JAIDEV EDUCATION SOCIETY'S

J D COLLEGE OF ENGINEERING AND MANAGEMENT

KATOL ROAD, NAGPUR

Education to Eternity

Website: www.jdcoem.ac.in E-mail: info@jdcoem.ac.in

An Autonomous Institute, with NAAC "A" Grade

Department of Electronics and Telecommunication Engineering

"Rectifying Ideas, Amplifying Knowledge"

Session: 2021-22

Course Structure and Syllabus (Autonomous)

For

B. Tech. Seventh and Eighth Semester

B. Tech Seventh Semester											
Sr. No.	**Category of Subject**	**Course Code**	**Course Name**	**Teaching Scheme**			**Evaluation Scheme**				**Credit**
				L	**T**	**P**	**CA**	**MSE**	**ESE**	**Total**	
1	PCC	ET7T001	Digital Communication	3	0	0	20	20	60	100	3
2	PEC	ET7E002	Professional Elective Course-III	3	0	0	20	20	60	100	3
3	PEC	ET7E003	Professional Elective Course-IV	3	0	0	20	20	60	100	3
4	PEC	ET7E004	Professional Elective Course-V	3	0	0	20	20	60	100	3
5	OEC	ET7O003	OPEN Elective Course-III	4	0	0	20	20	60	100	4
6	ESC	ET7L005	Basic Electronic Simulation Lab	0	0	2	60	0	40	100	1
7	PCC	ET7L001	Digital Communication Lab	0	0	2	60	0	40	100	1
8	Internship	ET7P001	Field Training-3	0	0	0	30	0	20	50	1
9	Project	ET7P002	Major Project Part-1	0	0	6	25	0	25	50	3
10	MC	ET7T006	Intellectual Property Rights	2	0	0	10	15	25	50	Audit
			Total	**18**	**0**	**10**	**285**	**115**	**450**	**850**	**22**

B. Tech Eighth Semester											
Sr. No.	**Category of Subject**	**Course Code**	**Course Name**	**Teaching Scheme**			**Evaluation Scheme**				**Credit**
				L	**T**	**P**	**CA**	**MSE**	**ESE**	**Total**	
1	PEC	ET8E001	Professional Elective Course-VI	3	0	0	20	20	60	100	3
2	OEC	ET8O004	OPEN Elective Course-IV	4	0	0	20	20	60	100	4
3	Project	ET8P001	Major Project Part-2	0	0	12	75	0	75	150	6
			Total	**7**	**0**	**12**	**115**	**40**	**195**	**350**	**13**

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ET7T001	Digital Communication	3 Credit

Prerequisites: Basic knowledge of communicating transmitter and receiver.

Course Objectives:

1. To know the principles of sampling & quantization
2. To study the various waveform coding schemes
3. To learn the various baseband transmission schemes
4. To understand the various band pass signaling schemes
5. To know the fundamentals of channel coding

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. **Understand** knowledge about various techniques of digital communication Systems.
2. **Explain**the knowledge oftheory and practice related to Digital communication.
3. **Identify** andsolve engineering problems related to Mobile communication system
4. **Analyze** the spectral characteristics of band pass signaling schemes and their noise performance
5. **Design** error control coding schemes

Course Contents:

Module-1 Information Theory **[5 Hrs]**

Discrete Memoryless source, Information, Entropy, Mutual Information - Discrete Memory less channels – Binary Symmetric Channel, Channel Capacity - Hartley - Shannon law - Source coding theorem - Shannon – Fano & Huffman codes.

Module-2 Waveform Coding & Representation **[6 Hrs]**

Prediction filtering and DPCM - Delta Modulation - ADPCM & ADM principles-Linear Predictive Coding- Properties of Line codes- Power Spectral Density of Unipolar / Polar RZ & NRZ – Bipolar NRZ - Manchester

Module-3 Baseband Transmission & Reception **[6 Hrs]**

ISI – Nyquist criterion for distortion less transmission – Pulse shaping – Correlative coding - Eye pattern – Receiving Filters- Matched Filter, Correlation receiver, Adaptive Equalization

Module-4 Digital Modulation Scheme **[7 Hrs]**

Geometric Representation of signals - Generation, detection, PSD & BER of Coherent BPSK, BFSK & QPSK - QAM - Carrier Synchronization - Structure of Non-coherent Receivers - Principle of DPSK.

Module-5 Error Control Coding **[7 Hrs]**

Channel coding theorem - Linear Block codes - Hamming codes - Cyclic codes - Convolutional codes - Viterbi Decoder.

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Module-6 Mobile Communication **[6 Hrs]**

Cellular Telephone systems: Digital cellular telephone, Mobile communication system, Role of mobile communication, mobile hotspot and mobile applications related to rural development, GPS.

Text Books:

1. S. Haykin, ―Digital Communications‖, John Wiley, 2015

Reference Books:

1. B.P. Lathi and Z. Ding, "Modern Digital and Analog Communication Systems," 4th Ed., Oxford University Press, 2009.
2. U. Madhow, "Fundamentals of Digital Communication," Cambridge Univ. Press, 2008.
3. T. M. Cover and J. A. Thomas, "Elements of Information Theory," Wiley Student Edition, 1999, Reprint 2009
4. J.G Proakis, ―Digital Communication‖, 4th Edition, Tata McGraw Hill Company, 2001.

E-Resources:

1. https://www.researchgate.net/publication/268508509_Types_of_E-Resources_and_its_utilities_in_Library
2. https://www.ojcmt.net/article/digital-communication-in-educational-process-development-trends-and-new-opportunities-7928
3. https://journals.ala.org/index.php/lrts/article/view/5158/6260

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Professional Elective Course-III

ET7E002A	Introduction to IOT	3 Credit

Prerequisites: Fundamentals of computer network, Network Security, internet technology.

Course Objectives:

1. Student will explore various components of Internet of things such as Sensors, internetworking and cyber space.
2. Students will able to use real IoT protocols for communication
3. Students will able to transfer IoT data to the cloud and in between cloud providers
4. In the end they will also be able to design and implement IoT circuits and solutions.

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Understand general concepts of Internet of Things (IoT).
2. Recognize various devices, sensors and applications.
3. Apply design concept to IoT solutions.
4. Analyze various M2M and IoT architectures.
5. Evaluate design issues in IoT applications.
6. Create IoT solutions using sensors, actuators and Devices.

Course Contents:

Module-1 Introduction to IoT Components **[6 Hrs]**

Sensing, Actuation, Networking basics, Communication Protocols, Sensor Networks, Machine-to-Machine Communications, IoT Definition, Characteristics. IoT Functional Blocks, Physical design of IoT, Logical design of IoT, Communication models & APIs.

