illustrates suspending and resuming processes using signals.
24. Write Client and Server programs in C for connection oriented communication between Server and Client processes using Unix Domain sockets to perform the following: Client process sends a message to the Server Process.The Server receives the message,reverse S it and sends it back to the Client.The Client will then display the message to the standard output device.
25. Write Client and Server programs in C for connection oriented communication between Server and Client processes using Internet Domain sockets to perform the following: Client process sends a message to the Server Process.The Server receives the message,reverse S it and sends it back to the Client.The Client will then display the message to the standard output device.
26. Write C programs to perform the following: One process creates a shared memory segment and writes a message(”Hello”) into it.Another process opens the shared memory segment and reads the message. “Hello”).It will then display the message(”Hello”) to standard output device.

Total Hours : 30

TEXT BOOK:

1. N. Matthew, R. Stones, Beginning Linux Programming, 4 Edition, Wrox, Wiley India Edition.
2. N.B. Venkateswar, Advanced Unix Programming, BS Publications.
3. M.G. Venkatesh Murthy, Unix and Shell Programming, Pearson Education.
4. EIIlie Quigley, Unix Shells by Example, 4th Edition, Pearson Education.

OUTCOMES:

Upon Completion of course the students will be able to:

- Understand the Linux environment.
- Perform the file management in Linux environment.
- Organize multiple tasks using shell scripts in Linux environment.
- Solve the security issues in Linux environment.
- Execute secure communication to remote systems.
- Analyze and identify security attacks.

CYBER FORENSICS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To inculcate the fundamentals of digital forensics from the viewpoint of courtroom legalities.
- To introduce the different types of cybercrimes.
- To begin the policies and procedures to investigate cybercrime.
- To create forensics concepts and practices focusing on networks and internet.
- To gain the knowledge on digital investigations.
- To explore the current techniques and tools for forensic examinations.

MODULE I FORENSICS FUNDAMENTALS 7

Introduction-Law Enforcement – Services- Benefits of Professional Forensics Methodology – Types of computer forensics technology.

MODULE II FORENSICS SYSTEM & SERVICES 8

Internet Security Systems – Intrusion Detection System – Firewall Security System – Storage area network security systems – Network disaster Recovery System – Satellite Encryption Systems – Fighting Cyber Crime with Risk Management Techniques, Computer Forensics Investigation Services – Forensics Process Improvement.

MODULE III DATA RECOVERY 8

Live data collection – Forensics Duplication – Collecting Network based Evidence – Evidence Handling – Hiding and Recovering Hidden Data – Data backup and Recovery

MODULE IV EVIDENCE COLLECTION & DATA SEIZURE 7

Collection Options – Types of Evidence – Rules of Evidence – Volatile Evidence – Collection& Archiving – Methods of Collection – Artifacts – Collection Steps – Reconstructing the Attack.

MODULE V DATA ANALYSIS 8

Computer System Storage Fundamentals – Data analysis techniques – Analyzing network traffic – Investigating hacker Tool –Investigating Routers – Writing Computer Forensics Reports.

MODULE VI CYBER CRIME INVESTIGATION 7

Types of cybercrime -Credit card and cybercrime-Web hacking - Digital Detective Work-Cell Phone Forensics - Email and Webmail Forensics - Cyber laws of different countries.

Total Hours : 45

REFERENCES:

1. John Sammons, “The Basics of Digital Forensics, The Primer for Getting Started in Digital Forensics”, Elsevier, 2nd Edition, 2014.
2. Eoghan Casey, “Digital Evidence and Computer Crime: Forensic Science, Computers and the Internet“, Elsevier, 3rd Edition, 2011.
3. Computer Forensics: Evidence Collection and Preservation, Cengage Learning, EC Council, 2010

OUTCOMES:

Upon completion of this course, students will be able to

- Analyze the digital and cyber forensics policies and procedures.
- Apply the hacking techniques to secure the Applications.
- Identify the legal and ethical issues surrounding cybercrime and forensics.
- Assess digital evidence and practice forensic investigation.
- Express the legalities, penalties, and punishment associated with cyber.
- Identify the current techniques and tools for forensic examinations.

ETHICAL HACKING

L	T	P	C
2	0	2	3

OBJECTIVES:

- To learn the fundamentals of hacking.
- To introduce port scanning and vulnerability assessment.
- To know about network sniffing using various tools.
- To explore the current techniques and tools for web hacking.
- To test the system by performing the various attacks.
- To gain the knowledge for developing own hacking tools.

MODULE I INTRODUCTION TO HACKING 7

Important Terminologies - Categories of Penetration Test - Writing Reports - Structure of a Penetration Testing Report- Risk Assessment & Methodology - Information Gathering Techniques - Active & Passive Information Gathering - Sources of Information Gathering - Copying Websites Locally - Interacting with DNS Servers

MODULE II PORT SCANNING & VULNERABILITY ASSESSMENT 8

Host Discovery - Scanning for Open Ports and Services - Types of Port Scanning - TCP Three-Way Handshake – TCP Connect Scan - UDP Port Scan - IDLE Scan - Vulnerability Scanners - Pros and Cons - Vulnerability Assessment with Nmap - Updating the Database - Testing SCADA Environments with Nmap - Nessus Vulnerability Scanner - Installing Nessus on BackTrack - Port Range

MODULE III NETWORK SNIFFING 8

Introduction - Types of Sniffing – Hubs versus Switches - Promiscuous versus Nonpromiscuous Mode - MITM Attacks - ARP Attacks - Denial of Service Attacks - ARP Spoof to Perform MITM Attacks - Sniffing the Traffic with Dsniff - Sniffing Pictures with Drifnet - Urlsnarf and Webspy - Sniffing with Wireshark - Hijacking Session with MITM Attack - Real-Life Example

MODULE IV WEB HACKING 7

Attacking the Authentication - Brute Force and Dictionary Attacks - Types of Authentication - Password Reset Vulnerability - Crawling Restricted Links - Testing for the Vulnerability - Authentication Bypass with Insecure Cookie Handling - SQL Injection attacks - Testing for SQL Injection - Real-World Example

Theory Hours: 30

Laboratory Practice

- DoS and DDOS attacks
- Website penetration testing

- System penetration testing
- SQL injection attack
- Man in the middle attacks
- Social engineering
- Writing ethical hacking tools with Python

Lab Hours: 30

Total Hours : 60

REFERENCES:

1. Rafay Baloch, Ethical Hacking And Penetration Testing Guide, CRC Press, 2015.
2. John Slavio, Hacking: A Beginners' Guide to Computer Hacking, Basic Security and Penetration Testing, 2017.
3. Peter Kim, The Hackers Playbook 2 - Practical Guide To Penetration Testing, Secure Planet LLC, 2015.

OUTCOMES:

Upon completion of this course, students will be able to

- Explore the general hacking methods.
- Accomplish port scanning and vulnerability assessment.
- Monitor network traffic using various sniffing tools.
- Perform web hacking and test for vulnerability.
- Accomplish various attacks and handle them using various tools.
- Able to write own tools for ethical hacking.

SCHOOL OF COMPUTER, INFORMATION AND MATHEMATICAL SCIENCES

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

MINOR DEGREE – DATA SCIENCE

CURRICULUM AND SYLLABUS

S.No	Semester	Course Title	L	T	P	C
1	I	Data Mining and Analysis	3	0	0	3
2		Data Mining Lab	0	0	2	1
						4
3	II	R Programming	3	0	2	4
		Model Training	0	0	2	2
						6
4	III	Data Science with Python	3	0	0	3
5		Machine Learning Techniques	3	0	0	3
						6
6	IV	Mini Project	0	0	4	4
		* Value Added Course				-
						4
		Total Credits				**20**

SEMESTER I

DATA MINING AND ANALYSIS	**L**	**T**	**P**	**C**
	3	**0**	**0**	**3**

OBJECTIVES :

- To know the various types of attributes.
- To discover the association between item set.
- To extract the pattern from the frequent item set.
- To gain knowledge of the different types of clustering algorithms.
- To learn the classification algorithms for prediction.
- To know the various data mining applications.

MODULE I INTRODUCTION TO DATABASES **07**

Example – Characteristics of Database - Data Bases and Database Users – Advantages – Disadvantages – Data Models, Schema and Instances – Three Schema Architecture – DataBase Languages and Interfaces – DataBase System Environment.

MODULE II INTRODUCTION TO DATA MINING

Data Mining and Analysis – Data Matrix – Attributes – Algebraic and Geometric View – Probablistic View – Data Mining – Data Analysis Foundations – Numerical Attributes - Categorical Attributes - Univariate Analysis - Bivariate Analysis - Data Normalization.

MODULE III ASSOCIATION MINING **08**

Item set Mining - Frequent Item sets and Association Rules – Item set Mining Algorithms - Generating Association Rules - Summarizing Item sets - Maximal and Closed Frequent Item sets - Mining Maximal Frequent Item sets - Mining Closed Frequent Item sets.

MODULE IV CLUSTERING **08**

Representative-based Clustering - K-means Algorithm - Expectation-Maximization Clustering - Hierarchical Clustering - Density-based Clustering - DBSCAN Algorithm - Clustering Validation.

MODULE V CLASSIFICATION **08**

Probabilistic Classification - Naive Bayes Classifier - K Nearest Neighbors Classifier – Decision Tree Classifier - Classification Assessment .

MODULE VI DATA MINING APPLICATIONS **07**

Data Mining for Business Data Analyses – Telecommunication Industry – Retail Industry – Healthcare – Case study.

L – 45; TOTAL HOURS-45

REFERENCES

1. Mehmed Kantardzic, “Data Mining: Concepts, Models, Methods, and Algorithms”, IEEE Press Wiley, 3rd Edition, ISBN:978-1-119-51604-0, 2019.
2. Mohammed j. Zaki, Wagner Meira JR, "Data Mining and Analysis Fundamental Concepts and Algorithms", First Edition, Cambridge University Press, ISBN: 978-0-521-76633-3,2014.
3. Jiawei Han, Jian Pei, Micheline Kamber, “Data Mining: Concepts and Techniques”, 3rd Edition, Morgan Kaufmann Publishers, ISBN: 978-0-12-381479-1, 2011.
4. Navathe, Shamkant B., Elmasri, Ramez, “Fundamentals of Database Systems”, 7th Edition, Pearson, ISBN: 978-0133970777, 2015.

OUTCOMES:

Students who complete this course will be able to

- apply various data analysis techniques.
- perform association rule mining for identifying the related items.
- generate rule for pattern matching algorithms.
- choose the appropriate algorithm for implementing real time problems.
- validate clustering or classification algorithms.
- perform case study on data mining applications.

DATA MINING LAB

L	T	P	C
0	0	2	1

OBJECTIVES :

- To obtain practical exposure on implementation of data mining tasks.
- To give exposure to real life data sets for analysis and prediction.
- To illustrate open source data mining tools.
- To know the associatively between two products.
- To learn the performance evaluation of classification algorithm.
- To implement the clustering algorithm.

SOFTWARE REQUIRED :

Basic tools : Data Mining Open Source Tool.

LIST OF EXERCISES:

1. Create an Employee Table with the help of Data Mining Tool.
2. Apply Pre-Processing techniques to the training data set.
3. Demonstration of Association rule process on dataset using apriori algorithm.
4. Demonstration of classification rule process on dataset using Naïve Bayes Algorithm.
5. Demonstration of clustering rule process on dataset using k-means clustering.

P-15;

TOTAL HOURS-15

OUTCOMES :

Students who complete this course will be able to

- collect data set from various sources.
- apply various preprocessing techniques to clean the data set.
- generate association rule by applying various supply and confidence values.
- demonstrate the usage of classification algorithm with real time data.
- categorize the similar properties of items together by applying clustering algorithm.
- handle a small data mining project for a given practical domain.

SEMESTER II

R PROGRAMMING	L	T	P	C
	3	0	2	4

OBJECTIVES :

- To explore and understand how to use the R documentation
- To read Structured Data into R from various sources
- To understand the different data types and data structures in R.
- To learn the main R data structures – vector and data frame.
- To use R for mathematical operations.
- Make use of R loop functions and debugging tools.

MODULE I INTRODUCTION 07

How to Run R – Functions - R Data Structures - Regression Analysis - Startup and Shutdown – Packages.

MODULE II VECTORS 07

Scalars, Vectors, Arrays, and Matrices – Declarations – Recycling - Vector Operations - Using all() and any() - Vectorized Operations - NA and NULL – Filtering - Vectorized if-then-else - Testing Vector Equality - Vector Element Names.

MODULE III MATRICES AND ARRAYS 08

Creating Matrices - Matrix Operations - Applying Functions - Adding and Deleting Matrix - Vector/Matrix Distinction - Unintended Dimension Reduction - Naming Matrix - Higher-Dimensional Arrays

MODULE IV LISTS, DATA FRAMES 09

Creating Lists - List Operations - Accessing List - Applying Functions - Recursive Lists - Creating Data Frames - Matrix-Like Operations - Merging Data Frames

MODULE V FACTORS AND TABLES, R PROGRAMMING STRUCTURES 07

Factors and Levels - Functions Used with Factors - Working with Tables - Control Statements – Environment – Recursion - Replacement Functions.

MODULE VI SIMULATIONS IN R 07

Math Functions - Statistical Distributions –Sorting - Set Operations - Simulation Programming in R – Debugging – Working with datasets.

L – 45;P-30;TOTAL HOURS-75

REFERENCES

1. W. N. Venables, D. M. Smith, “An Introduction to R”, 4th Edition, 2018.
2. Garrett Grolemund, "Hands-On Programming with R", First Edition, O’Reilly, ISBN: 978-1-449-35901-0,2014.
3. Norman Matloff, “The Art of R Programming”, First Edition, No Starch Press, ISBN-13: 978-1-59327-384-2, 2011.

OUTCOMES:

Students who complete this course will be able to

- Choose the appropriate R package for applying algorithms on the data set .
- import external data into R for data processing and statistical analysis
- create data frames and list and apply matrix operations and merge data frames
- perform data analysis using integrated collection of intermediate tools,
- Create and edit visualizations with R.
- Compute numerical statistics used in introductory statistics and create simple graphs and charts.

SEMESTER III

DATA SCIENCE WITH PYTHON	**L**	**T**	**P**	**C**
	3	**0**	**0**	**3**

OBJECTIVES :

- Clean and prepare data for analysis
- To learn the efficient and clean Python implementations
- To provide computational environments for data scientists using IPython.
- Use the NumPy for performing complex numerical analysis tasks
- Manipulate pandas DataFrame
- To includes capabilities for a flexible range of data visualizations in Python.

MODULE I DATA SCIENCE 07

Benefits and uses of data science and big data - Facets of data - The data science process - The big data ecosystem and data science. The data science process: Overview of the data science process - Defining research goals and creating - Retrieving data - Cleansing, integrating, and transforming data - Exploratory data analysis.

MODULE II PYTHON 07

Introduction – Firsts lithers with Python: Basic Types, Numbers, Strings, Complex Numbers, Lists, Tuples, Dictionaries – Control Flow: Functions, Scripts and Modules – Computation and Data manipulation.

MODULE III IPYTHON: BEYOND NORMAL PYTHON 07

Shell or Notebook- IPython Shell - IPython Magic Commands - Input and Output History - IPython and Shell Commands – Shell Related Magic Commands - Errors and Debugging

.

MODULE IV INTRODUCTION TO NUMPY 08

Understanding Data Types - The Basics of NumPy Arrays - Computation on NumPy Arrays - Universal Functions – Aggregations - Min, Max, Computation on Arrays- Sorting Arrays.

MODULE V DATA MANIPULATION WITH PANDA 08

Installing and Using Pandas - Introducing Pandas Objects - Data Indexing and Selection - Operating on Data in Pandas - Handling Missing Data - Hierarchical Indexing - Combining Datasets: Concat and Append, Merge and Join - Aggregation

and Grouping - Pivot Tables - Vectorized String Operations.

MODULE VI VISUALIZATION WITH MATPLOTLIB 08

General Matplotlib Tips - Two Interfaces for the Price of One - Simple Line Plots - Simple Scatter Plots - Visualizing Errors - Density and Contour Plots - Histograms, Binnings, and Density - Multiple Subplots - Text and Annotation - Three-Dimensional Plotting in Matplotlib.

TOTAL HOURS – 45

REFERENCES :

1. Jake VanderPlas, "Python Data Science Handbook"Jake. Published by O'Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, Copyright © 2019, ISBN-13:978-1491912050.
2. Jesus Rogel-Salazar "Data Science and Analytics with Python",CRC Press, ISBN: 0367240416, 9780367240417, 2019.
3. Davy Cielen, Arno D. B. Meysman, and Mohamed Ali "IntroducingData Science Big data, machine learning, and more, using Python tools" Manning ISBN9781633430037, 2016.
4. Wes McKinney "Python for Data Analysis", Published by O'Reilly Media, Inc.,2019

OUTCOMES:

Students who complete this course will be able to

- Demonstrate proficiency with statistical analysis of data.
- Write high quality, maintainable Python programs.
- Master the fundamentals of writing IPython scripts.
- Efficiently implemented multi-dimensional arrays using NumPy.
- Implement the pandas for operating on and maintaining structured data, manipulating, transforming, and cleaning data
- Produce high quality data visualizations using Matplotlib.

MACHINE LEARNING TECHNIQUES **L T P C**

3 0 0 3

OBJECTIVES :

- To understand the need for machine learning based on the scenario of application.
- To study the various supervised, semi-supervised and unsupervised learning algorithms in machine learning
- To study the innovative methods in machine learning
- To strategy suitable machine learning algorithms for problem solving.
- To generate graphical models from the data for better learning.
- To analysis various algorithms that learn massive quantities of data within less time and resources to train it properly.
-

MODULE I INTRODUCTION **08**

Learning – Examples of Machine Learning Applications– Supervised Learning – Vapnik-Chervonenkis (VC) Dimension -Probably Approximately Correct (PAC) Learning- Noise - Learning Multiple Classes - Regression - Model Selection and Generalization

MODULE II NEURONS, NEURAL NETWORKS, AND LINEAR DISCRIMINANTS **07**

The Brain and The Neuron - Neural Networks -The Perceptron - Linear Separability - Linear Regression - The Multi-Layer Perceptron- Back-Propagation of Error- Multi-Layer Perceptron

MODULE III LEARNING FUNCTIONS USING OPTIMIZATION **08**

Radial Basis Functions and Splines- Dimensionality Reduction- Probabilistic Learning- Support Vector Machines- Optimization and Search

MODULE IV EVOLUTIONARY MODEL **07**

The genetic algorithm - reinforcement learning-Markova decision processes-learning with trees-decision trees-classification and regression trees (cart)- boosting – bagging

MODULE V PROBABILISTIC MODELS **07**

Unsupervised Learning – K means Algorithms –Vector Quantization – Self Organizing Feature Map-Markov Chain Monte Carlo (MCMC) Methods

MODULE VI GRAPHICAL MODELS 08

Bayesian Networks – Markov Random Fields – Hidden Markov Models – Tracking Methods- Energetic Learning: The Hopfield Network- Stochastic Neurons — The Boltzmann Machine- Deep Learning

L – 45; TOTAL HOURS-45

REFERENCES :

1. Aurélien Géron -Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts. SecondEdition,O'reilly,2019.
2. Stephen Marsland, ―Machine Learning – An Algorithmic Perspective‖, Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2018.
3. EthemAlpaydin, ―Introduction to Machine Learning 3e (Adaptive Computation and Machine Learning Series)‖, Third Edition, MIT Press, 2019
4. Jason Bell, ―Machine learning – Hands on for Developers and Technical Professionals‖, First Edition, Wiley, 2014
5. Peter Flach, ―Machine Learning: The Art and Science of Algorithms that Make Sense of Data‖, First Edition, Cambridge University Press, 2012.
6. Tom M Mitchell, ―Machine Learning‖, First Edition, McGraw Hill Education, 2013.

OUTCOMES:

Students who complete this course will be able to

- Analyze and distinguish between different learning methods.
- Differentiateamid the data for different learning such as supervised, unsupervised and semi-supervised learning
- Apply the suitable machine learning algorithms for any given problem
- Proposeasuitable algorithm algorithm for any specified problem
- Enterprise systems that uses the suitable graph models of machine learning
- Modify existing machine learning algorithms to improve classification efficiency

SCHOOL OF COMPUTER, INFORMATION AND MATHEMATICAL SCIENCES

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

MINOR DEGREE – AUGMENTED REALITY AND VIRTUAL REALITY

CURRICULUM AND SYLLABUS

S.No	Semester	Course Title	L	T	P	C
1	I	Introduction to Augmented Reality and Virtual Reality	3	1	0	4
2		Environment Modeling and Interaction Techniques	3	0	0	3
						7
3	II	User Experience (UX) Design for VR	3	0	0	3
4		AR & VR - LAB	0	0	1	1
						4
5	III	Game Development using AR/VR	3	0	0	3
6		Game Development using AR/VR - Lab	0	0	1	1
						4
7	IV	Major AR/VR Project	0	0	3	3
		* Value Added Course				-
						3
		Total Credits				**18**

SEMESTER I

INTRODUCTION TO AUGMENTED REALITY AND VIRTUAL REALITY	**L**	**T**	**P**	**C**
	3	**1**	**0**	**4**

OBJECTIVES:

- To gain a solid understanding of augmented reality technology, its' history, and future potential.
- To understand the 3D development and various controls associated with AR
- To know the basic concept and framework of virtual reality.
- To teach the principles and multidisciplinary features of virtual reality.
- To teach the technology for multimodal user interaction and perception in VR, in particular the visual, audial, and haptic interface and behavior.
- To provide an introduction to the VR system framework and development tools.

MODULE I INTRODUCTION TO AUGMENTED REALITY 08

History of AR - Perceptual Foundations of AR - Sensors and Signal Processing - Computer Graphics – Dimensionality – Depth Cues - Hardware: Sensors, Processor, Displays - Software's – Contents: Audio, Visual and other Senses – Interactions in AR.

MODULE II AR 3D DEVELOPMENT 09

AR SDKs - 3D Modeling – System Control - Gesture _ Voice Commands - Symbolic Input – Designing and developing 3D user interfaces – Evaluation of 3D User Interface – Future of AR - Machine Learning, Deep Learning - Human Factors, Legal, and Social Considerations.

MODULE III VIRTUAL REALITY AND DEVICES 09

Introduction to VR - The three I's of virtual reality, commercial VR technology and the five classic components of a VR system - Input Devices: (Trackers, Navigation, and Gesture Interfaces): Three-dimensional position trackers, navigation and manipulation, interfaces and gesture interfaces - Output Devices: Graphics displays, sound displays & haptic feedback – Software's

MODULE IV MODELING AND HUMAN FACTORS 07

Modeling: Geometric modeling, kinematics modeling, physical modeling, behavior modeling, model management. Human Factors: Methodology and terminology, user performance studies, VR health, and safety issues.

MODULE V VR PROGRAMMING AND RENDERING 06

Toolkits: World Toolkit – General Haptics Open Software – Scene Graph - Programming language - Representation and Rendering: Visual – Aural - Haptic

MODULE VI SCOPE AND APPLICATIONS 06

AR Applications: Gaming and Entertainment - Architecture and Construction - Aerospace and

Defence - Information Control and Big Data Visualization - Telerobotics and Telepresence Traditional VR Applications: Medical Applications - Education, Arts, and Entertainment - Military – Manufacturing – Robotics

L – 45; T-15; TOTAL HOURS-60

REFERENCES :

5. Dieter Schmalstieg, Tobias Hollerer, “Augmented Reality: Principles and Practice (Usability)”, First Edition, Pearson Education India, ISBN-13: 978-9332578494, 2016.
6. Steve Aukstakalnis, “Practical Augmented Reality - A Guide to the Technologies, Applications, and Human Factors for AR and VR”, First Edition, Addison-Wesley, ISBN-13: 978-0134094236, 2016.
7. Joseph J. LaViola Jr., Ernst Kruijff, Ryan P. McMahan, Doug Bowman, Ivan P. Poupyrev, “3D User Interfaces: Theory and Practice”, 2nd Edition, Addison-Wesley, ISBN-13: 978-0134034324,2017.
8. Gregory C. Burdea & Philippe Coiffet, “Virtual Reality Technology”, Second Edition, John Wiley & Sons, Inc., ISBN: 978-1-119-48572-8, 2017.
9. William R.Sherman, Alan Craig, “Understanding Virtual Reality, interface, Application and Design”, Elsevier Inc., ISBN 978-0-12-800965-9, 2018.
10. Steven M. LaValle, “Virtual Reality”, Cambridge University Press, 2019.

OUTCOMES:

Students who complete this course will be able to

- Examine the various sensor and signal processing in AR and identify the hardware and software required for developing AR.
- Design and implement 3D modeling with various features like gesture, voice, and symbol input.
- Identify, examine, and develop software that reflects fundamental techniques for the design and deployment of VR experiences.
- Evaluate the benefits and drawbacks of specific VR techniques on the human body.
- Identify and examine state-of-the-art VR design problems and solutions from the industry and academia.
- Identify various fields where AR and VR can be put to place to a large extent.

