VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE
(VJTI)
MATUNGA, MUMBAI 400 019

(Autonomous Institute affiliated to University of Mumbai)

Curriculum
(Scheme of Instruction & Evaluation and Course contents)

For
Two Year Post Graduate Programme
Leading to Master of Technology
(M.Tech.) Degree in
Internet of Things (IoT)

Implemented from the batch admitted on Academic Year 2022-23

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For

Post Graduate Programme
Leading toMaster of Technology
Degree

In

Internet of Things (IoT)

From Academic Year 2022-23

M Tech Internet of Things
(IoT)

PROGRAM EDUCATIONAL OBJECTIVES (PEOs) :

PEO 1	Apply analysis, design, optimization and implementation skills in order to formulate and solve IoT and allied multidisciplinary problems.
PEO 2	Take up higher studies, innovation, research & development and other such creative efforts in technology.
PEO 3	Use their skills in professional manner to raise the satisfaction level of stake holders.

PROGRAM OUTCOMES(POs)

LIST OF PROGRAM OUTCOMES	
PO1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

M.Tech. Internet of Things (IoT)

Scheme of Instruction and Evaluation

SEMESTER I

Scheme of Instruction					Scheme of Evaluation			
S.No	**Course Code**	**Course Title**	**L-T-P**	**Credits**	**TA**	**MST**	**ESE**	**ESE hours**
1	EEIT5001S	Computational Methods (Program Specific Maths)	3-0-0	3	20	20	60	3
2	EEIT5011T	Principles of IoT (Core-1)	3-1-0	4	20	20	60	3
3	EEIT5012T	Intelligent Agents and Learning Machines (Core-2)	3-0-0	3	20	20	60	3
4	EEIT5022S	Program Elective 1	3-1-0	4	20	20	60	3
5	EEIT5031T	Program Elective 2	3-0-0	3	20	20	60	3
6	EEIT5061S	Open Elective-1	3-0-0	3	20	20	60	3
7	EEIT 5011P	Principles of IoT (Laboratory -1)	0-0-2	1	60%CIE		40	-
8	EEIT 5012P	Intelligent Agents and Learning Machines (Laboratory-2)	0-0-2	1	60%CIE		40	-
9	EEIT5031P	Program Elective 2 (Laboratory-3)	0-0-2	1	60%CIE		40	-
10	MTEC5081L	Liberal Learning	0-0-2	1	100%CIE		-	-
		Total	28	24				

Program Elective -1	**Program Elective – 2**
1. Embedded Systems Technology (EEIT5022S) 2. Modern Sensors and Transducers (EEIT5023S) 3. Biocomputing (EEIT5024S)	1. Wireless Sensor Networks (EEIT5031T) 2. Machine Vision (EEIT5032T) 3. Filtering Techniques (EEIT5033T)

Open Elective – 1	**Liberal Learning-1 (MTEC5081L)**
1. Artificial Neural Networks and Machine Learning (EEIT5061S)	1. Problem Solving and Critical thinking 2. Indian Knowledge System 3. Yoga and Stress Management 4. Corporate Culture and Organizational learning 5. Business Administration 6. German 7. French 8. Defence 9. Information Science

Abbreviations: **L:** Lecture, T: Tutorial, P: Practical, **TA:** Teacher Assessment/Term work Assessment, **MST:** Mid semester Test ,**ESE**: End semester Written Examination, **CIE:** Continuous In-semester Evaluation

SEMESTER II

Scheme of Instruction					Scheme of Evaluation			
S. No	**Course Code**	**Course Title**	**L-T-P**	**Credits**	**TA**	**MST**	**ESE**	**ESE hours**
1	EEIT5002S	Research Methodology &IPR (Mandatory Learning)	3-0-0	3	20	20	60	3
2	EEIT5013T	IoT Security (Core-1)	3-1-0	4	20	20	60	3
3	EEIT5014T	Industrial Internet of things (Core-2)	3-0-0	3	20	20	60	3
4	EEIT5041S	Program Elective 3	3-1-0	4	20	20	60	3
5	EEIT5051T	Program Elective 4	3-0-0	3	20	20	60	3
6	EEIT5062S	Open Elective -2	3-0-0	3	20	20	60	3
7	EEIT5013P	IoT Security (Laboratory - 4)	0-0-2	1	60%CIE		40	-
8	EEIT5014P	Industrial Internet of things (Laboratory -5)	0-0-2	1	60%CIE		40	-
9	EEIT5051P	Program Elective 4 (Laboratory - 6)	0-0-2	1	60%CIE		40	-
10	MTEC5082L	Liberal Learning	0-0-2	1	100%CIE		-	-
		Total	28	24				

Program Elective 3	**Program Elective 4**
1. Data Analytics and Visualization (EEIT5041S) 2. Real Time Embedded systems design and Analysis (EEIT5042S) 3. Industrial IoT for Smart Cities (EEIT5043S)	1. IoT Design for Connected Health Care (EEIT5051T) 2. Edge Computing (EEIT5052T) 3. IoT Applications and Web Development (EEIT5053T)

Open Elective-2	**Liberal Learning-2 (MTEC5082L)**
1. Mathematical foundation course for data analytics (EEIT5062S)	1. Agriculture 2. Holistic health 3. Political science 4. Computerised Modern Film Making 5. Interior design 6. Introduction to Japanese Language and Culture

Abbreviations: **L:** Lecture, T: Tutorial, P: Practical, **TA:** Teacher Assessment/Term work Assessment, **MST:** Mid semester Test, **ESE**: End semester Written Examination, **CIE:** Continuous In-semester Evaluation

SEMESTER III

Scheme of Instruction					Scheme of Evaluation
S. No	**Course Code**	**Course Title**	**L-T-P**	**Credits**	
1	EEIT5091D	Skill Based Course (Project Stage -I)	---	5	100%CIE
2	EEIT5092D	Skill Based Course (Project Stage -II)	---	5	100%CIE
3	EEIT5101S	Self-Learning Course -1	1-0-0	1	100% ESE of 3 hours or credit transfer
4	EEIT5201S	Self-Learning Course -2	1-0-0	1	100% ESE of 3 hours or credit transfer
5	EEIT5301S	Mandatory Non-Credit Course	2-0-0	0	100% ESE of 3 hours or credit transfer
		Total		12	

Self-Learning Course-1	**Mandatory Non-Credit Course**
1. Ayurvedic Inheritance of India (EEIT5101S) 2. Biology for engineers and other non-biologists (EEIT5102S) 3. Human resource planning (EEIT5103S) 4. Key to recognising cyber bullying (EEIT5104S) 5. Cooperation vs. competition (EEIT5105S) **Self-Learning Course-2** 1.Customer Relationship Management EEIT5201S) 2.Patent Search for Engineers and Lawyers (EEIT5202S) 3.Design Thinking - A Primer (EEIT5203S) 4.Assessment in democratic classroom (EEIT5204S) 5.Media and information disorder (EEIT5205S)	1. Leadership and Team Effectiveness (EEIT5301S) 2. Applied Econometrics (EEIT5302S) 3. National Security Policy of India (EEIT5303S) 4. Entrepreneurship (EEIT5304S) 5. Spatial Statistics and Spatial Econometrics (EEIT5305S) 6. Military history of India (EEIT5306S) 7. Human rights and Indian Constitutions (EEIT5307S) 8. Public Speaking (EEIT5308S) 9. Wars in post Independent India (EEIT5309S) 10. Consumer Behaviour (EEIT5310S)

SEMESTER IV

Scheme of Instruction					Scheme of Evaluation
S. No	**Course Code**	**Course Title**	**L-T-P**	**Credits**	
1	EEIT5093D	Skill Based Course (Project Stage -III)	---	5	100%CIE
2	EEIT5094D	Skill Based Course (Project Stage -IV)	---	7	100%CIE
		Total		12	

SEMESTER-I

Programme Name	**M. Tech. (IoT), SEMESTER I**
Course Code	**EEIT5001S**
Course Title	**COMPUTATIONAL METHODS**

COURSE OBJECTIVES

- After completion of this course, students should be able to
- Develop mathematical models of lower-level engineering problems.
- Learn how to curve fit (interpolation and regression) discrete data.
- Understand and solve problems using various transform techniques.
- Make use of various optimization Techniques.
- Earn how to analyse algorithms using various methods

COURSE OUTCOMES

- Understand the concept and steps of problem solving - mathematical modelling, solution and implementation.
- Knowledge and understanding of, and the ability to use, mathematical techniques.
- Ability to understand and apply mathematical reasoning in several different areas of mathematics.
- Describe apply and analyse complexity of greedy and dynamic programming strategy.

Overview

Module I: Review of Numerical Techniques	
	Newton's divided difference, interpolation polynomials, Lagrange interpolation polynomials, Linear and non-linear regression, multiple linear regression, general linear least squares
Module II: Transform Techniques	
	Orthogonal/Unitary transform, Fourier transform, Laplace transform, Z Transform, Applications of these transform.
Module III: Optimization Techniques for Engineers	
	Single Variable Optimization, Multi-Variable Optimization with equality and inequality constraints, Line searches, Steepest descent method, Conjugate gradient method, Quasi Newton method, Penalty function method
Module IV: Analysis of Algorithms	
	a) Greedy Method Approach: General Method, Single source shortest path: Dijkstra Algorithm, Fractional Knapsack problem, Job sequencing with deadlines, minimum cost spanning trees: Kruskal and Prim's algorithms. **b)** Dynamic Programming Approach: General Method, Multistage graphs, Single source shortest path: Bellman Ford Algorithm. All pair shortest path: Floyed Warshall algorithm, Assembly – line scheduling problem0/1 knapsack Problem, Travelling Salesperson problem, Longest common subsequence.