Module-2 M2M to IoT **[7 Hrs]**

The Vision-Introduction, From M2M to IoT, M2M towards IoT-the global context, A use case example, Differing Characteristics. Definitions, M2M Value Chains, IoT Value Chains, An emerging industrial structure for IoT,.

Module-3 M2M vs IoT an Architectural Overview **[7 Hrs]**

Building architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations. Reference Architecture and Reference Model of IoT.

Module-4 IoT Reference Architecture **[6 Hrs]**

Getting Familiar with IoT Architecture, Various architectural views of IoT such as Functional, Information, Operational and Deployment. Constraints affecting design in IoT world- Introduction, Technical design Constraints.

Module-5 Domain Specific Applications of IoT **[5 Hrs]**

Home automation, Industry applications, Surveillance applications, Other IoT application.

Module-6 Developing IoT Solutions **[7 Hrs]**

Introduction to Python, Introduction to different IoT tools, Introduction to Arduino and Raspberry Pi Implementation of IoT with Arduino and Raspberry, Cloud Computing, Fog Computing, Connected Vehicles, Data Aggregation for the IoT in Smart Cities, Privacy and Security Issues in IoT

Text Books:

1. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Aves and, Stamatis Karnouskos, David Boyle, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", 1st Edition, Academic Press, 2014.

2. Vijay Madisetti and Arshdeep Bahga, "Internet of Things (A Hands-on Approach)", 1st Edition, VPT, 2014.

Reference Books:

1. Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1st Edition, Apress Publications, 2013.

2. CunoPfister, Getting Started with the Internet of Things, O"Reilly Media, 2011, ISBN: 978-1-4493-9357-1

E-Resources:

1. https://www.udemy.com/course/internet-of-things-iot-for-beginners-getting-started/
2. https://playground.arduino.cc/Projects/Ideas/
3. https://runtimeprojects.com/
4. https://www.megunolink.com/articles/arduino-garage-door-opener/
5. https://www.willward1.com/arduino-wifi-tutorial/
6. https://www.makeuseof.com/tag/pi-overdose-heres-5-raspberry-pi-alternatives/
7. https://www.electronicshub.org/arduino-project-ideas
8. http://homeautomationserver.com/
9. https://www.youtube.com/watch?v=dC2GdEWHRxQ&list=PLy6JR9IR8VKOZBpDcETs
10. https://www.youtube.com/watch?v=kLd_JyvKV4Y
11. https://www.youtube.com/watch?v=TkA2LJctU1c

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ET7E002BC	Optical Communication Networks	3 Credits

Prerequisites: Basic knowledge of communication engineering

Course Objectives:

1. To learn the basic elements of optical fiber transmission link, fiber modes configurations and structures.
2. To understand the different kind of losses, signal distortion in optical wave guides and other signal degradation factors.
3. To learn the various optical source materials, LED structures, quantum efficiency, Laser diodes.
4. To learn the fiber optical receivers such as PIN APD diodes, noise performance in photo detector, receiver operation and configuration.
5. To learn the fiber optical network components, variety of networking aspects, FDDI, SONET/SDH and operational principles WDM.

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Explain the principles of operation of various optical fiber communication systems.
2. Analyze the performance of various digital and analogue optical fiber systems.
3. Calculate various key parameters of optical fiber systems. These include the system optical power budget and system rise time budget, receiver noise power, Q factor, bit error rate and maximum usable bit rate of a digital optical fiber system.
4. Explain/compare the factors affecting the performance of different optical fibre communication systems.
5. Communicate laboratory findings through written reports

Course Contents:

Module-1 Overview of Optical Fiber Wave Guides **[6 Hrs]**

General system, transmission link, advantage of optical fiber communication, basic structure of optical fiber waveguide, ray theory transmission, optical fiber modes and configuration, step index & graded index fiber, single mode fiber , fiber materials , fiber fabrication

Module-2 Signal Degradation in Optical Fiber **[7 Hrs]**

Introduction, attenuation, intrinsic & extrinsic absorption losses, linear & nonlinear scattering losses, bending losses, distortion in optical wave guide, intramodal and intermodal dispersion. Power launching and coupling Source to fiber power launching, power calculation, lensing schemes, fiber to fiber joints, fiber splicing technique, fiber connectors.

Module-3 Optical Sources **[6 Hrs]**

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LASER: Basic concepts of laser, Optical emission from semiconductors, Semiconductor injection laser (ILD), Injection laser characteristics.LED: power and efficiency, LED structures, LED characteristics.Optical detectors: p-n photodiodes, P-I-N photodiodes, Avalanche photodiodes, Quantum efficiency, speed of response, Phototransistor.

Module-4 Optical Receiver **[5 Hrs]**

Receiver operation, digital receiver noise, shot noise, pre-amplifier types, Digital receiver performance, introduction to analog receivers.

Module-5 Digital Transmission Systems **[7 Hrs]**

Point to point links, system considerations, link power budget, rise time budget, modulation formats for analog communication system, introduction to WDM concepts, Introduction to advanced multiplexing strategies.

Module-6 Optical Networks **[6 Hrs]**

Basic networks-SONET/ SDH-wavelength routed networks, nonlinear effects on network performance, performance of various systems (WDM, DWDM + SOA).

Text Books:

1. G.Keiser: Optical Fiber Communication – MGH
2. Jenkins & White: Fundamentals of Optics – MGH.

Reference Books:

1. Bhattacharya, Pallab / "Semiconductor Optoelectronics Devices" / Pearson Education.
2. Singh, Jasprit / "Optoelectronics An Introduction to Materials and Devices"/ McGraw-Hill
3. Khare, R.P. / "Fiber Optics & Optoelectronics" / Oxford University Press
4. Gupta, S.C. / "Text Book of Optical Fiber Communication & Its Applications"/ Prentice–Hall India
5. M. Senior: Optical Fiber Communication – PHI

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E-Resources:

1. https://nptel.ac.in/courses/108/106/108106167/
2. https://nptel.ac.in/courses/117101054

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ET7E002C	Advanced Cellular Communication	3 Credit

Prerequisites: Basic knowledge of Digital and wireless Communication System.