ENVIRONMENT MODELING AND INTERACTION TECHNIQUES	L	T	P	C
	3	0	0	3

OBJECTIVES:

- To understand the idea, methodology and basic tools of environmental modeling
- To understand the different modeling approaches, their scope and limitations
- To understand the fate and transport of pollutants
- To become aware of a wide range of applications of modelling in environmental management & decision making
- To identify the tools for environment modeling technique
- To analyze the quality model using application software.

MODULE I INTRODUCTION 09

Environmental modelling: scope and problem definition, goals and objectives, definition; modelling approaches– deterministic, stochastic and the physical approach; applications of environmental models; the model building process

MODULE II ELEMENTARY CONCEPTS, LAWS, THEORIES AND PROCESSES 12

The building blocks: extensive and intensive properties, properties relevant to of environmental systems, the material balance approach; the transport processes– advection, diffusion, dispersion, gravitational settling, transport in porous media; the transformation processes–the non-reactive processes, the reactive processes; simulation of transport and transformation processes– introduction, the completely stirred tank reactor, plug flow reactor, mixed flow reactor models; the general material balance models.

MODULE III ENVIRONMENTAL MODELLING - APPLICATIONS 09

Water quality modelling: surface water quality modelling – lakes and impoundments, rivers and streams, estuaries; ground water 24/8 pollution modelling. Air quality modelling: the box model, the Gaussian plume model point sources, line sources, area sources; special topics; Gaussian puff model.

MODULE IV COMPUTER BASED SOLUTIONS 10

Formulation of linear optimization models. Linear programming. Sensitivity testing and duality. Solution techniques and computer programming; Formulation of linear optimization models. Application of models – simulation, parameter estimation and

experimental design.

MODULE V CASE STUDIES **07**

Software package applications: Air quality modeling and water quality modeling

L – 45 TOTAL HOURS-45

REFERENCES:

1. John Wainwright and Mark Mulligan, —Environmental Modelling Finding Simplicity in Complexityǁ, John Wiley and sons Ltd, 2004
2. Nirmalkhandan N. Modeling Tools for Environmental Engineers and Scientists, CRC Press, Boca Raton, Florida, 2002.
3. Deaton and Wine brake, —Dynamic Modeling of Environmental Systemsǁ Wiley and Sons, 2002.
4. Martin Hachet and Jacek Jankowski, A Survey of Interaction Techniques for Interactive 3D Environments,2013.
5. Dunnivant F.M. and Anders E. (2006) A Basic Introduction to Pollutant Fate and Transport, John Wiley & Sons, Inc., New Jersey.
6. Ramaswami A., Milford J.B. and Small M.J. (2005) Integrated Environmental Modelling, John Wiley and Sons, Inc., New Jersey.

OUTCOMES:

Students who complete this course will be able to

- ❖ Develop models based on the mass-balance approach
- ❖ Predict the impact of the of external waste loading on different environmental matrices
- ❖ Predict and generate future conditions under various loading scenarios or management/intervention action alternatives
- ❖ Identify different types of environment models.
- ❖ Analyze the quality of environment engineering models
- ❖ Develop a new application environment modeling.

SEMESTER II

USER EXPERIENCE (UX) DESIGN FOR VR	L	T	P	C
	3	0	0	3

OBJECTIVES :

- To study the various realities perception modalities, current practices and recent trends
- To lay the foundation on emerging Virtual Reality technologies and their potential impact
- To provide knowledge on interactive and iterative design in VR.
- To explore the development of Virtual and Augmented reality systems.
- To understand and design the game play in VR
- To identify the interaction patterns and techniques for VR.

MODULE I INTRODUCTION TO VIRTUAL REALITY 07

HISTORY OF VR – An overview of various realities- Immersion, Presence and Reality Trade-offs-The Basics Design Guidelines- Perception-Perceptual Models and Processes-Perceptual Modalities-Perception of Space and Time-Perceptual Stability, Attention, and Action.

MODULE II CONTENT CREATION AND INTERACTION 08

High Level Concepts of Content Creation-Environmental Design-Affecting Behavior-Transitioning to VR Content Creation-Interaction-VR Interaction Concepts-Input Devices-Interaction Patterns and Techniques

MODULE III ITERATIVE DESIGN 08

Philosophy of Iterative Design-The Define Stage-The Make Stage-The Learn Stage-The Present and Future State of VR

MODULE IV USER EXPERIENCE IN VR SYSTEMS 07

Perceiving digital information-Shaping user experience-Development of Virtual and Augmented reality systems-The future of VR

MODULE V HUMAN CENTERED DESIGN PROCESS 07

VR Technology-Locomotion method-Setting up new game files in UE-VR Technology-Pros and Cons of VR

MODULE VI EXPLORING AND RIVETING GAMEPLAY IN VIRTUAL REALITY 08

Popular Game play mechanics-Designing the game play-User Interface and User Experience inside VR-Creating optimized game art for VR Technology

L – 45; TOTAL HOURS - 45

REFERENCES:

1. Jennifer Whyte, Dragana Nikolić, "Virtual Reality and the Built Environment", Routledge Publishers, 2nd Edition, ISBN: 9781317211136, 2018.
2. Jessica Plowman, "Unreal Engine Virtual Reality Quick Start Guide", 1st Edition, Packt Publishing Ltd, ISBN: 9781789617405, 2019.
3. Jeremy Bailenson, "Experience on demand : what virtual reality is, how it works, and what it can do", 1st Edition, New York, NY : W. W. Norton & Company , ISBN :9780393253696 0393253694, 2018.
4. **J**ason Jerald ,"The VR Book: Human-Centered Design for Virtual Reality", ACM Publishers, 1st Edition, ISBN: 9781970001129, 2016

OUTCOMES:

Students who complete this course will be able to

- Design an adaptive the virtual environment that meets the needs of trainee interpreters and those who need to learn about how to work with interpreters;
- Examine a range of interpreting scenarios (e.g. a business meeting room, a court room, a tourist office, a community centre) that can be run in different modes ('interpreting practice', 'exploration' and 'live')
- Analyze and interpret the effect of Game play in the Virtual Reality.
- Examine the various the designs and propose the solutions based on the need.
- Review the user experience and pros and cons in virtual reality.
- Identify different VR technologies and critique upon them

AUGMENTED REALITY (AR) & VIRTUAL REALITY (VR) LAB

L	T	P	C
0	0	1	1

OBJECTIVES :

- Make students knowledgeable in the concepts of AR/VR.
- Teach students the principles and multidisciplinary features of AR/VR.
- Educate students the importance of user interaction and perception in AR/VR.
- Familiarize students in the AR/VR system framework and development tools.
- Train students to identify real time challenges and develop solutions using AR/VR methodologies.

SOFTWARE REQUIRED : Unity 3D, C#

LIST OF EXERCISES:

6. Create Designs for Business Stationary
7. Create print ads, Social Media Banners
8. Create integrated Email Sequences, integrated info graphic and images
9. Create integrated presentation on PPT
10. Create funnels
11. Develop 3D animated products. (Portal with 360 Image and Video)
12. Develop animated explainer video
13. Develop an (AR/VR) App using UNITY

P - 15; TOTAL HOURS - 15

OUTCOMES :

Students who complete this course will be able to

- Identify different types of AR/VR experiences.
- Familiar with tools and platforms used in the AR/VR landscape.
- Understand the functions of hardware components used in AR/VR (Projectors, Gloves, Glasses and other Peripherals)
- Conceive knowledge on AR/VR software utilities (Software architecture, Components, Third party products)
- Understand the AR/VR workflow and create real time use cases.
- Start building an AR/VR experiences using Unity and other tools.

SEMESTER III

GAME DEVELOPMENT USING AR/VR	L	T	P	C
	3	0	0	3

OBJECTIVES :

- To give overview on game development and VR/AR fundamentals.
- To provide in-depth knowledge on virtual reality and augmented reality.
- To develop game in AR /VR using C++ by setting up the environment.
- To explore design games using unity components.
- To develop AR/VR games using unity by providing examples.
- To build location based augmented reality games.

MODULE I OVERVIEW OF GAME DEVELOPMENT AND VR/AR 07

Video games - Game writing – Game design – Game genres – Game world - Game development - Components of game development – Game development tools - Overview of VR and AR - Virtual Reality Vs Augmented Reality – VR and AR jobs in Gaming – Planning for future.

MODULE II VIRTUAL REALITY (VR) 06

Virtual Reality (VR) – Introduction – VR hardware – VR Applications – Working of VR – Challenges in VR – Designing and Developing VR - Immersion and presence – Best practices for VR.

MODULE III DEVELOPMENT ENVIRONMENT FOR VIRTUAL REALITY 08

Setting up Unreal Engine – Using Epic games launcher – Setting up for C++ development – Building unreal from source code – “Hello Word” first VR project – Installation of Unity for game development – Unity characters and components.

MODULE IV VIRTUAL REALITY USING UNITY 08

Contents, Objects and Scale – VR Build and Run – Gaze based control – Handy Interactables – World Space UI – Locomotion and Comfort – Playing with physics and fire – Animation and VR story telling.

MODULE V DEVELOPMENT ENVIRONMENT FOR AUGMENTED REALITY 08

AR devices – AR tool kits – GIS fundamentals: The power of mapping – Censored – The sound of flowery prose – Picture puzzle – Fitness for fun – Snap it ! Adding filters to pictures – To the Holo lens and Beyond.

MODULE VI AUGMENTED REALITY USING UNITY 08

Augmented Reality – Mapping the player’s location – Making Avatar – Spawning the catch – Catching the Prey in AR – Storing the Catch – Creating AR world – Interacting with AR world – Finishing the game.

L – 45; TOTAL HOURS-45

REFERENCES :

1. Jesse Glover, Jonathan Linowes, "Complete Virtual Reality and Augmented Reality Development with Unity: Leverage the power of Unity and become a pro at creating mixed reality applications", Packt Publishing Ltd, ISBN: 9781838644864,2019.
2. Jeff W. Murray,“ Building Virtual Reality with Unity and SteamVR,” Taylor & Francis Group, 2nd Edition, ISBN: 9780429295850, 2020.
3. Cathleen Small, “Using VR in Gaming VR on the Job: Understanding Virtual and Augmented Reality”, Cavendish Square Publishing, ISBN: 9781502645685, 2019.
4. Kevin Mack, Robert Ruud, “Unreal Engine 4 Virtual Reality Projects: Build immersive, real-world VR applications using UE4, C++, and Unreal Blueprints”, Packt Publishing Ltd, ISBN : 9781789133882, 2019.
5. Erin Pangilinan, Steve Lukas, Vasanth Mohan,” Creating Augmented and Virtual Realities: Theory and Practice for Next-Generation Spatial Computing”, O Reilly Media, Inc., ISBN : 9781492044147, 2019.

OUTCOMES:

Students who complete this course will be able to

- Explain game development, VR /AR fundamentals.
- Differentiate Virtual reality and Augmented Reality.
- Set up development environment for developing games using various tool kits.
- Design and develop VR /AR games using C++ application.
- Develop and enhance the VR/AR games in unity environment.
- Innovate and explore the latest and promising trend of AR/VR gaming industry.

GAME DEVELOPMENT USING AR/VR LAB

L	T	P	C
0	0	1	1

OBJECTIVES :

- Educate the students to understand the definition of “Game”, different types of games, their mechanics and rules behind.
- Assist the students to understand the basics of Game designing.
- Teach theoretical and practical foundations of game production using the Unity 3D engine.
- Introduce the Gaming framework and development tools to the students.
- Educate the students about the technological advancements in Gaming industry.
- Train the students to build a solid foundation for industry roles as a gameplay designer, level designer, technical designer and programmer.

SOFTWARE REQUIRED : Unity 3D, C#

LIST OF EXERCISES:

1. Installation of Unity and created first game project
2. Learn about different parts of Unity editor interface
   Move around the Scene view
   Enter the Game view
3. Change the color of objects in a scene
4. Edit properties of an object to change its behavior in a game
5. Instance creation by Prefabs and add objects to a scene
6. Build a game and share it with audience

P-15; TOTAL HOURS-15

OUTCOMES :

Students who complete this course will be able to

- Understand the Principles of Game Design.
- Develop a game concept; prototype, test, and iterate on ideas.
- Navigate licensing, marketing, and other business considerations related to game development.
- Get the exposure to game development tools, software utilities and hardware components.
- Understand the game industry and work effectively as part of a team.
- Pitch a game concept, develop a prototype and produce a polished final product.
- Start building Games using Unity.

SEMESTER IV

MAJOR AR/VR PROJECT	L	T	P	C
	0	0	3	3

The project work involves the following steps:

I. Preparing a project - brief proposal including
   a) Task Identification
   b) A statement of system / process specifications proposed to be developed (Block Diagram / Concept tree)
   c) List of possible solutions including alternatives and constraints

II. A report highlighting the design finalization (based on functional requirements)

III. A presentation including the following:
   a) Implementation Phase (Hardware / Software / both)
   b) Testing and Validation of the developed system
   c) Learning in the Project

IV. Consolidated report preparation

V. Value Added Course *

* Note: The students should attend a Value Added Course. This course should be relevant to the selected project work.

SCHOOL OF COMPUTER, INFORMATION AND MATHEMATICAL SCIENCES

DEPARTMENT OF INFORMATON TECHNOLOGY

MINOR DEGREE – SENSOR TECHNOLOGY

CURRICULUM AND SYLLABUS

S. No.	Course Group	Course Code	Course Title	L	T	P	C
1.			Introduction to sensors	3	0	0	3
2.			Smart Sensors and Internet of Things	3	0	0	3
3.			IoT and Sensor Networks	3	0	0	3
4.			Sensor Technology using Python	3	0	2	4
5.			Advanced Sensor Technologies	3	0	0	3
6.			Sensor Circuit Design (Project)	0	0	6	3

Total Credits: 19

INTRODUCTION TO SENSORS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

The aims of this course is to

1. introduce the Importance of sensors
2. discuss the Physical principles behind each sensor
3. explain the working principles of Pressure and flow sensors
4. discuss the various Acoustic, humidity and moisture sensors
5. expose how Light and radiation detection is used in sensing
6. elaborate the different Temperature , chemical and biological sensors

PRE REQUSITES: None

Module 1- Introduction **7**

The human body as a sensor system, sensors in an automobile, classification of sensors, Example of a gas sensor, sensor as a passive or active element, sensor as a part of a measurement system, sensor properties, Historical development of sensors, sensor system

Module 2 - Physical Principles of Sensing **8**

Electric Charges, Fields, and Potentials - Capacitance - Magnetism - Induction - Resistance - Piezoelectric Effect -Pyroelectric Effect - Hall Effect - Seebeck and Peltier Effects – SoundWaves - Temperature and Thermal Properties - Heat Transfer

Module 3 - Pressure and flow sensors **8**

Pressure Sensors : Concepts of Pressure - Units of Pressure - Mercury Pressure Sensor -Bellows, Membranes, and Thin Plates - Piezoresistive Sensors - Capacitive Sensors - VRP Sensors - Optoelectronic Sensors –Indirect pressure sensors -Vacuum Sensors

Flow Sensors - Basics of Flow Dynamics - Pressure Gradient Technique - Thermal Transport Sensors - Ultrasonic Sensors - Electromagnetic Sensors. -Microflow Sensors - Breeze Sensor - Coriolis Mass Flow Sensors - Drag Force Flow Sensors- Cantilever

MEMS sensors – Dust and smoke detectors

Module 4 - Acoustic , Humidity and Moisture Sensors 7

Acoustic Sensors: Microphone characteristics -Resistive Microphones - Condenser Microphones -Fiber-Optic Microphone - Piezoelectric Microphones - Electret Microphones –dynamic microphones

Humidity and moisture sensors : Concept of Humidity -Capacitive Sensors –Resistive sensors - Thermal Conductivity Sensor - Optical Hygrometer- Oscillating Hygrometer – Soil Moisture .

Module 5 - Light and Radiation Detectors 7

Light Detectors: Introduction -Photodiodes - Phototransistor –Photoresistors -Cooled Detectors –Imaging sensors –UV detectors -Thermal RadiationDetectors .
Radiation Detectors : Scintillating Detectors-Ionization Detectors - Ionization Chambers - Proportional Chambers . - Geiger–Müller Counters -Semiconductor Detectors – Cloud and Bubble chambers

Module 6 –Temperature, Chemical and Biological Sensors 8

Temperature Sensors-Thermoresistive Sensors - Resistance Temperature Detectors - Silicon Resistive Sensors - Thermistors -NTC Thermistors -Self-Heating Effect in NTC Thermistors - PTC Thermistors - Thermoelectric Contact Sensors - Semiconductor P-N Junction Sensors - Optical Temperature Sensors - Acoustic Temperature Sensor - Piezoelectric Temperature Sensors .

Chemical and Biological Sensors – Chemical and Bio-chemicalsensors - Chemical Sensor Characteristics –Electrical and Electrochemical sensors – Photo ionization detectors – Spectrometers – Pellister Catalytic sensors –Optical transducers

Total – 45 Hours

COURSE OUTCOMES

After completion of course, students would be able to:

1. describe the importance of sensors
2. outline the physical principles behind each sensor
3. explain different types of pressure & flow sensors, their designs and working principles
4. illustrate different acoustic , humidity & moisture sensors, their designs and working principles
5. identify different light and radiation detectors for sensing
6. explain the various temperature , chemical and biological sensors and their sensing capability.

References:

1. Jacob Fraden, " Handbook of Modern Sensors – Physics, Designs and Applications" Springer fifth edition, 2016
2. John Vetelino and AravindReghu, " Introduction to Sensors" CRC Press , 1st Edition, 2010.
3. Jose Luis Santos and FaramarzFarahi, " Handbook of Optical Sensors" CRC Press 1st Edition, 2018
4. Ion Sinclair," Sensors and tranducers" Newnws publisher, Third Edition, 2001.
5. Kalantar-zadeh and Kourosh , " Sensors - An Introductory Course" Springer, 2013

SMART SENSORS AND INTERNET OF THINGS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

The aims of this course is to

1. explain the application areas of IoT
2. give an exposure to the various sensors used in IoT.
3. Study the characteristics of the smart sensors
4. Explain the architecture of smart sensors
5. Discuss the interface circuit between smart sensors and internet
6. Have a knowledge about recent developments in smart sensor technology

PREREQUISITES: Knowledge in Basic Sensors and their uses

Module 1: Introduction **7**

Environmental Parameters- Measurement and Monitoring: Why measurement and monitoring are important, effects of adverse parameters for the living being for IOT

Module 2 – Sensors in IoT **8**

Sensors: Working Principles: Different types; Selection of Sensors forPractical Applications - Introduction of Different Types of Sensors such as Capacitive, Resistive, SurfaceAcoustic Wave for Temperature, Pressure, Humidity, Toxic Gas etc

Module 3 – Characteristics of Smart Sensors **7**

Important Characteristics of Sensors: Determination of theCharacteristics - Fractional order element: Constant Phase Impedance for sensing applications such as humidity, water quality, milk quality - Impedance Spectroscopy: Equivalent circuit of Sensors and Modelling of Sensors -Importance and Adoption of Smart Sensors

Module 4 – Architecture of Smart Sensors **8**

Architecture of Smart Sensors: Important components, their features - Fabrication of Sensor and Smart Sensor: Electrode fabrication: Screen printing,Photolithography, Electroplating Sensing film deposition: Physical and chemical Vapour, Anodization, Sol-gel

Module 5 – Smart Sensor Interface circut **7**

Interface Electronic Circuit for Smart Sensors and Challenges forInterfacing the Smart Sensor, Usefulness of Silicon Technology in Smart Sensor and future scope of research in smart sensor

Module 6 – Modern Smart Sensors **8**

Recent trends in smart sensor for day to day life, evolving sensors and their architecture.

Total Hrs: 45

COURSE OUTCOMES

On completion of the course the student would be able to

1. Explain the vision of IoT from a global context.
2. Illustrate the working principles of the sensors used in IoT.
3. Discuss the Importance and Adoption of Smart Sensors inIoT.
4. Explain the architecture and fabrication of smart sensors.
5. Outline the challenges for interfacing smart sensors with internet.
6. Illustrate the modern smart sensors and their architecture.

References:

1. Yasuura, H., Kyung, C.-M., Liu, Y., Lin, Y.-L., Smart Sensors at the IoT Frontier, Springer International Publishing, 2018.
2. Kyung, C.-M., Yasuura, H., Liu, Y., Lin, Y.-L., Smart Sensors and Systems, Springer International Publishing, 2015.
3. Gerard Meijer , Kofi Makinwa, MichielPertijs, “Smart Sensor Systems: Emerging Technologies and Applications”, Wiley Publishers, 2014.

IoT AND SENSOR NETWORKS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

- To give an overview of importance of IoT and its applications.
- To present design choices for various system quality capabilities.
- To discuss the basic concepts, models, terminology, and relationships in the IoT Architectural Reference Model.
- To give an exposure to the benefits of wireless sensor network technology and plan for its use and depeloyment.
- To give an overview of various topics related to wireless sensor networks, whichare expected to be the basis for the emerging internet-of-things.
- To explain wireless sensor network (WSN) specific issues such as localization,time synchronization, and topology control are addressed as well.

PRE REQUSITES: Wired Networks

Module 1 - Introduction to IoT , its applications and Design choices **7**

The History and Reasoning Behind the IoT - The IoT Architectural Reference Model as Enabler - IoT in Practice: Examples: IoT in Logistics and Health – Elements to protect in IoT - Risk sources –Design Choices – Addressing performance and scalability – Addressing Trust – Addressing Security – Addressing Privacy- Addressing Availability and Resilience

Module 2 - IoT Reference Architecture **9**

Interaction of all sub models – Domain Model – Information Model - Functional Model – Communication Model – Trust, Security and Privacy

Module 3 – Introduction to Wireless Sensor Networks(WSN) **7**

Background of Sensor Network Technology - Basic Sensor Network Architectural Elements- Brief Historical Survey of Sensor Networks - Challenges and Hurdle - Applications of Wireless Sensor Networks

Module 4 – MAC, Routing and Transport Protocols for WSNs 8

Fundamentals of MAC Protocols - MAC Protocols for WSNs - Sensor-MAC Case Study – Routing Challenges and Design Issues in WSNs - Routing Strategies in WSNs - Transport Protocol Design Issues- Examples of Existing Transport Control Protocols - Performance of Transport Control Protocols

Module 5 – Middleware and Operating systems for WSNs 7

WSN Middleware Principles- Middleware Architecture - Existing Middleware : MiLAN - IrisNet - AMF - DSWare - CLMF - MSM – Em –Impala – Dfuse -DDS – SensorWare.

Operating System Design Issues - Examples of Operating Systems – TinyOS - Mate – MagnetOS – MANTIS – OSPM - EYES OS – SenOS – EMERALDS – PicOS.

Module 6 – Network Performance and Traffic Management 7

Network Management Requirements - Traditional Network Management Models - Simple Network Management Protocol - Telecom Operation Map - Network Management Design Issues - Example of Management Architecture: MANNA - Other Issues Related to Network Management – Naming – Localization

WSN Design Issues - MAC Protocols - Routing Protocols -Transport Protocols - Performance Modeling of WSNs - Performance Metrics - Basic Models - Network Models - Case Study: Simple Computation of the System Life Span - Analysis

Total Hrs : 45

COURSE OUTCOMES

On completion of the course the student should be able to

- discuss the importance of IoT and its applications.
- illustrate design choices for various IoTsystem quality capabilities.
- explainthe basic concepts, models, terminology, and relationships in the IoT Architectural Reference Model.
- identify requirements from emerging WSN applications on WSN platforms, communication systems, protocols and middleware
- compare and evaluate communication and network protocols used in WSNs
- discuss design issues in network and traffic management in WSNs

References:

1. Mandler, B., Barja, J., MitreCampista, M.E., Cagá_ová, D., Chaouchi, H., Zeadally, S.,Badra, M., Giordano, S., Fazio, M., Somov, A., Vieriu, R.-L., “Internet of Things. IoTInfrastructures”, Springer International Publishing,

2. Alessandro Bassi ,Martin Bauer , Martin Fiedler, Thorsten Kramp , Rob van Kranenburg, Sebastian Lange, Stefan Meissner ,” Enabling Things to Talk- Designing IoT solutions with the IoT Architectural Reference Model”, Springer publication, 2013.

3. Wen, John T., Mishra, Sandipan , “Intelligent Building Control Systems”, Springer International Publishing, 2018

4. KazemSohraby, Daniel Minoli, TaiebZnati, “Wireless sensor networks: technology, protocols, and applications” Wiley Inter science publication, 2007.