Reference books

1. "Numerical Methods for Engineers', Steven C. Chapra and Raymond P. Canale, McGraw Hill, 8th edition (29October 2021)
2. "Operations Research – An Introduction", Hamdy A.TAHA, Pearson Education; Tenth edition (31 August 2019)
3. "Numerical Methods for Engineers", Santosh Gupta, New age international publishers 4th edition (01 August2019)
4. "Introduction to Algorithms", T. H. Cormen, C.E. Leiserson, R.L.Rivest, and C. Stein, 4th Edition, PHI Publication, (April 5, 2022).
5. "Fundamentals of computer Algorithms", Ellis Horowitz, Sartaj Sahni, S. Rajsekaran, University Press, 2nd edition, (4th September 2018)

Programme Name	**M. Tech. (IoT), SEMESTER - I**
Course Code	**EEIT5011T**
Course Title	**Principles of IoT**

Course Outcomes:

At the end of successful completion of the course, students will be able to

- Summarize the concepts of network connected embedded devices.
- Design suitable network architecture and use appropriate protocols for a given IOT application.
- Identify and summarize different components required for IOT applications.
- Analyse the system through Data Analytics tools.

Module I	**Introduction & Basic of IoT**
	Definition,Characteristics, Physical and Logical Designs, challenges, Technological trends in IOT, IoT Examples, M2M
Module II	**IoT: Components, Communication and Networking**
	Introduction to Sensing and Networking: Sensing & actuation, Wireless Senor network, Senor nodes, Communication Protocols, M2M Communication, Networking Hardware, Networking Protocols.
Module III	**IoT System Management**
	Network Operator Requirements, IoT Platform Design Specification – Requirements, Process, Domain Model, Service, IoT Level, Function, Operational view, Device and Component Integration, Application development.
Module IV	**Networking and Computing**
	File Handling, Python Packages for IoT, IoT Physical Servers – Cloud Storage Models, Communication APIs.
Module V	**IoT Clouds and Data Analytics**
	RESTful Web API, Amazon Web Services for IoT, Apache Hadoop, Batch Data Analysis, Chef, Chef Case Studies, Puppet**,** NETCONF-YANG.
Module VI	**IoT Applications**
	Case studies: smart cities, smart home, connected vehicles, Industrial IOT.

REFERENCE BOOKS:

1. Kamal, R.,"Internet of Things – Architecture and Design Principles," 1st Edition, Mcgraw Hill,2017.
2. Simone Cirani," Internet of Things- Architectures, Protocols and Standards", WILEY,2018.
3. Alessandro Bassi," Enabling Things to Talk- Designing IoT solutions with the IoT Architectural Reference Model", Springer,2013.

Programme Name	**M. Tech. (IoT), SEMESTER - I**
Course Code	**EEIT5011P**
Course Title	**Principles of IoT (LAB)**

Course Outcomes:

At the end of successful completion of the course, students will be able to

- Students should be able to do Embedded C programming and Python Programming.
- Students should be able to perform experiments on different development boards.

Module I	**Overview (Any three practical's/ Programs)**
	Embedded Software Development Tools: - Keil µ vision 3 and 4 project management, Study How to create Embedded Project, Compile and Test Project for 8051 and testing of 8051 based projects on Target Board, Programming of Flash Memory
Module II	**Python Programming (Any three practical's/ Programs)**
Module III	**Arduino Programming (Any three practical's/ Programs)**
	Arduino Programming, Integration of Sensors and Actuators with Arduino, Raspberry Pi, Implementation of IoT with Raspberry Pi.
Module IV	**Project work**

REFERENCE BOOKS:

1. Kamal, R.," Internet of Things – Architecture and Design Principles", 1st Edition, Mcgraw Hill,2017.
2. Simone Cirani," Internet of Things- Architectures, Protocols and Standards", WILEY.2018.
3. Alessandro Bassi," Enabling Things to Talk- Designing IoT solutions with the IoT Architectural Reference Model", Springer,2013.

Programme Name	**M. Tech. (IoT), SEMESTER – I**
Course Code	**EEIT5012T**
Course Title	**Intelligent Agents & Learning Machines**

Course Outcomes:

At the end of successful completion of the course, students will be able to:

- Comprehend concepts of intelligent agents
- Apply artificial intelligence, machine learning and statistical algorithms for IOT systems
- Develop a toolbox of algorithms that they can implement
- Develop IoT applications using machine learning algorithms & tools.

This course is aimed at introducing and developing IoT applications using machine learning algorithms & tools. It will provide a foundational understanding of how artificial intelligence, machine learning and statistical algorithms work. Students will have can use on their own datasets after they leave the course.

Module I	**Intelligent Agents**
	Introduction, Agents & environments, Concept of rationality, Structure of agents, Simple reflex agents, Model-based reflex agents, Goal based agents, Utility based agents, learning agents, learning processes (supervised, unsupervised, semi- supervised/reinforcement learning), Learning tasks, Distance metrics
Module II	**Artificial Neural Networks**
	Biological neuron, Models of a neuron, Artificial Neural Networks (ANN); Rosenblatt's perceptron, Perceptron convergence theorem, Typical applications of ANNs: Bayesian Classification, Function Approximation, Forecasting, Control, Optimization,
Module III	**Model Building through Regression**
	Linear regression model, Maximum a posteriori estimation of the parameter vector, Relationship between regularized least-square estimation and MAP estimation, Bias-variance dilemma, Regularization (Ridge, Lasso & Elasticnet)
Module IV	**Unsupervised Learning**
	K-means clustering, Expectation maximization algorithm, Winner-takes-all networks; Hamming networks; Maxnet; Simple competitive learning; Vector-Quantization; Counter propagation networks; Adaptive Resonance Theory; Kohonen's Self-organizing Maps; Principal Component Analysis
Module V	**Classical and Theoretical ML Topics**
	Concept Learning (also called Learning from Examples), Decision Tree Learning, Decision List Learning, Reinforcement learning, Oracle Based Learning, Probably Approximately Correct (PAC) Model, Boosting
Module VI	**Associated Models and Optimization Methods**
	Hopfield Networks, Brain-in-a-Box network; Boltzmann machine; Hopfield Networks for-TSP, Solution of simultaneous linearequations; Iterated Gradient Descent; Simulated Annealing; Genetic Algorithm.

Reference Books:

1. Simon Haykin, "Neural Networks - A Comprehensive Foundation", Macmillan Publishing Co., New York, 1994
2. A Cichocki and R. Unbehauen, "Neural Networks for Optimization and Signal Processing", John Wiley and Sons, 1993.
3. J. M. Zurada, "Introduction to Artificial Neural Networks", (Indian edition)Jaico Publishers, Mumbai, 1997.
4. Stuart Russell and Peter Norvig, "Artificial Intelligence- A ModernApproach", (Third Edition), Prentice Hall, 2010.
5. Tom Mitchell, "Machine Learning", McGraw-Hill, 1997

Programme Name	**M. Tech. (IoT), SEMESTER – I**
Course Code	**EEIT5012P**
Course Title	**Intelligent Agents & Learning Machines LAB**

COURSE OBJECTIVE:

- The course is designed to introduce the field of artificial neural networks systems and machine learning.
- The course will give the student the practical and implementation aspects of data processing algorithms.

COURSE OUTCOME:

- Students will be able to implement basic supervised learning algorithms.
- Students will be able to use algorithms for unsupervised methods.
- Students will be able to describe how statistical models work.
- Students will be able to develop IoT applications using machine learning algorithms and tools.

COURSE CONTENTS:

Module I	Intelligent Agents
Module II	Artificial Neural Networks
Module III	Model Building through Regression
Module IV	Unsupervised Learning
Module V	Classical and Theoretical ML Topics
Module VI	Associated Models and Optimization Methods

Reference Book :

1. Simon Haykin, "Neural Networks and Learning Machines", Pearson Publication, New Delhi, 2012.
2. Stuat Russell and Peter Norvig, "Artificial Intelligence- A Modern Approach", (Third Edition), Prentice Hall, 2010

Programme Name	**M. Tech. (IoT), SEMESTER – I (Elective-I)**
Course Code	**EEIT5022S**
Course Title	**Embedded Systems Technology**

COURSE OUTCOMES

At the end of successful completion of the course, students will be able to

- Describe the hardware and software architecture of embedded system.
- Identify the necessary communication Interface for the embedded system.
- Design and develop embedded systems
- Implement embedded systems for given applications

Module I	**Introduction to Embedded system**
	Introduction To Embedded Systems, Embedded Systems Vs General Computing Systems, History of Embedded Systems, Classification, Major Application Areas, Embedded Processor Requirements, Features, Types, RISC Processors, Harvard Architecture, Super Harvard Architecture, Selection of Processors &Microcontrollers.
Module II	**Architecture of Embedded System Processor**
	Embedded processor models, ARM core processor, Application specific processor like network processors, multimedia processors, industrial processors, superscalar processor, Advanced RISC processors.Architecture Of Embedded OS, Categories of Embedded OS, Application Software, Communication Software, Development and Testing Tools
Module III	**Communication Interfaces**
	Need For Communication Interfaces, OSI Reference Model, Basic Of Networks, Network Topology, RS232/UART, RS422/RS485, USB, Infrared, Ethernet, IEEE 802.11, Bluetooth, SPI, I2C, CAN, Wifi, FlexRay, LIN Bus, Zigbee.
Module IV	**Rapid prototyping**
	Arduino platform, hardware and software, Sensor's modules, Robo controlmodules, 3D printing module, ADC module, wearablesystems. etc.
Module V	**Embedded GUI interfacing**
	Arduino based graphic LCD, Touch screen, joy stick, VGA camera interfacing and programming in Python. Creative applications of Arduino.
Module VI	**Design Examples & Case Studies of Embedded System**
	Digital Thermometer, Navigation Systems, Smart Card, RF Tag.