Course Objectives:

1. To understand the basic cellular system concepts.
2. To have an insight into the various propagation models and the speech coders used in mobile communication.
3. To understand the multiple access techniques and interference education techniques in mobile communication
4. To identify the limitations of 3G and 4G wireless mobile communication and use design of 5G and beyond mobile communication systems

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Know the concept of cellular wireless communication system
2. Understand emerging technologies required for fourth and fifth generation mobile systems such as SDR, MIMO etc
3. Knowledge of GSM mobile communication standard, its architecture, logical channels, advantages and limitations
4. Apply frequency-reuse concept in mobile communications, and to analyze its effects on interference, system capacity, handoff techniques
5. Analyze various methodologies to improve the cellular capacity
6. Compare and explain various radio access technologies for 5G networks

Course Contents:

Module-1 Introduction to Wireless communication **[4 Hrs]**

Wireless communication systems, Applications of wireless communication systems, Types of wireless communication systems, trends in mobile communication systems

Module-2 Cellular Mobile Systems **[6 Hrs]**

Basic cellular systems, Performance criteria, Uniqueness of mobile radio environment, Operation of cellular systems, analog & digital cellular systems.

Module-3 Elements of Cellular Radio System Design **[6 Hrs]**

Concept of frequency reuse channels, Co-channel interference reduction factor, Desired C/I from a normal case in an omnidirectional antenna system, Handoff mechanism, Cell splitting.

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Module-4 Interference in Cellular Mobile System **[7 Hrs]**

Co-channel interference, Design of an omnidirectional antenna system in the worst case, Design of a directional antenna system, Lowering the antenna height, Power control, Reduction in CI by tilting antenna, umbrella pattern effect Adjacent-channel interference, Near-end – far-end interference, Effect on near-end mobile units

Module-5 Frequency Management, Channel Assignment and Handoffs **[7 Hrs]**

Frequency management, Frequency-spectrum utilization, Set-up channels, Fixed channel assignment schemes, Non-fixed channel assignment schemes, Concept of handoff, Initiation of a hard handoff, Delaying a handoff, Forced handoffs, Queuing of handoffs, Power difference handoffs, Mobile assisted handoff, Soft handoffs, Cell-site handoff, Intersystem handoff, dropout calls.

Module-6 GSM System Overview Over Wireless Networks And 5G Technology **[8 Hrs]**

GSM system architecture, GSM radio subsystem, GSM channel types, Frame structure for GSM, Signal processing in GSM, GPRS and EDGE. Overview of Wi-Fi, Wi-MAX and Bluetooth technology (Basic features and physical specifications).5G architecture, D2D: from 4G to 5G – Radio Resource Management for Mobile Broadband D2D –5G radio access technologies.

Text Books:

1. Mobile Cellular Telecommunications: Analog and Digital Systems by William C. Y. Lee; Tata McGraw Hill Publication.
2. H. Labiod, H. Afifi, C. De Santis: WI-FI, BLUETOOTH , ZIGBEE and WIMAX-Springer2007

Reference Books:

1. Asif Oseiran, Jose F.Monserrat and Patrick Marsch, "5G Mobile and Wireless Communications Technology", Cambridge University Press, 2016.
2. Jonathan Rodriquez, "Fundamentals of 5G Mobile Networks", Wiley, 2015
3. Patrick Marsch, Omer Bulakci, Olav Queseth and Mauro Boldi, "5G System Design – Architectural and Functional Considerations and Long Term Research", Wiley, 2018arson
4. Wireless Communications and Networks: 3G and Beyond by ItiSahaMisra; Tata McGraw Hill Publication
5. Wireless and Digital Communications by Dr. KamiloFeher; PHI Publication

E-Resources:

1. https://crln.acrl.org/index.php/crlnews/article/view/8545/8878
2. https://eudl.eu/journal/mca
3. https://www.researchgate.net/publication/286455750_mobile_technology_in_libraries_for_discovering_e-resources_and_services

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Professional Elective Course-IV

ET7E003A	Verilog HDL	3 Credit

Prerequisites: Basic knowledge of Digital Circuits, Microprocessor and Microcontroller.

Course Objectives:

1. To relate VHDL with Verilog and Understand the Digital Design with Verilog HDL.
2. To identify the various modules and ports in Digital Design with Verilog HDL.
3. To Compare the task and functions and make use of useful modeling techniques.
4. To analyze the gate level, data flow and behavioral modeling of Digital Design with Verilog HDL.
5. To design digital systems with various constraints.

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. **Relate** VHDL and Verilog
2. **Understand** the Digital Design with Verilog HDL.
3. **Identify** the various modules and ports in Digital Design with Verilog HDL.
4. **Compare** the task and functions and make use of useful modeling techniques.
5. **Analyze** the gate level, data flow and behavioral modeling of Digital Design with Verilog HDL.
6. **Design** digital systems with various constraints.

Course Contents:

Module-1 Overview of Digital Design with Verilog HDL **[6 Hrs]**

Evolution of CAD, emergence of HDLs, typical HDL-based design flow, why Verilog HDL?, trends in HDLs.

Hierarchical Modeling Concepts: Top-down and bottom-up design methodology, differences between modules and module instances, parts of a simulation, design block, stimulus block.

Module-2 Modules and Ports **[5 Hrs]**

Lexical conventions, data types, system tasks, compiler directives, Module definition, port declaration, connecting ports, hierarchical name referencing.

Module-3 Gate-Level Modeling **[7 Hrs]**

Modeling using basic Verilog gate primitives, description of and/or and buf/not type gates, rise, fall and turn-off delays, min, max, and typical delays.

Module-4 Dataflow Modeling **[6 Hrs]**

Continuous assignments, delay specification, expressions, operators, operands, operator types.

Module-5 Behavioral Modeling **[6 Hrs]**

Structured procedures, initial and always, blocking and nonblocking statements, delay control, generate statement, event control, conditional statements, multiway branching, loops, sequential and parallel blocks.

Module-6 Tasks, Functions & Useful Modeling Techniques **[7 Hrs]**

Differences between tasks and functions, declaration, invocation, automatic tasks and functions. Procedural continuous assignments, overriding parameters, conditional compilation and execution, useful system tasks.

Text Books:

1. Verilog HDL: A Guide to Digital Design and Synthesis, Second Edition, Samir Palnitkar, Prentice Hall PTR, February 21, 2003

Reference Books:

1. Steve Kilts, "Advanced FPGA Design: Architecture, Implementation and Optimization", J.Wiley and Sons, 2007.
2. Seetharaman Ramachandran, "Digital VLSI Systems Design", Springer Verlag, 2012.
3. Peter J. Ashenden, "The designer's guide top VHDL", Morgan Kaufmann, 2008.
4. Charles H. Roth Jr., "Digital Systems Design using VHDL", Cengage Learning, 2014.
5. Digital System Design–John Wakerley, McGraw Hill Publications.