5. Holger Karl & Andreas Willig, “Protocols And Architectures for Wireless Sensor Networks” , John Wiley, 2005.

6. Feng Zhao & Leonidas J. Guibas, Wireless Sensor Networks- An Information Processing Approach”, Elsevier, 2007.

Sensor Technology using Python

L	T	P	C
3	0	2	4

COURSE OBJECTIVE

- To introduce the mathematical background, tools, machine learning algorithms needed for sensor data analysis.
- To explain how to do the data analytics of the sensor data in IoT.
- To introduces core python programming basics including data types, control structures
- To introduce Lists, tuples, dictionaries, file and string manipulation in Python
- To introduce usage of functions in Python
- To give an exposure to use python packages related with IoT

PRE REQUSITES: Basic Programming concepts

Module 1: Sensor Fusion **7**

Terminology – Basic operations Maths –Orientation Representation – Virtual gyroscope – kalman filtering for orientation estimation – Tools for numerical analysis – Tools to create field implementation

Module 2: Machine Learning for Sensor Data **8**

Introduction – Sensor Data Acquisition –Feature extraction – Supervised Learning – unsupervised learning – Deep learning – integration points of machine learning algorithms – Tools for machine learning

Module 3 - Data types, conditional and control statements in Python **7**

The concept of data types; variables, assignments; immutable variables; numerical types; arithmetic operators and expressions; comments in the program; understanding error messages;

Conditions, boolean logic, logical operators; ranges; Control statements: if-else, loops (for,

while); short-circuit (lazy) evaluation

Module 4 – Lists, tuples, dictionaries, file and string manipulation in Python 7

Lists, tuples, and dictionaries; basic list operators, replacing, inserting, removing an element; searching and sorting lists; dictionary literals, adding and removing keys, accessing and replacing values; traversing dictionaries.

Strings and text files; manipulating files and directories, os and sys modules; text files: reading/writing text and numbers from/to a file; creating and reading a formatted file (csv or tab-separated). String manipulations: subscript operator, indexing, slicing a string; strings and number system: converting strings to numbers and vice versa. Binary, octal, hexadecimal numbers

Module 5 – Using functions in Python 7

Design with functions: hiding redundancy, complexity; arguments and return values; formal vs actual arguments, named arguments. Program structure and design. Recursive functions.

Module 6 – IoT with Python: Essential packages 9

Mraa – Socket **–** mysqldb – numpy – matplotlib – pandas – opencv – tkinter – tensorflow – pahomqtt

L- 45, P – 30, Total Hrs: 75

COURSE OUTCOMES

After completion of course, students would be able to:

- Explain mathematical background, tools, machine learning algorithms needed for sensor data analysis.
- do the data analytics of the sensor data in IoT.
- Write python code using different data types , conditional and control statements
- Write python codes using Lists, tuples, dictionaries.
- Write python code for file and string manipulation and using functions.
- Write python code for sensor data analysis

References:

1. Michael Stanley and Jongman Lee, “ Sensor Analysis for the Internet of Things”, Morgan and Claypool Publishers, 2018.
2. Kenneth Lambert , “Fundamentals of Python: First Programs” Course Technology, Cengage Learning, 2012.
3. Gastón C. Hillar , ” Internet of Things with Python”, Packt Publishing, 2016.

Advanced Sensor Technologies

L	T	P	C
3	0	0	3

COURSE OBJECTIVE

- To introduce advanced sensing and biological sensor systems .
- To explain the current state of sensor applications in the healthcare domain.
- to have a full awareness of the resistive and capacitive sensors and their applications.
- to give an exposure to the various inductive and magnetic sensors and their applications
- to explain the different advanced optical fiber sensors and their applications.
- To discuss the applications of embedded sensors in various novel field.

PRE REQUSITES: Basics of sensor and sensing principles.

Module 1 Biological sensor Technology **8**

Advanced sensing and communication in the biological world - DNA-derivative architectures for long-wavelength bio-sensing -Quartz crystal microbalance-based biosensors - Enzyme biosensors - Future directions for breath sensors - Solid-state gas sensors for clinical diagnosis

Module 2 Medical sensor Technology **8**

Bio-sensing and human behavior measurements - Sweat rate wearable sensors - Various aspects of medical imaging - The future of medical imaging - Spatial and spectral resolution aspects of semiconductor detectors in medical imaging - CMOS SSPM detectors - CdTe detectors and their applications to gamma-ray imaging - Positron emission tomography (PET)

Module 3 Resistive and capacitive sensor Technology **7**

Potentiometric sensor applications – Photoresistive and piezoresistive sensor applications – Chemoresistive sensor applications – Applications of Bioresistance/Bioimpedance sensors – cylindrical and spherical capacitive sensors- capacitive sensor arrays

Module 4 Inductive and Magnetic sensor Technology **8**

Inductive Air coil sensor applications – Inductive ferro magnetic core sensor applications – Transformer type sensor applications –Applications of Hall sensors – Magnetoresistive sensor Applications – Applications of magnetostrictive sensors- Applications of magnetic resonance sensors –Applications of MO and SQUID sensors

Module 5 Optical Fiber sensor technology **7**

Multimode optical fiber sensors – Bragg Grating in optical fibers – Nonlinear optics and optical fibers – Distributed fiber optic sensors – optical fiber chemical sensors

Module 6 Embedded Sensor Systems **7**

Sensor Nodes (SNs), Camera Sensor Nodes (C-SNs), and Remote Sensor Nodes (RSNs) - Clustering and Energy Consumption Minimization-Personal/Body Area Networks and Healthcare Applications-

Total Hours: 45

COURSE OUTCOMES

After completion of course, students would be able to:

- Discuss development and implementation of sensors for various applications used in biology.
- outline the various sensors used for medical applications.
- examines existing, new, and novel resistive and capacitive sensor technologies through real-world examples
- illustrate different novel inductive and magnetic sensors and their applications.
- explain various advanced optical fiber sensors and their applications.
- discuss the applications of embedded sensors in various novel fields

References:

1. Michael J. McGrath; CliodhnaNíScanaill, "*Sensor Technologies:* Healthcare, Wellness, and Environmental Applications" Springer 2020

2. Krzysztof Iniewski, “Biological and Medical Sensor Technologies (Devices, Circuits, and Systems)” CRC press, 2012.

3. Winncy.Y du, “Resistive, capacitive, Inductive and Magnetic sensor Technologies”, CRC Press, 2014.
4. K. T. V. Grattan B. T. Meggitt ,*“Optical Fiber Sensor Technology, Advanced Applications*”, Springer publications, 2000.
5. Agrawal, Dharma Prakash,” Embedded sensor systems”, Springer publications, 2017.

ST4201	Sensor circuit Design (Project)	L	T	P	C
				6	3

SCHOOL OF MECHANICAL SCIENCES

DEPARTMENT OF MECHANICAL ENGINEERING

MINOR DEGREE – ROBOTICS

CURRICULUM AND SYLLABUS

S #	Course Code	Course Title	L	T	P	C
1		MECHATRONICS AND MACHINE VISION	2	0	1	3
2		ROBOT OPERATING SYSTEM [ROS], CONTROL SYSTEMS & COMMUNICATIONS	2	0	1	3
3		SENSORS AND APPLICATIONS	2	0	1	3
4		KINEMATICS AND DYNAMICS OF ROBOTS	2	0	1	3
5		ROBOTS AND ITS APPLICATIONS	2	0	1	3
6		ROBOTICS PROGRAMMING AND SERVICING OF ROBOTS	2	0	1	3
7		MINI PROJECT	0	0	1	1
TOTAL CREDITS						**19**

ROBOTICS - SYLLABUS

MECHATRONICS AND MACHINE VISION

L	T	P	C
2	0	1	3

OBJECTIVES:

- To study the fundamentals of mechatronics
- To acquire knowledge on mechanical, fluid and pneumatic systems
- To educate about various motors and actuators
- To study about programmable logic controllers
- To impart knowledge on image processing techniques
- To understand machine intelligence

MODULE I INTRODUCTION 6

Introduction to Mechatronics- Concepts of Mechatronics approach – Need for Mechatronics - Basic building blocks of mechatronic systems - Mechatronics key elements - Mechatronics in home, office, and industry automation - Medical Mechatronics.

- Hands on Practices: Interfacing of a thermal sensor to monitor and control the temperature in a thermal chamber within a specified tolerance limit

MODULE II MECHANICAL, FLUID AND PNEUMATIC SYSTEMS 9

Mechanical systems - Gears, Belt and Pulley, Lead-Screw and Ball-Screw Mechanisms, Rack and Pinion Mechanism, Belt and Pulley, Cyclic motion, Cams Fluid systems - Introduction to fluid power, Advantages and applications - Fluid power systems - Pump classification, Construction, Working, Design, Advantages, Disadvantages - Hydraulic components in robots - Pneumatic systems - Properties of air - Compressor, Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves - Electro Pneumatic System.

- Exposure on various mechanical and electrical systems available in Design Appreciation lab & Mechatronics Lab

MODULE III MOTORS & ACTUATORS 7

AC motors - Types, Construction and controls - DC motors - with or without brushes, construction and controls - DC stepper motors - Servo motors - Actuators - Hydraulic and pneumatic actuators, Piezoelectric actuators, Electrical actuators, Electromagnetic actuators - Actuator selection and its applications.

- Hands on Practices: Electro Pneumatic trainer kit and simulation software.

MODULE IV PROGRAMMABLE LOGIC CONTROLLER (PLC) 8

Programmable Logic Controllers – Basic Structure, Input / Output Processing, Programming, Mnemonics, Timers, Internal relays and counters, Shift Registers, Master and Jump Controls, Data Handling, Analogs Input / Output, Selection of a PLC.

- Hands on Practices: Simulation of real-life automation viz., bottling plant and punching operation using PLC Ladder Diagram.

MODULE V IMAGE PROCESSING 8

Digital image representation - Fundamental steps in image processing - Elements of digital image processing systems digitization - Relationship between Pixel, Image Formats, Image Transforms - Image processing - Object description & recognition, Interpretation, Noises in Image, Histogram processing.

- Hands on Practices: Simple image processing exercises using MATLAB/SCILAB .

MODULE VI MACHINE INTELLIGENCE 7

Introduction - Scope - Problems - Approaches of AI - Search algorithms- Decision theory

- Hands on Practices: Simple exercises on search algorithms and decision theory

Total Hours –45

TEXTBOOKS:

1. Kenji Uchino and Jayne R. Giniewicz, Mechatronics, Marcel Dekker, Inc.
2. A. Smaili and F. Mrad, Applied Mechatronics- Oxford university press.
3. Shetty and Kolk, Mechatronics System Design, Cengage Learning, India Edition
4. Alciatore and Histand, Introduction to Mechatronics and Measurement Systems, Tata McGraw-Hill
5. Necsulescu, Mechatronics, Pearson education.
6. Mill, Mechatronics - Electromechanics and Control Mechanics, Springer-Verlag
7. Bolton, Mechatronics - Electronic Control Systems in Mechanical Engineering, Pearson Education
8. Bradley et al., Mechatronics - Electronics in products and processes, Chapman and Hall
9. Jain A.K., Fundamentals of Digital Image Processing, Prentice Hall (2007).
10. Sonka M., Image Processing and Machine Vision, Prentice Hall (2007) 3rd ed.
11. D. Forsyth and J. Ponce, Computer Vision - A modern approach, Prentice Hall.
12. B. K. P. Horn, Robot Vision, McGraw-Hill.

REFERENCES:

1. Walsh, Electromechanical Design Handbook, , McGraw-Hill
2. Fraser and Milne, Electro-mechanical Engineering - An Integrated Approach,
3. Hurricks Longman, John Wiley, Handbook of Electromechanical Product Design, Addison Wesley
4. Kamm, Understanding Electro-Mechanical Engineering - An Introduction to Mechatronics, IEEE
5. E. Trucco and A. Verri, Introductory Techniques for 3D Computer Vision, Prentice Hall.
6. Richard Szeliski, Computer Vision: Algos and Applications, Springer

OUTCOMES:

Students should be able to

- Explain the fundamentals of mechatronics
- Design basic mechanical, fluid and pneumatic systems
- Demonstrate the various types of motors and actuators
- Select appropriate PLC
- Demonstrate various image enhancement techniques
- Discuss about machine intelligence

ROBOT OPERATING SYSTEM [ROS], CONTROL SYSTEMS & COMMUNICATIONS	L	T	P	C
	2	0	1	3

OBJECTIVES:

- To study the fundamentals of ROS
- To learn to program in ROS
- To understand the significance of point clouds and vision sensor in robotics
- To study the fundamentals of control systems
- To acquire knowledge on signal processing
- To educate about various communication systems

MODULE I INTRODUCTION TO ROS 6

Master - Node - Topic - Messages - Subscriber - Publisher - ROS packages - ROS file system - Services and actions.

MODULE II PUBLISHER & SUBSCRIBER 7

Custom publisher - Custom subscriber - ROS topic list and ROS topic information - ROS topic echo - ROS topic pub - Custom messages

MODULE III SIMULATION & VISUALIZATION 9

Gazebo - Importing robot - Program for Robot movement - Keyboard control of robot - Rviz for laser point cloud - rqt graph - 2D mapping - Maze solving of robot - ROS logger - ROS parameter server

MODULE IV CONTROL SYSTEMS 7

Distributed Control Systems - Central Control Systems - Open-Loop Control - Closed-Loop Control - Designing the Control System - Multivariable Control Systems

MODULE V SIGNAL PROCESSING 8

The Nyquist-Shannon Sampling Theorem - A/D Conversion - A/D Dithering - Sample and Hold (S/H) - Antialias Filters - D/A Effects: Sinc Compensation - DSP Filter Design

MODULE VI COMMUNICATIONS 8

OSI Seven-Layer Model - Physical layer - Base band transmission - Modulated communications - Error Control - Shared access - Compression - Encryption and security - Popular communication channels

Total Hours –45

TEXTBOOKS:

1. Lentin Joseph, Robot Operating System for Absolute Beginners: Robotics Programming Made Easy, Apress
2. Charles M. Bergren, Anatomy of a Robot, McGraw-Hill
3. Clarence W. De Silva, Mechatronic Systems: Devices, Design,Control, Operation and Monitoring, CRC Press, Taylor& Francis
4. Morgan quigley, Brian gerkey and William D Smart, Programming Robots with ROS
5. Bolton.W, “Mechatronics”, Pearson education, second edition, fifth Indian Reprint, 2003
6. YoonSeok Pyo, HanCheol Cho, RyuWoon Jung, TaeHoon Lim, ROS Robot Programming.

REFERENCES:

1. Francis N-Nagy Andras Siegler, Engineering foundation of Robotics, Prentice Hall Inc., 1987
2. Richard D. Klafter, Thomas. A, Chmielewski, Michael Negin, Robotics Engineering an Integrated Approach, Prentice Hall of India Pvt. Ltd., 1989
3. John J. Craig, Introduction to Robotics Mechanics and Control, Second Edition, Addison Wesly Longman Inc. International Student edition, 1999

OUTCOMES:

Students should be able to

- Create custom messages, publisher & subscriber
- Create program to control the robot in Gazebo
- Visualize and map the environment using RViz
- Explain fundamentals of control systems
- Select appropriate signal processing
- Explain the various communications

SENSORS AND APPLICATIONS

L	T	P	C
2	0	1	3

OBJECTIVES:

- To acquire knowledge on sensor basics
- To create awareness on various resistive and capacitive sensors
- To educate about different magnetic and optical sensors
- To learn about basics of piezoelectric sensors
- To understand about special sensors
- To impart knowledge on bio sensors and signals

MODULE I INTRODUCTION 7

Significance of Sensors - Classification of Sensors - Analog vs Digital Sensors - Sensor nomenclature - Sensors and Information - Selection of sensors - Sensor fundamentals - Physical quantities, Sensor specification, Sensor error reduction techniques, Filtering, Modulation, Demodulation, Correction methods - Sensors vs Transducers.

MODULE II RESISTIVE AND CAPACITIVE SENSORS & TRANSDUCERS 7

Resistive sensors - Potentiometric Sensors - Strain gauges – Piezo resistive sensors - Magneto resistive sensors – Thermo resistive sensors – Opto resistive sensors - Capacitive sensors - Types and applications

MODULE III MAGNETIC AND OPTICAL SENSORS & TRANSDUCERS 9

Inductive and magnetic sensors - Magnetic and electromagnetic quantities, magnetic field sensors, Magnetic and Induction based displacement and force Sensors, Applications - Optical Sensors - Electro optical components, optical displacement sensors, Interfacing, applications

- Hands on Practices: Potentiometer, Strain gauge, Torque, LVDT, Hall effect, speed, Vibration, Pressure - Practices on Transducer – Temperature, optical - operational amplifier circuits.

MODULE IV SENSORS & MEASUREMENTS 8

Piezoelectric sensors - Piezoelectricity, Force, Pressure and Acceleration Sensors, Interfacing and applications - Acoustic Sensors - Properties of the Acoustic Medium, Acoustic sensors, Measurement methods, Applications - Flow Measurement: Bernoulli's flow meters, Ultrasonic Flow meter, Magnetic flow meter, rotameter - Temperature Measurement - Electrical methods of temperature measurement, Resistance thermometers, Thermistors and thermocouples, Pyrometers, Thermal cameras.

MODULE V MISCELLANEOUS SENSORS IN ROBOTICS 7

Different sensing variables - Smell, Humidity, Light, Speech or Voice recognition Systems, Telepresence and related technologies - Chemical Sensors, Hall Effect Sensors, Optical Light sensors, Tactile/Touch sensors, Cameras and image analysis.

MODULE VI SENSOR SELECTION & MEASUREMENT OF BIO SIGNALS 7

Selection of sensors - Basic methods for sensor selection - Based on parameters, product classification, application, replacing the sensors by brand, simple sensor selection – Source of bioelectric potentials - Electrode – electrolyte interface, electrode potential, resting and action potential – Electrodes for their measurement, ECG, EEG.

Total Hours –45

TEXTBOOKS:

1. Paul W Chapman, "Smart Sensors", an Independent Learning Module Series, 1996.
2. Sensors and Actuators: Control System Instrumentation -Clarence W Silva, CRC Press USA
3. Sensors and Actuators in Mechatronics: Design and Applications: Andrzej M Pawlak, CRC Press USA
4. Measurement Systems (Applications and Design) 5th ed.- E.O. Doebelin - McGraw Hill.
5. Mechanical Engineering Measurement - Thomas Beckwith, N.Lewis Buck, Roy Marangoni -Narosa Publishing House, Bombay.
6. Mechanical Engineering Measurements - A. K. Sawhney – DhanpatRai & Sons, New Delhi.
7. Instrumentation Devices & Systems - C.S. Rangan & G.R.Sarrna - Tata McGraw Hill.

8. Instrumentation & Mechanical Measurements - A.K. Thayal.

REFERENCES:

1. P.A. Janaki Raman, Robotics and Image Processing an Introduction, Tata Mc Graw Hill Publishing company Ltd., 1995
2. Richard D. Klafter, Thomas. A Chmielewski, Michael Negin, Robotics Engineering an Integrated Approach, Prentice Hall of India Pvt. Ltd., 1998.
3. Mikell P. Groover, Mitchell weiss, Roger N. Nagel, Nicholas G.Odrey, Industrial Robotics, Technology programming and Applications, 1986
4. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, Robotics Control, Sensing Vision and Intelligence, Mc Graw Hill Book Company, 1987.

OUTCOMES:

Students should be able to

- Explain fundamentals of sensor
- Select appropriate resistive sensor for robot application
- Device suitable optical and magnetic sensor
- Demonstrate the piezoelectric sensors and measurements
- Explain about special sensors
- Apply suitable sensors in medical field

KINEMATICS AND DYNAMICS OF ROBOTS

L	T	P	C
2	0	1	3

OBJECTIVES:

- To understand the concepts of coordinate frames, rotations, homogeneous coordinates of robots
- To learn about the link coordinates kinematics of robots
- To impart the inverse kinematics for robots
- To study workspace analysis for robots
- To impart trajectory planning for robots
- To understand the manipulator dynamics

MODULE I INTRODUCTION 7

Introduction - Position and orientation of objects - Objects coordinate frame Rotation matrix - Euler angles Roll, pitch and yaw angles coordinate Transformations - Joint variables and position of end effectors - Rigid body rotations - Dot and cross products, Coordinate frames, Rotations matrix - Homogeneous coordinates.

- Hands on Practices: Simple kinematic problem solving
-

MODULE II KINEMATICS OF SERIAL ROBOTS 7

Introduction - Direct and inverse kinematics problems - Examples of kinematics of common serial manipulators - Wworkspace of a serial robot - Inverse kinematics of constrained and redundant robots - Tractrix based approach for fixed and free robots and multi-body systems - Simulations and experiments - Solution procedures using theory of elimination - Inverse kinematics solution for the general 6R serial manipulator.

MODULE III KINEMATICS OF PARALLEL ROBOTS 8

Degrees-of-freedom of parallel mechanisms and manipulators - Active and passive joints - Constraint and loop-closure equations - Direct kinematics problem - Mobility of parallel manipulators - Closed-from and numerical solution - Inverse kinematics of parallel manipulators and mechanisms - Direct kinematics of Gough-Stewart platform.

MODULE IV VELOCITY AND STATIC ANALYSIS OF ROBOT MANIPULATORS 8

Linear and angular velocity of links - Velocity propagation - Manipulator Jacobians for serial and parallel manipulators - Velocity ellipse and ellipsoids - Singularity analysis

for serial and parallel manipulators - Loss and gain of degree of freedom - Statics of serial and parallel manipulators - Statics and force transformation matrix of a Gough-Stewart platform - Singularity analysis and statics.

- Hands on practice: Simple calculations in Robo lab

MODULE V **DYNAMICS OF SERIAL MANIPULATORS** **8**

Mass and inertia of links - Lagrangian formulation for equations of motion for serial - Generation of symbolic equations of motion using a computer - Simulation (direct and inverse) of dynamic equations of motion - Examples of a planar 2R and four-bar mechanism.

- Hands on Practices: Simple Problems with NPTEL learning

MODULE VI **MOTION PLANNING AND CONTROL** **7**

Joint and Cartesian space trajectory planning and generation - Classical control concepts using the example of control of a single link - Independent joint PID control,

- Hands on Practices: Simple Problems with NPTEL learning

Total Hours –45

TEXTBOOKS:

1. Murray, R.M., Li, Z., and Sastry,S.S.,A Mathematical Introduction to Robotic Manipulator, CRC Press, 1994.
2. Merlet, J.-P.,Parallel Robots,Kluwer Academic, Dordrecht, 2001.
3. Featherstone, R.S., Robot Dynamics Algorithms,Kluwer Academic Publishers, 1987.
4. Haug,E.J., Computer-Aided Kinematics and Dynamics of Mechanical Systems:Basic Methods,Vol. 1,Allyn and Bacon, 1989.
5. Siciliano,B., and Khatib, O.(Editors), Handbook of Robotics,Springer, 2008.
6. Craig, J. J., Introduction to Robotics: Mechanics and Control, 2nd Edition,Addison-Wesley, 1989.
7. Robotics: Fundamental Concepts and Analysis, Oxford University Press,Second reprint, May 2008

REFERENCES:

1. Francis N-Nagy Andras Siegler, “Engineering foundation of Robotics”, Prentice Hall Inc.,1987.
2. Bernard Hodges, “Industrial Robotics”, Second Edition, Jaico Publishing house,

1993.
3. Tsuneo Yohikwa, “Foundations of Robotics Analysis and Control”, MIT Press., 2003.
4. John J. Craig, “Introduction to Robotics Mechanics and Control”, Third Edition, Pearson,2008.
5. Robert J. Schilling, “Fundamentals of Robotics Analysis and Control”, PHI Learning.,2009.
6. Richard D. Klafter, Thomas. A, Chri Elewski, Michael Negin, “Robotics Engineering an Integrated Approach”, Phi Learning.,2009.
7. Klafter. R.D, Chmielewski.T.A and Noggin’s, “Robot Engineering : An Integrated Approach”, Prentice Hall of India Pvt.Ltd.,1994.

OUTCOMES:

Students should be able to

- Apply the concepts of coordinate frames, rotations, homogeneous coordinates of robots
- Solve link coordinate kinematics of robots.
- Determine the inverse kinematics solutions for robots
- Perform workspace analysis
- Select trajectory planning for robots
- Explain the manipulator dynamics

ROBOTS AND ITS APPLICATIONS

L	T	P	C
2	0	1	3

OBJECTIVES:

- To understand the concepts of robots' anatomy
- To learn about the robots' end effector
- To impart the knowledge on robot assembly and aerial robots
- To understand the various applications of robots
- To learn the future technologies of robots
- To understand the humanoid robots

MODULE I INTRODUCTION 7

Robot – Definition – Robot Anatomy – Co-ordinate Systems - Work envelope types and classification – Specifications – Pitch, Yaw, Roll, Joint notations, Speed of motion, Pay load – Robot Parts and their functions – Need for robots.

MODULE II ROBOT END EFFECTOR 8

Introduction - Classifications of end effector - Other types of end effector, tools as end effector - Types of Grippers - Gripper force analysis - Design of drive system for gripper.

- Simple exercises in Robo lab

MODULE III ROBOT ASSEMBLY AND AERIAL ROBOTS 8

Robotic assembly automation - Parts presentation methods - Assembly operations - Assembly system configurations - Design for robot assembly - Basics of aerial robots - Modelling and control of small Unmanned Aerial vehicles - Guidance and navigation of small range aerial robots.