ReferenceBooks:

1. David Simon, "An embedded Software Primer" PearsonPublication,2021.
2. Frank Vahid, "Embedded system — A unified HardwareSoftware Introduction" John Wiley and Sons,2005.
3. Tammy Noergaard," Embedded System Architecture", Elsevier publication,2014.

4. Prasad ―Embedded Real time systems‖ Dream tech WileyPublication.2003
5. Embedded Systems- Architecture, Programming and Design | 3rd Edition Paperback – 1 July 2017

Programme Name	**M. Tech. (IoT), Semester I (Elective-I)**
Course Code	**EEIT5023S**
Course Title	**MODERN SENSORS AND TRANSDUCERS**

COURSE OUTCOMES

After learning the course students should be able to:

- Classify and characterize different types of transducers and sensors.
- Identify transducers and sensors for measurement of various quantities.
- Analyse the use of transducers and sensors for various applications in electronics engineering.
- Design schematic diagrams and circuits using transducers and sensors for various applications.

Module I	**Introduction**
	Measurement systems, Basic electronic measuring system, Classification oftransducers, General transducer characteristics, Criteria for transducer and sensor selection.
Module II	**Resistive, Capacitive and Inductive Transducers**
	Resistance Potentiometers-Principles of operation, construction, theory,advantages and disadvantages, applications of Potentiometers Strain gauges, (metallic and semi-conductor type) Resistance Thermometer and Thermistors. Types of Inductive transducer, Principles of operation, construction, Advantages & disadvantages and applications. Various variable Inductive Transducers, LVDT (Linear variable differential transformer). Types of capacitive transducer, Principles of operation, construction, advantages, disadvantages and applications of capacitive transducers.
Module III	**Elastic and Active Transducer**
	Principle of operation, construction, theory, advantages and disadvantages and applications of following transducers: Thermocouple, Piezo-electric transducer. Spring bellows, diaphragm, bourdon tube – their special features and application.
Module IV	**Modern Sensor**
	Interface Electronic Circuits, Detectors of Humans, Force and Strain, Pressure Sensors, Flow Sensors, Microphones, Humidity and Moisture Sensors, Chemical and Biological Sensors.
Module V	**Capacitive Sensors**
	Capacitive sensors: variable distance-parallel plate type, variable area- parallel plate, serrated plate/teeth type and cylindrical type, variable dielectric constant type. Stretched diaphragm type: microphone, Proximity sensor.
Module VI	**Thermal sensors**
	Various types and applications
Module VII	**Magnetic sensors:**
	Sensors based on Villari effect: Wiedemann effect, Thomson effect, Hall effect and applications Radiation sensors.
Module VIII	**Introduction to smart sensors**
	Introduction ,Components of smart sensors ,Architecture and evolutions of smart sensors, Advantages and disadvantages, Industrial applications

REFERENCE BOOKS

1. D. Patranabis, "Sensor & Transducers", Murthy Prentice Hall India Learning Private Limited, 2nd edition, 2009.
2. Jacob Fraden," Handbook of Modern Sensors", Physics, Designs,and Applications, Fifth Edition, Spinger,2016.
3. H. K. P. Neubert, "Instrument Transducers", Oxford University press,1975.
4. E. A. Doebelin," Measurement systems: Application & design",McGraw-Hill Higher Education,5th edition, 2003.

Programme Name	**M. Tech (IoT), Semester-I (Elective-I)**
Course Code	**EEIT5024S**
Course Title	**Biocomputing**

COURSE OUTCOMES

After successful completion of this course, students will be able to

- Comprehend utility of learning algorithms in healthcare
- Analyze and interpret nature of clinical data
- Understand structure of healthcare information system and flow
- Apply learning algorithms on medical data for knowledge representation and inference.

COURSE CONTENTS

Module I	**Introduction**
	Nature of clinical data, standards, data in narrative texts, gene, expression and protein data, architecture of healthcare informationsystems
Module II	**Probabilistic and graphical models**
	Information theoretic metrics, decision support via probabilities and utilities,decision support via expert systems, modelling and Bayesian network, learning Bayesian networks, classical machine learning algorithms, feature extraction and mapping, local alignment (BLAST), Comparative Genomic Analysis of Gene Regulation, Clustering, Model Selection, and BIC Scores
Module III	**Knowledge representation and inference**
	Propositional and first order logic, rule-based systems, graph search, constraint satisfaction, privacy and security issues, medical expert systems, Genome analysis, RNA-sequence Analysis: Expression, Isoforms, modellingbiological functions, Modelling and Discovery ofSequence Motifs (Gibbs Sampler, Alternatives), Probabilistic Grammatical Models of RNA Structure
Module IV	**Adleman Technique**
	Introduction, self-assembly, nanodevices, Quoram sensing, biological computational device, engineered and naturally occurring molecular switches,ciliates, molecular gates and circuits, building and deciphering networks,

Reference books:

1. Jones, Neil C., and Pavel Pevzner, “An Introduction to Bioinformatics Algorithms”, MIT Press, 2004. ISBN:9780262101066.
2. Adleman, L. M. "Molecular computation of solutions to combinatorial problems." Science 266, November 11, 1994,1021-4.
3. Shortliffe, E. H., L. E. Perreault, G. Wiederhold, and L. M. Fagan,”Medical Informatics: Computer Applications in Health Care and Biomedicine”, 2nd ed.New York, NY: Springer, 2003

4. Yurke, B., A. J. Turberfield, A. P. Mills, F. C. Simmel, and J. L.Neumann. "ADNA-fueled molecular machine made of DNA." Nature406 (August 10, 2000): 605-8

5. Schwartz, W. B., R. S. Patil, and P. Szolovits. “Artificial intelligence in medicine: where do we stand.” New England Journal of Medicine pp: 685-688,1987.

6. National Center for Biotechnology Information. "The Statistics of Sequence Similarity Scores." BLAST Tutorial.
7. Li, Heng, and Richard Durbin. "Fast and Accurate Short Read Alignment with Burrows–wheeler Transform." Bioinformatics 25, no. 14, pp1754–60,2009.

Programme Name	**M. Tech. (IoT), SEMESTER – I (Elective-II)**
Course Code	**EEIT5031T**
Course Title	**WIRELESS SENSOR NETWORKS**

COURSE OUTCOMES

After successful completion of this course, students should be able to

- Describe the concepts, network architectures and applications of ad hoc and wireless sensor networks.
- Analyze the protocol design issues of ad hoc and sensor networks.
- Explain the concepts of communication, MAC, routing protocols and also study about the naming and addressing in WSN.
- Describe routing protocols for ad hoc and wireless sensor networks with respect to some protocol design issues.

COURSE CONTENTS

Module I	**Overview Of Wireless Sensor Networks**
	Challenges for Wireless Sensor Networks, Enabling Technologies for Wireless Sensor Networks, Advantagesof sensor networks- energy advantage, detection advantage, Sensor network applications- Habitat Monitoring, Tracking chemicalplumes- Smart transportation.
Module II	**Architectures**
	Single-Node Architecture - Hardware Components, Energy Consumption of Sensor Nodes, Operating Systems and Execution Environments, Network Architecture -Sensor Network Scenarios, Optimization Goals andFigures of Merit, Gateway Concepts.
Module III	**Networking Sensors**
	Physical Layer and Transceiver Design Considerations, MAC Protocols forWireless Sensor Networks, Low Duty Cycle Protocols and Wakeup Concepts- S-MAC, The Mediation Device Protocol, Wakeup Radio Concepts, Address and Name Management, Assignment of MAC Addresses, Routing Protocols- Energy-Efficient Routing, Geographic Routing.
Module IV	**Infrastructure Establishment**
	Topology Control, Clustering, Time Synchronization,Localization and Positioning, Sensor Tasking and Control.
Module V	**Sensor Network Platforms and Tools**
	Sensor Node Hardware- Berkeley Motes, ProgrammingChallenges, Node- level software platforms, Node-level Simulators,State-centric programming.

REFERENCE BOOKS:

1. Holger Karl & Andreas Willig, "Protocols and Architectures for WirelessSensor Networks", Wiley, 2005.
2. Feng Zhao & Leonidas J. Guibas, “Wireless Sensor Networks- An Information Processing Approach", Elsevier, 2007.
3. Kazem Sohraby, Daniel Minoli, & Taieb Znati, “Wireless Sensor Networks- Technology, Protocols, and Applications”, Wiley, 2007.
4. Anna Hac, “Wireless Sensor Network Designs”, Wiley, 2003.
5. Philip Levis, “TinyOS Programming”, Cambridge University Press,2009.
6. Anna Ha´c, “Wireless Sensor Network Designs”, Wiley, 2005

Programme Name	**M. Tech. (IoT), SEMESTER – I (Elective-II)**
Course Code	**EEIT5031P**
Course Title	**WIRELESS SENSOR NETWORKS (LAB)**

COURSE OUTCOMES

After successful completion of this course, students should be able to

- Familiarize with protocol, design requirements, algorithms, and the cloud platform to meet the industrial requirement.
- Establish the concept of addressing in WSN.
- To design and connect, hardware platforms and software frameworks used to realize dynamic Wireless sensor network.