E-Resources:

1. https://onlinecourses.nptel.ac.in/noc19_cs73
2. https://www.classcentral.com/course/swayam-synthesis-of-digital-systems-10067

ET7E003B	UHF & Microwave Engineering	3 Credit

Prerequisites: Basic knowledge of Electromagnetic field and Antenna & Wave Propagation.

Course Objectives:

The Course Objectives are:

1. To study the principles of the advanced microwave engineering.
2. To study the design of passive and active microwave components and microwave circuits including Micro strip line, guided wave device
3. To study Klystron amplifier and oscillator.
4. To study magnetron & other devices.
5. To study the free space communication link and its mathematical analysis.

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Describe the use of active and passive microwave devices.
2. Demonstrate the use of different Klystrons, magnetron devices.
3. Analyze different UHF components with the help of scattering parameter.
4. Describe micro strip lines.
5. Analyze the different power distribution Tees.
6. Describe the transmission and waveguide structures and how they are used as elements in impedance matching and filter circuits.

Module-1 Microwave Active Devices (O-type) **(6 Hrs)**

Interaction of electron beam with electromagnetic field, power transfer condition. Principles of working of two cavity and Reflex Klystrons, arrival time curve and oscillation conditions in Reflex klystrons, mode-frequency characteristics, Effect of repeller voltage variation on power and frequency of output. Slow wave structures, Principle and working of TWT amplifier & BWO Oscillator.

Module-2 Microwave Active Devices (M-type) **(7 Hrs)**

Principle of working of M-type TWT, Magnetrons, Electron dynamics in planar and cylindrical Magnetrons, Cutoff magnetic field, phase focusing effect, mode operation, Mode separation techniques, Tuning of magnetron.

Module-3 Transmission Line **(6 Hrs)**

Input impedance, Standing wave distribution, Quarter Wave and Stub Matching using Smith chart, losses in Transmission lines, Planar Transmission line types, Introduction - Types of MICs and their technology, Fabrication process of MMIC, Hybrid MICs.

Module-4 Microwave Networks and Passive Components **(8 Hrs)**

Transmission line ports of microwave network, Scattering matrix, Properties of scattering matrix of reciprocal, nonreciprocal, loss-less, Passive networks, Examples of two, three and four port networks, wave guide components like attenuator. Principle of operation and properties of E-plane, H-plane Tee junctions of wave guides, Hybrid T, Directional couplers, Microwave resonators-rectangular, Excitation of wave guide and resonators .Principles of operation of non-reciprocal devices, properties of ferrites, Gyrators, Isolators ,Circulator and phase shifters.

Module-5 Microwave Measurements **(6 Hrs)**

Function of Tuning Probes, Detector mounts and Detector diode, Slotted line section and VSWR meter, Measurement of wave-guide impedance at load port by slotted line, Measurement of scattering matrix parameters, High, Medium and low-level power measurement techniques, Characteristics of bolometer, bolometer mounts, Power measurement bridges, Calorimetric method, Microwave frequency measurement techniques, calibrated resonators (transmission and absorption type), Network Analyzer and its use in measurements.

Module-6 Microwave Solid State Devices and Application **(6 Hrs)**

PIN diodes-Properties and applications, Microwave detector diodes-detection characteristics, Varactor diodes, Parametric amplifier fundamentals-Manley-Rowe Power relation, MASERS, Transferred electron devices, Gunn effect, Various modes of operation of Gunn oscillator, IMPATT, TRAPATT and BARITT.

Text Books:

1. Samuel Y. Liao, 'Microwave Devices and Circuits', Pearson Education, 5th Edition.

Reference Books:

1. Manojit Mitra, 'Microwave engineering', 3rd edition, DhanpatRai& Company.
2. Peter A. Rizzi, 'Microwave Engineering Passive Circuits', PHI, 1999.
3. Annapurna Das, Sisir Das, 'Microwave Engineering', April 1987, Tata McGraw Hill Publication.
4. Herbert J. Reich, J.G. Skalnik, P.F. Ordung and H.L. Krauss , 'Microwave Principles',4th edition, 1998.
5. G. S. Raghuvanshi, 'Microwave Engineering', CENGAGE Learning

Professional Elective Course-V

ET7E004A	Machine Learning	3 Credits

Course Objectives:

1. To understand the basic theory underlying machine learning.
2. To be able to formulate machine learning problems corresponding to different applications.
3. To understand a range of machine learning algorithms along with their strengths and weaknesses.
4. To be able to apply machine learning algorithms to solve problems of moderate complexity.
5. To apply the algorithms to a real-world problem, optimize the models learned and report on the expected accuracy that can be achieved by applying the models.

Course Outcomes:

After completing this course, the student will be able to

1. Understand a very broad collection of machine learning algorithms and problems.
2. Appreciate the importance of visualization in the data analytics solution.
3. Apply structured thinking to unstructured problems.
4. Learn algorithmic topics of machine learning and mathematically deep enough to introduce the required theory.
5. Develop an appreciation for what is involved in learning from data.

Course Contents:

Module-1 Introduction **[5 Hrs]**

Learning Problems, Perspectives and Issues, Concept Learning, Version Spaces and Candidate Eliminations, Inductive bias, Decision Tree learning, Representation, Algorithm, Heuristic Space Search.

Module-2 Neural Networks and Genetic Algorithms **[7 Hrs]**

Neural Network Representation, Problems, Perceptrons, Multilayer Networks and Back Propagation Algorithms, Advanced Topics, Genetic Algorithms, Hypothesis Space Search, Genetic Programming, Models of Evaluation and Learning.

Module-3 Bayesian and Computational Learning **[7 Hrs]**

Bayes Theorem, Concept Learning, Maximum Likelihood, Minimum Description Length Principle, Bayes Optimal Classifier, Gibbs Algorithm, Naïve Bayes Classifier, Bayesian Belief Network, EM Algorithm, Probability Learning, Sample Complexity, Finite and Infinite Hypothesis Spaces, Mistake Bound Model.

Module-4 Instant Based Learning **[6 Hrs]**

K- Nearest Neighbour Learning, Locally weighted Regression, Radial Bases Functions, and Case Based Learning.

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Module-5 Advanced Learning **[7 Hrs]**

Learning Sets of Rules, Sequential Covering Algorithm, Learning Rule Set, First Order Rules, Sets of First Order Rules, Induction on Inverted Deduction, Inverting Resolution, Analytical Learning, Perfect Domain Theories, Explanation Base Learning, FOCL Algorithm, Reinforcement Learning, Task, Q-Learning, Temporal Difference Learning. "Current Streams of Thought".

