Savitribai Phule Pune University

Faculty of Science and Technology



Syllabus for

B.E (Electronics & Telecommunication Engineering)

(Course 2019)

(w.e.f. June 2022)

Savitribai Phule Pune University, Pune
B.E. (Electronics & Telecommunication) 2019 Course
(With effect from Academic Year 2022-23)

Semester-VII

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit			
		Theory	Practical	Tutorial	In-Sem	End-Sem	TW	PR	OR	Total	TH	PR	TUT	Total
404181	Radiation & Microwave Theory	03	-	-	30	70	-	-	-	100	03	-	-	03
404182	VLSI Design and Technology	03	-	-	30	70	-	-	-	100	03	-	-	03
404183	Cloud Computing	03	-	-	30	70	-	-	-	100	03	-	-	03
404184	Elective - 3	03	-	-	30	70	-	-	-	100	03	-	-	03
404185	Elective - 4	03	-	-	30	70	-	-	-	100	03	-	-	03
404186	Lab Practice - 1 (RMT & Cloud Computing)	-	04	-	-	-	25	-	50	75	-	02	-	02
404187	Lab Practice - 2 (VLSI Design & Elective -3)	-	04	-	-	-	25	50	-	75	-	02	-	02
404188	Project Stage - I	-	02	-	-	-	50	-	-	50	-	01	-	01
404189	Mandatory Audit Course 7	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**15**	**10**	**-**	**150**	**350**	**100**	**50**	**50**	**700**	-	-	-	-
	Total Credits										**15**	**05**	**-**	**20**

Elective - 3	**Elective - 4**
1. Speech Processing	1. Data Mining
2. PLC SCADA & Automation	2. Electronic Product Development
3. JAVA Script	3. Deep Learning
4. Embedded & RTOS	4. Low Power CMOS
5. Modernized IoT	5. Smart Antennas

Mandatory Audit Course - 7
1. Management Information System
2. Patent Search & Analysis
3. Knowledge Management
4. Energy Economics & Policy
5. Educational Leadership
6. Human Resource Development

Program Outcomes (PO's)	
Engineering Graduates will be able to:	
1.	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2.	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3.	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4.	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of theinformation to provide valid conclusions.
5.	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6.	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant tothe professional engineering practice.
7.	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and needfor sustainable development.
8.	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9.	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10.	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11.	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12.	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Savitribai Phule Pune University

Fourth Year of E & Tc Engineering (2019 Course)

404181: Radiation and Microwave Theory

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 Hrs. / Week	03	In-Sem (Theory): 30 Marks End Sem (Theory): 70 Marks

Prerequisite Courses, if any:

1. Electromagnetic Field Theory

Companion Course, if any:

1. Lab Practice – 1

Course Objectives:

1. To introduce fundamental theory of radiation and microwaves.
2. To understand theory of passive and active components of microwave systems.
3. To know the characteristics of various microwave solid state active devices.
4. To learn microwave measurement techniques.

Course Outcomes: On completion of the course, learner will be able to

CO1: Apply the fundamentals of electromagnetic to derive free space propagation equation and distinguish various performance parameters of antenna.

CO2: Identify various modes in the waveguide. Compare: coaxial line, rectangular waveguides & striplines and identify applications of the same.

CO3: Explore construction and working of principles passive microwave devices/components.

CO4: Explore construction and working of principles active microwave devices/components.

CO5: Analyze the structure, characteristics, operation, equivalent circuits and applications of various microwave solid state active devices.

CO6: Know the various microwave systems, device set ups of microwave measurement devices and Identify the effect of radiations on environmental sustainability.

Course Contents

Unit I	Fundamental Theory of Radiation and Radiating Elements	6 Hrs.

Fundamental equations for free space **(Friis transmission equation)**, Definition of antenna, radiation mechanism and types of antenna, performance parameters such as radiation pattern, directivity, gain, efficiency, half power beam width, bandwidth, polarization, input impedance, radiation efficiency, effective length, effective area, radiation sphere.

Mapping of Course Outcomes for Unit I	**CO1: Apply** the fundamentals of electromagnetic to derive free space propagation equation and distinguish various performance parameters of antenna.

Unit II	Transmission Lines and Waveguides	6 Hrs.
Introduction to microwaves, short history of microwave engineering, frequency band definitions, advantages and applications of microwaves (overall applications). Introduction to wave guides, advantages of waveguides, comparison of waveguides and co-axial cables, Rectangular waveguides, modes of propagation in waveguides, cut off frequency, dominant mode, waveguide characteristics and parameters, excitation in waveguides, coupling methods (probe, slot, loop), application of re-entrant cavities, coupling of cavities, Striplines: Structural details, types and applications.		
Mapping of Course Outcomes for Unit II	**CO2: Identify various modes in the waveguide. Compare: coaxial line, rectangular waveguides & striplines and identify applications of the same.**	
Unit III	**Passive Microwave Components**	**6 Hrs.**
Construction, working principle and scattering analysis of passive microwave components such as E-plane, H-plane and magic tee. Ferrite composition, characteristics and Faraday rotation principle. Construction, working principle and scattering analysis of Isolator, Circulator and Directional coupler. Construction and operation of Gyrator, Microwave Filters, Phase Shifter, Microwave Attenuator.		
Mapping of Course Outcomes for Unit III	**CO3: Explore construction and working of principles passive microwave devices / components.**	
Unit IV	**Active Microwave Components**	**6 Hrs.**
Limitations of conventional tubes, O and M type classification of microwave tubes, re-entrant cavity, velocity modulation. Construction, operation, performance analysis and applications of -Single cavity and two cavity klystron, Cylindrical wave Magnetron and Helix Traveling wave, Numericals.		
Mapping of Course Outcomes for Unit IV	**CO4: Explore construction and working of principles active microwave devices/components.**	
Unit V	**Solid State Microwave Devices**	**6 Hrs.**
Introduction, Principle of operation, construction, characteristics, parameters with analysis of Microwave transistors, MOSFET, Varactor diodes, Parametric amplifiers, PIN diodes, Tunnel diodes, application as amplifiers, oscillators, modulators, demodulators, Schottky Barrier diodes, Transferred Electron devices: Gunn diode, Avalanche diode, Transit Time devices like IMPATT, TRAPATT diodes.		
Mapping of Course Outcomes for Unit V	**CO5: Analyze the structure, characteristics, operation, equivalent circuits and applications of various microwave solid state active devices.**	

Unit VI	Microwave Systems and Microwave Measurement Techniques	6 Hrs.
Microwave terrestrial and satellite communication system, Fundamentals of RADAR and RADAR range equation. Industrial applications of microwaves such as microwave heating, medical application such as microwave diathermy. Microwave measurement devices such as slotted line, tunable detector, VSWR meter, power meter, and their working principles. Microwave measurement techniques to measure S-parameters, frequency, power, attenuation, VSWR, impedance. Radiation hazards and protection.		
Mapping of Course Outcomes for Unit VI	**CO6: Know the various microwave systems, device set ups of microwave measurement devices and Identify the effect of radiations on environmental sustainability.**	

Learning Resources

Text Books:

1. C.A. Balanis, "Antenna Theory - Analysis and Design", 4th Edition, John Wiley.
2. Samuel Y. Liao, "Microwave Devices and Circuits", 3rd Edition, Pearson.
3. Annapurna Das and Sisir K. Das, "Microwave Engineering", 2nd Edition, Tata McGraw Hill.

Reference Books:

1. K. D. Prasad, "Antenna & Wave Propagation", 3rd Edition, Satya Prakashan, New Delhi.
2. E.C. Jordon and E.G. Balman, "Electromagnetic Waves and Radiation Systems", 2nd Edition, Prentice Hall Inc.
3. David M. Pozar, "Microwave Engineering", 4th Edition, John Wiley.
4. Ahmad Shahid Khan, "Microwave Engineering: Concepts and Fundamentals", CRC Press
5. M. Kulkarni, "Microwave and Radar Engineering, 3rd Edition, Umesh Publication

MOOC / NPTEL Courses:

1. NPTEL Course on "**Microwave Theory and Techniques**", By Prof. Girish Kumar, IIT Mumbai
   Link: https://nptel.ac.in/courses/108101112

2. NPTEL Course on "**Antenna**", By Prof. Girish Kumar, IIT Mumbai
   Link: https://nptel.ac.in/courses/108101092

Savitribai Phule Pune University

Fourth Year of E & Tc Engineering (2019 Course)

404182: VLSI Design and Technology

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 Hrs. / Week	03	In-Sem (Theory): 30 Marks End Sem (Theory): 70 Marks

Prerequisite Courses, if any:

1. Digital Electronics

Companion Course, if any:

1. Lab Practice – 2

Course Objectives:

1. To explore Hardware Description Language (HDL) and respective digital design methodologies.
2. To train the students for Complementary Metal Oxide Semiconductor (CMOS) circuit designs.
3. To realize importance of testability in logic circuit design.
4. To overview an Application Specific Integrated Circuit (ASIC) issues and to understand Programmable Logic Devices (PLD) architectures with advanced features.

Course Outcomes: On completion of the course, learner will be able to

CO1: Develop effective HDL codes for digital design.
CO2: Apply knowledge of real time issues in digital design.
CO3: Model digital circuit with HDL, simulate, synthesis and prototype in PLDs.
CO4: Design CMOS circuits for specified applications.
CO5: Analyze various issues and constraints in design of an ASIC.
CO6: Apply knowledge of testability in design and Build In Self Test (BIST) circuit.

Course Contents

Unit I	Design with HDL	7 Hrs.
Design Flow, Language constructs, Data objects, Data types, Entity, Architecture & types of modeling, Sequential statements, Concurrent statements, Packages, Sub programs, Attributes, HDL modeling of Combinational, Sequential circuits and FSM. Simulations, Synthesis, Efficient coding styles, Hierarchical and flat designs, Partitioning for synthesis, Pipelining, Resource sharing.		
Mapping of Course Outcomes for Unit I	**CO1: Develop effective HDL codes for digital design.**	
Unit II	**Digital Design and Issues**	**6 Hrs.**
Sequential synchronous machine design, Moore and Mealy machines, HDL code for Machines, FIFO. Meta-stability and solutions. Noise margin, Fan-out, Skew, Timing considerations, Hazards, Clock distribution, Clock jitter, Supply and ground bounce, Power distribution techniques, Power optimization. Interconnect routing techniques, Wire parasitic, Signal integrity issues. I/O architecture.		
Mapping of Course Outcomes for Unit II	**CO2: Apply knowledge of real time issues in digital design.**	

Unit III	PLD Architectures and Applications	6 Hrs.
Design Flow. CPLD Architecture, Features, Specifications, Applications. FPGA Architecture, Features, Specifications, Applications. Clock management techniques. The Simulation and Synthesis Tools, FPGA synthesis and implementation. Comparison of CPLD & FPGA.		
Mapping of Course Outcomes for Unit III	**CO3: Model digital circuit with HDL, simulate, synthesis and prototype in PLDs.**	
Unit IV	**Digital CMOS Circuits**	**7 Hrs.**
N-MOS, P-MOS and CMOS. MOSFET parasitic, Technology scaling, Channel length modulation, Hot electron effect, Velocity saturation. CMOS Inverter, Device sizing, CMOS combinational logic design, Power dissipations, Power delay product, Body Effect, Rise and fall times, Latch Up effect, Transmission gates.		
Mapping of Course Outcomes for Unit IV	**CO4: Design CMOS circuits for specified applications.**	
Unit V	**Application Specific Integrated Circuits**	**7 Hrs.**
Design Flow, Cell design specifications, Spice simulation, AC and DC analysis, Transfer Characteristics, Transient responses, Noise analysis, Lambda rules, Design Rule Check, Fabrication methods of circuit elements, Layout of cell, Library cell designing for NAND & NOR, Circuit Extraction, Electrical Rule Check, Layout Vs. Schematic, Post-layout Simulation and Parasitic extraction, Design Issues like Antenna effect, Electro migration effect, Cross talk and Drain punch through, Timing analysis.		
Mapping of Course Outcomes for Unit V	**CO5: Analyze various issues and constraints in design of an ASIC.**	
Unit VI	**VLSI Testing and Analysis**	**6 Hrs.**
Types of fault, Need of Design for Testability (DFT), DFT Guideline, Testability, Fault models, Path sensitizing, Test pattern generation, Sequential circuit test, Built In Self Test, JTAG & Boundary scan, TAP Controller.		
Mapping of Course Outcomes for Unit VI	**Apply knowledge of testability in design and Build In Self Test (BIST) circuit.**	

Learning Resources

Text Books:

1. Charles H. Roth, "Digital Systems Design using VHDL", 2nd Edition, Thompson Learning
2. Wyane Wolf, "Modern VLSI Design (IP-Based Design)", 4th Edition, Prentice Hall.
3. Steve Kilts, "Advanced FPGA Design Architecture, Implementation and Optimization" Wiley Interscience.
4. E. Weste, David Money Harris, "CMOS VLSI Design: A Circuit & System Perspective", 4th Edition, Pearson Publication.