Module I	**Wireless Sensor Networks (Any three practical's/ Programs)**
	Network IP and basic network command and network configuration Commands, Routing Protocols, Simulation of Four Node Point to Point Network. Network simulators used for wireless Ad Hoc and Sensor Networks.
Module II	**Architecture of WSN's (Any three practical's/ Programs)**
	Demonstrate one small network simulation script. Study various trace file formats of network simulators.
Module III	**Protocols for WSN's (Any three practical's/ Programs)**
	To implement and compare various MAC layer protocols. To implement and compare AODV and DSR routing algorithms in MANET. To implement DSDV routing algorithms in MANET
Module IV	**Protocols Management for WSN's (Any three practical's/ Programs)**
	To implement signal strength-based link management routing protocols. To calculate and compare average throughput for various TCP variants. To implement and compare various routing protocols for wireless sensor networks.
Module V	**Autonomic sensing and secure protocol design**
	Hands-on-experience on sensor network simulators (preferably: **NS3** and QualNet).

REFERENCE BOOKS:

1. Holger Karl & Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", Wiley, 2005.
2. Feng Zhao & Leonidas J. Guibas, "Wireless Sensor Networks- An Information Processing Approach", Elsevier, 2007.
3. Kazem Sohraby, Daniel Minoli, & Taieb Znati, "Wireless Sensor Networks- Technology, Protocols, and Applications", Wiley, 2007.
4. Anna Hac, "Wireless Sensor Network Designs", Wiley, 2003.
5. Philip Levis, "TinyOS Programming", Cambridge University Press,2009.
6. Anna Ha´c, "Wireless Sensor Network Designs", Wiley, 2005

Programme Name	**M. Tech. (IoT), SEMESTER – I (Elective-II)**
Course Code	**EEIT5032T**
Course Title	**Machine Vision**

Course Outcomes:

At the end of successful completion of the course, students will be able to:

- Comprehend concepts of machine vision
- Apply binary machine vision algorithms for segmentation and analysis
- Explain statistical approaches for pattern recognition and discrimination
- Analyse morphological models for vision
- Describe Facet model and apply segmentation techniques to images

Module I	**Machine Vision: Overview**
	Introduction, recognition methodology, conditioning, labeling,grouping ,extracting, matching
Module II	**Binary Machine Vision**
	Introduction, thresholding (within class variance minimization,Kullback information distance minimization), connected component labelling; operators, algorithms, signature segmentation and analysis, region analysis, region properties, spatial moments, mixed spatial grey level moments, signature properties
Module III	**Statistical Pattern Recognition**
	Bayesian rules: maximum utility model for pattern discrimination, economygain matrix, maximum decision rule, decision rule error, reserving judgment, nearest neighbour rule, binary decision tree classifier, decision rule estimation
Module IV	**Mathematical Morphology**
	Binary morphology; dilation, erosion, hit-and-miss transform, opening, closing, connectivity, gray scale morphology, Umbra homomorphism, grey scale opening and closing, medians, bounding second order derivatives, distance transforms and recursive morphology, medial axis analysis, morphological sampling theorem
Module V	**The Facet model**
	Introduction, relative maxima, sloped Facet parameter and estimation, Facet-based peak noise removal, Bayesian approach to edge detection, Zero-crossing edge detector, directional derivative gradient operator, corner detection, isotropic derivatives, ridges and ravines
Module VI	**Image Segmentation**
	Measurement-space-guided spatial clustering; thresholding, multidimensional clustering, region growing; single linkage, hybrid linkage, centroid linkage, hybrid linkage combinations, spatial clustering, split and merge, rule-based segmentation, motion-based segmentation, arc extraction, linking one-pixel-wide edges/lines, Hough transform, Iso-data segmentation

ReferenceBooks:

1. Robert Haralick and Linda Shapiro, Computer and Robot Vision, Addison-Wesley Publishing Company, 1992.
2. Duda, Richard O., Peter E. Hart, and David G. Stork. Pattern Classification. New York, NY: John Wiley & Sons, 2000.

Programme Name	**M. Tech. (IoT), SEMESTER – I**
Course Code	**EEIT5032P**
Course Title	**Machine Vision Lab**

Course Outcomes:

At the end of successful completion of the course, students will be able to:

- Comprehend concepts of machine vision
- Apply binary machine vision algorithms for segmentation and analysis
- Explain statistical approaches for pattern recognition and discrimination
- Analyse morphological models for vision
- Describe Facet model and apply segmentation techniques to images

Module I	**Statistical Pattern Recognition**
	Any practical on • Bayesian classifier, • nearest neighbour classier, binary decision tree classifier
Module II	**Mathematical Morphology**
	Practical on • Dilation, erosion • opening, closing • Hit-miss transform • Gray scale operation • Medial axis analysis
Module III	**The Facet model**
	Practical on • Edge detection using Bayesian • Zero-crossing edge detector • Corner detector • Ridge and ravine detector
Module IV	**Image Segmentation**
	Practical on • Multidimensional spatial clustering • Rule based segmentation • Motion based segmentation • Arc extraction • Hough transform • Iso data transform

Reference Books:

1. Robert Haralick and Linda Shapiro, Computer and Robot Vision, Addison- Wesley Publishing Company, 1992.
2. Duda, Richard O., Peter E. Hart, and David G. Stork. Pattern Classification. New York, NY: John Wiley & Sons, 2000.

Programme Name	**M. Tech. (IoT), SEMESTER – I (Elective-II)**
Course Code	**EEIT5033T**
Course Title	**Filtering Techniques**

COURSE OUTCOMES

After successful completion of this course, students should be able to

- Analyse discrete-time signals in the time domain and frequency domain, using different transforms.
- Design various types of Digital Filters
- Comprehend DSP processor architecture for filtering applications
- Describe predictive and adaptive filters with applications

Module I	**Introduction**
	Review of Discrete Time Signals, representation of signals on orthogonal basis; A/D and D/A conversion: sampling and quantization, antialiasing andsmoothening filters, reconstruction of signals, Discrete system attributes, Analysis of discrete LTI systems, Z-Transform, Inverse Systems
Module II	**Frequency domain analysis**
	Frequency domain characteristics of digital LTI systems, frequency response, Discrete Time Fourier Transform and Discrete Fourier Transform,Fast Fourier Transform algorithm, Correlation functions and spectra
Module III	**Digital filters**
	LTI systems as frequency selective filters, digital resonators, notch filters,comb filters, Concept of linear phase and distortion, Frequency SamplingTechniques, Park-McClellan's method, Hilbert transformer, frequency transformation in digital domain
Module IV	**Linear Prediction and Adaptive Filters**
	Random signals in sensors, correlation functions, innovation representation of random process, forward and backward linear prediction, Levinson- Durbin algorithm, Wiener filters for filtering and prediction, adaptive filters;Direct form FIR filters (LMS and RLS techniques)
Module V	**DSP Processors**
	DSP processor architecture, Software developments, Selections of DSP processors, Implementation considerations, finite word length effects, real time implementation, Hardware interfacing TMS 320C54XX, Applicationsof Design using fixed point and floating point implementations: FIR filter
Module VI	**Applications**
	Case studies; applications of filtering to wireless sensors data, channel equalization, echo-cancellation in data transmission with demonstration, noise cancelling.

REFERENCE BOOKS:

1. John G. Proakis and D.G. Manolakis, "Digital Signal Processing: Principles, Algorithms And Applications", Prentice Hall,2007.
2. A.V. Oppenheim and Schafer, "Discrete Time Signal Processing", PrenticeHall,2009.
3. L.R. Rabiner and B. Gold, "Theory and Application of Digital Signal Processing",Prentice Hall,1975.
4. J.R. Johnson, "Introduction to Digital Signal Processing", Prentice Hall,1989.
5. Hall D. J. DeFatta, J. G. Lucas and W. S. Hodgkiss," Digital Signal Processing",JWiley and Sons, Singapore,1992.
6. Salivahanan S, Vallavaraj A, Gnanapriya, "Digital Signal Processing", Mc GrawHill,2017.

Programme Name	**M. Tech. (IoT), SEMESTER – I**
Course Code	**EEIT5033P**
Course Title	**Filtering Techniques Lab**

Course Outcomes:

At the end of successful completion of the course, students will be able to:

- Analyse discrete-time signals in the time domain and frequency domain, using different transforms.
- Design various types of Digital Filters
- Comprehend DSP processor architecture for filtering applications
- Describe predictive and adaptive filters with applications

Module I	**Introduction**
	Any practical on • Z transform • LTI system
Module II	**Frequency domain analysis**
	Practical on • Discrete Time Fourier Transform • Discrete Fourier Transform, • Fast Fourier Transform algorithm
Module III	**Digital filters**
	Practical on • Frequency Sampling Techniques, • Park-McClellan's method, • Hilbert transformer
Module IV	**Linear Prediction and Adaptive Filters**
	Practical on • Levinson- Durbin algorithm, • Wiener filters for filtering and prediction, adaptive filters; • Direct form FIR filters (LMS and RLS techniques)
Module V	**DSP Processors** Practical on: Implementation of one algorithm on a DSP processor

REFERENCE BOOKS:

1. John G. Proakis and D.G. Manolakis, "Digital Signal Processing: Principles,Algorithms And Applications", Prentice Hall,2007.
2. A.V. Oppenheim and Schafer, "Discrete Time Signal Processing", PrenticeHall,2009.
3. L.R. Rabiner and B. Gold, "Theory and Application of Digital Signal Processing", Prentice Hall,1975.
4. J.R. Johnson, "Introduction to Digital Signal Processing", Prentice Hall,1989.
5. Hall D. J. DeFatta, J. G. Lucas and W. S. Hodgkiss," Digital Signal Processing",JWiley and Sons, Singapore,1992.
6. Salivahanan S, Vallavaraj A, Gnanapriya, "Digital Signal Processing", Mc Graw Hill,2017.