Module-6 Introduction to Cluster Analysis & Clustering Methods **[6 Hrs]**

The Clustering Task and the Requirements for Cluster Analysis, Overview of Some Basic Clustering Methods, Hierarchical Methods: Agglomerate versus Divisive Hierarchical Clustering, Distance Measures, Probabilistic Hierarchical Clustering, Multiphase Hierarchical Clustering Using Clustering

Text Books:

1. Tom M. Mitchell, —Machine Learning, McGraw-Hill Education (India) Private Limited, 2013.
2. Ethem Alpaydin, —Introduction to Machine Learning (Adaptive Computation and Machine Learning), The MIT Press 2004.

Reference Books:

1. Machine Learning Engineering, AndriyBurkov, ISBN-10 : 1999579577, True Positive Inc. (8 September 2020)
2. Stephen Marsland, —Machine Learning: An Algorithmic Perspective, CRC Press, 2009.
3. Bishop, C., Pattern Recognition and Machine Learning. Berlin: Springer-Verlag.

E-Resources:

1. https://onlinecourses.nptel.ac.in/noc22_cs29/preview
2. https://nptel.ac.in/courses/106106139

ET7E004B	Digital Image Processing	3 Credit

Prerequisites: Digital Signal Processing, Transform techniques.

Course Objectives:

1. To study the image fundamentals and mathematical transforms necessary for image processing.
2. To study the image enhancement techniques
3. To study image restoration procedures.
4. To study the image compression procedures.

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. **Recall** the fundamental concepts of a digital image processing system.
2. **Understand** images in the frequency domain using various transforms.
3. **Apply** various techniques for image enhancement and image restoration.
4. **Analyze** various compression techniques.
5. **Interpret** Image compression standards.
6. **Design** image segmentation and representation techniques.

Course Contents:

Module-1 Introduction and Digital Image Fundamentals **[6 Hrs]**

Digital Image Fundamentals, Need for DIP, Fundamental steps in DIP, Human visual system, Image representation – Gray scale and Color images,Types of neighborhoods, Basic relationships between pixels, Distance Measures,

Module-2 Basic operations on Images and Color Fundamentals. **[6 Hrs]**

Image addition, subtraction, logical operations, scaling, translation, rotation, Image Histogram, Color fundamentals & models – RGB, HSI YIQ, image sampling and quantization.

Module-3 Image Enhancement and Restoration **[8 Hrs]**

Spatial domain enhancement: Point operations-Log transformation, Power-law transformation, Piecewise linear transformations, Histogram equalization. Filtering operations- Image smoothing, Image sharpening.Basic gray level Transformations, Low pass filtering, High pass filtering, Noise Models, Noise Reduction, Inverse Filtering, MMSE (Wiener) Filtering,

Module-4 Image Compression **[4 Hrs]**

Fundamentals of redundancies, Basic Compression Methods: Huffman coding, Arithmetic coding, LZW coding, JPEG Compression standard.

Module-5 Image Segmentation and Morphological Operations **[8 Hrs]**

Image Segmentation: Point Detections, Line detection, Edge Detection-First order derivative –Prewitt and Sobel, Second order derivative – LoG, DoG, Canny, Edge linking, Hough Transform, Region Growing, Region Splitting and Merging,Dilation, Erosion, Opening, Closing, Hitor-Miss transform, Boundary Detection, Thinning, Thickening, Skeleton.

Module-6 Representation and Description **[6 Hrs]**

Representation – Chain codes, Polygonal approximation, Signatures. Boundary Descriptors – Shape numbers, Fourier Descriptors.

Text Books:

1. Gonzalez & Woods, —Digital Image Processing, 3rd ed., Pearson education, 2008

Reference Books:

1. Milan Sonka, Vaclav Hlavav, Roger Boyle, —Image Processing, Analysis and Machine Vision‖, 2nd ed., Thomson Learning, 2001
2. Rangaraj M. Rangayyan, —Biomedical Image Analysis‖, CRC Press, 2005
3. Pratt W.K, —Digital Image Processing‖, 3rd ed., John Wiley & Sons, 2007
4. Jain Anil K., —Fundamentals Digital Image Processing‖, Prentice Hall India, 2010

E-Resources:

https://nptel.ac.in/courses/117105079

https://onlinecourses.nptel.ac.in/noc19_ee55/preview

https://nptel.ac.in/courses/117105135

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ET7E004C	Advanced Digital Signal Processing	3 Credit

Prerequisites: Signals and Systems, Digital Signal Processing.

Course Objectives:

1. To study in depth knowledge of processing digital signals.
2. To study the designing of filters.
3. To study multirate digital signal processing.
4. To study the power spectral estimation.

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. **Represent** discrete-time signals analytically and visualize them in the time domain.
2. **Summarize** the requirement of theoretical and practical aspects of DSP with regard to sampling and reconstruction.
3. **Apply** various techniques of filter designs for various applications.
4. **Analyze** Multi Rate Signal Processing and describe how to apply it for the wavelet transform.
5. **Comprehend** the Finite word length effects in Fixed point DSP Systems.
6. **Estimate** the power spectral estimation methods.

Course Contents:

Module-1 Multirate Digital Signal Processing **[6 Hrs]**

Introduction, Review of Decimation and Interpolation, Sampling Rate Conversion by a Rational Factor I/D, Filter Design and Implementation for sampling rate Conversion Multirate Digital Signal Processing Multistage, Implementation of Sampling Rate Conversion.

Module-2 Applications of Multirate Digital Signal Processing **[4 Hrs]**

Applications of Multirate Signal Processing, Sampling Rate Conversion of Bandpass Signals Linear Prediction and Optimum Linear

Module-3 Filters **[7 Hrs]**

Innovations Representation of a Stationary Random Process, Forward and Backward Linear Prediction, Solution of the Normal Equations, Properties of linear prediction - Error Filter, AR Lattice and ARMA Lattice-Ladder Filters.

Module-4 Power Spectral Estimation **[6 Hrs]**

Estimation of Spectra from Finite Duration Observations of a signal, the Periodogram, Use DFT in power Spectral Estimation, Bartlett, Welch and Blackman, Tukey Methods, Comparison of performance of Non-Parametric Power Spectrum Estimation Methods

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Module-5 Parametric Method of Power Spectrum Estimation **[7 Hrs]**

Parametric Methods for power spectrum estimation, Relationship between Auto-Correlation and Model Parameters, AR (Auto-Regressive) Process and Linear Prediction, Moving Average(MA) and ARMA Models Minimum Variance Method.

