Savitribai Phule Pune University

Faculty of Science and Technology

Syllabus for

M.E (Electronics and Telecommunications)
(IoT and Sensor System)

(2017 Pattern/Course)

Savitribai Phule Pune University, Pune
M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course
(With effect from Academic Year 2020-21)

Semester-I

Course Code	Course Name	Teaching Scheme (Hours/Week)		Examination and Marking Scheme					Credit		
		Theory	Practical	In-Sem	End-Sem	TW	OR	Total	TW	OR	Theory
504801	Sensors & Measurements	04	-	50	50	-	-	100	-	-	04
504802	Data Communication & Networking	04	-	50	50		-	100	-	-	04
504803	Wireless Sensor Network for IoT	04	-	50	50	-	-	100	-	-	04
504804	Research Methodology	04	-	50	50	-	-	100	-	-	04
504805	Elective – I	05	-	50	50	-		100	-	-	05
504806	Lab Practice-I	-	08	-	-	50	50	100	02	02	04
504807	Non- Credit Course-I										-
	Total	21	08	250	250	50	50	600	02	02	25
								Total Credits		**25**	

Abbreviations:

In-Sem: In semester — End-sem: End semester — TH : Theory
TW : Term Work — PR : Practical — OR: Oral

Elective – I

1. **Biomedical & Image Sensor Design and Applications**
2. **IoT Security and Trust**
3. **Microwave sensors & RF IC Design**
4. **Big Data Analytics for IoT**
5. **AI & Machine Learning for IoT**

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Semester-II

Course Code	Course Name	Teaching Scheme (Hours/Week)		Examination and Marking Scheme					Credit		
		Theory	Practical	In-Sem	End-Sem	TW	OR	Total	TW	OR	Theory
504808	Embedded System Design	04	-	50	50	-	-	100	-	-	04
504809	Cloud Architecture & Protocols	04	-	50	50		-	100	-	-	04
504810	IoT Architecture and Protocols	04	-	50	50	-	-	100	-	-	04
504811	Elective - II	05	-	50	50	-	-	100	-	-	05
504812	Mini Project / Seminar-I	-	04	-	-	50	50	100	02	02	04
504813	Lab practice-II	-	08	-	-	50	50	100	02	02	04
504814	Non- Credit Course-II										-
Total		**17**	**12**	**200**	**200**	**100**	**100**	**600**	**04**	**04**	**25**
								Total Credits		**20**	

Abbreviations: In-Sem: In semester, End-sem: End semester, TH : Theory, TW : Term Work, PR : Practical, OR : Oral

Elective – II / MOOCs

1. **Fiber Optic Sensors and Photonics**
2. **Smart Convergent System**
3. **Energy and Power Management for IoT Devices**
4. **Cloud Storage and Computing**
5. **Wearable Computing, Mixed Reality and Internet of Everything**

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Semester-III

Course Code	Course Name	Teaching Scheme (Hours/Week)		Examination Scheme and Marks					Credit		
		Theory	Practical	In-Sem	End-Sem	TW	PR	Total	TW	PR	Theory
604801	Microsystem Fabrication	04	-	50	50	-	-	100	-	-	04
604802	IoT Applications & Web Development	04	-	50	50	-	-	100	-	-	04
604803	Elective - III	05	-	50	50	-	-	100	-	-	05
604804	Industry Internship-I/ In-house Research Project-I / Seminar - II	-	04	-	-	50	50	100	02	02	04
604805	Dissertation Stage - I	-	08	-	-	50	50	100	04	04	08
604806	Non- Credit Course-III										-
Total		**13**	**12**	**150**	**150**	**100**	**100**	**500**	**06**	**06**	**25**
								Total Credits			**25**

Abbreviations: In-Sem: In semester End-sem: End semester TH : Theory
TW : Term Work PR : Practical OR : Oral

Elective – III

For 3 credits

1. **Value Education, Human rights and Legislative procedures**
2. **Environmental studies**
3. **Renewable Energy Studies**
4. **Disaster Management**
5. **Knowledge Management**
6. **Foreign Language**
7. **Economics for Engineers**
8. **Engineering Risk – Benefit and analysis**

For 2 Credit

1. **Optimization techniques**
2. **Fuzzy Mathematics**
3. **Design and Analysis of Algorithms**
4. **CUDA**

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Semester-IV

Course Code	Course Name	Teaching Scheme (Hours/Week)	Examination and Marking Scheme			Credit	
		Practical	TW	OR	Total	TW	OR
604807	Industry Internship-II/ In-house Research Project-II / Seminar-III	05	50	50	100	02	03
604808	Dissertation Stage - II	20	150	50	200	10	10
Total		**25**	**200**	**100**	**300**	**12**	**13**
					Total Credits	**25**	

Abbreviations: TW : Term Work PR : Practical OR : Oral

SEMESTER - I

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504801: Sensors & Measurements

Teaching Scheme	Credit	Examination Scheme
Theory: 04 Hrs. / Week	04	In-Sem: 50 Marks End Sem: 50 Marks

Course Objective: To make the students understand:

1. To provide in depth knowledge in physical principles applied in sensing, measurement and a comprehensive understanding on how measurement systems are designed, calibrated, characterized, and analyzed.
2. To introduce the students to sources and detectors of various Optical sensing mechanisms and provide in-depth understanding of the principle of measurement, and theory of instruments and sensors for measuring velocity and acceleration
3. To give a fundamental knowledge on the basic laws and phenomena on which operation of sensor transformation of energy is based.
4. To impart a reasonable level of competence in the design, construction, and execution of mechanical measurements strain, force, torque and pressure.