MODULE IV APPLICATIONS 8

Implementation of Robots in Industries - Industrial application for material handling, Machine loading and unloading, Assembly, Inspection – Applications of robot in continuous arc welding, Spot welding, Spray painting, Assembly operation, Cleaning, Robot for underwater applications - Robots for agriculture, Mining, Exploration, Civilian and military applications, Nuclear applications, Space applications.

- Hands on Practices: Simple exercises in Robo lab

MODULE V FUTURE TECHNOLOGY 7

Robot intelligence - Advanced sensor capabilities - Telepresence and related technologies - Mechanical design features, Mobility, Locomotion, and navigation, System integration and networking.

MODULE VI HUMANOIDS 7

Wheeled and legged, Legged locomotion and balance - Arm movement, Gaze and auditory orientation control - Facial expression, Hands and manipulation, Sound and speech generation, Motion capture/Learning from demonstration - Human activity recognition using vision, touch, sound, Vision, Tactile Sensing, Interaction.

Total Hours –45

TEXTBOOKS:

1. Robert J. Schilling, “Fundamentals of Robotics Analysis and Control”, PHI Learning.,2009.
2. Richard D. Klafter, Thomas. A, Chri Elewski, Michael Negin, “Robotics Engineering an Integrated Approach”, Phi Learning.,2009.
3. M.P.Groover, “Industrial Robotics – Technology, Programming and Applications”, McGraw Hill, 2001.
4. Fu, K.S.Gonzaiz R.C., and Lee C.S.G., “Robotics Control, Sensing, Vision and Intelligence”, McGraw Hill Book Co., 1987

REFERENCES:

1. Francis N-Nagy Andras Siegler, “Engineering foundation of Robotics”, Prentice Hall Inc.,1987.
2. Bernard Hodges, “Industrial Robotics”, Second Edition, Jaico Publishing house, 1993.
3. Tsuneo Yohikwa, “Foundations of Robotics Analysis and Control”, MIT Press., 2003.
4. John J. Craig, “Introduction to Robotics Mechanics and Control”, Third Edition, Pearson,2008.

OUTCOMES:

Students should be able to

- Explain the concepts of robot anatomy
- Describe the various types of robot end effector
- Demonstrate the robot assembly and aerial robots
- Elucidate the applications of various robots

- Select appropriate future technologies
- Explain the humanoid robots

ROBOTICS PROGRAMMING AND SERVICING OF ROBOTS	L	T	P	C
	2	0	1	3

OBJECTIVES:

- To study the basics of robot programming
- To learn about VML & AML programming
- To learn about RAPID language
- To familiarize robot communication
- To educate the servicing of robots
- To acquire knowledge on safety in robot environment

MODULE I BASICS OF ROBOT PROGRAMMING 7

Introduction to Robot programming - Types - Coordinate systems of robot - Robot controller - Major components, Functions - Operating mode of robot, Jogging - Types, Robot specifications - Flex pendant - Lead through programming -Interpolation - Interlock commands - Motion commands, end effectors and sensors commands.

- Hands on Practice: programming and simulation of target and path planning.

MODULE II VAL LANGUAGE AND AML 10

VAL:

Robot Languages - Classifications, Structures - VAL language commands- Motion control, Hand control, Program control, Pick and place applications, Palletizing applications using VAL, Robot welding application using VAL program - WAIT, SIGNAL and DELAY command for communications using simple applications.

- Hands on Practice: Simple programming exercises using VAL

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AML:

General description, elements and functions, Statements, constants and variables - Program control statements - Operating systems, Motion, Sensor commands - Data processing.

- Hands on Practice: Simple programming exercises

MODULE III RAPID LANGUAGE 7

RAPID language basic commands - Motion Instructions - Pick and place operation using Industrial robot - Manual mode, Automatic mode, Subroutine command-based programming.

- Hands on Practice: Simple programming exercises for pick & place operation

MODULE IV ROBOT COMMUNICATION 6

Work cell - Parts of Robot controller - Smart components - Signals, Gates, End effector communication - Robot controller communication - Communication protocols.

MODULE V SERVICING & CALIBRATION OF ROBOTS 7

History of service robotics - Need for service of robots - Applications examples - Specifications of service and field Robots - Non-conventional Industrial robots - Robot calibration - Parametric, Non parametric, Accuracy and error sources, Measurement systems

MODULE VI ROBOT ENVIRONMENT 8

Robot Peripherals in Assembly Processes - Assembly Production Line Configurations - Feeding Devices - Conveyors - Robot Grippers and Tools -Safety considerations in industrial robot operations.

Total Hours –45

TEXTBOOKS:

1. Deb. S. R. “Robotics Technology and Flexible Automation”, Tata McGraw Hill publishing company limited,1994
2. Mikell. P. Groover, “Industrial Robotics Technology”, Programming and Applications, McGraw Hill Co,1995.
3. Klafter. R.D, Chmielewski.T.A and Noggin’s, “Robot Engineering : An Integrated Approach”, Prentice Hall of India Pvt.Ltd.,1994.
4. Kelly, Alonzo; Iagnemma, Karl; Howard, Andrew, "Field and Service Robotics” Springer, 2011.
5. Bruno Siciliano, Oussama Khatib, Springer Handbook of Robotics.

REFERENCES:

1. Fu.K. S, Gonzalez.R. C. & Lee .C.S.G, “Robotics Control, Sensing, Vision and Intelligence”, McGraw Hill Book co,1987.
2. Craig.J. J, “Introduction to Robotics Mechanics and Control”, Addison- Wesley, 1999.Robotics Lab manual, 2007.
3. Howie Choset, Kevin LynchSeth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, — Principles of Robot Motion-Theory, Algorithms, and Implementation‖, MIT Press, Cambridge, 2005.

OUTCOMES:

Students should be able to

- Explain the basic concepts of robot programming

- Explain the VML and AML programming of robots
- Perform the RAPID language programming
- Discuss about robot communications
- Describe the various aspects of servicing of robots
- Demonstrate the safety followed in robot environment

MINI PROJECT

L	T	P	C
0	0	1	1

The main objective is to inculcate problem based learning and to promote team spirit.

Students will be asked to take a real world problem and solve it by designing or fabricating a system.

The students will work in groups.

SCHOOL OF MECHANICAL SCIENCES

DEPARTMENT OF MECHANICAL ENGINEERING

MINOR DEGREE – 3D PRINTING

CURRICULUM & SYLLABUS

S. No	Course Code	Course Title	L	T	P	C
1		INSIGHTS INTO 3D PRINTING	3	0	0	3
2		REVERSE ENGINEERING	2	0	1	3
3		DESIGN FOR ADDITIVE MANUFACTURING	2	0	1	3
4		LAYERED MANUFACTURING	3	0	0	3
5		ADDITIVE MANUFACTURING OF METAL AND POLYMERIC MATERIALS	2	0	1	3
6		RAPID PROTOTYPING OF BIO-MATERIALS	3	0	0	3
7		MINI PROJECT	0	0	1	1
TOTAL CREDITS						**19**

	L	T	P	C
INSIGHTS INTO 3D PRINTING	**3**	**0**	**0**	**3**

OBJECTIVES:

- To understand the basics of additive manufacturing (AM)
- To learn the different classifications of additive manufacturing
- To study the AM process chain
- To understand about various materials, design and quality involved in AM
- To impart the applications of AM
- To understand the business and market strategies of AM

MODULE I Introduction & Origin of AM 7

Traditional manufacturing - Advent of computers - Additive manufacturing - Distinction between AM and CNC machining - Rapid Prototyping - Rapid Tooling - Layer manufacturing - 3D Printing - Origins of 3D metal printing - Classes of Machines for AM.

MODULE II Classifications of AM 8

Classification – Liquid Polymer Systems- Discrete Particle Systems - Molten Material Systems - Solid Sheet Systems - Metal Systems -Hybrid Systems.

MODULE III AM Process chain 8

Introduction - Generation of Computer-Aided Design Model - Conversion of CAD Model into AM Machine Acceptable Format - CAD Model Preparation - Machine Setup - Build Removal - Post-processing.

MODULE IV Materials, Design and Quality aspects of AM 8

Materials for AM - Basic Properties - Physical, Chemical, Mechanical and Metallurgical - Metals - Polymers - Ceramics - Composites - Graded materials - Other materials.

MODULE V Applications of AM 7

Automotive industries- Aerospace Industry - Consumer goods - Toy industry - Medical - Architecture and Landscaping - Miscellaneous.

MODULE VI Trends in AM (Market and Business) 7

Introduction - New Types of Products and Employment - Business and commerce - Intellectual property, security and regulation - Digiproneurship - Use of AM in building a brand.

Total Hours –45

TEXT BOOKS:

1. John O. Milewski, Additive Manufacturing of Metals:From Fundamental Technology to Rocket Nozzles, Medical Implants, and Custom Jewelry, Springer Series in Materials Science.
2. Li Yang, Keng Hsu, Brian Baughman, Donald Godfrey, Francisco Medina, Mamballykalathil Menon, Soeren Wiener, Additive Manufacturing of Metals: The Technology, Materials, Design and Production, Springer Series in Advanced Manufacturing
3. Olaf Diegel, Axel Nordin, Damien Motte, A Practical Guide to Design for Additive Manufacturing, Springer Series in Advanced Manufacturing.
4. Andreas Gebhardt, Understanding Additive Manufacturing, Hanser Publications.
5. Ian Gibson, David W. Rosen, Brent Stucker, Additive manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010.

REFERENCES:

1. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: principles and applications, 3rd Edition, World Scientific, 2010.
2. Paul F.Jacobs, Rapid Prototyping and Manufacturing, “Fundamentals of Stereolithography”, McGraw Hill,2002.
3. Dongdong Gu, “Laser Additive Manufacturing of High-Performance Materials”, Springer- Verlag Berlin Heidelberg, 2015.
4. Chee Kai Chua, “Lasers in 3D Printing and Manufacturing, World Scientific, 2016.
5. Rafiq I.Noorani, “Rapid Prototyping: Principles and Applications”, Wiley & Sons, 2006.
6. N.Hopkinson, R.J.M, Hauge, P M, Dickens, “Rapid Manufacturing: An Industrial revolution for the digital age”, Wiley,2006.
7. D.T.Pham and S.S.Dimov, “Rapid Manufacturing”, SpringerVerlog, 2001
8. L. Jyothish Kumar, Pulak M. Pandey, David Ian Wimpenny, 3D Printing and Additive Manufacturing Technologies, Springer Singapore
9. Adedeji B. Badiru, Vhance V. Valencia, David Liu, Additive Manufacturing Handbook: Product Development for the Defense Industry, CRC Press
10. André, Jean-Claude, From additive manufacturing to 3D/4D printing 3 Breakthrough Innovations: Programmable Material, 4D Printing and Bio-printing, Wiley-ISTE

11. Maniruzzaman Mohammed, 3D AND 4D Printing in Biomedical Applications: Process Engineering and Additive Manufacturing, WILEY VCH
12. Milewski, John O, Additive Manufacturing of Metals : From Fundamental Technology to Rocket Nozzles, Medical Implants, and Custom Jewelry, Springer
13. Chee Kai Chua, Chee How Wong and Wai Yee Yeong (Auth.), Standards, Quality Control, and Measurement Sciences in 3D Printing and Additive Manufacturing, Academic Press
14. Li Yang, Keng Hsu, Brian Baughman, Donald Godfrey, Francisco Medina, Mamballykalathil Menon, Soeren Wiener (auth.), Additive Manufacturing of Metals: The Technology, Materials, Design and Production, Springer International Publishing.
15. Bandyopadhyay, Amit, Bose, Susmita, Additive manufacturing, CRC Press.
16. Steinar Westhrin Killi, Additive Manufacturing: Design, Methods, and Processes, Pan Stanford Publishing.
17. Linkan Bian, Nima Shamsaei, John Usher, Laser-Based Additive Manufacturing of Metal Parts: Modeling, Optimization, and Control of Mechanical Properties, CRC Press

OUTCOMES:

Students should be able to

- Apply the basics of additive manufacturing techniques.
- Explain the classifications of AM.
- Generate and Convert the CAD Model into AM Machine Acceptable Format
- Utilize the different materials for rapid prototyping system
- Produce the components based on the requirement of industries
- Explain the market and business trends of AM

REVERSE ENGINEERING

L	T	P	C
2	0	1	3

OBJECTIVES:

- To learn the basics of reverse engineering (RE) process.
- To understand the methodologies and techniques for reverse engineering
- To understand the different hardware and software of reverse engineering
- To acquire knowledge on cloud data modeling
- To study the medical parts data capturing and image processing.
- To acquire knowledge on build 3D model using RE.

MODULE I Reverse Engineering Basics 8

Introduction - Generic process - Relationship between reverse engineering and rapid prototyping - Reverse Engineering in the Automotive Industry - Reverse Engineering in the Medical Industry - Legal Aspects of Reverse Engineering.

MODULE II Methodologies and Techniques for Reverse Engineering 7

Computer-aided Reverse Engineering - Computer Vision and Reverse Engineering - Structured-light Range Imaging - Scanner Pipeline.

- Hands on practice : Generation of data points for the given component in Co-ordinate Measuring Machine (CMM)

MODULE III Reverse Engineering–Hardware and Software 6

Introduction - Reverse Engineering Hardware - Reverse Engineering Software - Selection process

MODULE IV Cloud Data Modeling 8

Modeling Cloud Data in Reverse Engineering - Layer-based Model Generation - Adaptive Slicing Approach for Cloud Data Modeling, Planar Polygon Curve Construction for a Layer - Determination of Adaptive Layer Thickness - Case studies

- Simple exercises

MODULE V Medical Parts Data Capturing and Image Processing 7

Introduction to medical imaging - X-Ray technology - Computed Tomography (CT) - Magnetic Resonance Imaging (MRI) - Ultrasound imaging - 3-D laser scanners, Industrial CT Scanners - 3D reconstruction and Reverse Engineering (RE).

MODULE VI Build 3D model 9

Accuracy and Positioning the Probe - Post-processing the Captured Data - Handling Data Points - Curve and Surface Creation - Inspection Applications - Manufacturing Approaches - Processing of medical data from CT/MRI scan to 3D model using

freeware

- Simple exercises : Building 3D model using 2D images

Total Hours –45

TEXT BOOKS:

1. Vinesh Raja and Kiran J. Fernandes, Reverse Engineering, An Industrial Perspective, Springer Series in Advanced Manufacturing.
2. Prof. Dr. Josef Hoschek and Prof. Dr. Werner Dankwort, Reverse Engineering.
3. Linda Wills and Philip Newcomb, Reverse Engineering, Kluwer Academic Publishers.
4. Dennis Yurichev, Reverse Engineering for Beginners

REFERENCES:

1. Andreas Gebhardt, Understanding additive manufacturing: Rapid prototyping, Rapid tooling, Rapid manufacturing, Hanser Publishers, 2011.
2. Zhiqiang Fan and Frank Liou, Numerical modeling of the additive manufacturing (AM) processes of titanium alloy, lnTech, 2012.
3. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: principles and applications, 3rd Edition, World Scientific, 2010.
4. Paul F.Jacobs, Rapid Prototyping and Manufacturing, “Fundamentals of Stereolithography”, McGraw Hill,2002.
5. Dongdong Gu, “Laser Additive Manufacturing of High-Performance Materials”, Springer- Verlag Berlin Heidelberg, 2015.
6. Chee Kai Chua, “Lasers in 3D Printing and Manufacturing, World Scientific, 2016.
7. Rafiq I.Noorani, “Rapid Prototyping: Principles and Applications”, Wiley & Sons, 2006.
8. N.Hopkinson, R.J.M, Hauge, P M, Dickens, “Rapid Manufacturing: An Industrial revolution for the digital age”, Wiley,2006.
9. D.T.Pham and S.S.Dimov, “Rapid Manufacturing”, SpringerVerlog, 2001
10. L. Jyothish Kumar, Pulak M. Pandey, David Ian Wimpenny, 3D Printing and Additive Manufacturing Technologies, Springer Singapore
11. Adedeji B. Badiru, Vhance V. Valencia, David Liu, Additive Manufacturing Handbook: Product Development for the Defense Industry, CRC Press
12. André, Jean-Claude, From additive manufacturing to 3D/4D printing 3 Breakthrough Innovations: Programmable Material, 4D Printing and Bio-printing, Wiley-ISTE
13. Maniruzzaman Mohammed, 3D AND 4D Printing in Biomedical Applications:

Process Engineering and Additive Manufacturing, WILEY VCH
14. Milewski, John O, Additive Manufacturing of Metals : From Fundamental Technology to Rocket Nozzles, Medical Implants, and Custom Jewelry, Springer
15. Chee Kai Chua, Chee How Wong and Wai Yee Yeong (Auth.), Standards, Quality Control, and Measurement Sciences in 3D Printing and Additive Manufacturing, Academic Press
16. Li Yang, Keng Hsu, Brian Baughman, Donald Godfrey, Francisco Medina, Mamballykalathil Menon, Soeren Wiener (auth.), Additive Manufacturing of Metals: The Technology, Materials, Design and Production, Springer International Publishing.
17. Bandyopadhyay, Amit, Bose, Susmita, Additive manufacturing, CRC Press.
18. Steinar Westhrin Killi, Additive Manufacturing: Design, Methods, and Processes, Pan Stanford Publishing.
19. Linkan Bian, Nima Shamsaei, John Usher, Laser-Based Additive Manufacturing of Metal Parts: Modeling, Optimization, and Control of Mechanical Properties, CRC Press

OUTCOMES:

Students should be able to

- Explain the basics of reverse engineering (RE) process
- Select various techniques involved in RE
- Utilize the different RE hardware and software
- Explain the cloud data modeling
- Explain the medical parts data capturing and 3D image building
- Build 3D model using reverse engineering (RE)

	L	T	P	C
DESIGN FOR ADDITIVE MANUFACTURING	**2**	**0**	**1**	**3**

OBJECTIVES:

- To know the basics of CAD, CAM, CAE and Robotics
- To acquire the basics of geometric modelling
- To study the design considerations and rules for AM
- To learn about design for AM
- To understand the pre and post-processing of AM
- To learn the various inspection methods and quality of AM products

MODULE I CAD, CAM, CAE and Robotics 7

Computer-Aided Design - AutoCAD, Pro/E, UNIGRAPHICS, CATIA, Solid Works, ANSYS, Computer-Aided Engineering - Computer-Aided Manufacturing - Computerized Numerical Control - Robotics - Monitoring and Real-Time Control

- Simple exercises : Part modeling of given component using software

MODULE II Basics of Geometric Modeling 9

Introduction - Translations, Scaling, Reflection, Rotation, Concatenation of transformations - Analytic Curves - Bezier, B-spline Non-uniform rational basis spline (NURBS) - Parametric representation, Curves on surface - B-rep of Solid Modeling, Constructive Solid Geometry (CSG) approach of solid modeling - Data exchange formats - Slicing Algorithms

- Simple exercises : Geometric modeling

MODULE III Design Considerations and Rules 7

Elements of Design - Material Selection, Process Selection - Design Requirements - Support structure design, Design of fixtures, jigs and tooling, Prototype design, Hybrid design, Cost analysis, Tolerance, Relative fit - Material Properties - Grain Size, Tensile, Fatigue, Creep, Fracture tolerance .

- Simple exercises : Jigs and Fixtures

MODULE IV Design for Additive Manufacturing 8

Design for AM - Part Orientation, Removal of Supports, Hollowing Out Parts, Inclusion of Undercuts and Other Manufacturing Constraining Features, Interlocking Features, Reduction of Part Count in an Assembly - Design Analysis of AM Parts - Material Data, Surface Finish, Geometry, Simplifying Geometry, Mesh-Based Versus Parametric Models, Geometry Distortion - Optimisation - Topology Optimisation, Objective and Constraints, Common Settings - Build Process Simulation, Layer-by-Layer Simulation , Scan Pattern Simulation.

MODULE V Pre and Post processing 9

Introduction- Preparation of CAD Models – the STL File, STL File Format, Binary/ASCII Creating STL Files from a CAD System, Calculation of Each Slice Profile, Technology Specific Elements - STL File Manipulation - Viewers, STL Manipulation on the AM Machine - Beyond the STL File - Direct Slicing of the CAD Model, Color Models, Multiple Materials, Use of STL for Machining - Additional Software to Assist AM - Post-processing - Support Material Removal- Polymer, Metal - Polymer Surface Treatments, Vapour Smoothing, Tumbling, Dying, Painting, Using Textures, Sand Blasting, Machining, Metalizing, Wrapping, Hydrographics - Metal Surface Treatments - Shot-Peening, Plasma Cleaning and Ion Beam Cleaning, Machining and Grinding, Abrasive Flow Machining, Anodizing, Plasma Spraying, Plating and PVD- Gluing and Welding AM Parts - Heat Treatment and Aging - Residual Stress Relief, Case Hardening and Gas Nitride Treatment.

- Hands on practice : Post processing treatments
- Hands on practice: Designing a part using CAD software.

MODULE VI Inspection, Quality and Software Issues of AM 5

Bulk Deposit Defects - Dimensional Accuracy, Shrinkage, and Distortion - Inspection, Quality, and Testing of AM Metal Parts - Nondestructive Test Methods - Destructive Test Methods, Form, Fit, Function, and Proof Testing - Standards and Certification - STL file Errors and corrections.

Total Hours –45

TEXT BOOKS:

1. Ibrahim Zeid “CAD/CAM Theory and Practice” TMH.
2. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: principles and applications, 3rd Edition, World Scientific, 2010.
3. Michael E. Mortenson, “Geometric Modeling”, Wiley, NY, 1997.
4. Anupam Saxena, Birendra Sahay, “Computer Aided Engineering Design”, Springer, 2005.
5. Ian Gibson, “Software Solutions for Rapid Prototyping”, Professional Engineering Publishing Limited, UK, 2002.
6. Ali K. Kamrani and Emad Abouel Nasr, “Engineering Design and Rapid Prototyping”, Springer, 2010.

REFERENCES:

7. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: principles and applications, 3rd Edition, World Scientific, 2010.
8. Paul F.Jacobs, Rapid Prototyping and Manufacturing, “Fundamentals of

Stereolithography", McGraw Hill,2002.
9. Dongdong Gu, "Laser Additive Manufacturing of High-Performance Materials", Springer- Verlag Berlin Heidelberg, 2015.
10. Chee Kai Chua, "Lasers in 3D Printing and Manufacturing, World Scientific, 2016.
11. Rafiq I.Noorani, "Rapid Prototyping: Principles and Applications", Wiley & Sons, 2006.
12. N.Hopkinson, R.J.M, Hauge, P M, Dickens, "Rapid Manufacturing: An Industrial revolution for the digital age", Wiley,2006.
13. D.T.Pham and S.S.Dimov, "Rapid Manufacturing", SpringerVerlog, 2001
14. L. Jyothish Kumar, Pulak M. Pandey, David Ian Wimpenny, 3D Printing and Additive Manufacturing Technologies, Springer Singapore
15. Adedeji B. Badiru, Vhance V. Valencia, David Liu, Additive Manufacturing Handbook: Product Development for the Defense Industry, CRC Press
16. André, Jean-Claude, From additive manufacturing to 3D/4D printing 3 Breakthrough Innovations: Programmable Material, 4D Printing and Bio-printing, Wiley-ISTE
17. Maniruzzaman Mohammed, 3D AND 4D Printing in Biomedical Applications: Process Engineering and Additive Manufacturing, WILEY VCH
18. Milewski, John O, Additive Manufacturing of Metals : From Fundamental Technology to Rocket Nozzles, Medical Implants, and Custom Jewelry, Springer
19. Chee Kai Chua, Chee How Wong and Wai Yee Yeong (Auth.), Standards, Quality Control, and Measurement Sciences in 3D Printing and Additive Manufacturing, Academic Press
20. Li Yang, Keng Hsu, Brian Baughman, Donald Godfrey, Francisco Medina, Mamballykalathil Menon, Soeren Wiener (auth.), Additive Manufacturing of Metals: The Technology, Materials, Design and Production, Springer International Publishing.
21. Bandyopadhyay, Amit, Bose, Susmita, Additive manufacturing, CRC Press.
22. Steinar Westhrin Killi, Additive Manufacturing: Design, Methods, and Processes, Pan Stanford Publishing.
23. Linkan Bian, Nima Shamsaei, John Usher, Laser-Based Additive Manufacturing of Metal Parts: Modeling, Optimization, and Control of Mechanical Properties, CRC Press

OUTCOMES:

Students should be able to

- Explain the basics of CAD, CAM, CAE and Robotics

- Apply the basics of geometric modeling
- Demonstrate the different design considerations and rules of AM
- Perform the design for AM.
- Use the concepts Pre and Post-processing in AM.
- Utilize the suitable inspection methods to ensure the quality.

LAYERED MANUFACTURING

L	T	P	C
3	0	0	3

OBJECTIVES:

- To acquire knowledge on extrusion based Layered Manufacturing (LM)
- To impart knowledge on photopolymer based LM
- To learn the information about powder based LM
- To gain the knowledge on direct write technologies and hybrid LM
- To understand supporting structures used in LM
- To study the issues in LM

MODULE I Extrusion based LM 7

Introduction - Types - Basic principles - Plotting and path control -Fused deposition modeling (FDM) machine types -Materials - Limitations of FDM - Bio extrusion - FDM of ceramics – Robocasting - Process and limitations.