Module-6 Wavelet Transform **[6 Hrs]**

Window Selection, Wavelet Transform, STFT to Wavelet conversion, Basic Wavelet, Discrete time orthogonal Wavelet, Continuous Time Orthogonal Wavelets.

Text Books:

1. J. G. Proakis & D. G. Manolokis, "Digital Signal Processing – Principles, Algorithms Applications", PHI.

Reference Books:

1. S. M .Kay, "Modern spectral Estimation techniques", PHI, 1997.Emmanuel C. Ifeacher Barrie. W. Jervis, "DSP – A Practical Approach", Pearson Education.
2. Oppenheim, Alan V. Discrete-time signal processing. Pearson Education India, 1999.
3. Mitra, Sanjit Kumar, and Yonghong Kuo. Digital signal processing: a computer-based approach. Vol. 2. New York: McGraw-Hill Higher Education, 2006.

E-Resources:

https://nptel.ac.in/courses/117101001

https://onlinecourses.nptel.ac.in/noc21_ee20/preview

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ET7L005	Basic Electronic Simulation Lab	1 Credit

Course Objectives:

1. Familiarize with the CAD tool to write HDL programs.
2. Understand simulation and synthesis of digital design.
3. Program FPGAs/CPLDs to synthesize the digital designs.
4. Interface hardware to programmable ICs through I/O ports.
5. Choose either Verilog or VHDL for a given Abstraction level.

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. **Develop** the Verilog/VHDL programs to simulate Combinational circuits in Dataflow, Behavioral and Gate level Abstractions.
2. **Describe** sequential circuits like flip flops and counters in Behavioral description and obtain simulation waveforms.
3. **Synthesize** Combinational and Sequential circuits on programmable ICs and test the hardware.
4. **Interface** the hardware to the programmable chips and obtain the required output

List of Experiments:

PART A

1. Develop a Verilog program for 2 to 4 decoder.
2. Develop a Verilog program for 8 to 3 encoder (without priority & with priority).
3. Develop a Verilog program for 8 to 1 multiplexer.
4. Design 4 bit binary to gray converter in Verilog.
5. Model in Verilog for a full adder and add functionality to perform logical operations of XOR, XNOR, AND and OR gates.
6. Write a Verilog code to model 32 bit ALU.
7. Write Verilog code for SR, D and JK and verify the flip flop.
8. Write Verilog code for 4-bit BCD synchronous counter.
9. Write Verilog code for counter with given input clock and check whether it works as clock divider performing division of clock by 2, 4, 8 and 16. Verify the functionality of the code.

PART-B

1. Develop a Verilog code to design a clock divider circuit that generates 1/2, 1/3rd and 1/4thclock from a given input clock. Port the design to FPGA and validate the functionality through oscilloscope.
2. Interface a DC motor to FPGA and write Verilog code to change its speed and direction.
3. Interface a Stepper motor to FPGA and write Verilog code to control the Stepper motor rotation

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which in turn may control a Robotic Arm. External switches to be used for different controls like rotate the Stepper motor

(i) +N steps if Switch no.1 of a Dip switch is closed

(ii) +N/2 steps if Switch no. 2 of a Dip switch is closed

(iii) –N steps if Switch no. 3 of a Dip switch is closed etc.

4. Interface a DAC to FPGA and write Verilog code to generate Sine wave of frequency F KHz (eg. 200 KHz) frequency. Modify the code to down sample the frequency to F/2 KHz. Display the Original and Down sampled signals by connecting them to an oscilloscope.

5. Write Verilog code using FSM to simulate elevator operation.

6. Write Verilog code to convert an analog input of a sensor to digital form and to display the same on a suitable display like set of simple LEDs, 7-segment display digits or LCD display.

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ET7L001	Digital Communication Lab	1 Credit

Prerequisites: Communication System Engineering, Digital Communications, Signals and Systems.

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Evaluate the performance of PCM, DPCM and Delta modulation schemes.
2. Implement different digital modulation schemes like FSK, PSK, and DPSK.
3. Analyze source/channel encoding & decoding methods.
4. Simulate Pulse Digital Modulation & demodulation using MATLAB.
5. Simulate digital communication techniques like ASK, FSK & PSK.

List of Experiments:

Trainer Kit Based Experiments

1. Generation and Detection of Pulse Code Modulation for both A.C and D.C signals
2. Generation and Detection of Differential Pulse Code Modulation
3. Generation and Detection of Delta Modulation
4. Generation and Detection of PSK.
5. Generation and Detection of FSK.
6. Generation and Detection of DPSK.
7. Generation and Detection of QPSK.
8. Linear Block code-Encoder and Decoder
9. Convolution code-Encoder and Decoder
10. To study the Spectrum Analyzer

Simulation Based Experiments (Open Source/Matlab/Multisim)

1. Amplitude Shift Keying
2. Phase Shift keying
3. Time Division Multiplexing
4. Pulse Code Modulation

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Professional Elective Course-VI

ET8E001A	5G Wireless Networks	3 Credit

Course Objectives:

1. Discuss and analyze the latest technologies in wireless networks including wireless components
2. Analyze different techniques and technologies required for the development of 5G Wireless Networks
3. Discuss the recent development of 5G Wireless Networks and next generation 5G protocols in current and emerging communications.

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Understanding the objectives of 5G.
2. Compare 5G Architecture with 4G Architecture.
3. Analyze the principles of Softwarization in 5G.
4. To study the concept of MEC and Fog computing.
5. Evaluate physical layer design in 5G.
6. Characterize and analyze network security aspect in 5G.

Course Contents:

Module-1 Introduction **[6 Hrs]**

5GPP & NGMN, 5G Design Objective Part 1, 5G Design Objective Part 2, ITU-R IMT-2020 vision for 5G, 5G Spectrum Requirements, Globally Harmonised 5G Spectrum, 5G Industry Progress, 5G Network Perspectives

Module-2 Architecture **[7 Hrs]**

5G Scenarios, 5G RAN, 5G Mobile Core and Operating System, 5G Architecture View, 5G Network Slicing, 5G Architecture Plane Part 1, 5G Architecture Plane Part 2, Logical and Functional 5G Architecture, Dynamic CRAN, 5G NR Logical Architecture

Module-3: Programmability and Softwarization **[5 Hrs]**

Network Programmability and Softwarization, Network Programmability.