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

CO1: Use concepts in common methods for converting a physical parameter into an electrical quantity.

CO2: Choose an appropriate sensor comparing different standards and guidelines to make sensitive measurements of physical parameters like pressure, flow, acceleration, etc.

CO3: Evaluate performance characteristics of different types of sensors.

CO4: Locate different types of sensors used in real life applications and paraphrase their importance.

CO5: Create analytical design and development solutions for sensors.

Course Contents

Module 1	Sensor fundamentals, Types and Detectors	(10 Hrs.)

Sensor Classification, Performance and Types, Error Analysis characteristics, Electronic and Optical properties of semiconductor as sensors, LED, Semiconductor lasers, Fiberoptic sensors, Thermal detectors, Photo multipliers, photoconductive detectors, Photodiodes, Avalanche photodiodes, CCDs. Strain gages, strain gage beam force sensor, piezoelectricforce sensor, load cell, torque sensor, Piezo-resistive and capacitive pressure sensor, optoelectronicpressure sensors, vacuum sensors. Design of signal conditioning circuits for strain gauges, piezo,capacitance and optoelectronics sensors.

Module II	Intensity Polarization, Interferometric Sensors , Velocity & Acceleration sensors	(10 Hrs.)

Intensity sensor, Micro bending concept, Interferometers, Mach Zehnder, Michelson, Fabry-Perot and Sagnac, Phase sensor: Phase detection, Polarization maintaining fibers. Electromagnetic velocity sensor, Doppler with sound, light, Accelerometer characteristics, capacitive, piezo-resistive, piezoelectric accelerometer, thermal accelerometer, rotor, monolithic and optical gyroscopes.

Module III	Position, Direction, Displacement and Level	(10 Hrs.)
Potentiometric and capacitive sensors, Inductive and magnetic sensor, LVDT, RVDT, eddy current, transverse inductive, Hall effect, magneto resistive, magnetostrictive sensors. Fiber optic liquid level sensing, Fabry Perot sensor, ultrasonic sensor, capacitive liquid level sensor. Signal condition circuits for reactive and self generating sensors.		
Module IV	**Flow, Temperature and Acoustic sensors**	**(10 Hrs.)**
Flow sensors: pressure gradient technique, thermal transport, ultrasonic, electromagnetic and Laser anemometer. Micro flow sensor, coriolis mass flow and drag flow sensor. Temperature sensors-thermoresistive, thermoelectric, semiconductor and optical. Piezoelectric temperature sensor. Acoustic sensors-microphones-resistive, capacitive, piezoelectric, fiber optic, solid state - electrect microphone.		

Learning Resources

Text Books:

1. Jacob Fraden, "Hand Book of Modern Sensors: physics, Designs and Applications", Springer, 3rd Edition.
2. Jon. S. Wilson, "Sensor Technology Hand Book", Elsevier, 1st Edition, 2011.

Reference Books:

1. GerdKeiser, "Optical Fiber Communications", McGraw-Hill Science, 5th Edition, 2017.
2. John G Webster, "Measurement, Instrumentation and sensor Handbook", CRC Press, 2nd Edition,2017.
3. Eric Udd and W.B. Spillman, "Fiber optic sensors: An introduction for engineers and scientists", Wiley, 2nd Edition, 2013.
4. Bahaa E. A. Saleh and Malvin Carl Teich, "Fundamentals of photonics",John Wiley, 1st Edition, 2012.

List of Experiments

1) Plot the measurement result using Ultrasound sensor in various medium. Use different reflecting media to analysis the sensor response and accuracy.
2) Perform human step counting using triple axis accelerometer.
3) Create a setup to measure revolution of motor shaft using hall effect sensor.
4) Use MEMS vibration sensor to measure the various vibration pattern and plot the graph for the same.
5) Create a liquid level measurement setup with ToF IR sensor.
6) Plot the flow measurement comparison chart for different type of fluid by using flow measurement sensor.
7) Using Half bridge strain gauge method create a setup to measure the weighing scale to measure the weight from 0-20 Kg.
8) Compare the response of various Acoustic sensors for different audio frequencies.
9) Create solid state levelling device using gyro sensor.

Sensor needed: Ultrasonic Sensor, Accelerometer, Hall effect sensor, Vibration Sensor, ToF IR sensor, Liquid Flow meter, Piezoelectric microphone, Condenser microphone, Gyro Sensor, Magneto meter.

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504802: Data Communication & Networking

Teaching Scheme	Credit	Examination Scheme
Theory: 04 Hrs. / Week	04	In-Sem: 50 Marks End Sem: 50 Marks

Course Objective:

1. Expose the students to distinguishing features of wireless network

Course Outcomes: The students are expected to have the ability to:
CO1: Design and optimize wireless network architectures.
CO2: Implement security techniques for wireless networks.

Course Contents

Module I	Fundamentals	(10 Hrs.)