Reference Books:

1. R. Jacob Baker, “CMOS Circuit Design, Layout, and Simulation”, 3rd Edition, Wiley-IEEE Press.
2. John F. Wakerly, “Digital Design Principles and Practices”, 3rd Edition, Prentice Hall.
3. M. Morris Mano , “Digital Design”, 3rd Edition , Pearson.
4. Cem Unsalan, Bora Tar, “Digital System Design with FPGA: Implementation Using Verilog and VHDL”, McGraw-Hill.

MOOC / NPTEL Courses:

1. NPTEL Course on “**VLSI Technology**”, By Dr. Nandita Dasgupta, IIT Madras

   Link: https://nptel.ac.in/courses/117106093

2. NPTEL Course on “**VLSI Circuits**”, By Prof. S.Srinivasan, IIT Madras

   Link: https://nptel.ac.in/courses/117106092

Savitribai Phule Pune University Fourth Year of E & Tc Engineering (2019 Course) 404183: Cloud Computing		
Teaching Scheme:	**Credit**	**Examination Scheme:**
Theory: 03 Hrs. / Week	**03**	**In-Sem (Theory): 30 Marks** **End Sem (Theory): 70 Marks**

Prerequisite Courses, if any:

1. Database Management

Companion Course, if any:

1. Lab Practice – 1

Course Objectives:

1. To introduce the fundamentals of Cloud computing, its technologies, Challenges and Applications
2. To give Insights into the virtualization technologies and Architecture.
3. To know the relationship between Cloud and SOA.
4. To classify and evaluate Cloud Security Issues.
5. To apply theory to practical knowledge through case Studies.

Course Outcomes: On completion of the course, learner will be able to

CO1: Understand the basic concepts of Cloud Computing.
CO2: Describe the underlying principles of different Cloud Service Models.
CO3: Classify the types of Virtualization.
CO4: Examine the Cloud Architecture and understand the importance of Cloud Security.
CO5: Develop applications on Cloud Platforms.
CO6: Evaluate distributed computing and the Internet of Things.

Course Contents

Unit I	Fundamentals of Cloud Computing	6 Hrs.

Introduction to Cloud Computing, History of Cloud Computing, Characteristics of Cloud Computing, Cloud Types: NIST, Cloud cube, Cloud service models, Cloud Computing deployment models, Exploring the Cloud Computing Stack, Advantages, Disadvantages and Applications of cloud computing.

Mapping of Course Outcomes for Unit I	CO1: Understand the basic concepts of Cloud Computing.

Unit II	Cloud Service Models	6 Hrs.

Introduction and benefits of Cloud services, Characteristics, benefits, applications of different cloud service models, Software as a service(SaaS), Platform as a service (PaaS), Infrastructure as a service (IaaS), Network as a service (NaaS), Identity as a service (IdaaS), Database as a service (DbaaS), Comparison of cloud services.

Mapping of Course Outcomes for Unit II	**CO2: Describe the underlying principles of different Cloud Service Models.**	
Unit III	**Virtualization**	**6 Hrs.**
Introduction to Virtualization, Difference between Cloud Computing and Virtualization **Types of Virtualization:** Hardware, Software, Operating system, Server, Storage, Methods of implementing storage Virtualization, Network Virtualization Types, Advantages, Disadvantages, Virtualization Architecture and Software, Virtual Clustering, Applications of Virtualization.		
Mapping of Course Outcomes for Unit III	**CO3: Classify the types of Virtualization.**	
Unit IV	**Service Oriented Architecture and Cloud Security**	**7 Hrs.**
Cloud Computing Architecture (COA): Design principles, Cloud computing life cycle (CCLC), Cloud computing reference architecture, Service Oriented Architecture (SOA) characteristics and fundamental components. **Cloud Security:** Cloud CIA security model (Confidentiality, Integrity and Availability), Cloud computing security architecture, Service provider security issues, Cloud Security Issues and challenges, Security issues in virtualization, Host Security, Data Security, Firewalls.		
Mapping of Course Outcomes for Unit IV	**CO4: Examine the Cloud Architecture and understand the importance of Cloud Security.**	
Unit V	**Cloud Environment and Application Development**	**7 Hrs.**
Cloud Platforms: Google App Engine, Compute Services, Storage Services, Communication Services, Amazon Web Services Architecture and core concepts, Application Lifecycle, Cost Model, Microsoft Azure Cloud services Azure core concepts, Windows Azure Platform Appliance.		
Mapping of Course Outcomes for Unit V	**CO5: Develop applications on Cloud Platforms.**	
Unit VI	**Distributed Computing and Internet of Things**	**6 Hrs.**
Distributed Computing: Need, Distributed computing vs. Cloud computing, Enabling Technologies for the Internet of Things, Innovative Applications of the Internet of Things, Online Social and Professional Networking.		
Mapping of Course Outcomes for Unit VI	**CO6: Evaluate Distributed Computing and the Internet of Things.**	

Learning Resources

Text Books:

1. Kailash Jayaswal, Jagannath Kallakurchi, Donald J. Houde, Dr. Deven Shah, "Cloud Computing: Black Book", Dreamtech Press.
2. Surbhi Rastogi, "Cloud Computing Simplified", 2021 Edition, BPB Publications.
3. Kai Hwang, Geoffrey.C.Fox., Jack J. Dongarra, "Distributed and Cloud Computing: From Parallel Processing to Internet of Things", MK Publications, Elsevier

Reference Books:

1. Kamal Kant Hiran, et al. "Cloud Computing: Master the concepts, Architecture and Applications with Real-world examples and Case Studies", 1st Edition, BPB Publication.
2. Judith Hurwitz, "Cloud Computing for dummies", 2nd Edition, Wiley India.
3. A. Srinavasan, J. Suresh, "Cloud Computing: A Practical Approach for Learning and Implementation", Pearson.
4. Anthony T. Velte Toby J. Velte, Robert Elsenpeter, "Cloud Computing: A Practical Approach", McGraw-Hill.
5. Barrie Sosinsky, "Cloud Computing Bible", Wiley Publishing Inc.
6. Rajkumar Buyya, Christian Vecchiola, S. Thamarai Selvi, "Mastering Cloud Computing", McGraw Hill Education

MOOC / NPTEL Courses:

1. NPTEL Course on "**Cloud Computing**", By Prof. Soumya Kanti Ghosh, IIT Kharagpur.

   Link: https://nptel.ac.in/courses/106105093

2. NPTEL Course on "**Google Cloud Computing Foundation Course**", By Prof. Soumya Kanti Ghosh, IIT Kharagpur.

   Link: https://nptel.ac.in/courses/106105223

Recommended Websites:

1. www.whatiscloud.com
2. www.cloudcomputingpatterns.org
3. www.w3schools.com

Savitribai Phule Pune University

Fourth Year of E & Tc Engineering (2019 Course)

404184 (A): Speech Processing (Elective - III)

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 Hrs. / Week	03	In-Sem (Theory): 30 Marks End Sem (Theory): 70 Marks

Prerequisite Courses, if any:

1. Signals & Systems
2. Digital Signal Processing

Companion Course, if any:

1. Lab Practice – 2

Course Objectives:

1. To understand basics of Human speech production mechanism and classification of speech sounds.
2. To understand the short-term analysis of speech signal in time and frequency domain.
3. To extract the information of the speech signal in terms of cepstral features.
4. To understand various audio and speech coding techniques using speech Modelling algorithms.
5. To provide a platform for developing applications in the field of speech and audio processing.

Course Outcomes: On completion of the course, learner will be able to

CO1: Understand basics of Human speech production mechanism.

CO2: Classify speech sounds based on acoustic and articulatory phonetics.

CO3: Analyse speech signal to extract the characteristic of vocal tract (formants) and vocal cords (pitch).

CO4: Evaluate speech signal for extracting LPC and MFCC Parameters of speech signal.

CO5: Implement algorithms for processing of speech and audio signals considering the properties of acoustic signals.

CO6: Design speech recognition application for speech signal analysis.

Course Contents

Unit I	Fundamentals of Speech Processing	6 Hrs.

Human speech production mechanism, LTI model for speech production, Nature of speech signal, phonetics, articulators, manner of articulation, place of articulation, linear time varying model.

Classification of speech sounds: vowels, semivowels, nasal diphthongs, stops, affricates, fricative, vowel triangle.

Parameters of speech: Fundamental frequency or pitch frequency-Autocorrelation method for finding pitch period, AMDF method for finding pitch period. Formants.

Mapping of Course Outcomes for Unit I	**CO1: Understand basics of Human speech production mechanism.**

Unit II	Time and Frequency domain methods for Speech and Audio signal analysis.	7 Hrs.
Time dependent speech processing. Short-time energy, short time average magnitude, Short time average zero crossing rate. Speech Vs. silence discrimination using energy and zero crossing rate. Short-time autocorrelation function, short-time average magnitude difference function. Audio feature extraction, Spectral centroid, spectral spread, spectral entropy, spectral flux, spectral roll-off. Spectrogram: narrow band and wide band spectrogram.		
Mapping of Course Outcomes for Unit II	**CO2: Classify speech sounds based on acoustic and articulatory phonetics.**	
Unit III	**Linear prediction and cepstral analysis**	**6 Hrs.**
Basic principles of linear predictive analysis, Linear prediction of speech, auto correlation, formulation of LPC equation, solution of LPC equations, Cepstral analysis of speech, cepstral coefficients, Computation of Mel Frequency Cepstral Coefficients (MFCC).		
Mapping of Course Outcomes for Unit III	**CO3: Analyse speech signal to extract the characteristic of vocal tract (formants) and vocal cords (pitch).**	
Unit IV	**Speech and Audio Coding**	**6 Hrs.**
Time domain waveform coding: Linear PCM, Companded PCM, DPCM. **Spectral coders:** Filter bank analysis, sub-band coders, Adaptive transform coders (ATC), Harmonic coding. Linear predictive coders (LPC), Non-LP source voice coders: phase vocoders, Homomorphic (Cepstral) vocoders.		
Mapping of Course Outcomes for Unit IV	**CO4: Evaluate speech signal for extracting LPC and MFCC Parameters of speech signal.**	
Unit V	**Applications of Speech Processing**	**6 Hrs.**
Automatic Speech Recognition, Feature Extraction for ASR, Deterministic sequence recognition, Statistical Sequence recognition, ASR systems, Speaker identification and verification. **Speech Synthesis:** Text-to-Speech Synthesis: Concatenative and waveform synthesis methods, intelligibility and naturalness in speech synthesis, role of prosody.		
Mapping of Course Outcomes for Unit V	**CO5: Implement algorithms for processing of speech and audio signals considering the properties of acoustic signals.**	
Unit VI	**Speech Processing using Machine Learning techniques**	**6 Hrs.**
Comparison of speech processing applications **Automatic Speech Recognition** and **Speech Synthesis- Text-to-Speech Synthesis** using Support Vector Machine (SVM), Convolutional Neural Networks (CNN) and Recurrent Neural Networks (RNN). Performance parameters for comparison - Accuracy, True Positives, True Negatives, False Positives, False Negatives, Sensitivity, Specificity, Area Under Curve (AUC), Receiver Operating Characteristic (ROC).		