- Hands on practice : FDM machine

MODULE II Photo Polymer Based LM 8

Introduction - Photopolymerization Materials - Vector Scan SL - SL Resin Curing Process - SL Scan Patterns -Mask Projection Photopolymerization Technologies and Processes - Two-Photon SL - Solid Ground Curing (SGC) - Liquid thermal polymerization - Material Jetting - Inkjet printing (IJP) /Multi jet modeling (MJM) - Materials used in printing deposition - Droplet formation technologies - Continuous mode, Drop on demand mode - Material modification methods - Hot melt deposition, Solution and Dispersion based deposition.

MODULE III Powder Based LM 7

Introduction - Powder Fusion Mechanisms - Powder Handling - Approaches to Metal and Ceramic Part Creation - Variants of Powder Bed Fusion Processes - Process Parameters - Applied Energy Correlations and Scan Patterns - Materials and Applications - Selective Laser Sintering - Selective Laser Melting- Electron Beam Melting (EBM) - Historical Development of 3D Printing - Commercially Available Printing Machines - Advantages of Printing

MODULE IV Direct Write and Hybrid LM 8

Direct write technologies - Ink-based DW -Laser transfer DW - Thermal Spray DW - Beam Deposition DW - Liquid-Phase Direct Deposition - Beam Tracing

Approaches to Additive/Subtractive DW - Hybrid technologies

MODULE V Other methods and Supporting Structures in LM 8

Laminated Object Manufacturing (LOM) - Paper laminations, Plastic laminations - Introduction - Principles of support design - Support structure Modeling - Optimal part orientation - Sacrificial or Soluble Materials as Support - Support Structure Optimization - Topology, Standardized model of support structures for different process.

MODULE VI Issues in LM 7

Introduction - Material Issues - Software Issues - Size limitations - Qulaity consistency - Scalability - Standardization - Training

Total Hours –45

TEXT BOOKS:

1. John O. Milewski, Additive Manufacturing of Metals:From Fundamental Technology to Rocket Nozzles, Medical Implants, and Custom Jewelry, Springer Series in Materials Science.
2. Li Yang, Keng Hsu, Brian Baughman, Donald Godfrey, Francisco Medina, Mamballykalathil Menon, Soeren Wiener, Additive Manufacturing of Metals: The Technology, Materials, Design and Production, Springer Series in Advanced Manufacturing
3. Olaf Diegel, Axel Nordin, Damien Motte, A Practical Guide to Design for Additive Manufacturing, Springer Series in Advanced Manufacturing.
4. Andreas Gebhardt, Understanding Additive Manufacturing, Hanser Publications.
5. Ian Gibson, David W. Rosen, Brent Stucker, Additive manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010.

REFERENCES:

1. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: principles and applications, 3rd Edition, World Scientific, 2010.
2. Paul F.Jacobs, Rapid Prototyping and Manufacturing, “Fundamentals of Stereolithography”, McGraw Hill,2002.
3. Dongdong Gu, “Laser Additive Manufacturing of High-Performance Materials”, Springer- Verlag Berlin Heidelberg, 2015.
4. Chee Kai Chua, “Lasers in 3D Printing and Manufacturing, World Scientific, 2016.
5. Rafiq I.Noorani, “Rapid Prototyping: Principles and Applications”, Wiley & Sons, 2006.
6. N.Hopkinson, R.J.M, Hauge, P M, Dickens, “Rapid Manufacturing: An Industrial revolution for the digital age”, Wiley,2006.

7. D.T.Pham and S.S.Dimov, “Rapid Manufacturing”, SpringerVerlog, 2001
8. L. Jyothish Kumar, Pulak M. Pandey, David Ian Wimpenny, 3D Printing and Additive Manufacturing Technologies, Springer Singapore
9. Adedeji B. Badiru, Vhance V. Valencia, David Liu, Additive Manufacturing Handbook: Product Development for the Defense Industry, CRC Press
10. André, Jean-Claude, From additive manufacturing to 3D/4D printing 3 Breakthrough Innovations: Programmable Material, 4D Printing and Bio-printing, Wiley-ISTE
11. Maniruzzaman Mohammed, 3D AND 4D Printing in Biomedical Applications: Process Engineering and Additive Manufacturing, WILEY VCH
12. Milewski, John O, Additive Manufacturing of Metals : From Fundamental Technology to Rocket Nozzles, Medical Implants, and Custom Jewelry, Springer
13. Chee Kai Chua, Chee How Wong and Wai Yee Yeong (Auth.), Standards, Quality Control, and Measurement Sciences in 3D Printing and Additive Manufacturing, Academic Press
14. Li Yang, Keng Hsu, Brian Baughman, Donald Godfrey, Francisco Medina, Mamballykalathil Menon, Soeren Wiener (auth.), Additive Manufacturing of Metals: The Technology, Materials, Design and Production, Springer International Publishing.
15. Bandyopadhyay, Amit, Bose, Susmita, Additive manufacturing, CRC Press.
16. Steinar Westhrin Killi, Additive Manufacturing: Design, Methods, and Processes, Pan Stanford Publishing.
17. Linkan Bian, Nima Shamsaei, John Usher, Laser-Based Additive Manufacturing of Metal Parts: Modeling, Optimization, and Control of Mechanical Properties, CRC Press

OUTCOMES:

Students should be able to

- Explain the extrusion based LM
- Describe the photopolymer based LM
- Demonstrate the various powder fusion processes of LM
- Elucidate the direct write technologies used in LM and hybrid LM
- Clarify the supporting structures used in LM
- Identify the issues in LM processes

ADDITIVE MANUFACTURING OF METAL AND POLYMERIC MATERIALS	L	T	P	C
	2	0	1	3

OBJECTIVES:

- To gain the knowledge on polymeric and metallic materials used in AM
- To learn about the basics of laser
- To impart the basics of electron beam.
- To study the process of solid and liquid based AM
- To impart the knowledge on metal based AM
- To understand various testing of AM products

MODULE I Polymeric and Metallic materials for AM 8

Polymer materials - Standard Polymers, Engineering Polymers, High performance Engineering Polymers - Metals - Stainless steel, tool steel, Titanium, Magnesium, Aluminum, Co-Cr alloys, precious metals - Composites - Graded materials

- Hands on practice: Exposure to different metal and polymeric materials

MODULE II Basics of Laser & Electron Beam 8

Introduction - Laser theory and Operation - Components of a Laser - Types of Lasers - Laser ablation - Characteristics of materials - The role of lasers in AM - Laser as tool in AM, laser matter interaction in AM – Applications- Introduction - Mechanism of electron beam generation - Electron-matter interactions - Role of electron beam in AM.

- Demo on laser machine

MODULE III Solid based AM 6

Fused Deposition Modeling (FDM) - Principle, Process description, Process Parameters, Advantages and Disadvantages - Shape Deposition Manufacturing (SDM) - Principle, Process description, Process Parameters, Advantages and Disadvantages - Laminated Object Manufacturing (LOM) - Principle, Process description, Process Parameters, Advantages and Disadvantages

MODULE IV Liquid based AM 7

Streolithography (SLA) - Principle, Process description, Process Parameters, Advantages and Disadvantages - Solid Ground Curing (SGC) - Principle, Process description, Process Parameters, Advantages and Disadvantages - Three Dimensional Printing (3DP) - Principle, Process description, Process Parameters, Advantages and Disadvantages

- Hands on training : FDM process - Simple toys of students own design

MODULE V Metal Based AM 9

Selective Laser Sintering (SLS) - Principle, Process description, Process Parameters, Advantages and Disadvantages - Electron Beam Melting (EBM) - Principle, Process description, Process Parameters, Advantages and Disadvantages - Laser Engineered Net Shaping (LENS) - Principle, Process description, Process Parameters, Advantages and Disadvantages. Selective Laser Melting (SLM)

MODULE VI Testing of AM products and Applications 7

ASTM test standards for AM products - Chemical and Physical tests - Mechanical test - Metallography tests - Non-destructive test - Penetrant Testing, Eddy Current Testing, Structured Light, Ultrasonic Testing - applications in medical, nuclear and aerospace industries.

- Hands on practice: Simple material testing by metallography method.

Total Hours –45

TEXT BOOKS:

1. Karl F. Renk, Basics of Laser Physics: For Students of Science and Engineering, Springer
2. Orazio Svelto and David C. Hanna, Principles of Lasers, Springer Science.
3. Milan Brandt, Laser Additive Manufacturing Materials, Design, Technologies, and Applications, Woodhead Publishing Series in Electronic and Optical Materials: Number 88.
4. John O. Milewski, Additive Manufacturing of Metals:From Fundamental Technology to Rocket Nozzles, Medical Implants, and Custom Jewelry, Springer Series in Materials Science.
5. Li Yang, Keng Hsu, Brian Baughman, Donald Godfrey, Francisco Medina, Mamballykalathil Menon, Soeren Wiener, Additive Manufacturing of Metals: The Technology, Materials, Design and Production, Springer Series in Advanced Manufacturing.
6. Olaf Diegel, Axel Nordin, Damien Motte, A Practical Guide to Design for Additive Manufacturing, Springer Series in Advanced Manufacturing.
7. Andreas Gebhardt, Understanding Additive Manufacturing, Hanser Publications.
8. Ian Gibson, David W. Rosen, Brent Stucker, Additive manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010.
9. J.D. Majumdar and I. Manna, Laser-assisted fabrication of materials, Springer Series in Material Science, e-ISBN: 978-3-642- 28359-8.

10. L. Lu, J. Fuh and Y.-S. Wong, Laser-induced materials and processes for rapid prototyping, Kluwer Academic Press, 2001.

REFERENCES:

1. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: principles and applications, 3rd Edition, World Scientific, 2010.
2. Paul F.Jacobs, Rapid Prototyping and Manufacturing, “Fundamentals of Stereolithography”, McGraw Hill,2002.
3. Dongdong Gu, “Laser Additive Manufacturing of High-Performance Materials”, Springer- Verlag Berlin Heidelberg, 2015.
4. Chee Kai Chua, “Lasers in 3D Printing and Manufacturing, World Scientific, 2016.
5. Rafiq I.Noorani, “Rapid Prototyping: Principles and Applications”, Wiley & Sons, 2006.
6. N.Hopkinson, R.J.M, Hauge, P M, Dickens, “Rapid Manufacturing: An Industrial revolution for the digital age”, Wiley,2006.
7. D.T.Pham and S.S.Dimov, “Rapid Manufacturing”, SpringerVerlog, 2001
8. L. Jyothish Kumar, Pulak M. Pandey, David Ian Wimpenny, 3D Printing and Additive Manufacturing Technologies, Springer Singapore
9. Adedeji B. Badiru, Vhance V. Valencia, David Liu, Additive Manufacturing Handbook: Product Development for the Defense Industry, CRC Press
10. André, Jean-Claude, From additive manufacturing to 3D/4D printing 3 Breakthrough Innovations: Programmable Material, 4D Printing and Bio-printing, Wiley-ISTE
11. Maniruzzaman Mohammed, 3D AND 4D Printing in Biomedical Applications: Process Engineering and Additive Manufacturing, WILEY VCH
12. Milewski, John O, Additive Manufacturing of Metals : From Fundamental Technology to Rocket Nozzles, Medical Implants, and Custom Jewelry, Springer
13. Chee Kai Chua, Chee How Wong and Wai Yee Yeong (Auth.), Standards, Quality Control, and Measurement Sciences in 3D Printing and Additive Manufacturing, Academic Press
14. Li Yang, Keng Hsu, Brian Baughman, Donald Godfrey, Francisco Medina, Mamballykalathil Menon, Soeren Wiener (auth.), Additive Manufacturing of Metals: The Technology, Materials, Design and Production, Springer International Publishing.
15. Bandyopadhyay, Amit, Bose, Susmita, Additive manufacturing, CRC Press.

16. Steinar Westhrin Killi, Additive Manufacturing: Design, Methods, and Processes, Pan Stanford Publishing.
17. Linkan Bian, Nima Shamsaei, John Usher, Laser-Based Additive Manufacturing of Metal Parts: Modeling, Optimization, and Control of Mechanical Properties, CRC Press.
18. Gibson, Rosen, Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing. Springer, 2009.

OUTCOMES:

Students should be able to

- Identify the polymeric and metallic materials used in AM
- Explain the basics of laser in AM process
- Describe the mechanism of electron beam and its role in AM
- Demonstrate the process of solid and liquid based AM
- Describe the metal based AM processes
- Select a suitable testing method to check the quality of AM products

RAPID PROTOTYPING OF BIO-MATERIALS	L	T	P	C
	3	0	0	3

OBJECTIVES:

- To understand the basics of RPT of bio-materials
- To learn the techniques used in fabrication of bio-materials
- To know the fabrication techniques of Nanomaterial's
- To study the fabrication methods of different biosensors and tissue materials
- To learn about RPT of bioscaffolds.
- To learn the design and fabrication of prosthetic limbs

MODULE I Introduction to RPT of Bio-materials 7

Introduction - Basic Process - RP of Bio-materials - Future trends in RP of Bio-materials

MODULE II Techniques used in Fabrication of Bio-materials 8

Introduction - 3D printing techniques for metallic bio materials - Powder bed fusion, Direct energy deposition - 3D printed metallic bio materials -316 stainless steel, Ti-6Al-4V, Co-Cr-Mo.

MODULE III Fabrication of Nano-materials 7

Introduction - Laser based SFF techniques - Droplet based SFF techniques - Nozzle based SFF techniques - Dry powder printing

MODULE IV Fabrication of Bio Sensors and Tissue Materials 8

Introduction - RP of microfluidic systems - Functionalization - Biomaterials compatibility - Tissue engineering - RP in scaffold fabrication - Laser tweezers, Laser ablation - Bio plotter - Inkjet printing - Micro extrusion bio printing

MODULE V RPT of Bio Scaffolds 8

Introduction - Scaffold materials and macromicrostructure design - extrusion free forming with and without material melting - Overview of organ fabrication - material types, physical properties, temporal expectations, bio-fabrication.

MODULE VI RPT of Prosthetics 7

Introduction - History of prosthetic fabrication - Prosthetic design considerations - Technical process - Designing a prosthetic limb - Biomimetic approach to design.

Total Hours – 45

TEXT BOOKS:

1. Roger Narayan, Rapid prototyping of Biomaterials: Techniques in Additive Manuafcturing, Woodhead Publishing Series in Biomaterials, Elseiver, 2019.
2. Mohammed Maniruzzaman, 3D and 4D Printing in Biomedical Applications:

Process Engineering and Additive Manufacturing, Wiley-VCH.

REFERENCES:

1. Liou W.Liou, Frank W.Liou, Rapid Prototyping and Engineering applications : A tool box for prototype development, CRC Press, 2007.
2. Ali K. Kamrani, Emad Abouel Nasr, Rapid Prototyping: Theory and practice, , Springer, 2006.
3. Chua Chee Kai., Leong Kah Fai., Chu Sing Lim, Rapid Prototyping: Principles and Applications in Manufacturing, World Scientific, 2010.
4. Peter D. Hilton, Hilton/Jacobs, PaulF, Rapid Tooling: Technologies and Industrial Applications, .Jacobs, CRC press, 2000.

OUTCOMES:

students should be able to

- Explain the basics of RPT of bio-materials
- Apply the techniques used in fabrication of bio-materials.
- Demonstrate the fabrication techniques of Nanomaterial's
- Explain the fabrication methods of different bio-sensors and tissue materials
- Create the RPT of bioscaffolds
- Design and fabricate working models of prosthetic limbs

MINI PROJECT

L	T	P	C
0	0	1	1

The main objective is to inculcate problem based learning and to promote team spirit.

Students will be asked to take a real world problem and solve it by designing or fabricating a system.

The students will work in groups.

SCHOOL OF ELECTRICAL AND COMMUNICATION SCIENCES

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

MINOR DEGREE – ELECTRIC VEHICLES

CURRICULUM & SYLLABUS

Sl. No.	Course Code	Course Title	L	T	P	C
1		Fundamental of Electric and Hybrid Vehicles	3	0	0	3
2		Energy devices for electric vehicles	3	0	0	3
3		Electrical & Electronics for Automotive system	3	0	0	3
4		Automotive transmission & communication	3	0	0	3
5		HEV / xEV Motor drives and controllers	3	0	0	3

FUNDAMENTALS OF ELECTRIC AND HYBRID VEHICLES	L	T	P	C
	3	0	0	3

OBJECTIVES:

To impart Knowledge on -

- Various alternative vehicles and its architecture
- Fundamentals of vehicle dynamics
- Working principle of electric propulsion systems and regenerative braking
- Various energy storage systems

MODULE I INTRODUCTION TO ALTERNATIVE VEHICLES 8

History of Electric and Hybrid Vehicle - Electric Vehicle Types – Electric and Hybrid Vehicle Components – Vehicle Mass and Performance – Electric Motor and Engine Ratings – Well to Wheel Analysis – EV/ICEV Comparison – Electric Vehicle Market – International standards and codes.

MODULE II VEHICLE MECHANICS 9

Roadway Fundamentals – Laws of Motion and Vehicle Kinetics – Vehicle Resistance - Dynamics of Vehicle Motion – Propulsion Power – Velocity and Acceleration – Tire-Road Force Mechanics – Propulsion System Design

MODULE III ALTERNATIVE VEHICLE ARCHITECTURE 9

Electric Vehicles – Hybrid Electric Vehicles Plug-In Hybrid Electric Vehicle – Powertrain Component Sizing – Mass Analysis and Packaging – Vehicle Simulation – Simulation Model and Standard Drive Cycles – Traction, Acceleration and Range Modelling.

MODULE IV ELECTRIC PROPULSION SYSTEMS 7

DC Motor Drives – Principle of Operation and Performance – Chopper Control of DC Motors – Multi-quadrant Control of Chopper-Fed DC Motor – Induction Motor Drives - Principle of Operation and Performance – Power Electronic Control – Special Machine Drives

MODULE V FUNDAMENTALS OF REGENERATIVE BRAKING 7

Energy Consumption in Braking – Braking Power and Energy on Front and Rear Wheels – Brake System of EVs and HEVs - Series Brake – Optimal Feel and Optimal Energy Recovery – Parallel Brake – Antilock Brake System (ABS).

MODULE VI ALTERNATIVE ENERGY STORAGE 5

Fuel Cells – Types – Model – Hydrogen Storage Systems – Fuel Cell Electric Vehicle – Ultracapacitors – Compressed Air Storage.

TOTAL HOURS – 45

REFERENCES:

1. Husain, I. (2011). Electric and hybrid vehicles: design fundamentals. CRC press.
2. Ehsani, M., Gao, Y., Longo, S., & Ebrahimi, K. (2018). Modern electric, hybrid electric, and fuel cell vehicles. CRC press.
3. Hybrid Electric Vehicle System Modeling and Control -Wei Liu- General Motors- USA- John Wiley & Sons- Inc.- 2017.
4. Hybrid Electric Vehicles – Teresa Donateo- Published by ExLi4EvA- 2017.
5. Electric and Hybrid Vehicles Power Sources- Models- Sustainability- Infrastructure and the Market Gianfranco Pistoia Consultant- Rome- Italy- Elsevier Publications- 2017.
6. Modern Electric- Hybrid Electric- and Fuel Cell Vehicles- Mehrdad Ehsani Yimin Gao Stefano Longo Kambiz M. Ebrahimi- Taylor & Francis Group- LLC- 2018.

OUTCOMES:

At the end of the course, the student will be

- Analyze the importance of alternative vehicles
- Identify the opportunities and challenges of electric vehicle mechanics.
- Choose desired system architecture for electric vehicle design.
- Design suitable electric propulsion system.
- Identify & model regenerative braking system.
- Identify the opportunities and challenges of energy storage systems

ENERGY DEVICES FOR ELECTRIC VEHICLES	L	T	P	C
	3	0	0	3

OBJECTIVES:

To impart Knowledge on -

- Environmental impact of present fuel energy systems and history of modern transportation systems
- Various Energy storage systems
- Energy devices such as Battery storage, fuel cells, ultra capacitors and flywheels\
-

MODULE I ENVIRONMENTAL IMPACT AND HISTORY OF MODERN TRANSPORTATION **5**

Air Pollution – Global Warming – Petroleum Resources – Induced Costs – Importance of Different Transportation Development Strategies to Future Oil Supply.

MODULE II ENERGY STORAGE SYSTEMS **9**

Mechanical Storage Systems – Pumped Hydro Storage – Compressed Air Energy Storage – Flywheel Energy Storage – Electrochemical Storage Systems – Flow Batteries – Secondary Batteries- Chemical Storage Systems – Electrical Energy Storage Systems - Thermal Energy Storage Systems

MODULE III BATTERY ENERGY STORAGE **9**

Batteries in Electric and Hybrid Vehicle – Battery Basics – Battery Specific Parameters – Electrochemical Cell Fundamentals – Battery Modeling – Electric Circuit Models – Empirical Models - Different Types of Traction Batteries – Battery Pack Management

MODULE IV BATTERY TECHNOLOGIES **9**

Electrochemical Batteries – Electrochemical Reactions – Thermodynamic Voltage – Specific Energy and Power – Energy Efficiency – Battery Technologies – Lead Acid Batteries – Nickel based Batteries – Nickel/Iron System – Nickel/Cadmium System – Nickel Metal Hydride (Ni-MH) Battery – Lithium Based Batteries – Lithium Polymer (Li-P) Battery – Lithium – Ion (Li-Ion) Battery.

MODULE V FUEL CELLS **7**

Fuel Cells – Operating Principles – Electrode Potential and Current-Voltage Curve – Fuel and Oxidant Consumption – Characteristics - Fuel Supply – Hydrogen Storage – Compressed Hydrogen – Cryogenic Liquid Hydrogen – Metal Hydrides – Steam Reforming – POX Reforming – Autothermal Reforming – Ammonia as Hydrogen Carrier – Non hydrogen Fuel Cells.

MODULE VI ULTRACAPACITORS AND FLYWHEELS **6**

Ultracapacitors – Features – Basic Principles – Performance – Ultracapacitor Technologies –

Ultrahigh-Speed Flywheels – Operation Principles and Power Capacity of Flywheel System – Flywheel Technologies – Hybridization of Energy Storages

TOTAL HOURS – 45

REFERENCES:

1. Ehsani, M., Gao, Y., Longo, S., & Ebrahimi, K. (2018). Modern electric, hybrid electric, and fuel cell vehicles. CRC press.
2. Hannan, M. A., Hoque, M. M., Mohamed, A., & Ayob, A. (2017). Review of energy storage systems for electric vehicle applications: Issues and challenges. Renewable and Sustainable Energy Reviews, 69, 771-789.
3. Husain, I. (2011). Electric and hybrid vehicles: design fundamentals. CRC press.
4. Hybrid Electric Vehicles – Teresa Donateo- Published by ExLi4EvA- 2017.
5. Electric and Hybrid Vehicles Power Sources- Models- Sustainability- Infrastructure and the Market Gianfranco Pistoia Consultant- Rome- Italy- Elsevier Publications- 2017.
6. Modern Electric- Hybrid Electric- and Fuel Cell Vehicles- Mehrdad Ehsani Yimin Gao Stefano Longo Kambiz M. Ebrahimi- Taylor & Francis Group- LLC- 2018.

At the end of the course, the student will be able to

- Apply the knowledge of fuel energy systems for electric vehicles
- Design an energy storage system
- Select appropriate battery energy storage system
- Model an energy efficient battery system
- Choose suitable fuel cell system for electric/hybrid vehicle.
- Apply the basic principles of Ultracapacitor Technologies and Ultra-high Speed Technologies for e-vehicles.

ELECTRICAL & ELECTRONICS FOR AUTOMOTIVE SYSTEM	L	T	P	C
	3	0	0	3

OBJECTIVES:

- To understand all the sensors and actuators used in automotive systems
- To provide in depth knowledge of batteries, starting system, charging and ignition system, lighting and other electrical systems inside an automobile.
- To conceptualize battery management & energy estimation
-

MODULE I SENSORS AND ACTUATORS 8

Introduction, Basic Sensor Arrangement, Types of Sensors, Oxygen Sensor, Cranking Sensor, Position Sensor, Engine Oil Pressure Sensor, Linear and Angle Sensor, Flow Sensor, Temperature and Humidity Sensor, Gas Sensor, Speed and Acceleration Sensor, Knock Sensor, Torque Sensor, Yaw Rate Sensors, Tire Pressure Sensor, Actuators.

MODULE II STARTING SYSTEMS AND IGNITION SYSTEMS 8

Requirements of the Starting System, Starter Motors And Circuits, Types Of Starter Motor, Diagnosing Starting System Faults, Advanced Starting System Technology. Ignition Fundamentals, Types of Ignition System, Electronic Ignition, Programmed Ignition, Distributor Less Ignition, Direct Ignition, Spark-Plugs, Diagnosing Ignition System Faults, Advanced Ignition Technology.