Layered architecture overview, data communication techniques, motivations for cross-layer protocol design, motivations for performance analysis, forward error correction and re-transmission performances

Module II	Network Layer and Topology Design	(10 Hrs.)

Markov and semi-Markov processes, Little's theorem, M/M/m/k, M/G/1 systems, priority queueing, network of queues, network traffic behavior, routing algorithms and analysis, distributed networks,design constraints, bounded latency networks, optimization, cognitive networks.

Module III	Network Management	(10 Hrs.)

Power management, time synchronization, localization, energy-Mod-efficient protocols for sensor networks Mechanisms to improve performance: Self-Organizing Network, Software-Defined Networking.

Module IV	Transport and Application Layers	(10 Hrs)

Congestion control and quality of service, scheduling, multimedia, key aspects and design issues Reliability and security: Security requirement and attacks, Encryption techniques, reliable and securecommunication protocols.

Learning Resources

Text Books:

Dargie, W., and Poellabauer, C., "Fundamentals of Wireless Sensor Networks: Theory andPractice", Wiley.

1. Stallings, W., "Data and Computer Communications", Pearson, 8th Edition.
2. Bertsekas, D. P. and Gallager, R. G., "Data Networks", Prentice Hall, 2nd Edition.

List of Experiments
1. Write a program in NS3 to implement star/bus topology. 2. Write a program in NS3 for connecting multiple routers and nodes and building a hybrid topology. 3. To analyze network traces using Wireshark packet analyzer tool. 4. Create a network of RF nodes using NRF24L0 radio chips, measure the various parameters such packet delivery, packet dropped, error rate.

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504803: Wireless Sensor Network for IoT

Teaching Scheme:	Credit	Examination Scheme:
Theory: 04 hrs. / week	04	In-Sem: 50 Marks End Sem: 50 Marks

Course Objectives

1. To identify and expose the students to the central elements in the design of communication protocols for the WSNs.
2. To disseminate the design knowledge in analyzing the specific requirements for applications in WSNs regarding energy supply, memory, processing, and transmission capacity.
3. To get the perception of mobile ad hoc networks, design, implementation issues, and solutions based on different algorithms and protocols for power management, sensor data routing and query processing.
4. To associate, hardware platforms and software frameworks used to realize dynamic Wireless sensor network.

Course Outcomes

CO1: Assess the applicability and limitations of communication protocols for a real time WSN application.

CO2: Confirms the behavior of mobile ad hoc networks (MANETs)and correlates the infrastructure-based networks.

CO3: Proactive in understating the routing protocols function and their implications on data transmission delay and bandwidth.

CO4: Able to establish networks with an attempt to reduce issue of broadcast and flooding techniques.

CO5: Contribute appropriate algorithms to improve existing or to develop new wireless sensor network applications.

CO6: Familiarize the protocol, design requirements, suitable algorithms, and the state-of-the-art cloud platform to meet the industrial requirement.

CO7: On a profound level to implement hardware & software for wireless sensor networks in day to day life.

Course Contents

Module I	Network for Embedded Systems and Protocols	(08 Hrs.)

RS232, RS485, SPI, I2C, CAN, LIN, FLEXRAY, Bluetooth, Zigbee, Wifi, MiWi, Nrf24, Wireless LAN &PAN, UWB.

Module II	Wireless Sensor Network	(12 Hrs.)

Characteristic and challenges, WSN vsAdhoc Networks, Sensor node architecture, Physical layer and transceiver design considerations in WSNs, Energy usage profile, Choice of modulation scheme, Dynamic modulation scaling, Antenna considerations.

Fundamentals of MAC protocols - Low duty cycle protocols and wakeup concepts, Contention Based protocols, Schedule-based protocols - SMAC – BMAC, Traffic-adaptive medium access protocol (TRAMA), The IEEE 802.15.4 MAC protocol.

Module III	Sensor Network Architecture	(08 Hrs.)

Data Dissemination, Flooding and Gossiping-Data gathering Sensor Network Scenarios, Optimization Goals and Figures of Merit, Design Principles for WSNs- Gateway Concepts, Need for gateway, WSN and Internet Communication, WSN Tunneling.

Module IV	IP Based WSN	(12 Hrs.)
Circuit switching, packet switching, concept of IPV4, IPV6, 6LOWPAN and IP, IP based WSN, 6LOWPAN based WSN. Tiny OS for WSN and IoT, M2M communication, Alljoyn network.		

Learning Resources

Text Books:

1. Holger Karl, Andreas Willig, “Protocols and Architectures for Wireless Sensor Networks” John Wiley & Sons, 1st Edition, 2011.
2. Jun Zheng, Abbas Jamalipour, “Wireless Sensor Networks: A Networking Perspective”, Wiley-IEEE Press,1st Edition, 2014.

Reference Books:

1. Waltenegus W. Dargie, Christian Poellabauer, "Fundamentals of Wireless Sensor Networks: Theory and Practice", John Wiley & Sons, 1st Edition, 2014.
2. Ian F. Akyildiz, Mehmet Can Vuran, "Wireless Sensor Networks",John Wiley & Sons, 1st Edition,2011.
3. Zach Shelby, Carsten Bormann, "6LoWPAN: The Wireless Embedded Internet", John Wiley & Sons, 1st Edition, 2009.