Mapping of Course Outcomes for Unit VI	CO6: Design speech recognition application for speech signal analysis.

Learning Resources

Text Books:

1. L.R.Rabiner and S.W.Schafer, "Digital Processing of Speech Signals" 1st Edition Pearson Education.
2. Daniel Jurafsky and James H Martin, "Speech and Language Processing – An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition", 2nd Edition, Pearson Education.

Reference Books:

1. Thomas F. Quateri, "Discrete-Time Speech Signal Processing: Principles and Practice", Prentice Hall- Signal Processing Series.
2. Shaila Apte, "Speech and Audio Processing", 1st Edition, Wiley India Publication.
3. Ben Gold and Nelson Morgan, "Speech and Audio Signal Processing: Processing and Perception of Speech and Music", 2nd Edition, Wiley India Publication.
4. Uday Kamath, John Liu, James Whitaker, "Deep Learning for NLP and Speech Recognition", 1st Edition , Springer Publication

MOOC / NPTEL Courses:

1. NPTEL Course on "**Digital Speech Processing**", By Prof. Shyamal Kumar Das Mandal, IIT Kharagpur.

   Link: https://nptel.ac.in/courses/117105145

Savitribai Phule Pune University

Fourth Year of E & Tc Engineering (2019 Course)

404184 (B): PLC SCADA and Automation (Elective - III)

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 Hrs. / Week	03	In-Sem (Theory): 30Marks End Sem (Theory): 70 Marks

Prerequisite Courses, if any:

1. Control Systems
2. Sensor's in Automation
3. Power Devices and Circuits

Companion Course, if any:

1. Lab Practice – 2

Course Objectives:

1. Understanding and Recognize Industrial control problems.
2. Concept of PLC's and Its Importance in Industrial Automation.
3. Development of Ladder Programming in PLC and PLC Interface in real time applications.
4. Overview of technology of advanced automation Systems such as SCADA, DCS Systems.
5. Learning of CNC fundamentals and Important Protocols in Industrial Automation

Course Outcomes: On completion of the course, learner will be able to

CO1: Understand and Recognize Industrial Control Problems.
CO2: **Analyze** & explain different hardware functions of PLC.
CO3: Develop Ladder Programming in PLC and PLC Interface in real time applications.
CO4: Explore and interpret functionality of SCADA.
CO5: Identify and interpret the functionality of DCS.
CO6: Define and explain CNC machines and Applications of Industrial Protocols.

Course Contents

Unit I	Elements of Process Control Automation	7 Hrs.

Process control principles, Control System Evaluation, Analog control, Digital control, Architecture of Industrial Automation Systems (Automation Pyramid), Advantages and limitations of Automation, Concept and Need of transmitters, Standardization of signals, Current, Voltage and Pneumatic signal standards, 2-Wire & 3-Wire transmitters, Concept of VFD, Energy conservation schemes through VFD.

Mapping of Course Outcomes for Unit I	CO1: Understand and Recognize Industrial Control Problems

Unit II	Fundamentals of PLC	7 Hrs.

Architecture of PLC- Types of PLC's, Applications of PLC's, PC v/s PLC, Different Modules, Power Supply Unit etc. Need of PLC, Different Types of Sensors- Sinking, Sourcing. Operation and function. Monitoring of Process through Sensors- Connection Details. Analog Addressing, continuous Process Monitoring and Control.

Mapping of Course Outcomes for Unit II	CO2: Analyze & explain different hardware functions of PLC.

Unit III	Programming of Programmable Logic Controllers	7 Hrs.
PLC programming, NO/ NC Concept, Ladder diagram: of logic gates, arithmetic instructions, multiplexer, Ladder diagram for different logical conditions or logical equations or truth table. Timers: types of timer, Characteristics, Function of timer in PLC, Classification of a PLC timer, Ladder diagram using timer, PLC counter, Ladder diagram using counter. PLC Programming of Branded PLCs. Concept of P,PI,PD,PID w.r.t. PLC, Data File Handling- Forcing I/O.		
Mapping of Course Outcomes for Unit III	**CO3: Develop Ladder Programming in PLC and PLC Interface in real time applications.**	
Unit IV	**Supervisory Control and Data Acquisition Systems (SCADA)**	**6 Hrs.**
Concept of SCADA, Architecture of SCADA, Components of SCADA Systems, MTU- functions of MTU, RTU- Functions of RTU, Directly interact with devices such as sensors, valves, pumps, motors, and more through human-machine interface (HMI) software. Working of SCADA, Applications of SCADA in Industrial Automation like Oil and gas, Power etc.		
Mapping of Course Outcomes for Unit IV	**CO4: Explore and interpret functionality of SCADA.**	
Unit V	**Distributed Control Systems (DCS)**	**6 Hrs.**
Basic Concept of DCS, History and Hierarchy of DCS, Basic Componenents of DCS as Operator Station, Control Module, and I/O module , Types of DCS, Need of DCS, Functions of each level, Advantages and Disadvantages, Applications of DCS such as Water Treatment Plant, Comparison of PLC, DCS and SCADA		
Mapping of Course Outcomes for Unit V	**CO5: Identify and interpret the functionality of DCS.**	
Unit VI	**CNC Machines and Industrial Protocols**	**7 Hrs.**
Introduction of CNC Machines, Basics and need of CNC machines, NC, CNC and DNC (Direct NC) systems, Structure of NC systems, Applications of CNC machines in manufacturing, Advantages of CNC machines. Industrial Communication: Devicenet, Foundation Fieldbus, PROFIBUS, MODBUS, Ethernet, TCP/IP, Concept of Industry 4.0.		
Mapping of Course Outcomes for Unit VI	**CO6: Define and explain CNC machines and Applications of Industrial Protocols.**	

Learning Resources

Text Books:

1. Curtis Johnson, "Process Control Instrumentation Technology", 8th Edition, Pearson Education.
2. Madhuchhanda Mitra, Samarjit Sen Gupta, "Programmable Logic controllers and Industrial Automation", 2nd Edition, Penram International Publishing India Pvt. Ltd.

Reference Books:

1. Stuart A. Boyer, "SCADA Supervisory Control and Data Acquisition", 4th Edition, ISA Publication.
2. John W. Webb, Ronold A Reis," Programmable Logic Controllers, Principles and Applications", 5th Edition, Prentice Hall of India Pvt. Ltd.
3. Kilian, "Modern control technology: components & systems", 2nd Edition, Delmar.
4. Bela G Liptak "Process Software and Digital Networks", 4th Edition, CRC Press
5. Pollack. Herman, W & Robinson., T. "Computer Numerical Control", Prentice Hall.
6. Pabla, B.S. &Adithan, M. "CNC Machines", New Age Publishers.
7. R.G. Jamkar, "Industrial Automation Using PLC SCADA & DCS" Global Education Limited

MOOC / NPTEL Courses:

1. NPTEL Course on "**Industrial Automation and Control**", by Prof. S. Mukhopadhyay, IIT Kharagpur.

Link: https://nptel.ac.in/courses/108105088

Savitribai Phule Pune University

Fourth Year of E & TC Engineering (2019 Course)

404184 (C): Java Script (Elective - III)

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 Hrs. / Week	03	In-Sem (Theory): 30 Marks End Sem (Theory): 70 Marks

Prerequisite Courses, if any:

1. Fundamentals of Java Programming
2. Advanced Java Programming

Companion Course, if any:

1. Lab Practice – 2

Course Objectives:

1. To learn the syntax and semantics of Java script.
2. To understand the data types and variables in Java script.
3. To learn how functions and objects are used in Java script.
4. To learn how to use regular expressions in java script for handling various string operations.
5. To understand the concept of object models and event handling in java script programs.
6. To learn the use of java script for controlling Windows and form handling

Course Outcomes: On completion of the course, learner will be able to -

CO1: Use basic features of java script.

CO2: Use relevant data types for developing application in java script.

CO3: Use the function and objects as self-contained, with data passing in and out through well-defined interfaces in development of small systems.

CO4: Apply the regular expression for Text matching and manipulation.

CO5: Explore use of the various aspects of JavaScript object models that are fundamental to the proper use of the language.

CO6: Develop the application using windows controlling and form handling.

Course Contents

Unit I	Introduction to Java Scripts	6 Hrs.

Introduction – First Look at JavaScript, Adding JavaScript to XHTML Documents- The <script> Element, Using the <script> Element, Event Handlers, Linked Scripts, History and Use of JavaScript, JavaScript Core Features- Overview-Basic Definitions, Language Characteristics, Variables, Basic Data Types, Composite Types, Flow Control Statements, Loops, Functions, Input and Output in JavaScript, Regular Expressions.

Mapping of Course Outcomes for Unit I	CO1: Use basic features of java script.