Module-4 Mobile Edge Computing and FOG Computing **[6 Hrs]**

MEC Introduction, MEC Concept, MEC Architecture, MEC Benefits, Fog Computing

Module-5 Radio Access Technologies **[7 Hrs]**

Millimeter Wave Propagation, Flexible Physical Layer Design Part 1, Flexible Physical Layer Design Part 2, Distributed Massive MIMO Principles, Energy Transfer for Massive MIMO

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Module-6 Network Security **[7 Hrs]**

5G Security, 5G Security Goals, 5G New Trust Model, Diversified Identity Management, User Privacy Protection Requirement, 5G Core Security, 5G Radio Network Security

Text Books:

1. R. Vannithamby and S. Talwar, Towards 5G: Applications, Requirements and Candidate Technologies., John Willey & Sons, West Sussex, 2017.
2. Manish, M., Devendra, G., Pattanayak, P., Ha, N., 5G and Beyond Wireless Systems PHY Layer Perspective, Springer Series in Wireless Technology

Reference Books:

1. T. S. Rappaport, R. W. Heath Jr., R. C. Daniels, and J. M. Murdock,, Millimeter Wave Wireless Communication., Pearson Education, 2015.
2. M. Vaezi, Z. Ding, and H. V. Poor,, Multiple Access techniques for 5G Wireless Networks and Beyond., Springer Nature, Switzerland, 2019

E-Resources:

https://onlinecourses.nptel.ac.in/noc21_ee12/preview

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ET8E001B	Modern Digital Communication System	3 Credit

Course Objectives:

1. The course aims at understanding principles, theories and practices, which are fundamental to the successful design of a digital communication system
2. In this course students are introduced to advanced topics in digital communications and also acquire information about the latest emerging modern communication standards and underlying design principles
3. Evaluate and compare the performance of the various digital communication schemes in wired and wireless channels
4. Make Students well equipped for research or cutting edge development in Communication System

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. **Recall** to possess the principles and theories required to design reliable communication link
2. **Compare** different digital communication techniques and judge their applicability and performance in different application scenarios.
3. **Apply** mathematical modeling to problems in wire line and wireless digital communications, and explain how this is used to analyze and synthesize methods and algorithms within the relevant communication standards
4. **Demonstrate** skillset to choose and optimize design parameters (e.g., power distribution, modulation, redundancy, speed) in advanced communication technologies used in the telecommunication industry
5. **Possess** fundamental grounding and sophistication needed to explore topics in Advanced and Emerging wireless communication standards like 4G, 5G and different WLAN that include MIMO, mmWave communication

Course Contents:

Module-1 Introduction **[5 Hrs]**

Introduction to Digital Communication, Elements of Digital Communication, Mathematical Models for Communication Channels and their characteristics, Review system designing and performance aspects, Networks aspects of digital interface, Historical background and developments in modern digital communication.

Module-2 Mathematical Preliminaries **[6 Hrs]**

Signals, LTI system, The Nyquist Sampling theorem, Complex envelope representation, the spectrum of bandpass signal, low pass equivalent of bandpass signal, Energy considerations, low pass equivalent of a bandpass system. Signal space representation of waveforms: Vector space concepts, Signal space concepts, Orthogonal expansions of signals, Gram-Schmidt procedure.

Module-3 Digital Modulation Schemes and Optimum Receivers for AWGN Channels **[8 Hrs]**

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Representation of digitally modulated signals, Multidimensional Signaling, Signaling Schemes with Memory: CPFSK, CPM. Spectral properties of various modulation schemes and their comparison, The Nyquist criterion for ISI avoidance, Optimum Receivers for AWGN Channels: Waveform and Vector Channel models, Optimum reception in AWGN, error probability of band-limited and power limited signaling, detection non-coherent detection.

Module-4 Carrier and symbol Synchronization **[7 Hrs]**

Receiver design requirements, Signal Parameter estimation: Carrier recovery and symbol synchronization in signal demodulation, Carrier Phase estimation, Symbol timing estimation, Joint estimation of Carrier Phase and Symbol timing, Performance characteristics of ML estimators.

Module-5 Information-Theoretic Limits and Channel Coding **[7 Hrs]**

The capacity of AWGN Channel: modeling and geometry, Shannon theory basics: entropy, mutual information, and divergence, channel coding theorem, the capacity of standard constellations, parallel Gaussian channels and water filling

Channel codes: Binary convolution codes, Turbo codes and iterative coding, LDPC codes, bandwidth-efficient coded modulation.

Module-6 Digital Modulation for Wireless Communication **[6 Hrs]**

Physical modeling for wireless channels, Fading and diversity, OFDM, CDMA, MIMO- linear array, Beam-steering, MIMO-OFDM, Spatial Multiplexing, Space-time coding.

Text Books:

1. John. G. Proakis, Digital Communications, McGraw Hill
2. Upamanyu Madhow, Fundamentals of Digital Communication, Cambridge University Press, 2012

Reference Books:

1. B. P. Lathi, Modern Digital and Analog Communication Systems, Oxford University Press, 4th Ed., 2009
2. J. R. Barry, E. A. Lee, and D. G. Messerschmitt, Digital Communication, Kluwer Academic Publishers, 2004
3. U. Madhow, "Fundamentals of Digital Communication," Cambridge Univ. Press, 2008.
4. Simon Haykin, "Communication Systems," John Wiley & Sons, 5th Ed., 2009.

E-Resources:

1. https://eng.uok.ac.ir/mohammadkhani/courses/AdvDigitalComm_94_2.html
2. https://www.psa.gov.in/technology-frontiers/advanced-communication-technologies/758

Open Elective Courses

ET7O003A	Advanced Controller & Applications	4 Credit

Course Objectives:

The objective of this course is to provide students with

1. Understanding of ARM architecture and its organization.
2. Interfacing and Programming concepts of ARM based microcontroller.
3. Fundamental concepts of Real Time Operating Systems (RTOS)
4. To understand the usage of Gateways, cloud service and design of IOT based embedded systems.

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Apply the knowledge of ARM architecture and organization for modern ARM Contex - M devices.
2. Utilize knowledge, techniques & skill to integrate microcontroller hardware and software component using Contex - M.
3. Apply the concepts of Embedded OS.
4. Implement OS based embedded system.
5. Understand different IoT platform for embedded applications.

Course Content:

Module-1 ARM Processor Architecture and Programming **[8 Hrs]**

ARM Processor Architecture, Pipeline Characteristics, ARM Addressing Modes, ARM Instruction Set, Programming Techniques, Exception Modes and Handling, Thumb Instructions.

Module-2 The Cortex - M processor **[9 Hrs]**

Applications, Simplified view – block diagram, programming model – Registers, Operation modes, Exceptions and Interrupts, Reset Sequence, Instruction Set, Unified Assembler Language, Pipeline, Bus, Priority, Vector Tables, Interrupt Inputs and Pending behavior, Fault Exceptions, Supervisor and Pendable Service Call, Nested Vectored Interrupt Controller.