List of Experiments

1. Study of RS232 and RS485 protocols using USB-to-serial hardware.
2. Study other wireless sensor network simulators (Mannasim. Contiki, OMNeT++, TOSSIM etc).
3. Write TCL script for transmission between mobile nodes.
4. Generate TCL script for UDP and CBR traffic in WSN nodes.
5. Implementation of routing protocol in NS2 for AODV protocol.

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504804: Research Methodology

Teaching Scheme	Credit	Examination Scheme
Theory: 04 Hrs. / Week	04	In-Sem: 50 Marks End Sem: 50 Marks

Course Objectives:

1. To learn the process of identification of research problem
2. To understand the importance of statistics involved in research
3. To understand the process of analysis and verification of developed system model
4. To develop a skill to prepare research proposals

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

CO1: Outline research problem, its scope, objectives and errors

CO2: Understand basic instrumentation schemes and its data collection methods

CO3: Learn various statistical techniques

CO4: Develop model and can predict the performance of experimental system

CO5: Write research proposals of their own domain

Course Contents

Module I	Research Problem & Basic instrumentation	(10 Hrs.)

Research Problem: Meaning of research problem, Sources of research problem, Criteria/ Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Basic instrumentation: Instrumentation schemes, Static and dynamic characteristics of instruments used in experimental set up, Performance under flow or motion conditions, Data collection using a digital computer system, Linear scaling for receiver and fidelity of instrument, Role of DSP is collected data contains noise.

Module II	Applied Statistics	(10 Hrs.)

Applied Statistics: Regression analysis, Parameter estimation, Multivariate statistics, Principal component analysis, Moments and response curve methods, State vector machines and uncertainty analysis.

Module III	Modelling and prediction of performance:	(10 Hrs.)

Modelling and prediction of performance: Setting up a computing model to predict performance of experimental system, Multi-scale modelling and verifying performance of process system, Nonlinear analysis of system and asymptotic analysis, Verifying if assumptions hold true for a given apparatus setup, Plotting family of performance curves to study trends and tendencies, Sensitivity theory and applications.

Module IV	Developing a Research Proposal	(10 Hrs.)
Developing a Research Proposal: Format of research proposal, Individual research proposal, Institutional proposal. Proposal of a student – a presentation and assessment by a review committee consisting of guide and external expert only. Other faculty members may attend and give suggestions relevant to topic of research.		

Learning Resources

1. Melville Stuart, Goddard Wayne, "Research methodology: An Introduction for Science & Engineering students" .
2. Ranjit Kumar, "Research Methodology: A Step by Step Guide for Beginners", 2nd Edition.
3. Dr. Kothari C R, "Research Methodology: Methods and Trends".
4. Dr. Sharma S D, KedarNath, "Operational Research".

List of Assignments

1. Design a typical research problem using scientific method.
2. Design a data collection system using digital computer system.
3. Study the various analysis techniques.
4. Design and develop a computing model to predict the performance of experimental system.
5. Develop the following research proposal :A. Individual B. Institutional.

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504805 (A): Bio Medical & Image Sensor Design and Applications (Elective- I)

Teaching Scheme	Credit	Examination Scheme
Theory: 05 Hrs. / Week	05	In-Sem: 50 Marks End Sem: 50 Marks

Course Objectives:

1. Introduce the students to different types of electrodes used in bio potential recording
2. To facilitate the students in recognizing electrode configuration and issues related with the Electrode relative motions.
3. To expose the students to perceive the need for bio amplifiers and their characteristics needed to be design for various bandwidth and frequency response.
4. Review the cardiac, respiratory and muscular physiological systems. Study the designs of several Instruments used to acquire signals from living systems.
5. To proclaim the conception in detection of chemical and biomolecules.
6. Students will be expedient in applying specific radiology methods in diagnostics and analysis.
7. The students also understand the theory behind the sound and tissue interaction, and able to apply in therapeutic application

Course Contents

Module I	Biopotential Electrodes and Graphs EEG, EMG & ECG	(10 Hrs.)

Biopotential Electrodes and Graphs : Origin of bio potential and its propagation. Electrode-electrolyte interface, electrode–skin interface, half-cell potential, impedance, polarization effects of electrode – nonpolarizable electrodes. Types of electrodes - surface, needle and micro electrodes and their equivalent circuits. Recording problems - measurement with two electrodes.

EEG, EMG & ECG: Bio signal characteristics – frequency and amplitude ranges. ECG – Einthoven's triangle, standard 12 lead system. EEG – 10-20 electrode system, unipolar, bipolar and average mode. EMG– unipolar and bipolar mode. EEG- procedure, signal artefacts, signal analysis, evoked potential, EMG- procedure and signal analysis, Nerve conduction study.

Module II	Physical Sensors in Biomedicine	(10 Hrs.)

Temperature measurement: core temperature,-surface temperature- invasive. Blood flow measurement: skin blood- hot film anemometer- Doppler sonography- electromagnetic sensor - blood pressure measurement: noninvasive- hemodynamic invasive. Spirometry- sensors for pressure pulses and movement- ocular pressure sensor- acoustic sensors in hearing aid, in blood flow measurement, sensors for bio-magnetism, tactile sensors for artificial limbs, sensors in ophthalmoscopy, artificial retina.