MODULE III LIGHTING SYSTEMS AND INSTRUMENTATION 7

Lighting fundamentals, Lighting circuits, Gas discharge and LED lighting, Diagnosing lighting system faults, Advanced lighting technology, new developments in lighting systems. Gauges and sensors, Driver information, Visual displays, GPS, Diagnosing instrumentation system faults, advanced instrumentation technology.

MODULE IV CHARGING SYSTEMS AND ELECTRONIC FUEL CONTROL 7

Requirements of the Charging System, Charging System Principles, Alternators and Charging Circuits - Battery Charging methods – Static and dynamic methods - Diagnosing Charging System Faults, Advanced Charging System Technology. Combustion, Engine Fuelling And Exhaust Emissions, Electronic Control of Injection Systems, Diesel Fuel Injection, Diagnosing Fuel Control System Faults, Advanced Fuel Control Technology.

MODULE V BATTERY MANAGEMENT SYSTEMS 8

Block Diagram - Main Functions of a BMS, Sensing Requirements, Cell/module level: cell voltage, cell/module temperature, (humidity, smoke, air/fluid flow), Pack level: current, precharge temperature, bus voltage, pack voltage, isolation, Control Requirements, Contactor control, pre-charge circuitry, Thermal system control – On Board and Off board chargers – Thermal Management in battery – Fast Charging Architectures.

MODULE VI ENERGY ESTIMATION **7**

Cell Balancing: Active versus passive, strategies, Estimation Requirements, Strategies: different approaches and benefits of model based approach, model creation via cell tests, State of Charge estimation; State of Health estimation, Power estimation, Energy estimation (range estimation).

TOTAL HOURS – 45

REFERENCES:

1. Tom Denton, 'Automotive Electrical and Electronic Systems', Routledge, 5th Edition,2017.
2. Young A.P. and Griffiths. L., "Automotive Electrical Equipment", ELBS & New Press,1999.
3. William B.Ribbens, "Understanding Automotive Electronics",6th Edition, Elsevier,2003.
4. Kholi.P.L, "Automotive Electrical Equipment",Tata McGraw-Hill Ltd,1975.
5. Robert Bosch, " Automotive Hand Book", SAE, 5th Edition,2000.
6. Advanced Electric Vehicle Fast-Charging Technologies and Extreme Fast Charging Technology - Prospects to Enhance Sustainable Electric Transportation, Energies 2019

OUTCOMES:

At the end of the course, the student will be able to

- Construct electrical and electronic components of the new generation vehicles
- Characterize sensor and actuators related to instrumentation, control, security and warning systems.
- Select starting & ignition system for any vehicle.
- Diagnose faults in charging and electronic fuel control.
- Design and develop Battery Management System.
- Estimate energy for battery-based system.

AUTOMOTIVE TRANSMISSION AND COMMUNICATION	L	T	P	C
	3	0	0	3

OBJECTIVES:

- To know about the various components in transmission system and drive line units of automobiles
- To know the applications of automatic transmission in a vehicle
- To distinguish various communication modules in electric vehicle

MODULE I INTRODUCTION TO VEHICLE TRANSMISSION 7

Traction demand and torque supply at constant speed and transient driving states – Fuel Economy Optimization – Launch and Synchronizing Speeds – Gear Ratios and their design.

MODULE II POWER TRAIN DYNAMICS 8

Power train model – Inertia – Spring Stiffness – Substitute system – Eigen frequencies and Eigen modes – Excitation – Forced Oscillation – Rotational vibration damping on the transmission input – Vehicle dynamics – Dynamic coupling.

MODULE III ACTUATION, SERVO AND AUXILIARY SYSTEMS 8

Fundamentals and active principles – Transfer elements – Cooling and Lubrication – Electromechanical actuation – Energy and power balance.

MODULE IV VEHICLE CONTROL 8

Electronic Control Units – Software Architecture – Signal processing – Selecting the shift point – Shift execution – Safety in transmission system – In vehicle Networking (IVN) protocols: Local Interconnect Network(LIN),Control Area Network (CAN), Media Oriented System Transport (MOST) and FlexRay - Wireless Access in Vehicular Environment (WAVE).

MODULE V POWER TRAIN ELECTRIFICATION AND COMMUNICATION 7

Electric and hybrid power train – Requirements – Components and configurations – Functions – Strategies Case studies – Truck, Bus, Tractor, Motor cycle, Racing Transmissons - Communication Between Plug-In Vehicles and Off-Board DC Chargers.

MODULE VI COMMUNICATION IN ELECTRIC VEHICLE 7

Transmission network – Distribution network – Demand side management and Control – Communication standards and technologies – Inter and Intra control center communications – Communication requirements & Performance metrics.

TOTAL HOURS – 45

REFERENCES:

1. “The automotive transmission book”, Technology & Engineering , Springer May 2015.
2. Heinz Heisler, "Advance vehicle Technology", Butterworth-Heinemann, 2002
3. Iqbal Husain,“Electric and hybrid vehicles – Design Fundamentals”,CRC Press, 2nd Edition 2010.
4. “A survey on communication technologies and requirements for internet of electric vehicles”, RASIP Journal on Wireless Communications and Networking, 2014.

OUTCOMES:

At the end of the course, the student will be able to

- analyze the design ratio of gear box used in vehicles
- analyze the dynamics of an electric vehicle
- Compute the performance parameter for actuator, servo and ancillary system
- Design electronic control units to ensure safety in vehicle transmission system.
- Differentiate and analyze the performance of electrification for any application
- Apply suitable technique for automotive communication.

HEV/xEV MOTOR DRIVES AND CONTROLLERS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To learn about the use of different power electronics devices and converters used for HEVxEV.
- To provide an in-depth knowledge about electrical machines and its drives
- To apply electrical drives for HEV/Xev

MODULE I POWER ELECTRONIC DEVICES 8

Overview of Power Electronics Devices: Power diode, ESD protection diode – Insulated Gate Bipolar Transistor (IGBT), Metal-Oxide-Silicon Field Effect Transistor (MOSFET) – Principle of operation, power density, efficiency – Silicon carbide materials.

MODULE II POWER CONVERTORS 7

Converter Topologies: Buck, boost, transformer less - Inverter Topology: Basics of single & three phase inverter Six pack inverter - Sources of loss in Power Electronics - Conduction, switching, leakage and control losses - Effects of air vs. liquid cooling – Multi convertor vehicular dynamics & Control.

MODULE III MACHINES FOR ELECTRIC VEHICLES 7

DC motor, Induction motor and BLDC motor: Types, Principle, Construction – Peak Power Source(PPS) - Torque and Speed Coupling – Selection of Motors under variable parameters - Testing of Motors/Generators.

MODULE IV ELECTRIC VEHICLE DRIVES 8

Electric drive components – DC drives : Two & Four quadrant chopper, Open loop drive, Steady state analysis, Modes of operation - Operating point analysis – AC drive : Six step operation – PWM techniques, Current control methods – Vector control of Induction motor: Direct & Indirect control.

MODULE V ADVANCED MOTOR DRIVES AND MODELLING 8

BLDC motor drive: Speed and position control, Sensor less control technique and its methods, Back MEF sensing techniques – Modelling of an electric drive, Vehicle body – Drive & wheel and PID based drive.

MODULE VI CASE STUDIES ON HEV CONTROL 7

High voltage bus spike control – Thermal control of HEV battery system – HEV/xEV traction motor control – Online testing of SoC & Adaptive charging.

TOTAL HOURS – 45

REFERENCES:

1. Wie Liu,“Hybrid electric vehicle system modeling and control”, General Motors, 2nd Edition,2017.
2. Ali Emadi,“Advanced Electric Drive Vehicles”,CRC Press, 1st Edition, 2017.
3. Iqbal Husain,“Electric and hybrid vehicles – Design Fundamentals”,CRC Press, 2nd Edition 2010.
4. Ali Emadi,Mehrdad Ehsani,John M. Miller, “Vehicular Electric Power System – Land, Air and Space Vehicles”,CRC press, 1st Edition, 2003.
5. Mohan, N., “Electric Drives: An Integrative Approach”, MNPERE (2001).

OUTCOMES:

At the end of the course, the student will be able to

- Select appropriate power electronics device and control IC.
- Analyze and design power converters.
- Model various drives and analyze its performance.
- Design Model and modify an electric drive according to customer.
- Analyze the different control scheme of special electrical machine.
- Alleviate different issues on HEV control.

SCHOOL OF ELECTRICAL AND COMMUNICATION SCIENCES

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

MINOR DEGREE – INTERNET OF THINGS

CURRICULUM & SYLLABUS

Sl. No.	Course Code	Course Title	L	T	P	C
1.	ECMX01	Embedded System for IoT	2	0	2	3
2.	ECMX02	IoT Fundamentals and Security	3	0	0	3
3.	ECMX03	C and JAVA Programming for IoT	2	0	2	3
4.	ECMX04	IoT Applications	3	0	0	3
5.	ECMX05	Artificial Intelligence for IoT	2	0	2	3
6.	ECMX06	Industrial IoT	2	0	0	2
7.	ECMX07	Mini Project	0	0	2	1
						18

ECMX01 EMBEDDED SYSTEM FOR IOT

L	T	P	C
2	0	2	3

OBJECTIVES:

- To describe the concepts of Embedded system in IoT architecture
- To discuss basic principles of sensors, actuators, and controllers
- To study the operations of sensor and analyze sensor data with Real world design constraints
- To identify various IoT development boards

PREREQUISITE :

- Basics of Electronics
- Basic Programming Knowledge

MODULE I Embedded Systems 8

Introduction Embedded System- classification, characteristics and challenges- embedded system design process- overview of processors and hardware units in an embedded system- Embedded application

MODULE II Embedded Boards for IoT 10

Overview of IoT architecture- Hardware boards-Arduino – Node MCU- Configuring GPIO pins -Embedded C – Introduction to SoC - Raspberry pi-Embedded Python.

MODULE III Sensor Interfacing 10

Sensor- Classification of Sensors-Characteristics- Calibration- varieties of sensors- Acoustic Sensors- Automotive Sensors- Electric Current Sensors- Navigation Instruments- Proximity Sensor- Optical Sensor.

MODULE IV Actuator 10

Introduction to actuators- Electro Mechanical System-DC motor- Stepper motor- servo motor -interfacing with Embedded Boards.

MODULE V RTOS for IoT 10

RTOS Introduction –features – Characteristics- Compare OS and RTOS - Real time systems –Types- Need for RTOS in IoT device- Free RTOS

MODULE VI IoT connectivity with cloud 12

Cloud computing - Popular cloud computing services for the sensor management- Communicating with the cloud using web services – Recent development boars for IoT application- Silabs, Nordic, TI, NXP, MuRata, Nvidia.

Practicals:

1. Input and output programming in Embedded Boards
2. Interfacing IO devices with Embedded Boards
3. Interfacing sensors with Embedded Boards.
4. On chip calibration and programming
5. Interfacing different motors with Embedded Boards
6. Controlling the Device with Embedded Boards
7. Connecting Embedded board with cloud
8. Demonstrate the recent development boards
9. Study of Free RTOS

L : 30 Hours, P: 30 Hours TOTAL HOURS 60

TEXT BOOKS

1. Marilyn Wolf, "Computers as components", 4th Edition, Elsevier 2016.
2. Rajkamal, "Embedded Systems Architecture, Programming and Design", Tata McGraw-Hill, 2011.
3. Adrian McEwen (Author), Hakim Cassimally, “Designing the Internet of Things” ,Wiley -2013
4. Barrie Sosinsky, “Cloud Computing Bible”, Wiley-India, 2010
5. Jean-Philippe Vasseur, Adam Dunkels, “Interconnecting Smart Objects with IP: The Next Internet”, Morgan Kuffmann-2010

REFERENCES

1. R. Buyya, A. V. Dastjerdi, Internet of Things: Principles and Paradigms, Cambridge, MA, 2016
2. Piezoelectric Sensors and Actuators: Fundamentals and Applications, Springer, 2018
3. Vijay Madisetti and Arshdeep Bahga, “Internet of Things (A Hands-on Approach)”, 1 st Edition, VPT, 2014.
4. Reese, G. (2009). Cloud Application Architectures: Building Applications and Infrastructure in the Cloud. Sebastopol, CA: O'Reilly Media, Inc. (2009).

OUTCOMES:

On completion of the course, students will be able to

- Analyze the different sensors, actuators and microcontroller boards and standards for IoT
- Use of different sensors for different IoT applications

- Apply IoT concepts in real time applications using the IoT devices
- Identify the architecture and infrastructure of IoT.
- Describe role of electronics and embedded computing in IoT
- Monitor and control the device with cloud

ECMX02 IOT FUNDAMENTALS AND SECURITY

L	T	P	C
3	0	0	3

OBJECTIVES:

- To describe and explain basic principles of IoT
- To learn about the basics of IOT protocols
- To understand the Security requirements in IoT
- To understand the various types of Trust models and Cloud Security.

PREREQUISITE :

- Basic knowledge of computer networks

MODULE I Introduction to Internet of Things 7

Introduction - Overview of Internet of Things (IoT), Characteristics of devices and applications in IoT ecosystem, Building blocks of IoT, Various technologies making up IoT ecosystem, IoT levels, IoT design methodology, The Physical Design/Logical Design of IoT, Functional blocks of IoT and Communication Models, Development tools used in IoT.

MODULE II IoT Protocols 8

Protocol Standardization for IoT – Efforts – M2M and WSN Protocols – SCADA and RFID Protocols – Unified Data Standards – Protocols – IEEE 802.15.4 – BACNet Protocol – Modbus– Zigbee Architecture – Network layer – 6LowPAN – MQTT, CoAP, AMQP, DDS.

MODULE III Security in IoT 8

Security requirements in IoT architecture - Security in enabling technologies - Security concerns in IoT applications. Security architecture in the IoT - Insufficient Authentication/Authorization - Insecure access control - Threats to access control.

MODULE IV Privacy in IoT 7

Privacy and Availability - Attacks specific to IoT. Vulnerabilities – Secrecy and Secret-Key Capacity - Authentication/Authorization for Smart Devices - Transport encryption – Attack & Fault trees.

MODULE V IoT Data Security 7

Concerns in data dissemination – Lightweight and robust schemes for privacy

protection – Trust and Trust models for IoT – self-organizing Things - Preventing unauthorized access.

MODULE VI Cloud Security for IoT 8

Cloud services and IoT – offerings related to IoT from cloud service providers – Cloud IoT security controls – An enterprise IoT cloud security architecture – New directions in cloud enabled IoT computing

TOTAL HOURS 45

TEXT BOOKS:

1. David Hanes, Gonzalo Salgueiro, Rob Barton, “IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things”, Cisco Press, 2017.

2. Fei HU, “Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations”, CRC Press,2016

REFERENCES:

1. Russell, Brian and Drew Van Duren, “Practical Internet of Things Security”, Packt Publishing, 2016.

2. Ollie Whitehouse, “Security of Things: An Implementers' Guide to Cyber-Security forInternet of Things Devices and Beyond”, NCC Group, 2014.

OUTCOMES:

On completion of the course, students will be able to

- Acquire the knowledge on fundamentals of IoT
- Use security principles for Internet of Things
- Recognize and apply techniques for secured IoT devices
- Describe the authentication credentials and access control
- Use security methodologiesfor Internet of Things
- Apply new directions in cloud enabled IoT computing

ECMX03 C AND JAVA PROGRAMMING FOR IOT

L	T	P	C
2	0	2	3

OBJECTIVES:

- To explain basic concepts of C, and Java programming languages.
- To explore the concepts of Object Oriented Programming.
- To experiment the languages on IoT tools like Raspberry Pi.

PREREQUISITE :

- Basic awareness on computer programming.
- Familiarity in computer network and internet concepts.

MODULE I Basics of C Programming 8

C Fundamentals, Data types, Variables and Types, Operators, Expressions, Flow Control, Arrays and Strings.

Practical:

- C Program Exercise using data reading and data print to console.
- C Program Exercise using array and string processing.

MODULE II Advanced C Programming 10

Pointers, Functions, Data input and output, Files, Header files and Preprocessors, Structures and Unions.

Practical:

- C Programming Exercise for reading and writing to Files.
- C Programming Exercise for processing Data using Structures.

MODULE III Java Programming Fundamentals 10

Java Virtual Machine and Java Bytecode, Data Types, Variables, Arrays, Operators, Control Statements. Compiling and Execution of simple Java programs.

Practical:

- Java Programming Exercise using multiple control statements
- Java Programming Exercise using Arrays

MODULE IV OOP using Java Basic Java Programming 10

Principles of Object Oriented Programming – Abstraction, Encapsulation, Inheritance and Polymorphism, Java Classes, Objects, methods, Constructors, Inheritance, Method overloading, Dynamic method dispatch, final keyword.

Packages and Interfaces, static methods.

Practical:

- Exercise with Database maintenance using Java Objects.
- Exercise to demonstrate dynamic method dispatch in Java.

MODULE V Advanced Java Programming 10

Java Exception Handling, Multithreading, Java standard Libraries, String, the Collections Framework, Java IO, Java Networking, TCP/IP Client sockets, TCP/IP Server Sockets, Datagrams.

Practical:

- Java programming demonstrating multiple Threads execution.
- Java programming for File Handling

MODULE VI IoT Applications Programming in C and Java 12

Introduction to Embedded C, Overview of GCC compiler for Raspbian OS, bcm2835.hand WiringPi Library for C, Overview of J2ME, MySQL, Installing jdk on Raspberry Pi, Overview of pi4j API for Java , AngularJS.

Practical:

- C Programming Exercise to demonstrate controlling GPIO of Raspberry Pi.
- Java Program Exercise to demonstrate Client/Server Sockets on Raspberry Pi.
- Java programing Exercise to demonstrate the access of Cloud Platforms form Raspberry Pi.

L : 30 Hours, P: 30 Hours TOTAL HOURS 60

TEXT BOOKS

1. Will Norton, “C Programming Language for Beginners”, Amazon Asia-Pacific, 2019.
2. Simon Long, “Learn to Code with C”, The MagPi Essentials, 2017.
3. Herbert Schildt, “Java - The Complete Reference”, 11th Edition, McGraw Hill Education (Oracle Press), 2019.

REFERENCES

1. Harry Fairhead, “Raspberry Pi IoT In C”, IO Press, 2016.
2. Perry Xiao, “Practical Java Programming for IoT, AI, and Blockchain”, 1st

Edition, Wiley, 2019.

3. Stephen Chin, James L. Weaver, “Raspberry Pi with Java: Programming the Internet of Things”, Oracle Press, 2016.
4. Simon Long, “An Introduction to C And GUI Programming”, Raspberry Pi Press, 2019.

OUTCOMES:

On completion of the course, students will be able to

- Identify keywords and data types in C and Java.
- Interpret the program flows in C and Java through various control statements
- Apply OOP programming principles to their algorithms.
- Illustrate advanced programming concepts like multithreading and exception handling.
- Plan and judge the usage of cloud in IoT programming.
- Create an IoT based applications using C, or Java.

ECMX04	IoT APPLICATIONS	L	T	P	C
		2	0	2	3

OBJECTIVES:

- To describe and explain basic applications of IOT
- To identify and use the platform the platform for developing IOT
- To analyze Physical Servers & Cloud Offerings for IOT
- To discuss about the development of mobile application

PREREQUISITE :

- Fundamentals of IoT and IoT physical devices
- Programming skill

MODULE I Application of IoT 6

Home automation, Cities, Environment, Energy, Retail, Logistics, Agriculture, Industry, Health and Life style, M2M Machine to Machine, Difference between IoT and M2M.

MODULE II Developing IoT 6

IoT Platform design methodology, IoT system – Logical design – Python packages for IoT **–** Programming IoT physical devices – Overview IoT database.

MODULE III IoT Physical Servers & Cloud Offerings 9

Introduction to Cloud Storage Models & Communication APIs – WAMP – Xively Cloud for IoT – Python Web application Framework - Designing a RESTful Web API – Amazon Web Services for IoT.

MODULE IV Overview of Mobile App Development 8

Need for mobile Apps – App design issues and considerations - introduction to building a complete Android app.

Module V Android App Development 8

Android navigation and interface design – Persistent data– Lists – Maps and location – Access to hardware and sensors.

Module VI iOS App Development 8

iOS Navigation and Interface Design - Persistent Data - Tables – Maps and location – Access to hardware and sensors.

TOTAL HOURS 45

REFERENCES

1. Arshdeep Bahga and Vijay Madisetti, Internet of Things: A hands-on Approach, University Press, 2015.
2. Rajesh Singh, Anita Gehlot et. al.,Internet of Things with Raspberry Pi and Arduino, CRC Press Taylor & Francis Group, 2020.
3. Adrian McEwen and Hakim Cassimally, Designing the Internet of Things, Wiley, 2013.
4. Jakob Iversen and Michael Eierman, Learning Mobile App Development – A Hands-on Guide to Building Apps with iOS and Android, Addison - Wesley, 2014 Pearson Education.

OUTCOMES:

On completion of the course, students will be able to

- Analyze the different applications using IOT
- Use different design methodologies for developing an IOT application
- Apply programming skills to run the IOT based applications
- Identify a Cloud Storage Model for the application
- Describe Hardware and software required to design and build IoT
- Develop mobile Apps to access IoT data for further analysis

ECMX05 ARTIFICIAL INTELLIGENCE FOR IOT

L	T	P	C
2	0	2	3

OBJECTIVES:

- To describe and explain basic principles of IOT
- To discuss the various machine learning algorithm and deep neural network algorithms
- To analyze data using statistics methods
- To identify suitable technique for various applications in IOT devices

PREREQUISITE :

- Basic knowledge in statistics
- Basic knowledge about internet, servers and android App developments

Module I Artificial intelligence and Internet of Things 8

Introduction of Artificial intelligence and IOT-Need for sharing data-Intelligent IOT-The role of AI in developing IOT devices.AI techniques and Problems.

MODULE II Python fundamentals 10

Python basics from scratch – Python Interpreter-Numbers-Strings- Lists**-**Control statements in python-Defining functions-Coding style-Data Structures-Essential Python libraries-variables.

Module III Data processing 10

Data types, sequence data, Best coding practices.-Data wrangling with Pandas - Working with data fetching APIS -Web scraping for data.

MODULE IV Statistics for data science 10

Basics of inferential statistics and parameter estimation-Hypothesis testing. ANOVA- Testing of Correlation, Testing of regression.

MODULE V Machine learning 10

Basics of Machine learning-Supervised and unsupervised learning-Linear regression-Logistic regression.-Statistical modelling.-Decision tree.-Random forest.-Gradient boosting.-K-means clustering.-Model selection, evaluation and interpretation concepts

Module VI Deep learning 12

Introduction of neural networks, back propagation and foundational techniques. Principals of deep neural network and Convolution neural networks-Layers of CNN- Convolution layer-Max pooling layer-fully connected layer-Application of deep learning in IOT devices development.

Lab Experiments:

1)Installation of Python softwares
2) Basic programs to practice data types, variables, operators.
3) sequence data operations using Numpy and Pandas.
4) Working with different file formats –txt,.csv etc.
5) Exploratory data analysis using Pandas
6) Data visualization using Matplotlib and Seaborn
7) Dealing with missing data in database using python packages.
8) Machine learning Classification using keras and Tensor flow,Scikit Learn
9) Data prediction using Regression using Keras.
10.Construction of convolution neural network using tensorflow.
11) Demonstrate with recent IoT boards

L : 30 Hours, P: 30 Hours TOTAL HOURS 60

TEXT BOOKS:

1. Sebastian Raschka and Vahid Mirjalili, “Python Machine Learning: Machine Learning and Deep Learning with Python, scikit-learn, and TensorFlow 2”, Packt Publishing Limited, 3rd Edition, 2019.
2. Josh Patterson , Adam Gibson , “Deep Learning: A Practitioner's Approach Paperback, Josh Patterson and Adam Gibson” , O’REILLY Media , 2017.
3. Barry Burd , “Android Application Development All–in–One for Dummies Paperback”, John Wiley & Sons; 2nd Edition, 2015.
4. Gaston C. Hillar,” Internet of Things with Python Paperback”, Ingram Publisher, 2016.
5. Christina Ahmet , “Artificial Intelligence: How Advanced Machine Learning Will Shape The Future Of Our World”, Shockwave Publishing, 2018.

REFERENCES:

1. Abhishek Vijayvargia, “Machine Learning with Python: Design and Develop Machine Learning and Deep Learning Technique using real world code examples”, BPB publications. 2018

2. U Dinesh Kumar Manaranjan Pradhan, "Machine Learning using Python", Kindle Edition , Wiley publisher 2019.
3. Ninad Sathaye, "Learning Python Application Development", Packt Publishing Limited, 2016.

OUTCOMES:

On completion of the course, students will be able to

- Acquire the knowledge about IOT platforms and cloud servers
- Identify suitable machine learning and techniques for applications
- Describe various techniques of statistical analysis on data
- Analyze various deep learning neural networks
- Use suitable prediction and regression techniques for data analytics
- Recognize and apply techniques for development of android app involving IOT and Machine learning techniques

ECMX06 INDUSTRIAL IOT

L	T	P	C
2	0	0	2

OBJECTIVES:

- To describe and explain basic principles of IOT
- Discuss the architecture, operation, and business benefits of an IoT solution
- To learn how to analyze the data in IOT.
- To identify suitable technique for various problems.