Unit II	Data Types and Variables	8 Hrs.
JavaScript's Primitive Types- Numbers, Hexadecimal Literals, Octal Literals, Special Values, Data Representation Issues, Data Representation Issues, Strings, Undefined and Null; Composite Types- Objects, The typeof Operator, Type Conversion, Variables. Operators, Expressions, and Statements- Statement Basics, Whitespace, Termination: Semicolons and Returns, Blocks. **Operators**- Assignment Operator, Arithmetic Operators, Bitwise Operators, Bitwise Shift Operators, Increment/Decrement, Logical Operators, void Operator, Object Operators **Core JavaScript Statements**- if Statements, switch, while Loops, do-while Loops, for Loops, for Loops, Object-Related Statements, Object Loops Using for in		
Mapping of Course Outcomes for Unit II	**CO2: Use relevant data types for developing application in java script.**	
Unit III	**Functions and Objects**	**6 Hrs.**
Function Basics- Parameter-Passing Basics, return Statements, Parameter Passing: In and Out. Global and Local Variables- Mask Out, Local functions **Functions as Objects**- Function Literals and Anonymous Functions, Static Variables, Advanced Parameter Passing, Recursive Functions, Using Functions **Objects**- Objects in JavaScript, Object Fundamentals Enumerating Properties, Objects Are Reference Types, Passing Objects to Functions, Common Properties and Methods, Array, Date, Math, Number, String, Object Types and Primitive Types		
Mapping of Course Outcomes for Unit III	**CO3: Use the function and objects as self-contained, with data passing in and out through well-defined interfaces in development of small systems.**	
Unit IV	**Regular Expressions**	**6 Hrs.**
The Need for Regular Expressions, Introduction to JavaScript Regular Expressions, Creating Patterns, Repetition Quantifiers, Grouping, Common Character Classes, RegExp Object, exec(). **String Methods for Regular Expressions:** search(), split(),replace(),replace() with Sub expressions **Advanced Regular Expressions:** Multiline Matching, Non-capturing Parentheses, Lookahead, Greedy Matching, Limitations of Regular Expressions.		
Mapping of Course Outcomes for Unit IV	**CO4: Apply the regular expression for Text matching and manipulation.**	
Unit V	**Fundamental Client-Side JavaScript and Event Handling**	**6 Hrs**
JavaScript Object Models: Object Model Overview, The Initial JavaScript Object Model, The Object Models **The Standard Document Object Model**: DOM Flavors, Document Trees, Accessing Elements, Creating Nodes, Inserting and Appending Nodes, Deleting and Replacing Nodes, The DOM and HTML Elements, The DOM and CSS, The DOM Versus DHTML Object Models. Overview of Events and Event Handling, The Basic Event Model, Netscape 4 Event Model, Internet Explorer 4+ Event Model, DOM2 Event Model, Event Model Issues.		
Mapping of Course Outcomes for Unit V	**CO5: Explore use of the various aspects of JavaScript object models that are fundamental to the proper use of the language.**	

Unit VI	Using Java scripts	8 Hrs.
Controlling Windows and Frames: Introduction to Window, Dialogs, Opening and Closing Generic Windows, Window Features, Writing to Windows, Controlling Windows, Window Events, Frames: A Special Case of Windows, Frames: A Special Case of Windows. **Form Handling:** Form Basics, Form Fields, Select Menus Option Groups, Other Form Elements: Label, Fieldset, and Legend, Form Validation, Form Usability and JavaScript, Dynamic Forms.		
Mapping of Course Outcomes for Unit VI	**CO6: Develop the application using windows controlling and for handling.**	

Learning Resources

Text Books:

1. Thomas Powell and Fritz Schneider, "JavaScript 2.0: The Complete Reference", 2nd Edition, McGraw Hill
2. Kogent Learning Solutions, "HTML, JavaScript, PHP, Java, JSP, XML and AJAX" Black Book, Dreamtech Press.

Reference Books:

1. Jon Duckett, "JavaScript & J Query: Interactive Front-End Web Development", John Wiley & Sons.
2. David Flanagan, "JavaScript: The Definitive Guide", 7th Edition, O'Reilly Media.
3. Mike Mackgrath, "Javascripts in Easy Steps" Dreamtech Press

MOOC / NPTEL Courses:

1. NPTEL Course on "**Internet Technology**", by Prof. Indranil Sengupta, IIT Kharagpur
   Link: https://nptel.ac.in/courses/106105084

2. Udemy course on **"JavaScript: Understanding the Weird Parts**"
   Link: **https://www.udemy.com/course/understand-javascript/**

Savitribai Phule Pune University

Fourth Year of E & Tc Engineering (2019 Course)

404184 (D): Embedded System & RTOS (Elective - III)

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 Hrs. / Week	03	In-Sem (Theory): 30 Marks End Sem (Theory): 70 Marks

Prerequisite Courses, if any:

1. ARM7 / ARM9 / ARM Cortex- M

Companion Course, if any:

1. Lab Practice - 2

Course Objectives:

1. To understand the Embedded system design issues.
2. To understand real time operating system concepts.
3. To understand the Embedded Linux environment
4. To understand embedded software development and testing tools.

Course Outcomes: On completion of the course, learner will be able to-

CO1: Apply design metrics of Embedded systems to design real time applications to match recent trends in technology.
CO2: Apply Real time systems concepts.
CO3: Evaluate µCOS operating system and its services.
CO4: Apply Embedded Linux Development Environment and testing tools.
CO5: Analyze Linux operating system and device drivers.
CO6: Analyze the hardware – software co design issues for testing of real time Embedded system.

Course Contents

Unit I	Introduction to Embedded Systems	8 Hrs.

Introduction to Embedded Systems, Architecture, Classification and Characteristics of Embedded System, Design Process, Design Metrics and optimization of various parameters of embedded system. Embedded processor technology, IC technology, Design technology. Software development life cycle. Various models like waterfall, spiral,V, Rapid Prototyping models and Comparison

Mapping of Course Outcomes for Unit I	CO1: Apply design metrics of Embedded systems to design real time applications to match recent trends in technology.

Unit II	Concepts of Real Time Operating System	6 Hrs.

Foreground/ Background systems, Critical section of code, Resource, Shared resource, multitasking, Task, Context switch, Kernel, Scheduler, Non-Preemptive Kernel , Preemptive Kernel, Reentrancy, Round robin scheduling, Task Priorities, Static & Dynamic Priority, Priority Inversion, Assigning task priorities, Mutual Exclusion, Deadlock, Clock Tick, Memory requirements, Semaphore as signaling & Synchronizing, External Interrupt, Advantages & disadvantages of real time kernels.

Mapping of Course Outcomes for Unit II	CO2: Apply Real time systems concepts.

Unit III	µCOS II	6 Hrs.
Features of µCOS II Kernel structure. µCOS II RTOS services: Task management, Time management, Intertask Communication and Synchronization.		
Mapping of Course Outcomes for Unit III	**CO3: Evaluate µCOS operating system and its services.**	
Unit IV	**Embedded Linux Development Environment**	**6 Hrs.**
Need of Linux, Embedded Linux Today, Open Source and the GPL, BIOS Versus Boot loader, Storage Considerations, Embedded Linux Distributions. Embedded Development Environment, Cross-Development Environment, Host System Requirements, Hosting Target Boards. Development Tools, GNU Debugger, Tracing and Profiling Tools, Binary Utilities.		
Mapping of Course Outcomes for Unit IV	**CO4: Apply Embedded Linux Development Environment and testing tools.**	
Unit V	**Linux Kernel Structure**	**6 Hrs.**
Linux Kernel Background, Linux Kernel Construction, Kernel Build System, Kernel Configuration. Role of a Bootloader, Bootloader Challenges. A Universal Bootloader: Das UBoot. Porting U-Boot. Device Driver Concepts, Module Utilities, Driver Methods. Linux File System & Concepts		
Mapping of Course Outcomes for Unit V	**CO5: Analyze Linux operating system and device drivers.**	
Unit VI	**Embedded Software Development and Testing**	**8 Hrs.**
Embedded Software development process and tool chain, Host and Target Machines, Porting Embedded Software into the Target System, Testing on Host Machine, Simulators. Introduction to Development Platform Trends (only introduce IDE, board Details and Application) Arduino, Beaglebone, Rasberry PI, Intel Galileo Gen 2 (Simple Programs to discussed)		
Mapping of Course Outcomes for Unit VI	**CO6: Analyze the hardware – software co design issues for testing of real time Embedded system.**	

Learning Resources

Text Books:

1. Jean J. Labrosse, "MicroC OS II, The Real-Time Kernel", 2nd Edition, CMP Books.
2. Christopher Hallinan, "Embedded Linux Primer -A Practical, Real-World Approach "2nd Edition, Prentice Hall.

Reference Books:

1. Raj Kamal, "Embedded Systems – Architecture, Programming and Design" 2nd Edition, McGraw Hill.
2. Frank Vahid and Tony Givargis, "Embedded System Design – A Unified Hardware/Software Introduction " 3rd Edition, Wiley.
3. David E. Simon, "An Embedded Software Prime", Pearson Education.

MOOC / NPTEL Courses:

1. NPTEL Course on "**Embedded System Design with ARM**", by Prof. Indranil Sengupta, and Prof. Kamalika Datta, IIT Kharagpur
   Link of the Course: https://nptel.ac.in/courses/106105193

2. NPTEL Course on "**Real-Time Systems**", by Prof. Rajib Mall, Prof. Durga Prasad Mohapatra, IIT Kharagpur
   Link of the Course: https://nptel.ac.in/courses/106105229

Savitribai Phule Pune University

Fourth Year of E & TC Engineering (2019 Course)

404184 (E): Modernized IoT (Elective - III)

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 Hrs. / Week	03	In-Sem (Theory): 30 Marks End-Sem (Theory): 70 Marks

Prerequisite Courses, if any:

1. Basics of sensors and hardware components
2. Basic networking concepts
3. Knowledge of Microcontroller and Embedded systems

Companion Course, if any:

1. Lab Practice- 2

Course Objectives:

1. To introduce the fundamentals of sensors and actuators along with the basic concepts of an IoT & IoE.
2. To give insights into the Architecture and M2M technology for an IoT.
3. To Exposing students to the usage of Protocol Standardization for IoT with IoT Edge and Gateway Network with Communication protocols.
4. To develop design skills in industrial IoT.
5. To provide IoT Solutions with sensor-based application through embedded system platform.

Course Outcomes: On completion of the course, learner will be able to

CO1: Comprehend and analyze concepts of sensors, actuators, IoT and IoE.
CO2: Interpret IoT Architecture Design Aspects.
CO3: Comprehend the operation of IoT protocols.
CO4: Describe various IoT boards, interfacing, and programming for IoT.
CO5: Illustrate the technologies, Catalysts, and precursors of IIoT using suitable use cases.
CO6: **Provide** suitable solution for domain specific applications of IoT.

Course Contents

Unit I	Sensors, Actuators, IoT & IoE	6 Hrs.

Definitions, Types of sensors, Types of Actuators, Example and Working, Networking Basics, RFID Principles and components, Wireless Sensor Networks, Definition, and characteristics of an IoT, Physical Design of an IoT, Logical design of IoT, Communication Models, Communication API's, What is the IoE? Difference between IoT and IoE, Pillars of the IoE, Connecting the Unconnected, Transitioning to the IoE, Bringing it all together.

Mapping of Course Outcomes for Unit I	CO1: Comprehend and analyze concepts of sensors, actuators, IoT and IoE.

Unit II	IoT Architecture Design Aspects	6 Hrs.

IoT-An Architectural Overview, building architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations. M2M and IoT Technology Fundamentals- Devices and gateways, Local and wide area networking, Data management, Business processes in IoT, Everything as a Service (XaaS), M2M and IoT Analytics, Knowledge Management

Mapping of Course Outcomes for Unit II	CO2: Interpret IoT Architecture Design Aspects.

Unit III	IoT Protocols	6 Hrs.
PHY/MAC Layer (3GPP MTC, IEEE 802.11, IEEE 802.15), Wireless HART, Z Wave, Bluetooth Low Energy, Zigbee Smart Energy, DASH7 - Network Layer-IPv4, IPv6, 6LoWPAN, 6TiSCH, ND, DHCP, ICMP, RPL, CORPL, CARP, Transport Layer (TCP, MPTCP, UDP, DCCP, SCTP)-(TLS, DTLS) – Session Layer HTTP, CoAP, XMPP, AMQP, MQTT		
Mapping of Course Outcomes for Unit III	**CO3: Comprehend the operation of IoT protocols.**	
Unit IV	**Interfacing Boards and Programming**	**6 Hrs.**
Introduction to IoT Boards, Interfacing with IoT Boards, IoT deployment for Raspberry Pi /Arduino/Equivalent platform – Reading from Sensors, Communication: Connecting microcontroller with mobile devices – communication through Bluetooth, WiFi and USB - Contiki OS- Cooja Simulator.		
Mapping of Course Outcomes for Unit IV	**CO4: Describe various IoT boards, interfacing, and programming for IoT.**	
Unit V	**Industrial IoT**	**6 Hrs.**
Introduction, Key IIOT technologies, Catalysts, and precursors of IIoT, Innovation and the IIoT, Applications of IIoT Examples: Healthcare, Oil and Gas Industry, Logistics and the Industrial Internet, Retail applications, IoT innovations and design methodologies, Industrial Internet Architecture Framework (IIAF): Control domain, operational domain and application domain, Three tier topology, Design of low power device network, legacy industrial protocols, Bluetooth, Zigbee IP, Z-wave, Wi-Fi backscatter in IIoT design.		
Mapping of Course Outcomes for Unit V	**CO5: Illustrate the technologies, Catalysts, and precursors of IIoT using suitable use cases.**	
Unit VI	**Applications of IoT**	**6 Hrs.**
Smart Environment: Forest Fire Detection, Air Pollution. **Smart Cities:** Parking, Structural Health, Noise Urban maps. **Smart Metering:** Smart Grid, Tank level, Photovoltaic Installations, Silos Stock Calculation, Health: Fall Detection, Medical Fridges, Sportsmen Care, Patients Surveillance, Ultraviolet Radiation		
Mapping of Course Outcomes for Unit VI	**CO6**: **Provide** suitable solution for domain specific applications of IoT.	