Programme Name	**M. Tech. (IoT), SEMESTER-I** **(Open Elective)**
Course Code	EEIT5061S
Course Title	**ARTIFICIAL NEURAL NETWORKS AND MACHINE LEARNING**

COURSE OBJECTIVE

The course is designed to introduce the field of neural network systems and Artificial Neural Networks. The basic concepts of machine learning are also the main goal of this subject.

COURSE OUTCOME

Students will be able to understand the fundamental concepts of the neural network systems.This area new field of research thus students will get to know about the recent trends in research fields.

Module 1: Introduction: Biological neurons and memory
Structure and function of a single neuron; Artificial Neural Networks (ANN);Typical applications of ANNs : Classification, Clustering, Vector Quantization, Pattern Recognition, Function Approximation, Forecasting, Control, Optimization.
Module 2: Supervised Learning
Single-layer networks; Perceptron-Linear separability, Training algorithm, Limitations; multi-layer networks-Architecture, Back Propagation Algorithm (BTA) Adaptive Multi-layer networks-Architecture, training algorithms; Recurrent Networks; Feed-forward networks;Radial-Basis-Function (RBF) networks;
Module 3: Unsupervised Learning
Winner-takes-all networks; Hamming networks; Maxnet; Simple competitive learning; Vector-Quantization; Counter propagation networks; Adaptive ResonanceTheory; Kohonen'sSelf-organizing Maps; Principal Component Analysis.
Module 4: Associated Models and Optimization Methods
Hopfield Networks, Brain-in-a-Box network; Boltzmann machine; Hopfield Networks for- TSP, Solution of simultaneous linear equations; Iterated Gradient Descent; Simulated Annealing; Genetic Algorithm.
Module 5: Introductory Material to Machine Learning and AI
Motivations for Studying ML, Supervised and Unsupervised learning, Machine Learning in the Large
Module 6: Classical and Theoretical ML Topics
Concept Learning (also called Learning from Examples), Learning from Analogy, Explanation Based Learning, Structure Learning, Reinforcement Learning, Decision Tree Learning, Decision List Learning , Oracle Based Learning, Probably Approximately Correct (PAC) Model, Boosting, Bayesian Learning: Maximum Likelihood Estimates, ParameterEstimation, Bayesian Belief Networks

Expectation Maximization as a fundamental technique, Hidden Markov Models (HMM): Motivation for Generative Models, Forward-backward Algorithm, BaumWelch Iteration, Feature Enhanced HMM.
Module 8: Maximum Entropy Markov Models (MEMM)
Motivation for Discriminative Models, Training of MEMMs (v) Introductory Optimization Based Methods: Neural Nets, Support Vector Machines, GeneticAlgorithms (v) Applications: Text Learning, Speech Processing, Data Mining, Bioinformatics

Reference Books:

1. Simon Haykin, "Neural Networks - A Comprehensive Foundation", Macmillan Publishing Co., New York, 1994.
2. A Cichocki and R. Unbehauen, "Neural Networks for Optimization and Signal Processing", John Wiley and Sons, 1993
3. J. M. Zurada, "Introduction to Artificial Neural Networks", (Indian edition) Jaico Publisher, Mumbai, 1997.
4. Hui Jiang, "Machine Learning Fundamentals: A Concise Introduction" Cambridge University Press, 2022
5. Alexander Jung, "Machine Learning: The Basics (Machine Learning: Foundations, Methodologies, and Applications)" Springer, 2022

SEMESTER-II

Programme Name	**M. Tech. IoT, SEMESTER II**
Course Code	**EEIT5002S**
Course Title	**RESEARCH METHODOLOGY and IPR**

COURSE OBJECTIVES

After completion of this course, students should be able to

- Develop understanding of the basic framework of research process, various researchdesigns and techniques.
- Identify various sources of information for literature review and data collection
- Develop an understanding of the ethical dimensions of conducting applied research

COURSE OUTCOMES

- Understand research terminology.
- Be aware of the ethical principles of research, ethical challenges and approval processes.
- Describe quantitative, qualitative and mixed methods approaches to research.
- Identify the components of a literature review process
- Critically analyse published research

Overview:

Module 1:	**Review of Statistics**
Concept of mean, mode, median, arithmetic mean, geometric mean,harmonic mean etc., Probability and problem solving, Distributions: Gaussian, chi-square, student-t distribution Design of experiment, Hypothesis, testing and identification, Problems on hypothesis testing	
Module 2:	**Research Skills**
What is research, why research needs to be done, Research problem formulation, Literature survey, Analysis of the problem, Experimental evaluation of the problem, Survey techniques, Statistical analysis. Writing of short and long abstracts, Writing and format of international and national journal papers, Report writing, English writing and communication skills, Power point and other presentation skills	
Module 3:	**Research theory and Practice**
Structuring the research project, research ethics, finding and reviewing the literature.	
Module 4:	**Data Collection and its Analysis**
Data sources, methods and approaches, the nature of data, collecting and analysing secondary data, collecting primary data, quantitative and qualitative data analysis, sampling and selection in qualitative research, making convincing arguments with qualitative data.	

Recommended Readings

- " Fundamentals of Research Methodology" 1st edition Dr Jayanta Kumar Nayak, Dr Priyanka Singh, SSDN Publishers and Distributers, 2015
- "Qualitative Researching": Jennifer Mason, 2nd edition, SAGE Publication, 2002
- "Research methods: the basics" : Walliman and Nicholas, Taylor and Francis India, 2021
- "The Essential Guide to Doing Research", 4th edition, Zina O' Leary, SAGE publications,2021
- "Research Methodology Handbook. Introductory Guide to Research Methods for SocialResearch": Stuart MacDonal & Nichola Headlam, CLES, 2008.

Programme Name	**M. Tech. IoT, Semester-II**
Course Code	**EEIT5013T**
Course Title	**IoT Security**

COURSE OUTCOME

At the end of successful completion of the course, students will be able to:

- Comprehend basics of IoT, Industrial IoT and Operational Technology (OT)vulnerabilities, threats & risks
- Realize IoT security requirements and management tools
- Comprehend ways to secure IoT

COURSE CONTENTS

Module I: Introduction to Operational Technology (OT)	
	Overview of industrial control systems (ICS), ICS operation & components,Perdue model, SCADA systems, Cyber-physical systems (CPS) & IoT
Module II	**IoT Vulnerabilities, Threats & Risks**
	STRIDE methodology, OWASP Iot vulnerabilities, Privacy & trust, Insufficient authentication/authorization, Insufficient access control, Attackson IoT data, Attacks on IoT layered architecture, Security concerns in IoT applications, Security concerns in SCADA
Module III	**IoT Pen testing**
	Active vulnerability analysis tools, Port scanning, Operating system fingerprinting and version scanning, Penetration testing, Attack surface mapping
Module IV	**Exploitation Tools & Frameworks**
	Exploitation using I2C & SPI, JTAG debugging and exploitation, Boundaryscan, Test access ports
Module V	**Firmware Reverse Engineering**
	Understanding firmware, Extracting firmware, Manual firmware extraction, Automated file system extraction, Firmware internals, Backdooring a firmware, Static & dynamic analysis
Module VI	**Radio & Side Channel Attacks**
	Software defined radio, Exploiting ZIGBEE & BLE, Power analysis attack, Invasive attack, Perturbation -attacks, Electromagnetic side channel attack, fault injection attack, timing attack, covert channel attacks
Reference Books:	
1	"Securing the Internet of Things", Shancang Li, Li Da Xu, Syngress,Elsevier, 2017
2	"Security and Privacy in Internet of Things (IoTs)Models, Algorithms, and Implementations", Edited by Fei Hu, CRC Press, 2016
3	"Practical Internet of Things Security", Brian Russell Drew Van Duren, Packt Publishing, 2016
Additional Material:	
1	Research papers

Programme Name	**M. Tech. IoT, Semester-II**
Course Code	**EEIT5013P**
Course Title	**IoT Security (LAB)**

COURSE OUTCOME

At the end of successful completion of the course, students will be able to:

- Comprehend basics of IoT, Industrial IoT and Operational Technology (OT) vulnerabilities, threats & risks
- Realize IoT security requirements and management tools
- Comprehend ways to secure IoT

COURSE CONTENTS

Module I	**Introduction to Operational Technology (OT)**
	Capture and Analyse system network traffic
Module II	**IoT Vulnerabilities, Threats & Risks**
	Perform foot printing, information gathering using various foot printing tools
Module III	**IoT Pen testing**
	Use Metasploit framework to exploit SCADA system
Module IV	**Exploitation Tools & Frameworks**
	Firmware exploitation using Jtag debugger port
Module V	**Firmware Reverse Engineering**
	Static firmware analysis
Module VI	**Radio & Side Channel Attacks**
	Dynamic Firmware Analysis; Side channel Attack
Reference Books:	
1.	"Securing the Internet of Things", Shancang Li, Li Da Xu Syngress,Elsevier, 2017
2.	"Security and Privacy in Internet of Things (IoTs)Models, Algorithms, and Implementations", Edited by Fei Hu, CRC Press, 2016
3.	"Practical Internet of Things Security",Brian Russell Drew Van Duren, Packt Publishing, 2016
Additional Material:	
1.	Research papers