Module III	Sensors in radiology and ultrasound	(10 Hrs.)

X ray imaging with sensors, detectors in nuclear radiology, magnetic field sensors for imaging, magnetic resonance imaging. Blood gas and pH sensor, electrochemical sensor, transcutaneous, optical fiber sensor, mass spectrometer, optical oximetry, pulseoximetry, earoximetry Interaction of Ultrasound with matter; Cavitations, Reflection, Transmission- Scanning systems – Artefacts- Ultrasound- Doppler- Double Doppler shift-Clinical Applications.

Module IV	Image sensors	(10 Hrs.)
Digital camera technologies, CCDs and CMOS image sensors, how to measure signal/noise ratio and camera performance parameters, Special sensors for low-light capture, high dynamic range image capture, slow motion capture, 3D stereo capture, Camera interfaces.		

Learning Resources

Text Books:

1. J. G. Webster, J. G. Webster ,"Medical Instrumentation; Application and Design", John Wiley & Sons, Inc., 4th Edition, 2015.
2. Khandpur R.S, "Handbook of Biomedical Instrumentation",Tata McGraw-Hill, 3rd Edition ,2014
3. John Enderle, Joseph Bronzino, "Introduction to Biomedical Engineering", Academic Press, 3rd Edition, 2011.
4. Myer Kutz, "Biomedical Engineering and Design Handbook, Volume 1: Volume I: Biomedical Engineering Fundamentals", McGraw Hill Publisher, 2nd Edition, 2009.
5. "Introduction to Image Sensors and Digital Cameras," in http://www.stanford.edu/class/ee392b.

List of Experiments

1. IoT based Patient health monitoring system.
2. Realtime ECG/EMG/EEG Signal analysis using Scilab/MATLAB.
3. Create a setup for continuous monitoring of patient temperature and heart rate data using existing temperature and heart rate sensor.
4. Plot the ECG signal graph using 3 probe ECG sensor setup.
5. Measure and analyze the myopotential at various places on body using simple bio sensors.
6. Measure blood oxygen saturation using Spo2 sensor.

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504805 (B): IoT Security and Trust (Elective- I)

Teaching Scheme	Credit	Examination Scheme
Theory: 05 Hrs. / Week	05	In-Sem: 50 Marks End Sem: 50 Marks

PURPOSE: The purpose of this course is to impart knowledge on IoT Security and trust, study their implementations.

Course Objectives: To make the students understand

- Ability to understand the Security requirements in IoT.
- Understand the cryptographic fundamentals for IoT
- Ability to understand the authentication credentials and access control
- Understand the various types Trust models and Cloud Security.

Course Contents

Module I	Securing the Internet of Things	(12Hrs.)

Security Requirements in IoT Architecture - Security in Enabling Technologies - Security Concerns in IoT Applications. Security Architecture in the Internet of Things . Security Requirements in IoT - Insufficient Authentication/Authorization - Insecure Access Control - Threats to Access Control, Privacy, and Availability - Attacks Specific to IoT. Vulnerabilities – Secrecy and Secret-Key Capacity - Authentication/Authorization for Smart Devices - Transport Encryption – Attack & Fault Trees.

Module II	Cryptographic fundamentals for IoT	(08 Hrs.)

Cryptographic primitives and its role in IoT – Encryption and Decryption – Hashes Digital Signatures – Random number generation – Cipher suites – key management fundamentals – cryptographic controls built into IoT messaging and communication protocols – IoT Node Authentication.

Module III	Identity & Access Management Solutions for IoT	(06 Hrs.)

Identity lifecycle – authentication credentials – IoT IAM infrastructure – Authorization with Publish / Subscribe schemes – access control.

Unit IV	Privacy Preservation and Trust Models for IoT Cloud Security for IoT	(14 Hrs.)

Privacy Preservation and Trust Models for IoT: Concerns in data dissemination – Lightweight and robust schemes for Privacy protection – Trust and Trust models for IoT – self-organizing Things - Preventing unauthorized access.

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

Learning Resources

Reference Books:

1. Brian Russell, Drew Van Duren, “Practical Internet of Things Security” (Kindle Edition).

2. Securing the Internet of Things Elsevier.

3. Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations**.**

List of Experiments

1. Implement the following Attack and compare and analyze with the help of various quality parameters:
   a) DoS Attack b) Brute Force Attack c) MiTM attack
2. Demonstrate intrusion detection system using any tool (such as snort or any other tools)
3. Case Study:Blockchain for IoT Security
4. Setup and test a secure https communication protocol between two wifi nodes working as the client and server.

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504805 (C): Microwave Sensors & RF IC Design (Elective- I)

Teaching Scheme	Credit	Examination Scheme
Theory: 05 Hrs. / Week	05	In-Sem: 50 Marks End Sem: 50 Marks

Course Objectives:

1. To introduce different Microwave sensors : Microwave antennas, RADAR, Radiometer, Microwave Power sensors
2. To introduce integrated circuit designing at radio frequencies.
3. Introduction of microwave sensors and various circuits and building blocks for communication applications.

Course Outcome:

CO1: Select a proper antenna design to be used in the RF spectral region.