Learning Resources

Text Books:

1. Ovidiu Vermesan, Peter Fresiss, “Internet of Things” From research and innovation to market Deployment”, River Publishers series in Communication, USA.
2. Olivier Hersent, David Boswarthick, and Omar Elloumi, “The Internet of Things: Key Applications and Protocols”, 2nd Edition, Wiley Publications.

Reference Books:

1. Dr. Ovidiu Vermesan, Dr. Peter Friess, "Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems", River Publishers Series in Communication
2. "Internet of Things: Case Studies", Libelium Inc, White papers, Spain
   http://www.libelium.com/resources/case-studies

3. Useful Links for IoT Applications and Use Cases:
   http://52.16.186.190/resources/case-studies/
   https://pressbooks.bccampus.ca/iotbook/chapter/iot-use-cases/
   https://research.aimultiple.com/iot-applications/
   https://www.jigsawacademy.com/101-applications-of-iot/
   https://www.youtube.com/watch?v=xmt6OCBeS94

MOOC / NPTEL Courses:

1. NPTEL Course on "**Introduction to IoT**", by Prof. Sudip Misra, IIT Kharagpur
   Link of the Course: https://nptel.ac.in/courses/106105166

2. NPTEL Course on "**Introduction to Industry 4.0 and Industrial Internet of Things**", by Prof. Sudip Misra, IIT Kharagpur
   Link of the Course: https://nptel.ac.in/courses/106105195

Savitribai Phule Pune University

Fourth Year of E & Tc Engineering (2019 Course)

404185 (A): Data Mining (Elective - IV)

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 Hrs. / Week	03	In-Sem (Theory): 30 Marks End Sem (Theory): 70 Marks

Prerequisite Courses, if any:

1. Database Management Systems
2. Signals and Systems

Companion Course, if any:

Course Objectives:

1. To understand the basic concepts of Data mining and major issues in Data Mining.
2. To be familiar with the Data warehouse architecture and its Implementation.
3. To characterize the kinds of patterns that can be discovered by classification, clustering, and association rule mining.
4. To describe and demonstrate basic data mining algorithms, methods, tools.
5. To understand and apply various classification and clustering techniques using tools.
6. To understand latest trends in Data Mining.

Course Outcomes: On completion of the course, learner will be able to -

CO1: Understand the process of data mining and performance issues in data mining.

CO2: Apply data preprocessing techniques to the historical data collected in data warehouse.

CO3: Analyze various types of Frequent pattern analysis methods and advanced Pattern mining Techniques.

CO4: Evaluate various data mining algorithms for developing effective data mining models.

CO5: Analyze different clustering and outlier detection methods.

CO6: Design data mining models in different mining application areas.

Course Contents

Unit I	Introduction to Data Mining	7 Hrs.

Introduction: Definition, Mining Functionalities, Kinds of Patterns, Technologies used for data mining- Machine Learning, Database Systems and Data Warehouses, Major Issues in Data Mining - Mining Methodology, User Interaction, Efficiency and Scalability, Diversity of Database Types, Data Mining and Society

Mapping of Course Outcomes for Unit I	CO1: Understand types of data to be mined, choose and major issues in Data Mining.

Unit II	Data Preprocessing and Data Ware housing	6 Hrs.

Data Objects and Attribute, Data Cleaning: Missing Values, Noisy Data- Binning, Clustering, Regression, Computer and Human inspection, Inconsistent Data, Data Integration and Transformation. Data Reduction.

Data Warehouse: Basic Concepts, Data Warehouse Modeling, Data Warehouse Design and Usage

Mapping of Course Outcomes for Unit II	CO2: Perform different data processing, Model and design the Data Warehouse

Unit III	Frequent Pattern Analysis and Advanced Pattern Mining	7 Hrs
Frequent Pattern Analysis: Basic Concepts, Frequent Itemset Mining Methods Pattern Evaluation Method. **Advanced Pattern Mining:** Basic Concepts, Pattern Mining in multi-level multidimensional space, Constraint-Based Frequent Pattern Mining, Mining High-Dimensional Data and Colossal Patterns, Mining Compressed or Approximate Patterns.		
Mapping of Course Outcomes for Unit III	**CO3: Understand the Frequent pattern analysis and advanced Pattern mining.**	
Unit IV	**Data mining algorithms**	**7 Hrs.**
Classification - Basic issues regarding classification and predication - General Approach to solving a classification problem- Decision Tree Classification, Attribute Selection Measures, Tree Pruning-Bayesian Classification – Rule Based Classification – Support Vector Machines, Techniques to Improve Classification Accuracy.		
Mapping of Course Outcomes for Unit IV	**CO4: Choose and employ suitable data mining algorithms to build analytical applications**	
Unit V	**Cluster Analysis and Outlier Detection**	**7 Hrs.**
Basics and Importance of Cluster Analysis- Different Types of Clusters Partitioning Methods, Clustering high dimensional data- Clustering with constraints, Outlier analysis-outlier detection methods. **Outlier Detection:** Need, Detection Methods, Approaches – Statistical, Proximity-Based, Clustering-Based, Classification-Based, Outlier Detection in High-Dimensional Data		
Mapping of Course Outcomes for Unit V	**CO5: Implement clustering and outlier detection methods.**	
Unit VI	**Advanced Concepts**	**6 Hrs.**
Basic concepts in Mining data streams: Mining Time series Data Mining sequence patterns in Transactional database Mining Object, Spatial Multimedia, Text - extracting attributes (keywords), structural approaches (parsing, soft parsing). **Web Mining:** Introduction to Web Mining, Web content mining, Web usage mining, Web Structure mining, Web log structure and issues regarding web logs, Spatial Data Mining.		
Mapping of Course Outcomes for Unit VI	**CO6: Orient towards the advanced approaches of Data mining.**	

Learning Resources

Text Books:

1. Jiawei Han & Micheline Kamber, "Data Mining: Concepts and Techniques", 3rd Edition Elsevier.
2. Margaret H Dunham, "Data Mining Introductory and Advanced topics", 1st Edition Pearson

Reference Books:

1. Ian H. Witten and Eibe Frank, "Data Mining: Practical Machine Learning Tools and Techniques" 2nd Edition, Morgan Kaufmann.

MOOC / NPTEL Courses:

1. NPTEL Course "**Data Mining**" by Prof. Pabitra Mitra IIT Kharagpur

   Link of the Course: https://nptel.ac.in/courses/106105174

2. NPTEL Course "**Business analytics and data mining Modeling using R**" by Dr. Gaurav Dixit IIT Roorkee

   Link of the Course: https://nptel.ac.in/courses/110107092

Savitribai Phule Pune University

Fourth Year of E & Tc Engineering (2019 Course)

404185 (B): Electronics Product Design (Elective - IV)

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 Hrs. / Week	03	In-Sem (Theory): 30 Marks End Sem (Theory): 70 Marks

Prerequisite Courses, if any:

1. Electronic Circuits
2. Digital Circuits
3. Data structures
4. Microcontrollers
5. Project Management
6. Power Devices & Circuits

Companion Course, if any:

Course Objectives:

1. To understand the stages of product (hardware/ software) design and development.
2. To learn the different considerations of analog, digital and mixed circuit design.
3. To be acquainted with methods of PCB design and different tools used for PCB Design.
4. To understand the importance of testing in product design cycle.
5. To understand the processes and importance of documentation.

Course Outcomes: On completion of the course, learner will be able to

CO1: Understand and explain design flow of design of electronics product.

CO2: Associate with various circuit design issues and testing.

CO3: Inferring different software designing aspects and the Importance of product test & test specifications.

CO4: Summarizing printed circuit boards and different parameters.

CO5: Estimating assorted product design aspects.

CO6: Exemplifying special design considerations and importance of documentation.

Course Contents

Unit I	Introduction to Electronic Product Design	6 Hrs.

Overview Of System Engineering, System Perspectives, Documentation, Concept Development, Requirements, Design Development, Rapid Prototyping And Field Testing, Validation, Verification And Integration, Maintenance And Life Cycle Costs, Failure, Iteration And Judgment, Good Engineering, Architecturing, Design Concerns And Heuristics, Teamwork And Trust.

Mapping of Course Outcomes for Unit I	**CO1: Understand and explain design flow of design of electronics product.**

Unit II	Circuit Design and Testing Methods	6 Hrs.
From Symbols to Substance, Convert Requirements into Design, Reliability, Fault Tolerance, High Speed Design, Low Power Design, Noise and Error Budget, Standard Data Buses And Networks, Reset And Power Failure Detection, Interface: Inputs, Outputs, Breadboards, Evaluation Boards And Prototypes.		
Mapping of Course Outcomes for Unit II	**CO2: Associate with various circuit design issues and testing.**	
Unit III	**Software Design and Testing Methods**	**6 Hrs.**
Types Of Software, Traditional Software Life Cycle, Models, Metrics and Software Limitations, Risk Abatement and Failure Preventions, Software Bugs and Testing, Good Programming Practice, User Interface, Embedded, Real Time Software, Case Studies and Design Examples.		
Mapping of Course Outcomes for Unit III	**CO3: Inferring different software designing aspects and the Importance of product test & test specifications.**	
Unit IV	**PCB Design**	**6 Hrs.**
Circuit Boards, Component Placement, Routing Signal Traces, Grounds, Returns and Shields, Connectors and Cables, Design for Manufacture, Testing and Maintenance, Power Conversion Choices, Power Distribution, Line Conditioning, Electromagnetic Interference, Heat Transfer, Mechanisms for Cooling, Heat Sink Selection, Heat Pipes and Thermal Pillows, Fans and Forced Cooling, Liquid Cooling, Evaporation and Refrigeration, Trade-Offs in Design.		
Mapping of Course Outcomes for Unit IV	**CO4: Summarizing printed circuit boards and different parameters.**	
Unit V	**Product Debugging and Testing**	**6 Hrs.**
Steps Of Debugging, Techniques for Troubleshooting, Characterization, Electromechanical Components, Passive Components, Active Components, Active Devices, Operational Amplifier, Analog-Digital Conversion, Digital Components, Inspection and Test of Components, Simulation, Prototyping and Testing, Integration, Validation and Verification. Procurement, Manufacturing, Maintenance and Repair.		
Mapping of Course Outcomes for Unit V	**CO5: Estimating assorted product design aspects.**	
Unit VI	**Documentation**	**6 Hrs.**
Definition, Need, Types of Documentation, Records, Accountability and Liability. Audience. Preparation, Presentation, Preservation of Documents. Methods of Documentation, Visual Techniques, Layout of Documentation, Bill of Material.		
Mapping of Course Outcomes for Unit VI	**CO6: Exemplifying special design considerations and importance of documentation.**	

Learning Resources

Text Books:

1. Kim Fowler, “Electronic Instrument Design”, Oxford University Press.
2. Robert J. Herrick, “Printed Circuit board design Techniques for EMC Compliance”, 2nd Edition, IEEE press.