PREREQUISITE :

- TCP/IP Networking,
- Basic Programming Language

MODULE I IIoT-Introduction 6

Industrial IoT: Business Model and Referece Architecture - Layers: Industrial Sensing - Processing- Communication- Networking- Modbus, Profibus, RS 485 protocol

MODULE II Design and Development of IIoT systems 8

Big Data Analytics and Software Defined Networks - IIoT Analytics - Introduction, Machine Learning and Data Science - Data Management - Data Centre Network - Security and Fog Computing: Cloud Computing in IIoT

MODULE III Industry 4.0: Smart Factory 8

Smart Manufacturing - Smart Devices and Products - Smart Cities - Smart Logistics – Cyber physical Systems - Robotic Automation and Collaborative Robots - Support System for Industry 4.0 - Cyber Security

MODULE IV Application domains and Case Studies 8

Application Domains: Factories and Assembly Line, Food Industry, Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security (Including AR and VR safety applications), Facility Management, chemical and pharmaceutical industry, Applications of UAVsin Industries,

Case studies: Asset tracking, Connected vehicles, Smart metering

TOTAL HOURS 30

TEXT BOOKS:

1. Antonio Capasso, Giacomo Veneri, "Hands-On Industrial Internet of Things: Create a Powerful Industrial IoT Infrastructure Using Industry 4.0", Packt, 2018.
2. Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat, "Industrial Internet of Things: Cybermanufacturing Systems", Springer, 2016
3. Perry Lea, "Internet of Things for Architects: Architecting IoT Solutions by Implementing Sensors, Communication Infrastructure, Edge Computing, Analytics, and Security", Packt, 2018

REFERENCES:

1. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 2016
2. Alp Ustundag, EmreCevikcan, "Industry 4.0: Managing The Digital Transformation", Springer, 2017
3. BK Tripathy and J Anuradha, "Internet Of Things (IoT) Technologies Applications Challenges And Solutions", Taylor & Francis, 2017

OUTCOMES:

On completion of the course, students will be able to

- Apply the concepts of IOT
- Apply IOT to different applications
- Analysis and evaluate the data received through sensors in IOT.
- outline the various systems used in a manufacturing plant and their role in an Industry 4.0 world
- Design and develop smart systems in IOT
- Design IoT applications in different domain and be able to analyze their performance

ECMX07	MINI PROJECT	L	T	P	C
		0	0	2	1

OBJECTIVES:

- To improve the professional competency and research aptitude of students
- To help the students to develop the work practice to apply the design skills for solving real life problems.

GUIDELINES:

Mini Project

- To be an experimental project on any of the topics related to Internet of Things
- Assigned as individual mini project work on different topics.
- The students shall be encouraged to do their project in the parent institute or through core industries.
- Department will constitute an Evaluation Committee to review the project Periodically.

Total Hours –30

OUTCOMES:

At the end of the project the student will be able to

- Design and analyze an IoT system
- Improve their presentation skills
- Improve the documentation skills
- Develop proto type working model and its demonstration.

SCHOOL OF ELECTRICAL & COMMUNICATION SCIENCES

DEPARTMENT OF ELCTRONICS & INSTRUMENTATION ENGINEERING

MINOR DEGREE ON INDUSTRIAL AUTOMATION

CURRICULUM & SYLLABUS

Sl. No.	Course Code	Course Title	L	T	P	C
1.	EIMX01	Sensors and Transducers	3	0	0	3
2.	EIMX02	Control system	3	0	0	3
3.	EIMX03	PLC and SCADA	3	0	2	4
4.	EIMX04	DCS and Computer Networks	3	0	2	4
5.	EIMX05	Piping and Plant Engineering	3	0	0	3
6.	EIMX06	Mini Project	0	0	4	2

Total credits – 19

EIMX01	SENSORS AND TRANSDUCERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the concepts of measurement technology.
- To learn the various sensors used to measure various physical parameters.
- To learn the fundamentals of signal conditioning, data acquisition and communication systems used in mechatronics system development.

MODULE I INTRODUCTION 9

Basics of Measurement – Classification of errors – Error analysis – Static and dynamic characteristics of transducers – Performance measures of sensors – Classification of sensors – Sensor calibration techniques – Sensor Output Signal Types.

MODULE II MOTION, PROXIMITY AND RANGING SENSORS 9

Motion Sensors – Potentiometers, Resolver, Encoders – Optical, Magnetic, Inductive, Capacitive, LVDT – RVDT – Synchro – Microsyn, Accelerometer– GPS, Bluetooth, Range Sensors

MODULE III FORCE, MAGNETIC AND HEADING SENSORS 9

Strain Gage, Load Cell, Magnetic Sensors –types, principle, requirement and advantages: Magneto resistive – Hall Effect – Current sensor

MODULE IV OPTICAL, PRESSURE AND TEMPERATURE SENSORS 9

Photo conductive cell, photo voltaic, Photo resistive, LDR – Fiber optic sensors – Pressure – Diaphragm, Bellows, Piezoelectric, Temperature – IC, Thermistor, RTD, Thermocouple. Acoustic Sensors – flow and level measurement, Radiation Sensors - Smart Sensors

MODULE V SIGNAL CONDITIONING and DAQ SYSTEMS 9

Amplification – Filtering – Sample and Hold circuits – Data Acquisition: Single channel and multi-channel data acquisition – Data logging - applications - Automobile, Aerospace, Home appliances, Manufacturing, Environmental monitoring.

L – 45; Total Hours –45

TEXT BOOKS:

1. Ernest O Doebelin, Measurement Systems – Applications and Design, Tata McGraw-Hill, 2009.

2. Sawney A K and Puneet Sawney, A Course in Mechanical Measurements and Instrumentation and Control, 12th edition, Dhanpat Rai and Co, New Delhi, 2013.

REFERENCES:

1. Patranabis D, Sensors and Transducers, 2nd Edition, PHI, New Delhi, 2010.
2. John Turner and Martyn Hill, Instrumentation for Engineers and Scientists, Oxford Science Publications, 1999.
3. Richard Zurawski, Industrial Communication Technology Handbook 2nd edition, CRC Press, 2015.

OUTCOMES:

At the end of this course, the students will

- Expertise in various calibration techniques and signal types for sensors.
- Apply the various sensors in the Automotive and Mechatronics applications
- Study the basic principles of various smart sensors.
- Implement the DAQ systems with different sensors for real time applications

EIMX02	CONTROL SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

1. To understand the use of transfer function models for analysis of different systems.
2. To provide adequate knowledge in the time response of systems and steady-state error analysis.
3. To accord basic knowledge in obtaining the open-loop and closed-loop frequency responses of systems
4. To introduce the different techniques for stability analysis of systems.

MODULE I SYSTEM MODELLING 12

Introduction to Control System - Open loop and Closed loop systems - Differential equation representation of systems - Transfer function representation of systems - Modelling of Electric systems, Translational and rotational mechanical systems - Block diagram reduction Techniques - Signal flow graph

MODULE II TIME DOMAIN ANALYSIS 11

Time domain specifications- First Order Systems - Step and Impulse Response analysis of second order systems - Error coefficients - Generalized error series - Steady state error

MODULE III FREQUENCY DOMAIN ANALYSIS 12

Frequency Response - Bode Plot - Polar Plot - Frequency Domain specifications from the plots --Constant M and N Circles - Nichols Chart - Use of Nichols Chart in Control System Analysis.

MODULE IV SYSTEM STABILITY ANALYSIS 10

Stability - Characteristics equation - Routh-Hurwitz Criterion - Root Locus Technique, Construction of Root Locus, Stability, Dominant Poles, Application of Root Locus Diagram - Nyquist Stability Criterion - Relative Stability

L – 45; Total Hours –45

TEXT BOOKS:

1. 1. Nagarath, I.J. and Gopal, M., “Control Systems Engineering”, New Age International Publishers, 2017.
2. Gopal, M., “Control Systems, Principles and Design”, Tata McGraw-Hill Pub. Co., 2nd Edition, New Delhi, 2012.
3. Ogata, K., “Modern Control Engineering”, Prentice Hall of India Ltd., 4th Edition, New

Delhi, 2006.

REFERENCES:

1. S.K.Bhattacharya, Control System Engineering, 3rd Edition, Pearson, 2013.
2. Benjamin C. Kuo, Automatic Control systems, 7th Edition, PHI, 2010.

OUTCOMES:

At the end of this course, the students will

1. Acquire knowledge about process dynamics.
2. Develop the transfer function model for any system and use of P, PI and PID controllers.
3. Analyse any physical system in time and frequency domain
4. Apply the concept of stability for any system

EIMX03	PLC and SCADA	L	T	P	C
		3	0	2	4

OBJECTIVES:

- To give an introductory knowledge about PLC and the programming languages.
- To provide knowledge about SCADA & interfacing with PLC.
- To give adequate knowledge about the applications of PLC and SCADA.

MODULE I PROGRAMMABLE LOGIC CONTROLLER (PLC) BASICS 9

Evolution of PLCs — Sequential and programmable controllers, PLC hardware components – Basics of PLC programming-developing fundamental PLC wiring diagrams - relay logic — Ladder logic — Functional blocks programming, sequential function chart, programming timers and counters.

Practical: Configuration of Input/Output, power supply, CPU in Siemen's PLC and Allen Bradley PLC, Development of Ladder program for simple on-off applications, Development of Ladder program to demonstrate latching, develop simple programming using FBD in Siemens PLC, program a PLC to use timers, Program a PLC to use counters.

MODULE II PLC INTERMEDIATE FUNCTIONS 9

Program control instructions-Data manipulation Instructions-Arithmetic instructions - Sequencer instructions- Design of interlocks and alarms using PLC.

Practical: Exercises to performing program control operations, Math instructions, Data Manipulation instructions, alarming using PLC..

MODULE III COMMUNICATION, INSTALLATION AND TROUBLE SHOOTING IN PLC 9

Requirement of communication networks for PLC — connecting PLC to computer - PLC applications in Industrial Automation. PLC installation and Trouble shooting.

Practical: Automate car parking, Automate bottle filling process operation.

MODULE IV INTRODUCTION TO SCADA 9

SCADA - Data acquisition system, evaluation of SCADA, communication technologies, monitoring and supervisory functions. Interfacing of PLC with SCADA, SCADA system components.

Practical: Creating a project, Configuring Communication in SCADA, Configuring process screens.

MODULE V SCADA ARCHITECTURE & Applications 9

Various SCADA Architectures, advantages and disadvantages of each system, SCADA

Communication - wired and wireless methods and fiber optics, open standard communication protocols, SCADA applications – Power sector, chemical plant etc.
Practical: Interfacing PLC & SCADA, Activating I/O devices using SCADA.

L: 45 P: 15 Total hours: 60

TEXT BOOKS:

1. Petrezeulla, Programmable Logic Controllers, tenth edition, Mc-Graw Hill, 2010.
2. Internet Sources.

REFERENCES:

1. G.K.Mc-Millan, Process/Industrial Instrument and controls and handbook, Mc Graw Hill, New York, 1999.
2. Hughes T, Programmable Logic Controllers, ISA Press, 1989.
3. Stuart A. Boyer: SCADA-Supervisory Control and Data Acquisition, Instrument Society of America Publications, USA,2004

OUTCOMES:

At the end of this course, the students will

- Evaluate the hardware components of PLC and develop basic wiring diagrams and ladder diagrams
- Analyze program control instructions, data manipulation instruction, arithmetic instructions and design alarms using PLC
- Identify the requirements of communications networks in PLC and analyze issues related to PLC applications, installation and trouble shooting.
- Familiar with the SCADA software and hardware system components
- Design and implement SCADA system for any industrial application.

EIMX04	DCS and Computer Networks	L	T	P	C
		3	0	2	4

OBJECTIVES:

- To give an overview of the automation technologies using DCS in industries.
- To provide a fundamental understanding of the different languages used in automation.
- To provide insight into some of the advanced principles those are evolving for present and future automation.

MODULE I DCS – INTRODUCTION 9

Introduction & Development History-Early Computer systems: Direct digital control, Centralized computer system, Distributed control Hierarchical Control: Hierarchical computer system for a large manufacturing process, overall task, detail task listing, lower level computer task, higher level computer task.

PRACTICAL

Study of DCS Configuration and Working with an example such as “Level Control of tank using Cascade Controller”.

MODULE II DCS BASIC - PACKAGES 9

Analog control, direct Digital control, Distributed process control, DCS configurations Local Control Units (Relay rack mounted equipment: Dedicated card controllers, Unit operations controllers, Multiplexers- Design, system configuration, Remote stations, Super-commutation and sub-commutation.

PRACTICAL

Study of various packages with an example such as “Feed forward Control for various disturbances in the temperature process control”.

MODULE III DCS COMPONENTS 9

Power supplies, - Input/ Output, - Controller file. The control console equipment: - Video display, - key board, - peripheral devices, - Displays: Group displays, Overview displays, Detail displays, Graphic displays, Trend displays, Alarm reporting, generation and acceptance Communication between components: Data highway designs, highway compatibility, Network access protocols, Network topologies, Maintenance considerations- Reliability, availability, Single loop integrity, backup systems, Redundant and Fault tolerant systems.

PRACTICAL

Distributed Control Systems application and logic operations with master and slave

controllers.

MODULE IV SOFTWARE CONFIGURATION 9

Operating system configuration, - Controller function configuration, - Algorithm libraries, Process control programming: - Types of program, Features of process control programs,. The executive program, Programming language for process control Algorithms- The position algorithm, Velocity algorithm, cascade and ratio control, Feed-forward, Other algorithm like Dead band control, emergency response, error squared.

PRACTICAL

Conveyor Sorting System with color sensing fiber unit by using PLC and DCS.

MODULE V FIELD BUS, MAP/TOP, NETWORK PROTOCOL 9

Computer integrated processing, communication hierarchy, Industrial communication systems: Management system – MAP/TOP protocol, Field buses- fieldbus standardization, Smart transmitters- Rackbus: Bus access method, transmitter, gateways, availability.

MODBUS - bus access method, application services, transmission modes, function, acceptance.

PROFIBUS- bus access method, data link services, application services, acceptance.

FIPBUS - bus access method, other features, acceptance, International FIELDBUS standard, wireless HART, Ethernet

PRACTICAL

Stamping Process by using Programmable Logic Controller and DCS.

MIMO system for multiple level, flow and temperature controls.

L: 45 P: 15 Total hours: 60

TEXT BOOKS:

1. F.D. Petruzella, Programmable Logic Controllers, TataMc-Graw Hill, Third edition, 2010
2. Michael P. Lukas, Distributed Control Systems: Their Evaluation and Design, Van Nostrand Reinhold Co.,1986

REFERENCES:

1. D. Popovic and V.P.Bhatkar, Distributed computer control for industrial Automation MarcelDekker, Inc., Newyork ,1990.
2. Clarke, G., Reynders, D. andWright, E., Practical Modern SCADA Protocols: DNP3,4. 60870.5 and Related Systems, Newnes, 1st Edition, 2004.
3. Hughes, T.A., Programmable Logic Controllers: Resources for Measurements and Control Series, 3rd Edition,ISAPress,2004.

4. McMillan, G.K., Process/Industrial Instrument and Controls Handbook, 5thEdition, McGraw- Hill handbook,NewYork, 1999.
5. NPTEL Notes on, Programmable Logic Control System by Department of Electrical Engg., IIT Kharagpur.

OUTCOMES:

At the end of this course, the students will

- Ability to understand all the important components such as DCS, I/O modules and field devices of an industrial automation system.
- Ability to develop DCS program in different languages for industrial sequential applications.
- Able to select and use most appropriate automation technologies for a given application.
- Ability to gain knowledge on the recent developments in industrial automation.

EIMX05	Piping and Plant Engineering	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide in depth knowledge on piping and instrumentation diagram
- To study the uses of P&ID in various stages
- To provide in depth knowledge on Plant Engineering
- To introduce detail engineering and P&ID

MODULE I PIPING AND INSTRUMENTATION DIAGRAM EVALUATION AND PREPARATION **10**

Flow Sheet and its types - process flow diagram - P & I D Symbols, line numbering, line schedule, P & I D development, various stages of P & ID - P& ID for pumps, compressors, process vessels, absorber, evaporator and Boiler.

MODULE II APPLICATION OF P&ID **9**

Applications of P& ID in design state, construction stage, commissioning state, operating stage revamping state, applications of P&ID in HAZOP and risk analysis.

MODULE III INTRODUCTION AND ELEMENTS OF PLANTS **9**

General Project Cycle – Feed – Sales - Plant Description, Component / Areas of Plant, Main Elements of a Plant, Process Flow Scheme - Plant Legend Finalization.

MODULE IV DETAIL ENGINEERING **12**

Major Discipline involvement and Inter discipline Interaction, Major Instrumentation and Control Systems – Electrical Area Classification, Fire Hazardous Classification - Development Phase – Instrument Index, I / O List, Specification Sheets, Data sheet, Instrument Installation.

MODULE V CASE STUDIES **5**

Case studies of Water Treatment Plant - Paper Industry – Power Plant etc

L – 45; Total Hours –45

REFERENCES:

1.Duncan C. Richardson, Plant Equipment and Maintenance Engineering Handbook, McGraw-Hill Education: New York, Chicago, San Francisco, Athens, London, Madrid, Mexico City, Milan, New Delhi, Singapore, Sydney, Toronto, 2014 McGraw-Hill Education

2. Gabriel Salvendy, Handbook of Industrial Engineering - Technology and operations management, John Wiley & Sons, 2001

3. Robert C Rosaler, Standard Handbook of Plant Engineering, McGraw-Hill third edition, 2004.

4. R. Keith Mobley, Plant Engineer's Handbook, Technology and Engineering, 2001.

OUTCOMES:

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

- develop flow sheets, process flow diagram and P&ID for various processes
- design and size the instruments based on the standards of area classification
- apply plant engineering in design and maintenance of water treatment plant / power plant etc
- work as maintenance, installation and commissioning engineer
- analyse risks and develop HAZOP documents

EIMX06	Mini Project	L	T	P	C
		0	0	3	2

OBJECTIVES:

- To design, develop, and deploy advanced state-of-the-art instrument systems and custom application software in support of the ongoing experimental research efforts.
- To provide in-house solutions to assist the researcher through a complete life cycle of system development.
- To gain competency in analysing experimental data and in comparing the results to data and theories in the literature.
- To acquire more knowledge in designing of hardware as well as applications of CAD software like Matlab, LabVIEW & embedded C.
- To apply basic and contemporary science, engineering, and experimentation skills to identifying manufacturing problems and developing practical solutions.

COURSE OUTLINE

Project shall be carried out in the following areas,

- Design/ fabrication of sensors and transmitters,
- Microcontroller based digital control system design,
- Embedded system design for automation,
- Micro-electronics and VLSI Design,
- Applications of Digital image processing for process industries,
- Analysis and design of advanced process control techniques,
- Medical imaging and instrumentation,
- Micro sensors and Micro actuators design
- MEMS in instrumentation and biomedical.

SOFTWARE:

SIMULINK, PSPICE, LabVIEW and CAD tool, embedded C, MEMS software

OUTCOMES:

At the end of this course, the students will

- Apply knowledge of mathematics, science, and engineering
- Design, model, analyze, and improve a manufacturing process or system utilizing modern technologies.
- Design and conduct experiments, as well as to analyze and interpret data
- Identify, formulate, and solve engineering problems

- Use the techniques, skills, and modern engineering tools necessary for engineering practice.
- Understand professional and ethical responsibilities and the impact of engineering towards societal and global context.
- Function on multi-disciplinary teams and to communicate effectively.

SCHOL OF INFRASTRUCTURE

DEPARTMENT OF CIVIL ENGINEERING

MINOR DEGREE - GIS AND REMOTE SENSING

CURRICULUM AND SYLLABUS

Sl. No.	Semester	Course Code	Course Title	L	T	P	C
1.	III		Fundamentals of remote sensing	3	0	0	3
2.	IV		Satellite Image Processing	2	0	2	3
3.	V		Geographical Information System	3	0	2	4
4.	VI		Global Navigation Satellite System	2	0	0	2
5.			Application of Remote Sensing and GIS	1	0	2	2
6.	VII		Project Work	0	0	8	4
Total Credits - 18							

Syllabus for GIS and Remote Sensing

Course Code	FUNDAMENTALS OF REMOTE SENSING	L	T	P	C
		3	0	0	3

OBJECTIVES:

The objectives of this course are

- To utilize the principles of remote sensing data acquisition and analysis of satellite data.
- To explore the interaction of EMR with the atmosphere, the spectral signatures of various earth features and electromagnetic interactions.

MODULE I BASIC PRINCIPLES 7

Remote sensing: definition – components of remote sensing- energy sensor, interacting body – Active and Passive remote sensing – platforms – aerial and space platforms – balloons ,helicopters, aircrafts and satellites – electromagnetic radiation (EMR) – EMR spectrum – visible, infrared (IR) near IR, middle IR, thermal IR and microwave – black body radiation – Planck's Law – Stefan –Boltzmann law.

MODULE II EMR INTERACTION WITH ATMOSPHERE 7

Atmospheric characteristics – Atmospheric absorption – scattering of EMR – Rayleigh, Mie, Non-selective and Raman scattering – EMR interaction with water vapor and ozone – atmospheric windows – significance of atmospheric windows.

MODULE III EMR INTERACTION WITH EARTH SURFACE FEATURES 7

EMR interaction with earth surface material, radiance, irradiance, incident, reflected, absorbed and transmitted energy – reflectance – specular and diffused reflection surfaces – spectral signature – spectral signature curves – EMR interaction with water, soil and earth surface.

MODULE IV MICROWAVE REMOTE SENSING 8

Microwave Remote Sensing: Basic principles – Advantages of Microwave Remote Sensing – Types of Microwave Remote Sensing – working principle of RADAR – components of RADAR imaging – Factors affecting the radar

backscattered energy, System and terrain parameters – spatial resolution of SAR system, geometric characteristics – Applications of Microwave Remote Sensing.

MODULE V MISCELLANEOUS REMOTE SENSING TECHNIQUES 8

Aerial photography / photogrammetry: Introduction – Types of photogrammetry – Basic Terminologies – Types of aerial photograph – Derivation of scale of vertical photograph, Orthophotos, Mosaics –Procedure for aerial survey – Flight planning – Digital Stereo Model (DSM) – Advantages – Applications – Drone Surveying – Airborne Laser Scanning (ALS) – Introduction, Components of ALS – Working principle of ALS – Applications of ALS, Case Studies.

MODULE VI REMOTE SENSING APPLICATIONS 8

Applications of remote sensing for environmental pollution – Drought Assessment – Organic farming – Tourism development – Disease control.

Total Hours – 45

TEXT BOOKS:

1. Anji Reddy, “Remote sensing and Geographical Information systems”, BS Publications, 2008.
2. Basudeb Bhatta, “Remote Sensing and GIS”, 2nd Edition, Oxford Higher Education / Oxford University Press, 2011.
3. Lillesand, T.M. and Kuefer, R.W., “Remote sensing and image interpretation”, John Wiley and sons, 2001.
4. Srinivas, M.G., “Remote sensing applications”, Narosa Publishing House, New Delhi, 2001.

REFERENCES:

1. De Merse and Michael, N., “Fundamentals of Geographic Information System”, 2nd Edition, John Wiley and sons, New York, 2003.
2. https://www.geospatialworld.net/article/technology-trends-in-remote-sensing-and-data-analysis

OUTCOMES:

On completion of the course, the students will be able to

- Utilize the basic principles of remote sensing data, types of remote

sensing and laws related to remote sensing.

- Explore the interactions of EMR with the atmospheric particles.
- Predict the interactions of EMR with earth features and the features based on spectral signatures.
- Categorize the characteristic features of microwave remote sensing.
- Apply the use of aerial photos for measurement of height determination.
- Solve the problems with the help of use of remote sensing for different applications.

Course Code	SATELLITE IMAGE PROCESSING	L	T	P	C
		2	0	2	3

OBJECTIVES:

The objectives of this course are

- To impart knowledge in processing the raw image using enhancement techniques.
- To understand the image classification concepts and bout their accuracy of the classified image.

MODULE I DIGITAL IMAGE 7

Introduction to data sources – Characteristics of digital Image data – Spatial data sources –Digital data acquisition – Digital Image Data formats – Image processing system considerations – Digital image data products – Histogram – Univariate and Multivariate Statistics.

MODULE II IMAGE PRE PROCESSING 8

Sources and Corrections of Radiometric distortions and Geometric distortions – Image registration – radiometric enhancement.

MODULE III IMAGE ENHANCEMENT & FILTERING TECHNIQUES 8

Linear contrast enhancement – Nonlinear Contrast enhancement – Histogram Equalization – Histogram Normalization – Histogram matching – Density slicing – Thresholding – LUT stretch – Filters – Low pass filters – High pass filters – edge detection filters.