CO2: Model specific radiation pattern and evaluate them in different domains.

CO3: Correlate the principle behind different radar systems and determine various applications based on the radar systems.

CO4: Understanding the design of integrated circuits at high frequencies.

CO5: Learning about the design of various active components like mixers, LNAs, power amplifiers at RF and microwave frequencies.

Course Contents

Module I	Microwave Antenna Sensors and Microwave Power Sensor	(10 Hrs.)

Microwave Antenna-I, types of Antenna, fundamental parameters of antennas, radiation Concepts of Printed Antennas, Antenna for communication and Antenna for sensing, Broadband Microstrip Patch Antennas, Antennas for Wearable Devices, Design Requirements, Modeling and Characterization of Wearable Antennas, WBAN Radio Channel Characterization and Effect of Wearable Antennas, Domains of Operation, Sources on the Human Body, Compact Wearable Antenna for different applications mechanism, Microwave Power Sensor- Diode Sensors: Diode detector principles, dynamic range average power sensors, Thermocouple Sensors: Principles of Thermocouple sensor, power meters for thermocouple sensors.

Module II	Radar and radiometer	(10 Hrs.)

RADAR-Introduction to RADAR, RADAR range equation, MTI and pulse Doppler RADAR, Tracking RADAR RADAR applications in Automotive, remote sensing, agriculture, medicine, detection of buried objects, NDT, defense, Radiometer- Radiative transfer theory, SMMR, Types of radiometers - and Bolometers, Applications of radiometers in automotive, agriculture, medicine, weather forecasting

Module III	RF Design and RF Amplifier Design	(10 Hrs.)

Concepts of RF Design: Wave Guides and Transmission Lines, coupled lines, S-Parameters, Smith Chart, single and double stub impedance matching, Two-port gain and stability analysis.

Amplifier Design: Concepts of nonlinearity, time variance and IIP3, model of MOS transistors and BJT at high frequencies, wideband amplifiers, constant gain amplifier, constant noise figure amplifier, power amplifiers, combining networks.

Module IV	Oscillators and Voltage Controlled Oscillators and PLL	(10 Hrs.)

Basic topologies VCO and definition of phase noise. Noise-power trade-off, quadrature and single-sideband generators.Mixers: Mixer Noise figure, port to port feed-through, single-balanced and double balanced mixers. Introduction to Phase-Locked Loops: Type I and Type II PLL's

Learning Resources

Text Books:

1.Finkenzeuer Klaus, "RFID Handbook",John Wiley and Sons, 3rd Edition, 2011.
2. Constantine A. Balanis, "Antenna Theory Analysis and Design", John Wiley and Sons,4th Edition,2016.
3. T. H. Lee, "The Design of CMOS Radio-Frequency Integrated Circuits" Cambridge, UK: Cambridge University Press, 1997.
4. B. Razavi, "RF Microelectronics", Pearson Education, 2nd Edition, 2014.
5. G. Gonzalez, "Microwave Transistor Amplifiers: Analysis and Design", Pearson, 2nd Edition,1996.

Reference Books:

1. B. Hoffman , Wellenhof, H.Lichtenegger and J.Collins, "GPS: Theory and Practice ", Springer, 5th Edition, 2012.
2 Lillesand& Kiefer, "Remote Sensing and Image Interpretation", John Wiley and Sons, 6th Edition 2011.
3. D. M. Pozar, "Microwave Engineering", Wiley, 4th Edition, 2011.

List of Experiments

1. Study of active and passive microwave sensors
2. Explain in detail the concept of RF power measurement. Carry out the RF power measurement using microwave bench. Write a detailed assignment on uncertainty analysis in various measurements.
3. Study the Network Analyzer, Carry out the measurements of s-parameter measurement for the various microstrip components.

Savitribai Phule Pune University, Pune
M.E. (Electronics& Telecommunications- IoT and Sensor System) 2017 Course
(With effect from Academic Year 2020-21)
504805 (D): Big Data Analytics for IoT (Elective- I)

Teaching Scheme	Credit	Examination Scheme
Theory: 05 Hrs. / Week	05	In-Sem: 50 Marks End Sem: 50 Marks

PURPOSE: To introduce the technology that enables IoT and access data using mobile computing devices.

Objectives:

- To learn the concepts of big data analytics
- Identify the technologies that enable IoT.
- Develop programs for interfacing with sensors and actuators and other IoT devices.

Set up the servers to upload IoT data to cloud for further analysis.

Course Outcome: Students should be able to:
CO1: Select a proper big data platform for a particular IOT application
CO2: Apply suitable data analysis algorithm.
CO3: Use hardware and software required to design and build IoT
CO4: Work on the application specific platform and data computing software.
CO5: To analyse multivariate metadata generated in IOT application

Course Contents

Module I	Big Data Platforms for the Internet of Things	(10 Hrs.)

Network protocol- data dissemination, current state of art- Improving Data and Service Interoperability with Structure, Compliance, Conformance and Context Awareness: interoperability problem in the IoT context- Big Data Management Systems for the Exploitation of Pervasive
Environments - Big Data challenges and requirements coming from different IOT applications such as smart home etc.

Module II	Big Data Analysis Algorithms.	(10 Hrs.)