Reference Books:

1. James K. Peckol, “Embedded Systems – A Contemporary Design Tool”, Wiley Publication
2. J.C. Whitakar, “The Electronics Handbook”, CRC press.

Udemy Courses :

1. Introduction to Product Management

   Link: **https://www.udemy.com/product-management/**

2. Fundamental Steps of Product Management

   Link: **https://www.udemy.com/productmgt/**

3. Digital Product Manufacturing: The Roadmap to Success

   Link: **https://www.udemy.com/digital-product-manufacturing/**

4. Agile Product Owner Career Guide

   Link: **https://www.udemy.com/product-owner-career-guide/**

Savitribai Phule Pune University Fourth Year of E & Tc Engineering (2019 Course) 404185 (B): Deep Learning (Elective - IV)		
Teaching Scheme:	**Credit**	**Examination Scheme:**
Theory: 03 Hrs. / Week	**03**	**In-Sem (Theory): 30 Marks** **End Sem (Theory): 70 Marks**

Prerequisite Courses, if any:

Companion Course, if any:

Course Objectives:

1. To comprehend the theoretical foundations, algorithms and methodologies of Neural Network.
2. To design and develop an application using specific deep learning models and know complexity of Deep Learning algorithms and their limitations
3. To examine the case studies of deep learning techniques

Course Outcomes: On completion of the course, learner will be able to:

CO1: Classify machine learning algorithms and its types.
CO2: Discuss the concepts of deep learning and its Frameworks.
CO3: Identify the deep learning architectures with respect to the applications.
CO4: Demonstrate different architectures of Convolutional neural networks.
CO5: Discuss natural language processing architectures.
CO6: Make use of various case studies and deep learning applications.

Course Contents

Unit I	Machine Learning	6 Hrs.
Introduction to Machine Learning, Types of Machines Learning, Linear Regression, Classification and Logistic Regression, Decision Tree and Random Forest, Naïve Bayes and Support Vector Machine. Applications of machine learning		
Mapping of Course Outcomes for Unit I	**CO1: Classify machine learning algorithms and its types.**	
Unit II	**Introduction to Deep Learning and Frameworks**	**6 Hrs.**
Deep Learning Basics: Intro, History, capabilities, the perceptron, Multi Layer Perceptron, ANN architecture. Tensor Flow, Creating and Manipulating Tensor Flow Variables, Tensor Flow Operations, Placeholder Tensors, Managing Models over the CPU and GPU, Specifying the Logistic Regression Model in Tensor Flow, Logging and Training the Logistic Regression, Introduction to Keras, PyTorch.		
Mapping of Course Outcomes for Unit II	**CO2: Discuss the concepts of deep learning and its Frameworks.**	

Unit III	Deep Learning Architecture	6 Hrs.
Width and Depth of Neural Networks, Different Activation Functions, Batch-normalization, Overfitting and generalization., Dropout, regularization Unsupervised Training of Neural Networks, Restricted Boltzmann Machines, Auto Encoders, Deep Learning Applications		
Mapping of Course Outcomes for Unit III	**CO3: Identify the deep learning architectures with respect to the applications.**	
Unit IV	**Computer Vision**	**6 Hrs.**
Architectural Overview, Motivation, Layers, Filters, Parameter sharing, Regularization, Convolution neural networks (CNNs), convolution, pooling and its variations, different deep CNN architectures - LeNet, AlexNet, VGG, PlacesNet, DenseNet, Training a CNNs: weights initialization, batch normalization, hyperparameter tuning. **Popular CNN Architectures:** ResNet, AlexNet – Applications.		
Mapping of Course Outcomes for Unit IV	**CO4: Demonstrate different architectures of Convolutional neural networks.**	
Unit V	**Natural Language Processing**	**6 Hrs.**
Recurrent Neural Networks, Bidirectional RNNs, Encoder-decoder sequence to sequence architectures - BPTT for training RNN, Long Short Term Memory Networks. Advanced RNN: LSTM, GRU, introduction to Generative Adversarial Networks (GANs).		
Mapping of Course Outcomes for Unit V	**CO5: Discuss natural language processing architectures.**	
Unit VI	**Case Study and Applictions**	**6 Hrs.**
Computer Vision: Image Classification, Image net- Detection-Audio Wave Net. **Natural Language Processing:** Sentimental Analysis, Text preprocessing and chatBot		
Mapping of Course Outcomes for Unit VI	**CO6: Make use of various case studies and deep learning applications.**	

Learning Resources

Text Books:

1. Nikhil Buduma, “Fundamentals of Deep Learning Designing Next-Generation Machine Intelligence Algorithms”, 1st Edition, O’REILLY.
2. Michael Nielsen, “Neural Networks and Deep Learning”, Determination Press.
3. Ian Goodfellow, YoshuaBengio and Aaron Courville, “Deep Learning”, MIT Press.
4. Josh Patterson, Adam Gibson "Deep Learning: A Practitioner's Approach", O'Reilly Media.
5. Kevin P. Murphy "Machine Learning: A Probabilistic Perspective", The MIT Press.
6. Ethem Alpaydin,"Introduction to Machine Learning”, 3rd Edition, Prentice Hall of India.
7. Umberto Michelucci “Applied Deep Learning. A Case-based Approach to Understanding”, Deep Neural Networks” Apress, 2018.

Reference Books:

1. Goodfellow. I., Bengio.Y., and Courville, A.,"Deep Learning", MIT Press.
2. Bishop, C.M., "Pattern Recognition and Machine Learning", Springer.
3. Satish Kumar, "Neural Networks: A Classroom Approach", Tata McGraw-Hill Education.

MOOC / NPTEL Courses:

1. NPTEL Course on "**Deep Learning**", by Prof. Prabir Kumar Bhiswas, IIT Kharagpur.

   Link of the Course: https://nptel.ac.in/courses/106105215

2. NPTEL Course on "**Deep Learning - Part I**", by Prof. Sudarshan Iyengar, Prof Sanatan Sukhija IIT Ropar

   Link of the Course: https://nptel.ac.in/courses/106106184

Savitribai Phule Pune University

Fourth Year of E & Tc Engineering (2019 Course)

404185 (D): Low Power CMOS (Elective - IV)

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 Hrs. / Week	03	In-Sem (Theory): 30 Marks End Sem (Theory): 70 Marks

Prerequisite Courses, if any:

1. Electronic Circuits
2. Digital Circuits

Companion Course, if any:

1. VLSI Design and Technology

Course Objectives: is to make the student

1. Identify sources of power in an IC.
2. To relate the power reduction techniques based on technology independent and technology. dependent power dissipation mechanism in various MOS logic style.
3. To describe suitable techniques to reduce the power dissipation.
4. To design memory circuits with low power dissipation.
5. To learn to use CAD tools for low power synthesis .

Course Outcomes: On completion of the course, learner will be able to

CO1: Explain the sources of power dissipation in CMOS.
CO2: Classify the special techniques to mitigate the power consumption in CMOS circuits.
CO3: Summarize the power optimization and trade off techniques in digital circuits.
CO4: Illustrate the power estimation at logic and circuit level.
CO5: Explain the software design for low power in various level.
CO6: Use the CAD tools for low power synthesis.

Course Contents

Unit I	Fundamentals of Power Dissipation in CMOS	07 Hrs.

Sources of power dissipation, Physics of power dissipation in MOSFET devices: The MIS structure, long channel MOSFET, Submicron MOSFET, gate induced drain leakage, Power dissipation in CMOS: short circuit dissipation, dynamic dissipation, load capacitance, Low power VLSI design: Limits, principles of low power design, hierarchy of limits, fundamental limit, material limit, device limit, system limit.

Mapping of Course Outcomes for Unit I	CO1: Explain the sources of power dissipation in CMOS.

Unit II	Power Optimization Techniques	08 Hrs.
Power Reduction in Clock Networks: Clock Gating, Reduced Swing Clock, Oscillator Circuit for Clock Generation, Frequency Division and Multiplication, Other Clock Power Reduction Techniques, CMOS Floating Node: Tristate Keeper Circuit, Blocking Gate, Low Power Bus: Low Swing Bus, Charge Recycling Bus, Delay Balancing, Low Power Techniques for SRAM: SRAM Cell, Memory Bank Partitioning, Pulsed Word line and Reduced bit line Swing. Introduction to Low-Power Design through Voltage Scaling: VTCMOS circuits, MTCMOS circuits, Architectural Level Approach –Pipelining and Parallel Processing Approaches. Switched Capacitance Minimization Approaches: System Level Measures, Circuit Level Measures, Mask level Measures.		
Mapping of Course Outcomes for Unit II	**CO2: Classify the special techniques to mitigate the power consumption in CMOS circuits.**	
Unit III	**Design of Low Power Circuits**	**07 Hrs.**
Transistor and Gate Sizing : Sizing an Inverter Chain, Transistor and Gate Sizing for Dynamic Power Reduction, Transistor Sizing for Leakage Power Reduction, Network Restructuring and Reorganization : Transistor Network Restructuring, Transistor Network Partitioning and Reorganization, Special Latches and Flip-flops : Self-gating Flip-flop, Combinational Flip-flop, Double Edge Triggered Flip-flop, Low Power Digital Cell Library : Cell Sizes and Spacing, Varieties of Boolean Functions, Adjustable Device Threshold Voltage.		
Mapping of Course Outcomes for Unit III	**CO3: Summarize the power optimization and trade off techniques in digital circuits.**	
Unit IV	**Power Estimation**	**07 Hrs.**
Modelling of signals, signal probability calculation, Statistical techniques, estimation of glitching power, Sensitivity analysis, Power estimation using input vector compaction, power dissipation in Domino logic, circuit reliability, power estimation at the circuit level, Estimation of maximum power: test generation based approach, steepest descent, generic based algorithm based approach.		
Mapping of Course Outcomes for Unit IV	**CO4: Illustrate the power estimation at logic and circuit level.**	
Unit V	**Software Design for Low Power**	**07 Hrs.**
Sources of software power dissipation, software power estimation: Gate level, architecture level, bus switching activity, instruction level power analysis, software power optimization: minimizing memory access costs, instruction selection and ordering, power management, Automated low power code generation, Co-design for low power.		
Mapping of Course Outcomes for Unit V	**CO5: Explain the software design for low power in various level**	
Unit VI	**Hardware Design for Low Power**	**06 Hrs.**
Adiabatic Switching Circuits, Battery-aware Synthesis, Variation tolerant design, CAD tools for low power synthesis.		
Mapping of Course Outcomes for Unit VI	**CO6: Able to use the CAD tools for low power synthesis**	

Learning Resources

Text Books:

1. Kaushik Roy and S. C. Prasad, “Low power CMOS VLSI Circuit Design”, Wiley Publication
2. Gary Yeap, “Practical Low Power Digital VLSI Design”, Springer
3. A. P. Chandrasekaran and R. W. Broadersen, “Low Power Digital CMOS Design”, Kluwer,1995

Reference Books:

1. J. B. Kulo and J.H Lou, “Low voltage CMOS VLSI Circuits”, Wiley Publication
2. Dimitrios Soudris, Christians Pignet, Costas Goutis, “Designing CMOS Circuits for Low Power”, Kluwer.
3. James B. Kulo, Shih-Chia Lin, “Low voltage SOI CMOS VLSI devices and Circuits”, John Wiley and sons.
4. Steven M. Rubin, “Computer Aids for VLSI Design”, Addison Wesley Publishing
5. Abdelatif Belaouar, Mohamed. I. Elmasry, “Low power digital VLSI design”, Kluwer.