MODULE IV IMAGE TRANSFORMATION AND CLASSIFICATION 7

Band ratio – Indices – Image Transformation – Land cover classification schemes – Principles of Image Classification – Supervised classification and unsupervised classification for thematic map generation – Classification Accuracy.

LIST OF EXPERIMENTS:

- Reading and Displaying satellite data from BIL, BSQ and BIP formats.
- Extracting area of Interest (AOI)
- Generating histogram of various bands
- Georeferencing the base image
- Enhancement using band ratio and NDVI
- Enhancement using different filtering techniques
- Supervised Classification
- Unsupervised Classification and Accuracy Assessment

L – 30; P – 30; Total Hours : 60

TEXT BOOKS:

1. John, R. Jensen, “Introductory Digital Image Processing”, Prentice Hall, New Jersey, 2006.
2. Lillesand and Keifer, Remote sensing and Image interpretation, John Wiley and Sons, 2009.
3. Paul R. Wolf, Elements of Photogrammetry, McGraw-Hill, 2008.

REFERENCES:

1. https://www.satimagingcorp.com/applications
2. https://emerj.com/ai-sector-overviews/ai-applications-for-satellite-imagery-and-data

OUTCOMES:

On completion of the course, the student will be able to

- Categorize on various visual and digital image processing techniques.
- Process the raw image using preprocessing techniques.
- Enhance the raw digital image using image enhancement techniques.
- Classify the processed image using training sites and to evaluate the accuracy of the classified image.

Course Code	GEOGRAPHICAL INFORMATION SYSTEM	L	T	P	C
		3	0	2	4

OBJECTIVES:

The objectives of this course are to

- To provide information to segregate real world data, different storage procedures and database structures to store the GIS data in a database management system.
- To impart knowledge on classification of real world data into raster and vector representation, to understand data quality and handling of errors.

MODULE I FUNDAMENTALS OF GIS 7

Introduction – definitions of GIS – components of GIS – Geographic data Presentation: maps – mapping process – coordinate systems – transformations – map projection – geo referencing - data acquisition

MODULE II GIS DATA MODELS & STRUCTURES 8

Geographic data representation, storage, quality and standards: storage: digital representation of data – database structures and database management systems.

MODULE III SPATIAL DATA STRUCTURES 7

Raster data representation – vector data representation – concepts and definitions of data quality – components of data quality – assessment of data quality – managing data errors – geographic data standards.

MODULE IV GIS DATA PROCESSING 8

GIS data processing : Raster based GIS data processing – vector based GIS data processing – queries – descriptive statistics – spatial autocorrelation – quadrant counts and nearest neighbour analysis – Relational Database Query: Use of SQL, Descriptive Statistics of Attribute Data – Spatial Data Query – Raster Data Query, Query by Cell Value – Query using Graphical Methods, Charts.

MODULE V SPATIAL ANALYSIS 8

GIS analysis and modeling: Raster Data Analysis – Overlay Operations, Slope & Aspects – Statistical Analysis – Feature Based Topological functions: Buffering

Overlay Analysis, Distance Measurements – Layer Based Topological Functions – Geographic Visualization, Data Classification, Spatial Aggregation – network analysis – surface modeling – DTM.

MODULE VI APPLICATIONS OF GIS 7

Applications of GIS: Business development – Vehicle Tracking – Electric utility mapping – Mobile applications – Automated transmission tower mapping – Pandemic disease tracking and mapping.

LIST OF EXPERIMENTS:

- Georeferencing and rectifying maps.
- Creation of GIS Data/Feature based digitization.
- Adding attributes, using joins and relates - Data Cleanup Tools.
- Convert data from one format to other format.
  1. Raster to Vector 2. Vector to Raster
- Road network - Shortest path analysis.
- Creating thematic maps such as land use, soil and sewer networks.
- Converting data into KML file and overlaying in Google Earth.

L – 45; P – 30; Total Hours : 75

TEXT BOOKS:

1. Anji Reddy, “Remote sensing and Geographical systems”, B.S Publications, Hyderabad, 2008.
2. Chor Pang Lo and Albert K.W. Yeung, "Concepts and Techniques of Geographic Information Systems", Pearson Educations Inc., 2019.
3. Clarke, K., “Getting Started with Geographic Information Systems”, Prentice Hall, New Jersey, 2001.

REFERENCES:

1. Burrough, P.A., “Principles of Geographical Information Systems”, Oxford Publication, 2001.
2. De Mers and Michael, N., “Fundamentals of geographic information system”, 2nd Edition, John Wiley and sons, 2003.
3. https://www.gislounge.com/gis-essentials
4. https://www.esri.com/training/catalog/5b73407f8659c25ea7014330/gis-fundamentals

OUTCOMES:

On completion of the course, the student will be able to

- List the different components of GIS and to identify different elements of a map.
- Design a GIS database scheme, data structure for storage of data and segregate the different layers that need to be stored for an application.
- Create raster, vector layers and to generate and create error free spatial data with its attributes.
- Categorize raster and vector data processing methods and to solve network and surface related problems.
- Generate spatial queries and analysis and to identify the outputs achieved.
- Solve real world problems on business development, electric utilities and mobile GIS through spatial analysis.

Course Code	GLOBAL NAVIGATION SATELLITE SYSTEM	L	T	P	C
		2	0	0	2

OBJECTIVES:

The objectives of this course are to

- To explore various GPS, their source, generation techniques, derivatives, errors and limitations.
- To understand about Global navigation satellite system (GNSS) and its applications in various fields.

MODULE I INTRODUCTION TO GLOBAL NAVIGATION SATELLITE SYSTEM 7

Introduction to Global Navigation Satellite System (GNSS) – Working principle of GNSS - Components / Segments of GNSS – Space segment – Control Segment – User segment - History of Satellite navigation- GNSS satellites work on the earth's orbit – GPS, GLONASS, Galileo, IRNSS.

MODULE II POSITION OF GLOBAL NAVIGATION SATELLITE SYSTEM 9

Basic principles of satellite navigation – Concept of Navigation message- Reception – Computation – Position equation – GNSS working Principle – GPS Time – GPS Signal Structure - Code Modulation – GPS satellite signals – Selective availability (SA) – Coarse acquisition (C/A) code – Precise (P) code – Navigation Message- The Almanac – Satellite Geometry - Satellite mask angle - Dilution Of Precision (DOP)- GPS Services – GPS Positioning- GPS Propagation – Computation – Accuracy – GPS Errors - Sources of errors in GPS.

MODULE III NAVSTR - GLOBAL POSITIONING SYSTEM 7

History of NAVSTR GPS – GPS general characteristics – GPS satellite signals and Data – GPS Modernization – GPS signals. Introduction to GLONASS – Segment Architecture – GLONASS Modernization – Coordinate systems – BeiDou Navigation Satellite system (BDS) - Indian Regional Navigation Satellite system (IRSNSS) – GALILEO.

MODULE IV DIFFERENTIAL GLOBAL NAVIGATION SATELLITE SYSTEM (DGNSS) 7

REAL-TIME KINEMATIC (RTK) - Satellite Based Augmentation System (SBAS) - GNSS Errors - GNSS Correction Methods - Global Navigation Satellite Systems (GNSS) Applications - Current Trends and Future.

Total Hours – 30

TEXT BOOKS:

1. Awange, J. L., "Environmental Monitoring using GNSS: Global Navigation Satellite Systems", Springer, London, 2012.
2. Bhatta, B., "Global Navigation Satellite Systems: Insights into GPS, Glonass, Galileo, Compass, and Others", BS Publications, New Delhi, 2010.
3. Grewal, M. S., Weill, L. R., Andrews, A. P., "Global Positioning Systems, Inertial Navigation, and Integration", John Wiley & Sons, New York, 2006.

REFERENCES:

1. https://www.gsa.europa.eu/links
2. https://novatel.com/industries/agriculture

OUTCOMES:

On completion of the course, the student will be able to

- Explore the clear understanding of the GPS signal, codes, biases and discuss the practical applications of GPS and the implications of its modernization.
- Enhance the opportunities afforded by the coming GNSS systems.
- Analyze the difficulties inherent in determining heights with satellite positioning.
- Categorize the differences between relative and autonomous GPS positioning, code phase carrier phase, DGPS and RTK.

Course Code	APPLICATION OF REMOTE SENSING AND GIS	L	T	P	C
		1	0	2	2

OBJECTIVES:

The objectives of this course are to

- To know the importance of mobile applications.
- To learn the fundamentals of Android application development.
- To develop simple mobile applications using Android.

THEORETICAL STUDY

MODULE I ANDROID APPLICATION DEVELOPMENT AND PYTHON PROGRAMMING 15

Android Basics - Android Architecture - Application Framework - The Manifest file - Libraries – Developing - Managing Virtual Devices - Building and Running – Debugging – Testing - Building Blocks - Application Components - Content Providers - Broadcast Receiver - Processes and Threads - Data storage - SQLite Databases - Localization - User Interface.

GIS with Python - Spatial data model - Geometric Objects - Running Python scripts - Spatial queries.

LABORATORY PRACTICE 30

. • Developing Simple Android Applications (4 exercises)

• Mobile application development in Android using Remote Sensing and GIS (Students can select their own problem to develop an Application)

Total Hours – 45

REFERENCES:

1. Dawn Griffiths, David Griffiths, “Head First Android Development: A Brain Friendly Guide”, O'Reilly Media, 2015.
2. Herbert Shieldt, “Java: A Beginner's Guide”, 7th Edition, Oracle Press, 2017.
3. John Horton, “Android Programming for Beginners”, Packt Publishing, 2015.

OUTCOMES:

On completion of the course, the student will be able to

- Analyze the limitations and challenges of working in a mobile and wireless environment as well as the commercial and research opportunities

presented by these technologies.

- Categorize the different types of application models/architectures used to develop mobile software applications.
- List the components and structure of a mobile development frameworks (Android SDK and Eclipse Android Development Tools (ADT)) and learn how and when to apply the different components to develop a working system.
- Work within the capabilities and limitations of a range of mobile computing devices.
- Design, implement and deploy mobile applications using an appropriate software development environment.

Course Code	PROJECT WORK	L	T	P	C
		0	0	8	4

OBJECTIVES:

The project aims to provide opportunity for the students to exhibit their capacity in executing a project work on data collection / analysis works using Remote Sensing / GIS domain as a team.

General Guidelines:

- The students will be given opportunity to select a project topic of his/her interest and advised to approach the faculty member with expertise in that field to appraise the project and get his/her willingness to guide the project.
- The students can also involve their project work in collaboration with the industry.
- The information related to proposed topic and the faculty member willing to act as guide shall be informed to the course coordinator within the stipulated time. The project coordinator in consultation with Professor in-charge and Dean of the Department shall give initial approval.
- In the project, students are expected to identify a suitable topic, draw the need for present study and scope of the investigation.
- The students are expected to analyse the obtained results and discuss the same in an elaborate manner by preparing necessary charts / tables to get an inference.
- The important conclusions need to be drawn and scope for further research also to be highlighted.
- The project coordinator shall arrange to conduct three reviews to ascertain the progress of the work and award the marks based on the performance.
- At the end, students should submit a report covering the various aspects of Project work. The typical components of the project report are Introduction, Need for present study, Scope of the Investigation, Methodology / Analysis / development of software packages, Results & discussion of GIS analytical work, Conclusions, References etc.
- The project coordinator shall arrange for final viva-voce examination to ascertain the overall performance in Project work.

OUTCOMES:

At the end of the project work, students will be able to

- Choose and solve real-world problems through challenging GIS projects.
- Formulate the methodology for solving the chosen problems.
- Apply the basic principles, tools and techniques for identified problems related to Geospatial engineering.
- Prepare technical reports and make technical presentations.

SCHOOL OF LIFE SCIENCES

MINOR DEGREE PROGRAM - COMPUTATIONAL BIOLOGY

CURRICULUM & SYLLABUS

Sl. No.	Course Code	Course Title	L	T	P	C
1.		**Fundamentals of Biotechnology**	3	0	0	**3**
2.		**Bioinformatics**	3	0	0	**3**
3.		**Systems Biology**	3	0	0	**3**
4.		**Programming in Computational Biology**	3	0	2	**4**
5.		**Algorithms in Computational Biology**	3	0	0	**3**
6.		**Mini project***	3	0	0	**4**

*Mini project in any computational project related to biology or device making related to their discipline.

Fundamentals of Biotechnology

L T P C
3 0 0 3

Objectives:

1. To provide information on different types of biomolecules
2. To offer basic knowledge of bioenergetics
3. To provide information basics of molecular biology
4. To provide information of tools and techniques of genetic engineering
5. To understand the basic function of our immune system

Module 1 Biomolecules **10**

Definition of biomolecules, types of biomolecules, Structure and function of carbohydrate, protein, lipid and nucleic acid

Module 2 Bioenergetics **8**

Fundamentals of bioenergetics, concept of Gibb's free energy, entropy, enthalpy; glucose metabolism pathways-glycolysis, pentose phosphate pathway; TCA cycle and ATP synthesis

Module 3 Molecular Biology **8**

Central dogma of molecular biology; basic idea on replication, transcription and translation; importance of molecular biology in healthcare

Module 4 Genetic Engineering **10**

Concept and application of gene manipulation; tools of gene manipulation- restriction enzyme, ligase, polymerase, reverse transcriptase; PCR technique; concept of molecular cloning

Module 5 Immunology **9**

Overview of immune system; Cell and organs of immune system; molecules of immune system; importance of immune system in fighting infection- bacterial and viral; monoclonal antibody production; diseases related to immune system- immune suppression and autoimmune disorder

L-45; H-45

Text books:

1. Lehninger's principles of biochemistry by Nelson and Cox
2. Principles of gene manipulation by Old and Primrose

3. Kuby immunology 7th edition by Owen, Punt and Stranford

References:

Research papers and other books related to biochemistry, cell and molecular biology, immunology and recombinant DNA technology

Outcomes:

At the end of the course

1. Students will learn the structure and function of biomolecules
2. Students will learn how biomolecules are used to generation of energy inside the cell
3. Students will learn the fundamentals of molecular biology and its application in healthcare
4. Students will learn the different gene manipulation techniques and its application in healthcare
5. Students will learn the fundamentals of immune system in our body and how our immune system saves us from infection and some immune related disease

Bioinformatics

L	T	P	C
3	0	0	3

Objectives:

1. To provide information on different types of biological databases
2. To provide information on two or more DNA or protein sequence comparison and database searching methods
3. To provide information on phylogenetic analysis
4. To provide information on different predictive methods in bioinformatics
5. To provide information on molecular modelling and other advances in bioinformatics

Module 1 Biological databases 8

Concept of database; importance of biological database; NCBI; retrieval of databases-Entrezstystem; primary database- nucleotide and protein; secondary database-PFAM, PROSITE etc.; Molecular structure database-PDB, CATH, SCOP, Pubchem; specialized database- KEGG

Module 2 Sequence comparison and Database searching 10

Importance of sequence comparison, Pairwise alignment- Local and global alignment; BLAST and FASTA; multiple sequence alignment- concept and application, different types of MSA; Progressivealignment methods, Motifs and patterns,Hocks, MOST, Probe, Presentation, methods, Abscript

Module 3 Phylogenetic analysis 10

Elements of phylogenetic models, data analysis: Alignment, substitution modelbuilding, tree building and tree evaluation, building methods, searching for trees,hooting trees, Evaluating trees and data, phylogenetic software Some simplepractical consideration

Module 4 Predictive Methods 9

Framework, marking repetitive DNA, Database search, Codon bias detection, Detecting function sites in the DM, Integrated gene passing, Finding tRNAgenes, Protein identity based on composition, Propsearch, Physical propertiesbased on sequences, secondary structure and folding classes, spread sopma,Specialized structures of features, Tertiary structure

Module 5 Advanced Bioinformatics 9

Further applications on the design of new molecules 3D data base searching and virtual screening, Sources of data, molecular similarity and similarity searching, combinatorial libraries-generation and utility

Text books:

1. Bioinformatics: A practical guide to the analysis of genes and proteins A.D. Baxevanis and B.F.F. Ouellette (Eds). 2002 John Wiley and Sons.

2. Bioinformatics: Sequence and Genome Analysis by D.W. Mount, 2001, Cold Spring Harbor Laboratory Press.

3. Applied Bioinformatics:An IntroductionSecond Edition by Selzer, Marhofer and Koch; Springer

Outcomes:

At the end of the course

1. Students shall be able to learn the types and importance of biological databases
2. Students shall be able to learn the method of two or more protein and nucleic acid sequence comparison and their application
3. Students shall be able to learn the evolutionary relationships of different sequences
4. Students shall be able to learn different predictive methods used in bioinformatics to analyze sequences
5. Students shall be able to learn the docking and molecular modelling of biomolecules

Systems Biology

L T P C
3 0 0 3

Objectives:

1. To give the introductory concept of systems biology
2. To provide information on biological network and motifs
3. To provide information on feedback and oscillation
4. To provide information on robustness of dynamic interaction
5. To give the introductory concept in synthetic biology

Module 1 Introduction 8

Basics of systems biology; Networks- basics of computer networks and Biological network. Basic concept and applications of Micro-Array technique in systems biology. Self-organizingmaps and Connectivity maps - definition and its uses. Networks and Pathways –Types and methods. Metabolic networks

Module 2 Networks and Motifs 10

Gene Networks: basic concepts, metabolic network, transcriptional regulatory network and signaling network; network motif: feedback loop or autoregulation and feed forward loop-AND gate, OR gate and other feed forward loop

Module 3 Positive feedback and biological oscillator 10

Bistability, two nodes positive feedback loops, long transcription network cascade, two nodes negative feedback loop; network motifs in neuronal network;Biological oscillator- damped oscillation and delay oscillation

Module 4 Robustness and Optimality 9

Robust signaling by bifunctional components, input-output curve, bacterial two component system, bacterial chemotaxis, insulin-glucose feedback loop; Optimality- Lac operon system

Module 5 Synthetic Biology 8

Introduction, definition and Basics, Synthetic Oligonucleotide/DNA-based, RNA-based, Peptide-based and polyketide Technologies and Applications, Technologies and Applications of Directed Evolution and Microbial Engineering, Potential Hazards of Synthetic Biology

Text books:

1. Systems Biology: Definitions and perspectives by L.Alberghina H.V.westerhoff, Springer. 2005
2. An Introduction to Systems Biology second edition by Uri Alon CRC Press, 2020
3. Synthetic Biology, A New Paradigm for Biological Discovery, a report by BeachheadConsulting, 2006

Outcomes:

At the end of the course

1. Students shall learn the concepts of systems biology and different biological networks
2. Students will understand the features of biological network like feedback and feedforward motifs
3. Students will understand the dynamic behavior of biological network like bistability and oscillation
4. Students shall lean the robustness of the robust of the biological network with real life examples like bacterial chemotaxis and glucose-insulin balance
5. Students shall learn the concept of synthetic biology

Programming in Computational Biology

L T P C
2 0 2 4

Objectives:

1. to give introduction to programming language
2. to give idea on object oriented programming C++
3. to discuss concept on PERL
4. to discuss concept on Biopython
5. to give introduction to Java basics
6. introduce R and bioconductor
7. practical experiments

Module 1 Introduction to programming languages 5

Introduction –Programming languages – Problem solving Technique: Algorithm, Flowchart,Compiling, Testing and Debugging, Documentation – Data structures – Array, Stack, Queue,Linked List concepts

Module 2 Object Oriented Programming 5

Programming in C++ : C++ programming – Object Oriented Concept: Encapsulation,Inheritance, Polymorphism – Different forms of Constructor – Destructor – Abstract class –Virtual function

Module 3 PERL 5

Basic Perl Data Types, References, Matrices, Complex/Nested Data Structures, Scope: my,local, our – Function/Subroutines, System and User Function, File handle and File Tests – statand lstat Functions – Perl Modules; Bioperl: Installation, archBitecture and uses

Module 4 Biopython 5

Overview, biopython packages, parsing sequence file format; sequence objects-alphabet, strings, slicing a sequence; concatenation; sequence annotation object-SeqRecord, slicing SeqRecord

Module 5 Java basics 5

Importance and features of java, Modifiers, Access Controls, Data types,Expressions, Declarations, Statements & Control Structures, Program

Structures, Stringhandling, Packages, Interfaces, Working with java util Package, Garbage Collection

Module 6 R and Bioconductor 5

Introduction to R; function and packages; R objects; graphical procedure; Sequence analysis in R and Bioconductor, Bioconductor packages- Affy package, Limma, RankProd, GeneOntology analysis

Practical: 30

1. Perl: Storing DNA fragment, concatenating DNA fragment, transcription, reverse transcription, reading proteins in file, genetic code, translation, reading DNA files from FASTA format, restriction maps, parsing annotations, reverse complementation, Mutation and randomization in Bioperl, Local and Global alignment of sequences
2. Java: Java Applets Basics, Graphics, Fonts and Color,Simple Animation and Threads, Creating simple JAVA graphical user interface
3. BioPython:Retrieve and annotate Entrez Gene IDS with the Entrez module; Concatenating multiple alignments NEXUS files with the Bio.Nexus module; Methods for Degenerated Codons; Workflow to extract intergenic regions from a sequence; Retrieve nonmatching blast queries; Sequence Cleaner; Split large file; phylogenetic tree construction by bio.phylo; reading motifs
4. R : Genome sequence analysis, Differential gene expression analysis, single cell experiment

Total- T-30, P-30

Text Books:

1. Object Oriented Programming using C++ (4th Ed.) by Lafore, R. Sams Publishers. 2002
2. Beginning PERL for Bioinformatics by James Tisdall. O'Reilly publications.2001
3. Biopython Tutorial and Cookbook by Chang et al. (http://biopython.org/DIST/docs/tutorial/Tutorial.pdf)
4. R and bioconductor manual by Thomas Girke (http://manuals.bioinformatics.ucr.edu/home/R_BioCondManual)

Outcomes:

1. Students shall be able to understand the concept of programming language

2. Students will understand C++ and they will apply their knowledge in practical experiments
3. Students shall understand PERL language and practice its application on biology
4. Students shall understandBiopython and apply to knowledge to biological data analysis
5. Students shall understand Java and they will apply their knowledge in practical experiments
6. Students shall understand R and Bioconductor and will apply in different high throughput biological data analysis

Algorithms in Computational Biology

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Objectives:

1. To give the introductory concept of algorithm
2. To provide the concept of different searching algorithm
3. To provide the theory of pattern matching and genetic algorithm
4. To provide concept of artificial neural network
5. To provide concept of clustering algorithm

Module 1 Introduction 8

Algorithms in Computing; Analyzing algorithms-Asymptotic notation, Standardnotations, Big 'O' notations; Algorithm design techniques- Exhaustive Search, Branch-and-Bound Algorithms, Greedy Algorithms, Dynamic Programming, Divide-and-ConquerAlgorithms, Machine Learning, Randomized Algorithms; Time and space complexity ofalgorithms, common Sort and Search algorithms.

Module 2 Searching algorithm 11

Exhaustive Search- Restriction Mapping, Finding Motifs; **Greedy Algorithms**-GenomeRearrangements, Sorting by Reversals, Finding Motifs; **Dynamic Programming algorithms**-Edit Distance and Alignments, Global and local Sequence Alignment, Scoring Alignments,Alignment with Gap Penalties, Gene Prediction, Multiple Alignment; **Divide-and-ConquerAlgorithms**- Divide-and-Conquer Approach to Sorting, Space-Efficient Sequence Alignment,Block Alignment

Module 3 Pattern matching and genetic algorithm 9

Combinatorial Pattern Matching- Hash Tables, Repeat Finding, Exact Pattern Matching; Expectation and Maximation (EM) with forward and backward algorithms, discriminative learning; Genetic Algorithm: Basic Concepts, Reproduction, Cross over, Mutation, Fitness Value, Optimization using GAs; Applications in bioinformatics

Module 4 Artificial neural network algorithm 11

Hidden Markov Models: Markov processes and Markov Models, Hidden Markov Models,Parameter estimation for HMMs, Optimal model construction, Applications of HMMsArtificial Neural Networks: Historic evolution – Perceptron,

NN Architecture, supervised andunsupervised learning, Back Propagation Algorithm, Training and Testing, Self-organizingFeature Map and Radial Basis Function Network; Overview of Support Vector Machines, Bayesian network

Module 5 Clustering approach 6

Hierarchical Clustering, k-Means Clustering, Evolutionary Trees, Distance-Based Tree Reconstruction, Reconstructing Trees from Additive Matrices, Character-Based Tree Reconstruction, Small and large Parsimony Problem.

Text books:

1. Fundamentals of Computer Algorithms by Horowitz, S. Sahini, and Rajasekharan. GalgotiaPublications.1984
2. An introduction to bioinformatics algorithms by Neil C. Jones, PavelPevzner. MIT Press.2004

Outcomes:

1. Students will learn the basic concepts of making algorithm
2. Students will learn the skills to develop algorithms to search required information
3. Students will be able to develop pattern matching and genetic algorithm
4. Students will be able to construct artificial neural network algorithm
5. Students will learn and apply clustering approaches to analyze biological data