Module-3 The Cortex - M processor Interfacing **[7 Hrs]**

SYSTICK Timer, Interrupt Sequences, Introduction to the Cortex microcontroller software interface standard (CMSIS), Interfacing of GPIOs, Timers, ADC, UART and other serial interfaces, PWM.

Module-4 Concept and Fundamentals of RTOS **[7 Hrs]**

RTOS examples, Interrupts, Handling an Interrupt, Interrupt Service Routines, Context Switching, Process States, Communication Mechanism, Scheduling Algorithm, Priority Inversion, Priority Inheritance. Inter-

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task Communication: Shared Variables, Monitors, Messages, Events, Semaphores, Priority inversion problem, Deadlocks, Starvation.

Module-5 Advanced Controller and Programming **[9 Hrs]**

Introduction to Raspberry PI and Platform Installation, Python Programming, OOP's and Modules in Python Programming, WiFi & Ethernet Setup, GPIO Programming

Module-6 Sensors Interfacing **[8 Hrs]**

Perform sensors interfacing (like PIR, pressure, DHT11, TMP35, gas sensor, Ultrasonic sensor, Accelerometer, LDR. 7- segment, LCD ,GLCD and wifi ESP8266 interfacing.

Text Books:

1. Definitive Guide to the ARM Cortex-M0 : Joseph Yiu, Elsevier , (1/E)2011
2. An Embedded Software Primer: David E Simon, Pearson education Asia, 2001

Reference Book:

1. Raspberry Pi IoT Projects: Prototyping, John C. Shovic
2. Experiments for Makers, Apress Publisher, First edition 2018
3. ARM System Developer's Guide Designing and Optimizing System Software: Andrew N. Sloss, Dominic Symes, Chris Wright, Morgan Kaufmann publications, (1/E) 2004.
4. ARM system on chip Architecture: Steve Furber, Pearson Education Addison Wesley, (2/E) 2000
5. Internet of Things with Raspberry Pi 3, Maneesh Rao, Packt Publisher, Second edition 2018

E-Resources:

1) https://developer.arm.com/ip-products/processors/cortex-m
2) https://nptel.ac.in/courses/117/106/117106111/
3) https://nptel.ac.in/courses/106/105/106105193/
4) https://www.youtube.com/watch?v=x0gH5JGNIKg
5) https://nptel.ac.in/courses/106/105/106105166/
6) https://intersog.com/blog/iot-platforms-overview-arduino-raspberry-pi-intel-galileo-and-others/
7) https://www.juit.ac.in/department/cse/IoT%20workshop%20with%20Intel%20Galileo.pdf
8) https://thingspeak.com/
8) https://ubidots.com/
10) https://www.youtube.com/watch?v=h0gWfVCSGQQ

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ET7O003B	Micro Electromechanical Systems	4 Credit

Course Objectives:

1. To give information of semiconductors and firm mechanics to make MEMS devices.
2. To teach on the basics of Micro manufacture techniques.
3. To pioneer a variety of sensors and actuators
4. To initiate diverse resources used for MEMS
5. To teach on the applications of MEMS to discipline away from Electrical engineering and Mechanical engineering.

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. **Understand** the fundamentals of micro electromechanical systems as well as their applications and reward
2. **Identify** the use of resources in micro manufacture and
3. **Explain** the production processes as well as surface micromachining, bulk micromachining and LIGA.
4. **Examine** the input routine aspects of electromechanical transducers as well as sensors and actuators
5. **Analyze** the need of Finite Element Method
6. **Model** the Coupled Electromechanical Systems

Course Contents:

Module-1 Introduction **[7 Hrs]**

Why Miniaturization?, Microsystems versus MEMS, Why Microfabrication? Smart Materials, Structures and Systems, Integrated Microsystems, Applications of Smart Materials and Microsystems

Module-2 Micro Sensors, Actuators, Systems and Smart Materials: An Overview **[8 Hrs]**

Silicon Capacitive Accelerometer, Piezoresistive Pressure Sensor, Conductometric Gas Sensor, An Electrostatic Comb-Drive, A Magnetic Microrelay, Portable Blood Analyzer, Piezoelectric Inkjet Print Head, Micromirror Array for Video Projection, Smart Materials and Systems

Module-3 Micromachining Technologies **[8 Hrs]**

Silicon as a Material for Micromachining, Thin-Film Deposition, Lithography, Etching, Silicon Micromachining, Specialized Materials for Microsystems, Advanced Processes for Microfabrication

Module-4 Modelling of Solids in Microsystems **[10 Hrs]**

The Simplest Deformable Element: A Bar, Transversely Deformable Element: A beam, Energy Methods for Elastic Bodies, Examples and Problems, Heterogeneous Layered Beams, Bimorph Effect, Residual Stresses

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and Stress Gradients, Poisson Effect and the Anticlastic Curvature of Beams, Torsion of Beams and Shear Stresses, Dealing with Large Displacements, In-Plane Stresses

Module-5 Finite Element Method **[8 Hrs]**

Need for Numerical Methods for Solution of Equations, Variational Principles, Weak Form of the Governing Differential Equation, Finite Element Method, Numerical Examples, Finite Element Model for Structures with Piezoelectric Sensors and Actuators, Analysis of a Piezoelectric Bimorph Cantilever Beam

Module-6 Modelling of Coupled Electromechanical Systems **[7 Hrs]**

Electrostatics, Coupled Electromechanics: Statics, Coupled Electromechanics: Stability and Pull-In Phenomenon, Coupled Electromechanics: Dynamics, Squeezed Film Effects in Electromechanics

Text Books:

1. G.K. Ananthasuresh, K.J. Vinoy, S. Gopalakrishnan, K.N. Bhat, V.K. Aatre, Micro and Smart Systems, Wiley India, First Edition, 2010..

References Books:

1. Nadim Maluf, "An Introduction to Micro Electro Mechanical System Design", Artech House, 2000.
2. Mohamed Gad-el-Hak, editor, "The MEMS Handbook", CRC press Baco Raton, 2001.
3. Julian w. Gardner, Vijay K. Varadan, Osama O.Awadelkarim, Micro Sensors MEMS and Smart Devices, John Wiley & Son LTD, 2002.
4. James J. Allen, Micro Electro Mechanical System Design, CRC Press Publisher, 2005.
5. Thomas M.Adams and Richard A.Layton, "Introduction MEMS, Fabrication and Application," Springer, 2010.

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