Online Resources:

1. https://www.youtube.com/watch?v=w0cSahiDvFQ
2. https://www.youtube.com/watch?v=LjDb6VQlOeQ
3. http://freevideolectures.com/Course/3059/Low-Power-VLSI-Circuits-and-Systems
4. http://www.springer.com/us/book/9788132219361

Savitribai Phule Pune University

Fourth Year of E & Tc Engineering (2019 Course)

404185 (E): Smart Antennas (Elective - IV)

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 Hrs. / Week	03	In-Sem (Theory): 30 Marks End Sem (Theory):70 Marks

Prerequisite Courses, if any:

1. Electromagnetic Field Theory
2. Cellular Networks

Companion Course, if any:

Course Objectives:

1. To understand design principles of various radiating elements.
2. To understand theory reconfiguration antenna and smart antenna.
3. To learn DOA estimation techniques for smart antenna.
4. To understand beam forming and MIMO technology.
5. The main focus will be on the 4G, 5G and beyond needs of antenna to improve the signal quality, power management and BW for higher data rate.

Course Outcomes: On completion of the course, learner will be able to

CO1: Compare various linear wire antenna and uniform array in terms of antenna parameters and analyze them based on the current distribution and identify an appropriate wire antenna for given application.

CO2: Classify Microstrip & re-configurable antenna and techniques.

CO3: Describe smart antenna systems and discuss the beam steering and mutual coupling effects.

CO4: Explain DOA estimation methods and classify.

CO5: Classify the beam forming methods.

CO6: Describe and Compare MIMO systems.

Course Contents

Unit I	Radiating Elements and Array	8 Hrs.

Comparison of various radiating elements- Infinitesimal dipole, small dipole, finite length dipole, half wave length dipole, and analytical treatment of these elements. Types of Array antenna, two element array, N-element array, Uniform amplitude-uniformed spaced linear broadside and end fire array.

Mapping of Course Outcomes for Unit I	CO1: Compare various linear wire antenna and uniform array in terms of antenna parameters and analyze them based on the current distribution and identify an appropriate wire antenna for given application.

Unit II	Microstrip and Reconfigurable Antenna	6 Hrs.

Microstrip antenna: Introduction, feeding techniques, Fractal antenna and array.

Re-configurable Antenna: Classification of re-configurable antenna, Re-configurable techniques, Multiple Re-configurable features in antenna.

Mapping of Course Outcomes for Unit II	CO2: Classify Microstrip & re-configurable antenna and techniques.

Unit III	Smart Antennas	8 Hrs.
Introduction, Need for Smart Antennas, Overview: Smart Antenna Configurations, Switched-Beam Antennas, Adaptive Antenna Approach, beam steering, degree of freedom. **Architecture of a Smart Antenna System:** Transmitter and Receiver, Types of Smart Antennas, Benefits and Drawbacks of Smart Antennas, Mutual Coupling Effects, Applications of Smart Antennas.		
Mapping of Course Outcomes for Unit III	**CO3: Describe smart antenna systems and discuss the beam steering and mutual coupling effects.**	
Unit IV	**Direction of Arrival Estimation (DOA) Methods**	**6 Hrs.**
Spectral estimation methods, linear prediction method, Maximum entropy method, Maximum likelihood method, Eigen structure methods, MUSIC algorithm – root music and cyclic music algorithm, the ESPRIT algorithm.		
Mapping of Course Outcomes for Unit IV	**CO4: Explain DOA estimation methods and classify.**	
Unit V	**Beam Forming Methods**	**6 Hrs.**
Classical Beam former, Statistically Optimum Beam-forming Weight Vectors, Maximum SNR Beam former, Multiple Sidelobe Canceler and Maximum, SINR Beam former, Minimum Mean Square Error (MMSE), Direct Matrix Inversion (DMI), Linearly Constrained Minimum Variance (LCMV), Adaptive Algorithms for Beam forming.		
Mapping of Course Outcomes for Unit V	**CO5: Classify the beam forming methods.**	
Unit VI	**MIMO Antennas**	**6 Hrs.**
Introduction, Principles of MIMO systems: SISO, SIMO, MISO MIMO, Hybrid antenna array for mm Wave, massive MIMO: concept and applications.		
Mapping of Course Outcomes for Unit VI	**CO6: Describe and Compare MIMO systems.**	

Learning Resources

Text Books:

1. C.A. Balanis “Antenna Theory: Analysis and Design”, 4th Edition, John Wiley & Sons.
2. Lal Chand Godara, “Smart Antennas”, CRC Press, LLC-20.
3. Ahmed El Zooghby, “Smart Antenna Engineering**”,** ARTECH HOUSE, INC, 2005**.**

Reference Books:

1. C.A.Balanis,“Introduction to Smart Antennas”, John Wiley & Sons
2. Mohammod Ali, “Reconfigurable antenna Design and Analysis”, Publisher: Artech House
3. George Tsoulos,“ MIMO system technology for wireless communications”, CRC- Taylor & Francis.
4. Long Zhao, Hui Zhao , Kan Zheng, Wei Xiang,“Massive MIMO in 5G Networks: Selected Applications”, Springer.
5. Jian Li and Petre Stoica,“ Robust adaptive Beamforming”, John Wiley.

Savitribai Phule Pune University

Fourth Year of E & Tc Engineering (2019 Course)

404186: Lab Practice - 1

Teaching Scheme:	Credit	Examination Scheme:
Practical: 04 Hrs. / Week	02	Term Work: 25 Marks Oral: 50 Marks

Companion Course, if any:

1. Radiation and Microwave Theory
2. Cloud Computing

Guidelines for Student's Lab Journal

The student's Lab Journal can be experimental write-ups. It should include following as applicable: Assignment No, Title of Assignment, Date of Performance, Date of Submission, Aims & Objectives, Theory, Description of data used, Results, Conclusion.

Guidelines for Lab /TW Assessment

The oral examination will be based on the work carried out by the student in the Lab course. Suitable rubrics can be used by the internal & external examiner for assessment.

Subject: Radiation and Microwave Theory

List of Experiments

1.	To study of different types of Microwave Components
2.	To measure radiation pattern and gain of horn or parabolic antenna at microwave frequency
3.	To measure and plot Mode characteristics of Reflex klystron.
4.	To measure V-I characteristics of Gunn Diode and study of PIN modulator.
5.	To measure and verify port characteristics of microwave tees (E, H, E-H or magic planes).
6.	To measure and verify port characteristics of directional coupler and calculate coupling factor, insertion loss and directivity.
7.	To measure and verify port characteristics of isolator and circulator and calculate insertion loss and isolation in dB.
8.	To measure wavelength of the microwave using microwave test bench and verify with its theoretical calculations.
9.	To plot standing wave pattern and measure SWR for open, short and matched termination at microwave frequency using slotted section with probe carriage.
10.	Study the network analyzer and carry out the measurements of s-parameters.
11.	To design and simulate any type of microwave antenna using EM simulation software.

Virtual Lab:

1. **https://www.ee.iitb.ac.in/course/~vel/ (Virtual Electromagnetics Lab.)**
2. **http://www.iitk.ac.in/mimt_lab/vlab/index.php (RF and Microwave Characterization Lab.)**

Subject: Cloud Computing	
List of Experiments (Any 6 to be performed)	
1.	Install Google App Engine. Create hello world app and other simple web applications using python / java.
2.	Use GAE launcher to launch the web applications.
3.	Simulate a cloud scenario using CloudSim and run a scheduling algorithm that is not present in CloudSim.
4.	Find a procedure to transfer the files from one virtual machine to another virtual machine.
5.	Find a procedure to launch virtual machine using try stack (Online Openstack Demo Version)
6.	Design and deploy a PaaS environment.
7.	Design and develop custom Application (Mini Project) using Cloud (like Salesforce/GCP/AWS.)
8.	Design an Assignment to retrieve, verify, and store user credentials using Firebase Authentication, the Google App Engine standard environment, and Google Cloud Data store.
Case Studies (Any 2 to be performed)	
1.	Data storage security in private cloud.
2.	Application of IoT / Ubiquitous based on cloud.
3.	Tools for building private cloud.
4.	Instance creation in cloud environment.

Savitribai Phule Pune University

Fourth Year of E & Tc Engineering (2019 Course)

404187: Lab Practice – 2

Teaching Scheme:	Credit	Examination Scheme:
Practical: 04 Hrs. / Week	02	Term Work: 25 Marks Practical: 50 Marks

Companion Course, if any:

1. VLSI Design and Technology
2. Speech Processing (Elective - III)
3. PLC SCADA and Automation (Elective - III)
4. JAVA Script (Elective - III)
5. Embedded System and RTOS (Elective - III)
6. Modernized IoT (Elective - III)

Guidelines for Student's Lab Journal

The student's Lab Journal can be experimental write-ups. It should include following as applicable: Assignment No, Title of Assignment, Date of Performance, Date of Submission, Aims & Objectives, Theory, Description of data used, Results, Conclusion.

Guidelines for Lab /TW Assessment

The oral examination will be based on the work carried out by the student in the Lab course. Suitable rubrics can be used by the internal & external examiner for assessment.

Subject: VLSI Design and Technology

Part A: To write VHDL code, simulate with test bench, synthesis, implement on PLD **(Any 5 to be performed)**

1.	4 bit ALU for Add, Subtract, AND, NAND, OR, XOR & XNOR.
2.	Universal shift register with mode selection input for SISO, SIPO, PISO, & PIPO.
3.	Mod - N Counter
4.	FIFO memory
5.	LCD Interface
6.	Keypad interface

Part B: To prepare CMOS layout in selected technology, simulate with & without capacitive load, comment on rise & fall times. **(Any 3 to be performed)**

1.	Inverter, NAND, NOR gates
2.	Half Adder & Full Adder
3.	2:1 Mux using logic gates & transmission gates
4.	One bit SRAM Cell

Virtual Lab:

1. **https://vlsi-iitg.vlabs.ac.in (Digital VLSI Design Lab.)**
2. **https://cse14-iiith.vlabs.ac.in/ (VLSI Lab.)**

Subject: Speech Processing (Elective - III)

NOTE:

1. To perform the experiments software like Python, SCILAB, OCTAVE or **any appropriate open source software can be used.**
2. For analysis of speech signals tools like PRAAT, Audacity, WAVESURFER, WEKA can be used.

Part A (Any 7 to be performed)

1.	Record speech signals (isolated words, continuous speech) and analyse the speech signal using speech analysis tool (e.g. PRAAT). Observe spectrogram, pitch, formants, intensity etc.
2.	Write a program for extracting pitch period for a voiced part of the speech signal using autocorrelation method and average magnitude difference function (AMDF).
3.	Write a program to compute short time Energy and ZCR for different frame rates and comment on the result.
4.	Write a program to classify voiced, unvoiced and silence frames using frame level energy and zero crossing rate.
5.	Write a program to compute narrow band and wide band spectrogram. Comment on the time and frequency resolution of wide band and narrow band spectrogram.
6.	Write a program to design a Mel filter bank and using this filter bank write a program to extract MFCC features.
7.	Write a program to perform the cepstral analysis of speech signal and detect the pitch from the voiced part using cepstrum analysis.
8.	Write a program to enhance the noisy speech signal using spectral subtraction method.
9.	Write a program to extract frequency domain audio features like SC, SF and Spectral roll off.