Programme Name	**M. Tech. IoT, Semester-II**
Course Code	**EEIT5014T**
Course Title	**INDUSTRIAL INTERNET OF THINGS (IIOT)**

COURSE OUTCOME

At the end of successful completion of the course, students will be able to:

- Understand key skills employed in the IIoT & IoRT space building applications.
- Design suitable network architecture and use appropriate learning algorithm.
- Comprehend IOT protocols
- Implement digital Twin
- Implement IOT systems for robotics

COURSE CONTENTS

Module I	**Introduction IIoT; Market Size and Potential**
	Definition, IoT v IIoT, Next Generation Sensors, Sensor's calibration and validate sensor measurements, placement of IoT devices, sensors, low-cost communication system design, Top application areas include manufacturing, oil & gas, Embedded systems in the Automotive and Transportation market segment.
Module II	**IIoT Methodology**
	Top operating systems used in IIoT deployments, Networking and wireless communication protocols used in IIoT deployments. Smart Remote Monitoring Unit, components of monitoring system, control and management, Wireless Sensor Networ(WSN).
Module III	**Data driven Analytics of IIoT**
	Implementing of industrial IoT Data flow, big data and how to prepare data for machine learning algorithms, Machine Learning algorithms, supervised learning & Un-supervised learning algorithms, Basics of neural network, activation functions, back-propagation.
Module IV	**IP and Non-IP Protocols for IoT**
	WPAN, IEEE 802.15.4, Bluetooth, NFC, 6LoWPAN; RFID, Zigbee Wireless HART Protocol, MQTT, IP and Non-IP Protocols, REST, CoAP.
Module V	**Implementing Digital Twin**
	Develops a physics-based and data-driven digital equipment model to monitor assets and systems, Introduction to device localization and tracking; different types of localization techniques, Radio-Frequency Identification (RFID) and fingerprinting, Device diversity/heterogeneity issue in IIoT networks
Module VI	**Internet of Robotic Things (IoRT)**
	Introduction to stationary and mobile robots, Brief introduction to localization, mapping, planning, and control of robotic systems; Introduction to cloud-enabled robotics; Applications of IIoT in robotics; Architectures for IoRT, Examples and case studies: Open issues and challenges.

Reference Books:	
1	"Industry 4.0: The Industrial Internet of Things", Alasdair Gilchrist, Apress, 2016
2	"Introduction to Industrial Internet of Things and Industry 4.0",Sudip Misra,Chandana Roy,Anadarup Mukherjee,CRC Press,2021
3	"Hands on Industrial Internet of Things",Giacomo Veneri,Antonio Capasso,Packt Press, 2018.
Additional Material:	
1	Research papers

Programme Name	**M. Tech. (IoT), SEMESTER – II**
Course Code	**EEIT5014P**
Course Title	**INDUSTRIAL INTERNET OF THINGS (IIOT) (LAB)**

COURSE OUTCOMES

At the end of successful completion of the course, students will be able to

- Students should be able to do Python programming.
- Students should be able to perform experiments on different development boards.
- Students should get introduced with application IIOT in different Fields.

Module I	**Overview (Any three practical's/ Programs)**
	Interfacing sensor and actuators with any processor (8051, ARM)
Module II	**Python Programming (Any three practical's/ Programs)**
Module III	**Arduino Programming (Any three practical's/ Programs)**
	Arduino Programming, Integration of Sensors and Actuators with Arduino, Raspberry Pi, Implementation of IoT with Raspberry Pi.
Module IV	**Project work (Implementing on any one Protocol)**
	WPAN, IEEE 802.15.4, Bluetooth, NFC, 6LoWPAN; RFID, Zigbee Wireless HART Protocol, MQTT, IP and Non-IP Protocols, REST, CoAP.

Reference Books:	
1	"Industry 4.0: The Industrial Internet of Things", Alasdair Gilchrist, Apress, 2016
2	"Introduction to Industrial Internet of Things and Industry 4.0",Sudip Misra,Chandana Roy,Anadarup Mukherjee,CRC Press,2021
3	"Hands on Industrial Internet of Things",Giacomo Veneri,Antonio Capasso,Packt Press, 2018.
Additional Material:	
1	Research papers

Programme Name	M. Tech. (IoT), SEMESTER – II (Elective -III)
Course Code	EEIT5041S
Course Title	Data Analytics and Visualization

COURSE OUTCOMES

After completion of this course, students will be able to

- Communicate data driven findings
- Process and transform raw data into suitable formats
- Describe statistical theories used in data analysis
- Interpret features of interest in numerical data
- Apply data analysis techniques in practical problems

COURSE CONTENTS

Module I	**Introduction**
	Revision to theory of probability for data analysis using case studies, central limit theorem, Review of Linear Algebra, Linear Transformations
Module II	**Data Visualization**
	Understanding experimental data, importing data, wrangling, string processing, Visualization using R/Python script, data filtering and cleansing
Module III	**Statistical methods**
	Random walks and Monte Carlo simulations, Linear and Quadratic Discriminants, Fisher Discriminant, Multilinear Analysis, Maximum Likelihood and Bayesian Parameter Estimation, Linear Discriminant/Perceptron Learning, Optimization by Gradient Descent, Mixture modelling, Expectation maximization
Module IV	**Inference and Modelling**
	Sampling and error, Bayesian statistics and predictive modelling
Module V	**Data classification and clustering**
	Bayesian framework and support vector machines, Feature selection, Bayesian interpretation of regularization, RBF interpolation schemes, clustering, kernel-based techniques, density estimation
Module VI	**Applications**
	Information extraction and feature selection, data analysis and interpretation (case studies), morphable models, Usage of GitHub to manage data science projects, demonstration using R to clean, analyse, and visualize data.
Text Books:	
1.	"Bayesian Data Analysis", Gelman, Andrew, et al 2nd edition,Chapman and Hall/CRC, 2003. ISBN: 9781584883883.
2.	"Introduction to Computation and Programming Using Python: With Application to Understanding Data", Guttag, John, 2nd ed. MIT Press, 2016. ISBN: 9780262529624.
Reference Books:	
1.	"The Elements ofStatistical Learning: Data Mining", Hastie, Trevor, Robert Tibshirani, and Jerome Friedman New York, Springer,2001.
2.	"Pattern Classificatio", Duda, Richard O., Peter E. Hart, and David G. Stork. New York, NY: John Wiley & Sons, 2000.
3.	"The Nature of Statistical Learning Theory", Vapnik, V. N.. Springer, 1995.

Programme Name	**M. Tech. (IoT), SEMESTER – II (Elective -III)**
Course Code	**EEIT5042S**
Course Title	**Real time Embedded Systems Design and Analysis**

COURSE OUTCOMES

At the end of successful completion of the course, students will be able to

- Describe the hardware and software architecture of embedded system.
- Identify the necessary communication Interface for the embedded system.
- Organize the complete embedded system development project.
- Design and develop the RTES.

Module I	**Introduction to RTOS**
	Overview Of RTOS, Architecture of Kernel, Task & Task Scheduler, ISR, Semaphore, Mutex, Mailbox, Message Queues, Event Registers, Pipes,Signals, Timers, Memory Management, Priority Inversion Problem.
Module II	**Real Time Embedded Software**
	Linux, RT Linux, multiprocessor software developments, data flow graph, Study and programming of RTOS like RTX51, Free RTOS etc. timing diagram analysis for fixed and dynamic priority software services.
Module III	**Real time Scheduling**
	Scheduling Real-Time Tasks: Types of Schedulers Table-driven scheduling Cyclic schedulers EDF RMA, Priority Pre-emptive Scheduler State Machine for Linux and VxWorks, Comparison of Cyclic Executive, Introduction to Worst Case Analysis, Example of scheduling, Real-Time Scheduling and Rate Monotonic Least Upper Bound.
Module IV	**Overview of Real-time Hardware Architectures and Software Stacks**
	Embedded Linux on the Raspberry Pi ARM A-Series System-on-Chip processors, Tracing Linux kernel and network stack events. Best Practices for RTES Programming, System Integration Testing (Hardware, Firmware, and Software),
Module V	**Real Time Communication**
	RT Services Communication and Synchronization, Performance of two Real-Time communication Protocols, Real time communication over network, Real Time database.
Module VI	**Verification and Validation of RTES project**
	Using Point-to-point Serial and TCP/IP for Embedded Systems, Case Studyof Coding for Sending Application Layer Byte Streams on A TCP/IP Network Using RTOS. Building a simple Linux multi-service system using POSIX real-time extensions on Raspberry Pi 3b using sequencing and methods to log and verify agreement between theory and practice.
Text Books:	
1.	"Embedded Real time systems", Prasad Dream tech Wiley Publication,2003.
2.	"Real-Time Systems: Theory and Practice," Rajib Mall Pearson, 2008.
Additional Reference Books:	
1.	"Real-TIme Systems Design and Analysis", Philip Laplante, 2nd Edition, Prentice Hall,2013.