Module content Algorithm design techniques: Divide and Conquer, Brute force, Greedy, Dynamic Programming, Time complexity (asymptotic notation, recurrence relations).

Overview of IoT supported Hardware Platforms: Raspberry pi, Arduino, Intel Galileo.

Module III	Spark	(10 Hrs.)

Introduction to Spark, Parallel programming with Spark, Spark built-in libraries, Design of key-value stores, Sliding window analytics, Spark streaming and sliding window analytics, Introduction to Cassandra Query Lnguage CQL)

Module IV	FOG Computing	(10 Hrs.)
Fog Computing: A Platform for Internet of Things and Analytics: a massively distributed number of sources. Big Data Metadata Management in Smart Grids: semantic inconsistencies – role of metadata.		

Learning Resources

Reference Books:

1. Stackowiak, R., Licht, A., Mantha, V., Nagode, L.," Big Data and The Internet of Things Enterprise Information Architecture for A New Age", Apress, 2015
2. Dr. John Bates , "Thingalytics - Smart Big Data Analytics for the Internet of Things", John Bates, 2015
3. NikBessis, CiprianDobre "Big Data and Internet of Things: A Roadmap for Smart Environments", Springer, 2014.
4. Dirk Slama, Frank Puhlmann, Jim Morrish, Rishi M Bhatnagar "Enterprise IoT: Strategies and Best Practices for Connected Products and Services", O'Reilly Media, 2015.
5. Honbo Zhou, "The Internet of Things in the Cloud: A Middleware Perspective", CRC Press, 2012.
6. Quinton Anderson "Storm Real-time Processing Cookbook", PACKT Publishers, 2013. OnurDundar,"Home Automation with Intel Galileo", Packt Publishing, 2015
7. NPTEL lectures on Big Data Computing by Prof Rajiv Misra, IIT Patna, https://nptel.ac.in/courses/106/104/106104189/

List of Experiments

1. (i) Perform setting up and Installing Hadoop in its two operating modes: Pseudo distributed, Fully distributed. (ii) Use web based tools to monitor your Hadoop setup.
2. (i) Implement the following file management tasks in Hadoop: Adding files and directories Retrieving files, Deleting files ii) Benchmark and stress test an Apache Hadoop cluster
3. Run a basic Word Count Map Reduce program to understand Map Reduce Paradigm. Find the number of occurrence of each word appearing in the input file(s) , Performing a Map ,Reduce Job for word search count (look for specific keywords in a file)

Savitribai Phule Pune University, Pune

M.E. (Electronics& Telecommunications- IoT and Sensor System) 2017 Course

(With effect from Academic Year 2020-21)

504805 (E): AI & Machine Learning for IoT (Elective- I)

Teaching Scheme	Credit	Examination Scheme
Theory: 05 Hrs. / Week	05	In-Sem: 50 Marks End Sem: 50 Marks

Objective:

To introduce AI & machine learning techniques that enables IoT and analyse data using computing devices.

Course outcomes: Students should be able to:

CO1: Understand fundamentals of various AI based techniques.
CO2: Analyse various AI techniques presented for electrical machines and drives.
CO3: Analyse various evolution techniques of machine learning.

Course Contents

Module I	Artificial Intelligent Based Systems	(10 Hrs.)

Natural language system – perception system for vision speech and touch - expert or knowledge based system – knowledge acquisition – knowledge of representation – inference strategy – expert controller. Definition, problem solving methods, searching techniques, knowledge representation, reasoning methods, predicate logic, predicate calculus, multi-value logic.

Module Ii	Basics of Machine Learning	(10 Hrs.)

Supervised and unsupervised learning, parametric vs non-parametric models, parametric models for classification and regression- Linear Regression, Logistic Regression, Naïve Bayes classifier, simple non-parametric classifier-K-nearest neighbour,support vector machines

Module III	Analysis using Machine Learning Techniques	(10 Hrs.)

The k-Means algorithm - Vector Quantization's - Linear Discriminant Analysis - Principal component analysis - Factor Analysis - Independent component analysis - Locally Linear embedding – Isomap - Least squares optimization - Simulated annealing.

Module IV	Neural Networks for Classification and Regression	(10 Hrs.)

ANN as a technique for regression and classification, structure of an artificial neuron, activation functions- linear activation, sigmoid and softmax. Feed-forward neural networks- shallow model- single layer perceptron, multi-layer perceptron as complex decision classifier- learning XOR-Gradient based learning, Back propagation algorithm, risk minimization, loss function, regularization, heuristics for faster training and avoiding local minima.