Part B (Any 1 to be performed)

1.	Write a program for Automatic Speech Recognition using Convolutional Neural Networks (CNN) or Recurrent Neural Networks (RNN).
2.	Write a program for Text to Speech synthesis using Convolutional Neural Networks (CNN) or Recurrent Neural Networks (RNN).

Virtual Lab:

1. **https://ssp-iiith.vlabs.ac.in/Introduction.html**
2. **https://vlab.amrita.edu/index.php?sub=59&brch=164**

Speech database:

http://festvox.org/databases/iiit_voices/

Subject: PLC SCADA and Automation (Elective - III)	
Part A (Any 5 to be performed)	
1.	Implementation of Logic Gates Using PLC(Software/Hardware Implementation).
2.	Development of a ladder program for DOL Starter.
3.	Implementation of Boolean Expression using PLC(Software/Hardware Implementation).
4.	Traffic Light Control using PLC (Any Application of Timer using PLC will be accepted) (Software/Hardware Implementation).
5.	Counting Objects (Any Application of Counter using PLC will be accepted) (Software/Hardware Implementation).
6.	Interfacing of Encoder with PLC to control a particular application.
7.	Interfacing of Limit Switch/ Proximity Switch/or any sensor/sensors with PLC to control a particular application.
Part B (Any 2 to be performed)	
1.	Interfacing of RTD with PLC for Temperature control application.
2.	Motor speed control using PLC and VFD.
3.	Pneumatic Trainer Kit/Hydraulic Trainer Kit control using PLC.
4.	Close Loop control using PID Controller (Any One Parameter Like Temperature, Flow, Pressure, Level)
Part C (Any 1 to be performed)	
1.	Any Example Using SCADA.
2.	Study of Hardware and Software Platform for DCS **https://ial-coep.vlabs.ac.in/exp/software-platforms-dcs/procedure.html**
3.	PLC controlled Case study- 1: **[Faculty will give (or students will choose) one problem statement to a group of 2/3 students. Students will develop a program and simulate it on their own]** **Suggested case studies (Not Limited to)** **a. Bottle Filling Plant using PLC** **b. Operation of Lift (Elevator) using PLC** **c. PLC based Gas Detection System using Ladder Logic Project** **d. Alarm Management Systems using PLC** **e. Water Distribution System using PLC**
Virtual Lab: 1. **http://plc-coep.vlabs.ac.in/ (Programmable Logic Controller Lab.)** 2. **http://ial-coep.vlabs.ac.in/List%20of%20experiments.html (Industrial Automation Lab.)**	

Subject: JAVA Script (Elective - III)

Part A (Compulsory)

1.	Write a JavaScript program to calculate area of triangle, area of rectangle and area of circle
2.	Write a JavaScript program to generate the multiplication table of a given number.
3.	Write a JavaScript program to following operations on a given string, • Reverse string • Replace characters of a string. • String is Palindrome.
4.	Write a JavaScript program to compare two strings using various methods.
5.	Write a JavaScript program that will create a countdown timer.

Part B (Any 2 to be performed)

1.	Write a JavaScript program that will create an array and perform following operations • To remove specific element from the array. • Check if an array contains a specified value. • To empty an array
2.	Write a JavaScript program that will append an object to an array and will check if an object is an array.
3.	Write a JavaScript program to illustrate different Set operations like- • Union • Intersection • Difference • Set Difference

Part C (Any 2 to be performed)

1.	Write a JavaScript program to create a Home page of any website and change background color using • On mouse over event • On focus event
2.	Create a student information Form to accept information like Name, Address, City, State Gender, Mobile Number, and email id. Perform validations for: • Correct Names • Mobile Names • Email I.D.'s • If no entered value • Re-display for wrongly entered values with message • Congratulation and Welcome page upon successful entries
3.	Design and implement a simple calculator using Java script for operations like addition multiplication, subtraction, division, square of a number etc: • Design a calculator like text field for input and output, buttons for numbers and operations etc. • Validate input values • Prompt / Alerts for invalid values etc.

Virtual Lab:

1. **https://cse02-iiith.vlabs.ac.in/List%20of%20experiments.html (Computer Programming Lab.)**

Subject: Embedded System and RTOS (Elective - III)	
Part A (Any 4 to be performed)	
NOTE: Practicals from 1 to 5 in Group A can be performed using µCOS -II / Free RTOS on ARM 7 / ARM Cotex – M / Arduino	
1.	Multitasking in µCOS II RTOS using minimum 3 tasks on ARM7/ ARM Cortex- M.
2.	Semaphore as signaling & Synchronizing on ARM7/ ARM Cortex- M.
3.	Mailbox implementation for message passing on ARM7/ ARM Cortex- M.
4.	Queue implementation for message passing on ARM7/ ARM Cortex- M.
5.	Implementation of MUTEX using minimum 3 tasks on ARM7/ ARM Cortex- M.
6.	Porting of linux operating system on ARM9/ARM Cortex-M.
Part B (Any 4 to be performed)	
1.	Interfacing sensors and actuators with Arduino Uno- Door opener using Ultrasonic sensor and servo motor.
2.	Weather Station- Build a cloud-ready temperature and Humidity sensor (DHT-11/22) with the Node MCU and the any IoT Platform.
3.	IoT based Wireless Controlled Home Automation using ESP8266.
4.	Interfacing of 4 LED bank with Raspberry Pi to blink.
5.	Interfacing Sensors and actuators with Raspberry Pi- Hand gesture robot.

Virtual Lab:

1. **https://docs.simuli.co/getting-started/arduino/arduino-ide-and-vlab**

2. **https://docs.simuli.co/getting-started/raspberry-pi/setting-up-iotify-virtual-lab**

Subject: Modernized IoT (Elective – III)	
List of Experiments	
1.	Study of Raspberry-Pi, Beagle board, Arduino, and different operating systems for Raspberry-Pi/Beagle board/Arduino. Understanding the process of OS installation on Raspberry-Pi/Beagle board/Arduino
2.	Open-source prototype platform- Raspberry-Pi/Beagle board/Arduino -Simple program digital read/write using LED and Switch -Analog read/write using sensor and actuators.
3.	Interfacing sensors and actuators with Arduino/Raspberry-pi.
4.	IoT based Stepper Motor/DC Motor Control with Arduino/Raspberry Pi.
5.	Introduction to MQTT/ CoAP and sending sensor data to cloud using Raspberry-Pi/Beagle board/Arduino.
6.	Get the status of a bulb at a remote place (on the LAN) through web.
7.	Interfacing Arduino to Bluetooth Module.
8.	Communicate between Arduino and Raspberry PI using any wireless medium like ZigBee.
9.	IoT based small project implementation on the topics based on small problem statements of the fields like chat bot, smart home (Home Automation), social issues and environmental issues etc. This project can be built on any IoT simulation platform like Tinkercad, Cooja etc.

Savitribai Phule Pune University

Fourth Year of E & Tc Engineering (2019 Course)

404188: Project Phase – I

Teaching Scheme:	Credit	Examination Scheme:
Practical: 02 Hrs. / Week	01	Term Work: 50 Marks

Course Objectives:

- To understand the basic concepts & broad principles of projects.
- To understand the value of achieving perfection in project implementation & completion.
- To apply the theoretical concepts to solve real life problems with teamwork and Multidisciplinary approach.
- To demonstrate professionalism with ethics; present effective communication skills and relate engineering issues to broader societal context.

Course Outcomes:

CO1: Demonstrate a sound technical knowledge in field of E&TC in the form of project.
CO2: Undertake real life problem identification, formulation and solution.
CO3: Design engineering solutions to complex problems utilizing a systematic approach.
CO4: Demonstrate the knowledge, effective communication skills and attitudes as professional engineer.

Project phase 1 is an integral part of the project work. The project work shall be based on the knowledge acquired by the student during the graduation and preferably it should meet and contribute towards the needs of the society. The project aims to provide an opportunity of designing and building complete system or subsystems in the field of Electronics and communication where the student likes to acquire specialized skills. The student shall prepare the duly certified Fourth report of project work in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute.

Guidelines:

1. Group Size: The student shall carry the project work individually or by a group of students. Optimum group size shall be 3 students. However, if project complexity demands a maximum group size of 4 students, the project committee should be convinced about such complexity and scope of the work. Projects selected should meet and contribute towards the needs of the society.
2. Selection and approval of topic: Topic should be related to real life application in the field of Electronics and Telecommunication engineering.
3. The topic may be based on : Investigation of the latest development in a specific field of Electronics or Communication / The investigation of practical problem in manufacture and / or testing of electronics or communication equipment/ Software based projects related to VHDL, Communication, Instrumentation, Signal Processing agriculture Engineering etc. with the justification for techniques used / any topic in the field of E&TC may be allowed.
4. Interdisciplinary projects should be encouraged. The examination of Interdisciplinary projects shall be conducted independently in respective departments.
5. The term work assessment of project phase 1 shall be based on Innovative Idea of selected project, literature survey, Depth of understanding, Applications, Individual contributions, presentation, project report, timely completion of work.
6. The department should prepare project planner and should follow accordingly
7. A log book of work carried out during the semester should be maintained with weekly review remarks by the guide and committee.
8. A certified copy of report preferably using LATEX is required to be presented to external examiner at the time of Fourth examination.
9. The project report must undergo by plagiarism check and the similarity index must be less than 15%. The plagiarism report should be included in the project report.

Savitribai Phule Pune University Fourth Year of E & Tc Engineering (2019 Course) 404189: Mandatory Audit Course - 7		
Teaching Scheme:	**Credit**	**Examination Scheme:**
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GUIDELINES FOR CONDUCTION OF AUDIT COURSE

In addition to credits courses, it is mandatory that there should be audit course (non-credit course) from second year of Engineering. The student will be awarded grade as AP on successful completion of audit course. The student may opt for two of the audit courses (One in each semester). Such audit courses can help the student to get awareness of different issues which make impact on human lives and enhance their skill sets to improve their employability. List of audit courses offered in the semester is provided in the curriculum. Student can choose one of the audit course from list of courses mentioned. Evaluation of audit course will be done at institute level.

The student registered for audit course shall be awarded the grade AP and shall be included such grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory in-semester performance and secured a passing grade in that audit course. No grade points are associated with this 'AP' grade and performance in these courses is not accounted in the calculation of the performance indices SGPA and CGPA. Evaluation of audit course will be done at institute level itself.

Selecting an Audit Course:

Using NPTEL Platform:

NPTEL is an initiative by MHRD to enhance learning effectiveness in the field of technical education by developing curriculum based video courses and web based e-courses. The details of NPTEL courses are available on its official website www.nptel.ac.in

- Student can select any one of the courses mentioned above and has to register for the corresponding online course available on the NPTEL platform as an Audit course.
- Once the course is completed the student can appear for the examination as per the guidelines on the NPTEL portal.

- After clearing the examination successfully; student will be awarded with certificate.

Assessment of an Audit Course:

- The assessment of the course will be done at the institute level. The institute has to maintain the record of the various audit courses opted by the students. The audit course opted by the students could be interdisciplinary.
- During the course students will be submitting the online assignments. A copy of same students can submit as a part of term work for the corresponding Audit course.
- On the satisfactory submission of assignments, the institute can mark as “Present” and the student will be awarded the grade AP on the marksheet.