Programme Name	M. Tech. (IoT), SEMESTER – II (Elective -III)
Course Code	EEIT5043S
Course Title	Industrial IoT for smart cities

COURSE OUTCOMES

At the end of successful completion of the course, students will be able to:

- Identify different IoT smart cities applications with IoT architecture.
- Establish IoT connectivity of smart devices to cloud having multiple communication medium, protocols, device management and monitoring.
- Summarize different learning methods and their application in smart cities.
- Apply machine learning techniques on IOT systems

Module I	**Introduction & Industry 4.0**
	IoT in smart city& their distinctive advantages like smart environment, smart streetlight, smart water management, Smart Road & Traffic, Smart Parking & waste management. The Fourth Revolution, LEAN Production Systems, Smart and Connected Business Perspective, Smart Factories.
Module II	**IoT Smart City Sensing and Power Management**
	Smart Sensors and actuators as per requirement for Smart Cities, air quality, noise pollution measured using Electrochemical Sensors, Ultrasonic Sensors, IR, Obstacle, Proximity. IoT Data Acquisition System, Energy harvesting, Battery based systems, Power management.
Module III	**Interoperability for Smart City IoT systems**
	Wireless communication modules and topology such as Zigbee, Bluetooth, GSM module, Wi-fi module &Things speak (IoT Platform) cloud, Ethernet, M2M Wireless Sensor Network (WSN).
Module IV	**Software Defined Network**
	Arduino Programming, Integration of Sensors and Actuators with Arduino, Raspberry Pi, Implementation of IoT with Raspberry Pi.
Module V	**Smart mobility**
	Smart cities concept and services, traffic congestion, city energyconsumption, IoT in carriage, solution, opportunities and threats.
Module VI	**Application Area of Smart cities IOT Systems**
	Working principle & Use of Geographical Information System (GIS), GPS module for vehicle speed measurement. Connected Parking - LoRaWAN private network.
Text Books:	
1.	"Designing, Developing, and Facilitating Smart CitiesUrban Design to IoT Solutions", Vangelis Angelakis Springer, 2019
2.	"Introduction to IoT", S. Misra, A. Mukherjee, and A. Roy ,Cambridge University Press, 2018
Additional Materials:	
	Research papers

Programme Name	**M. Tech. (IoT), SEMESTER – II (Elective -IV)**
Course Code	**EEIT5051T**
Course Title	**IoT Design for Connected Health Care**

COURSE OUTCOMES

At the end of successful completion of the course, students will be able to

- Understand and design multidisciplinary approach for design, development, simulation, and implementation of IoT health care systems.
- Apply the monitored health parameter sensor output data for further computing, analyzation and visualization.
- Identify and summarize remote health monitoring and Tele-health.

Module I	**Introduction to IoT based Health Care**	
	Introduction to IoT applications in smart healthcare& their distinctiveadvantages - Patient Health Monitoring System (PHMS), Tele-Health, Tele-Medicine, Tele-Monitoring, Mobile Health Things (m-health).	
Module II	**IoT Smart Sensing Heath Care and Power challenge**	
	Concept of Generic Biomedical sensors, Smart Sensors: Monitor health parameters, Wearable ECG sensors, IoT Data Acquisition System, Energy harvesting, Battery based systems, Power management.	
Module III	**Interoperability in IoT**	
	IoT protocols –Interfacing of Zigbee module to create Wireless sensor network, M2M Wireless Sensor Network, MQTT, COAP, Principle of operation & Application of IoT Gateway Using Wi-Fi and Ethernet.	
Module IV	**Software Defined Network**	
	Arduino Programming, Integration of Sensors and Actuators with Arduino, Raspberry Pi, Implementation of IoT with Raspberry Pi.	
Module V	**Internet of Medical Things**	
	Data Confidentially, Data Integrity, Data Protection, Security awareness, Emergent threats: Autonomous, IoT heterogeneity and ubiquity, Physicalenvironment.	
Module VI	**Emerging Technologies for Health and Medicine**	
	Virtual Reality, Augmented Reality, Artificial Intelligence, Robotics,Industry 4.0.	
Text Books:		
1.	"Emerging Technologies for Health and Medicine: Virtual Reality, Augmented Reality, Artificial Intelligence, Internet of Things, Robotics, Industry 4.0", Dac-Nhuong Le Wiley, 2019	
2.	"Introduction to IoT". S. Misra, A. Mukherjee, and A. Roy Cambridge University Press, 2017	
3.	"The Internet of Things: Do-It-Yourself at Home Projectsfor Arduino, Raspberry Pi and Beagle Bone Black", Donald Norris, 2014..	
Additional Material:		
	Research papers	

Programme Name	**M. Tech. (IoT), SEMESTER – II (Elective IV)**
Course Code	**EEIT5051P**
Course Title	**IoT Design for Connected Health Care (LAB)**

COURSE OUTCOMES

At the end of successful completion of the course, students will be able to

- Students should be able to do Embedded C programming & Python Programming.
- Students should be able to perform experiments on different development boards.
- Students should get introduced with application of IoT in field of heath care.

Module I	**(Any three practical's/ Programs)**
	Understanding and connectivity of Raspberry-Pi board with a Zigbee module. Creating a network application for communication between two devices using Zigbee or any other constrained device protocol.
Module II	**(Any three practical's/ Programs)**
	Interface generic Biomedical (various types of sensors) used in Smart Healthcare. Measure parameters: Normal Heart Rate, Measure the heart abnormality conditions and Real-time streaming data in healthcare applications through sensor signals.
Module III	**(Any three practical's/ Programs)**
	Identify the interfacing of Bluetooth module to create local sensor network and interfacing of GSM module to make node as a gateway. Apply IoT Gateway using WiFi and Ethernet.
Module IV	**Project work**
	Check Software analysis of real time ECG data. Design an application for IoT in Health care sector.
Text Books:	
1.	"Emerging Technologies for Health and Medicine: VirtualReality, Augmented Reality, Artificial Intelligence, Internet of Things, Robotics, Industry 4.0", Dac-Nhuong Le, Wiley, 2019
2.	"Introduction to IoT", S. Misra, A. Mukherjee, and A. Roy CambridgeUniversity Press, 2017
	"The Internet of Things: Do-It-Yourself at Home Projectsfor Arduino, Raspberry Pi and Beagle Bone Black", Donald Norris, 2014.
Additional M aterial:	
1.	Research Papers

Programme Name	**M. Tech. IoT, Semester-II (Elective IV)**
Course Code	**EEIT5052T**
Course Title	**Edge Computing**

COURSE OUTCOME

At the end of successful completion of the course, students will be able to:

- Comprehend concepts Edge Computing based on sensing and Internet connectivity.
- Identify and describe the key architectural features of Edge Computing and their network.
- Conceptualize applications implementing edge computing

COURSE CONTENTS

Module I	**IoT and Edge Computing Definition**
	History and potential of IoT, IoT and Edge Computing use cases and deployment: Smart city IoT, Government and military IoT, Industry and manufacturing, Energy, Healthcare.
Module II	**Secure Fog-Cloud of Things: Architectures, Opportunities &Challenges**
	IoT Architecture and Core IoT, Collaborative and Integrated Edge Security Architecture, A connected ecosystem, Threat and security in IoT.
Module III	**Sensors, Endpoints, and Power Systems**
	A Systemic IoT–Fog–Cloud Architecture for Big-Data Analytics and Cyber Security Systems. Functional examples.
Module IV	**Communications and Information Theory**
	Communications theory and Information theory and the radio spectrum, Limitations of Wireless Communication.
Module V	**Non-IP and IP Protocols**
	Non-IP Based WPAN ;802.15 standards, Zigbee, Z-wave, Bluetooth. IP-Based WPAN and WLAN, TCP/IP, WPAN with IP – 6LoWPAN, IEEE 802.11 protocols and WLAN, Edge to Cloud Protocols, MQTT, Constrained Application Protocol.
Module VI	**Security and Organizational Strategy**
	IoT and Edge Security, Physical and hardware security, Shell security, Cryptography, Software-Defined Perimeter, Blockchains and cryptocurrencies in IoT, Government regulations and intervention.
Text Books:	
1.	“IoT and Edge Computing for Architects” Perry Lea,”-second edition, Packt, March,2020.
2.	“Secure EdgeComputing: Applications, Techniques and Challenges”, Mohiuddin Ahmed (Editor), Paul Haskell-Dowland (Editor), CRC press, first edition, August 2021.
Additional Material:	
1.	Research Articles/Papers

Programme Name	**M. Tech. (IoT), SEMESTER – II (Elective -IV)**
Course Code	**EEIT5052P**
Course Title	**Edge Computing (LAB)**

COURSE OUTCOMES

At the end of successful completion of the course, students will be able to

- Students should be able to do Python Programming.
- Identify and understand the machine learning elements and algorithms.
- Students should get introduced with an application of edge computing.

Module I	**Overview (Any three practical's/ Programs)**
	Programming for IOT: R- programming, Python Libraries, Cloud platform Examining Machine Learning for IoT.
Module II	**(Any three practical's/ Programs)**
	Explore Machine Learning with Python. Perform data classification using any machine learning algorithm.
Module III	**(Any three practical's/ Programs)**
	Deploy IoT Edge module to a virtual Linux device. Deploy IoT Edge module to a Windows device.
Module IV	**Project work**
	Principle of Installation of Linux Operating System porting. Use IoT edge device as a gateway.
Text Books:	
1.	, "Mobile Computing," Asoke K Talukder and Roopa R Yavagal Tata McGraw Hill, 2010..
2.	"Secure Edge Computing: Applications, Techniques and Challenges", Mohiuddin Ahmed (Editor), Paul Haskell-Dowland (Editor), CRC press, first edition, August 2021.
Additional Material:	
1.	Research Papers

Programme Name	**M. Tech. (IoT), SEMESTER II**
Course Code	**EEIT5053T**
Course Title	**IOT Application and Web Development**

COURSE OBJECTIVES:

- TO acquire specific scripting knowledge to develop interactive applications and to understand the basics of android application development.
- To apply the programming skills in developing application pertaining to Industrial, medical, agricultural,

COURSE OUTCOMES:

- Understand the concept of basic fundamentals of IIOT and programming skills in developing application pertaining to medical, agricultural.
- Understand the concept Mobile app Development .
- Understand the concept programming skills in developing Wi-Fi Programming.
- Understand the concept programming skills for Embedded Web Development.

Module 1: Introduction of IIOT Fundamentals	
	IIoT Fundamentals and Components, Industrial,Manufacturing, Monitoring, Control, Optimization and Autonomy, Introduction to Hadoop and big data analytics
Module 2: Smart Farming and Healthcare Applications	
	Weather monitoring, Precision farming, Smart Greenhouse, Drones for pesticides. Energy Consumption Monitoring, Smart Energy Meters,Home automation, Smart Grid and Solar Energy,Harvesting, Intelligent Parking, Data lake services scenarios. Architecture of IoT for Healthcare Applications
Module 3: Mobile app Development	
	Mobile app development: Android Development environment, Simple UI Layouts and layout properties, GUI objects, Event Driven Programming, opening and closing a Database.
Module 4: Wi-Fi Programming	
	Wi-Fi Access Point: Wi-Fi Network , Access Point, ESP32 Wi-Fi Networking: Access Point ,Wi-Fi Station, Station ,ESP32 Wi-Fi Networking, TCP Server Internet Protocol Suite TCP Server ESP32 TCP. TCP Client :ESP32 TCP, HTTP Server, Hyper Text Transfer Protocol ,HTTP Server ,ESP32 HTTP Server HTTP Client :HTTP Client ,ESP32 HTTP Client .
Module 5: Embedded Web Development	
	Web Server:Web Server ,ESPAsyncWebServer Library, HyperText Markup Language (HTML):HyperText Markup Language (HTML), Web Page Data Exchange:Web Page Data Exchange , LED ,HTTP GET and POST Methods, JavaScript :JavaScript: Example Code: Dimming an LED with JS ,Example Code: Reading a Physical Button with JS ,Example Code: Reading the DHT11 Sensor with JS ,Wrapping Up: AJAX Technique

Reference books

- John Dean, Web Programming with HTML5, CSS and JavaScript, 2018, Jones and Bartlett Publishers Inc., ISBN-10: 9781284091793
- DiMarzio J. F., Beginning Android Programming with Android Studio, 2016, 4th ed., Wiley, ISBN-10: 9788126565580
- Fadi Al-Turjman, Intelligence in IoT- enabled Smart Cities, 2019, 1st edition, CRC Press, ISBN-10: 1138316849.
- Giacomo Veneri, and Antonio Capasso, Hands-on Industrial Internet of Things: Create a powerful industrial IoT infrastructure using Industry 4.0, 2018, Packt Publishing.

- Wiely,F Hasan, Internet Of Things A To Z: Technologies And Applications,IEEE press.
- Subhas Chandra Mukhopadhyay, Smart Sensing Technology for griculture and Environmental Monitoring, 2012, Springer, ISBN-10: 3642276377
- Vankamamidi S. Naresh1,Suryateja S. Pericherla,Pilla Sita Rama Murty,SivaranjaniReddi, Internet of Things in Healthcare: Architecture, Applications, Challenges, and Solutions, International Journal of Computer Systems Science &Engineering,vol 35 no 6 November 2020
- Erwin Ouyang, Hands-On IoT: Wi-Fi and Embedded Web Development, Developing with ESP32, Arduino, C/C++, HTML, CSS, and JavaScript by Examples,M

Programme Name	**M. Tech. (IoT), SEMESTER II**
Course Code	**EEIT5053P**
Course Title	**IOT Application and Web Development-Lab**

COURSE OBJECTIVES:

- TO acquire specific scripting knowledge to develop interactive applications and to understand the basics of android application development.
- To apply the programming skills in developing application pertaining to Industrial, medical, agricultural,

COURSE OUTCOMES:

- Understand the concept of basic fundamentals of IIOT and programming skills in developing application pertaining to medical, agricultural.
- Understand the concept Mobile app Development .
- Understand the concept programming skills in developing Wi-Fi Programming.
- Understand the concept programming skills for Embedded Web Development.

Module 1: Introduction of IIOT Fundamentals	
	1 .Apply HTML and CSS for developing web forms to acquire and process user & sensor data. 2. Data analysis by using Hadoop
Module 2: Smart Farming and Healthcare Applications	
	1.IoT-Based Health Monitoring System Development and Analysis. 2. IoT-Based Agriculture monitoring system development.
Module 3: Mobile app Development	
	1.Implement mobile application using android SDK
Module 4: Wi-Fi Programming	
	1.To implement code for ESP32 Wi-Fi Networking: Access Point for three mode : AP mode, Station mode, Combined AP-STA mode. Combined AP-STA mode. 2. To create a TCP server for controlling an LED from TCP client by sending specified commands. 3. To create a TCP client that connects to a TCP server. 4. To create a simple HTTP server on top of a TCP server and also to create a simple HTTP client on top of a TCP client.
Module 5: Embedded Web Development	
	To implement code for Simple web server using ESPAsyncWebServer. To implement code for Web Server for Controlling an LED and Dimming an LED. To implement code for Web Server for Reading a Physical Button.

Reference books

- John Dean, Web Programming with HTML5, CSS and JavaScript, 2018, Jones and Bartlett Publishers Inc., ISBN-10: 9781284091793
- DiMarzio J. F., Beginning Android Programming with Android Studio, 2016, 4th ed., Wiley, ISBN-10: 9788126565580
- Fadi Al-Turjman, Intelligence in IoT- enabled Smart Cities, 2019, 1st edition, CRC Press, ISBN-10: 1138316849.
- Giacomo Veneri, and Antonio Capasso, Hands-on Industrial Internet of Things: Create a powerful industrial IoT infrastructure using Industry 4.0, 2018, Packt Publishing.
- Wiely,F Hasan, Internet Of Things A To Z: Technologies And Applications,IEEE press.
- Subhas Chandra Mukhopadhyay, Smart Sensing Technology for griculture and Environmental

Monitoring, 2012, Springer, ISBN-10: 3642276377

- Vankamamidi S. Naresh1,Suryateja S. Pericherla,Pilla Sita Rama Murty,SivaranjaniReddi, Internet of Things in Healthcare: Architecture, Applications, Challenges, and Solutions, International Journal of Computer Systems Science &Engineering,vol 35 no 6 November 2020
- Erwin Ouyang, Hands-On IoT: Wi-Fi and Embedded Web Development, Developing with ESP32, Arduino, C/C++, HTML, CSS, and JavaScript by Examples

Programme Name	**M. Tech. (IoT), SEMESTER – II (Open Elective)**
Course Code	**EEIT5062S**
Course Title	**Mathematical Foundation Course for Data Analytics**

Course Objective

- The course will introduce the fundamental concepts of linear algebra, probability and statistics required for a program in data science.
- To enable learners to develop knowledge and skills in current and emerging areas of data analytics.
- To critically assess and evaluate business and technical strategies for data analytics.
- To demonstrate expert knowledge of data analysis, statistics, tools, techniques and technologies of data analytics.

Course Outcomes

- Ability to use the mathematical concepts in the field of data science.
- Employ the techniques and methods related to the area of data science in variety of applications.
- Apply logical thinking to understand and solve the problem in context.

Module 1: Introduction of Data Science	
	Basics of Data Science: Introduction; Typology of problems; Importance of linear algebra, statistics and optimization from a data science perspective; Structured thinking for solving data science problems.
Module 2: Linear Algebra	
	Linear Algebra: Matrices and their properties (determinants, traces, rank, nullity, etc.); Eigenvalues and eigenvectors; Matrix factorizations; Inner products; Distance measures; Projections; Notion of hyperplanes; half-planes.
Module 3: Probability, Statistics and Random Processes:	
	Probability, Statistics and Random Processes: Probability theory and axioms; Random variables; Probability distributions and density functions (univariate and multivariate); Expectations and moments; Covariance and correlation; Statistics and sampling distributions; Hypothesis testing of means, proportions, variances and correlations; Confidence (statistical) intervals; Correlation functions; White-noise process
Module 4 : Optimization Techniques	
	Optimization: Unconstrained optimization; Necessary and sufficiency conditions for optima; Gradient descent methods; Constrained optimization, KKT conditions; Introduction to non-gradient techniques; Introduction to least squares optimization; Optimization view of machine learning. Introduction to Data Science Methods: Linear regression as an exemplar function approximation problem; Linear classification problems.

Reference books

1. "Introduction to Linear Algebra", G. Strang . Wellesley-Cambridge Press, Fifth edition,2016.
2."Random Data: Analysis and Measurement Procedures", Bendat, J. S. and A. G. Piersol. fourth Edition. John Wiley & Sons, Inc., NY, USA, 2010
3. "Applied Statistics and Probability for Engineers", Montgomery, D. C. and G. C. Runger. Fifth Edition. John Wiley & Sons, Inc., NY, USA, 2011.
4. "Optimization by Vector Space Methods", David G. Luenberger, John Wiley & Sons (NY), 1969.
5 ."Doing Data Science", Cathy O'Neil and Rachel Schutt ,O'Reilly Media, 2013.