Learning Resources

Reference Books:

1. Rajasekaran S. and Pai G.A.V., "Neural Networks, Fuzzy Logic and Genetic Algorithm Synthesis and Applications", PHI, 2017.
2. Rich E and Knight K, "Artificial Intelligence", TMH, 2nd Edition,2011.
3. Tom M. Mitchell, "Machine Learning", McGraw-Hill Education (India) Pvt Ltd, 2013
4. Goldberg D.E. "Genetic Algorithms in Search Optimization & Machine Learning", Wesley Co., 2000.
5. Kosko B., "Neural Networks & Fuzzy Systems A dynamical systems approach to machine intelligence, Prentice Hall of India.,2008.
6. L.M. Rasdi, Simulated Annealing Algorithm for Deep Learning, Procedia Computer Science, Volume: 72, 2015.
7. Josh Patterson and Adam Gibson, "Deep Learning- A Practitioner's Approach" O'Reilly Media Inc., 2017, USA

List of Experiments

1. Develop an Application on Arduino/Raspberry-Pi to capture the values of temperature sensor after every 15 sec of time interval, store this values in .csv format and predict the temperature at particular time t using linear regression analysis.
2. Deploy your first Azure/Think Speak IoT Edge module to a virtual Linux or Windows device
   Exploring Code-First Machine Learning with Python
   1. Download the Dataset of your choice
   2. Divide the dataset into Training data and Testing data.
   3. Perform the classification of the instances using any machine learning algorithm like KNN Algorithm, Naïve Bayes, Decision Tree or any.
   4. Evaluate the machine learning model by considering the parameter (TPR, TNR, FPR, FNR, accuracy, precision, recall, error rate etc.)

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(With effect from Academic Year 2020-21)

504806: Lab Practice I

Teaching Scheme	Credit	Examination Scheme
Practical: 08 Hrs. / Week	04	TW: 50 Marks OR: 50 Marks

The laboratory work will be based on completion of minimum two assignments/experiments confinedto the courses of that semester.

SEMESTER – II

Savitribai Phule Pune University, Pune

M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course

(With effect from Academic Year 2020-21)

504808: Embedded System Design

Teaching Scheme	Credit	Examination Scheme
Theory: 04 Hrs. / Week	**04**	**In-Sem: 50 Marks** **End Sem: 50 Marks**

Course Objectives:

1. To understand design challenges of embedded hardware and software
2. To gain knowledge of testing and verification issues in design cycle
3. To introduce h/w and s/w design models with different technology
4. To learn the importance of documentation for technology transfer

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

CO1: Learn specifications and design challenges of embedded products.

CO2: Estimate cost of embedded product.

CO3: Understand the aspects of Mechanical Packaging, Testing, reliability and failure analysis, EMI / RFI Certification and Documentation.

CO4: Demonstrate the knowledge of embedded product design related hardware and software design Tools.

Course Contents

Module I	**Overview of Embedded System**	**(10 Hrs.)**

Overview of Embedded System : Need, Design challenges, System overview ,product survey, specifications of product need of hardware and software, Partitioning of the design into its software and hardware components, Iteration and refinement of the partitioning.

Module II	**Design Models and Techniques**	**(10 Hrs.)**

Deign Models and Techniques: various models of development of hardware and software, their features, different Processor technology, IC technology, Design Technology.

Module III	**Modules of Hardware and Software**	**(10 Hrs.)**

Modules of Hardware and Software: Tradeoffs, Custom Single-purpose processors, General-purpose processors, Software, Memory, Interfacing, Design technology-Hardware design, FPGA design, firmware design, driver development, RTOS porting, cost reduction, re-engineering, optimization, maintenance, validation and development, prototyping, turnkey product design.

Module IV	**Testing and verification**	**(10 Hrs.)**

Testing and verification: Embedded products-areas of technology, Design and verification, Integration of the hardware and software components, testing- different tools, their selection criterion. Certification and documentation: Mechanical Packaging, Testing, reliability and failure analysis, communication protocols, Certification (EMI/ RFI) and its documentation. Study of any two real life embedded products in detail.

Learning Resources

Reference Books:

1 Vahid Frankand Tony Givargis , “Embedded System Design: A Unified Hardware/Software Introduction”, John Wiley Publication.
2 Marwedel P, “Embedded System Design”, Springer Publication.

List of Experiments

1. Write a program to multiply two 16-bit numbers stored in r0 and r1 registers and write the result to r3. Put 0xFFFFFFFF and 0x80000000 into the source registers and verify the result.
2. Write a program to read the analog input connected to ADC and compare with threshold so as to control the Digital outputs (LEDs). Use standard peripheral library and interrupt method.
3. Transmit a string “Programming with ARM Cortex” to PC by configuring the registers of USART2. Use polling method.
4. Write an ARM code to implement the following register swap algorithm using only two registers. a) Using arithmetic instructions b) Using logical instructions

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M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course

(With effect from Academic Year 2020-21)

504809: Cloud Architecture & Protocols

Teaching Scheme	Credit	Examination Scheme
Theory: 04 Hrs. / Week	04	In-Sem: 50 Marks End Sem: 50 Marks

Course Objectives:

1. To achieve a insight into the basics of cloud computing along with virtualization
2. To understand cloud and virtualization along with it how one can migrate over it
3. To understand the Cloud Architecture, its features, services& cloud deployment models
4. To learn the cloud simulatorsand demonstrate a virtual machine using simulator

Course Outcomes :

CO1: To understand the fundamentals of cloud computing along with concept of Virtualization
CO2: To learn the cloud and virtualization along with it how one can migrate over it
CO3: To introduce the broad perceptive of cloud architecture and model and service
CO4: To understand and demonstrate a virtual machine using cloud simulators

Course Contents

Module I	Cloud Computing Overview	(10 Hrs.)

Origins of Cloud computing – Cloud components - Essential characteristics – On-demand selfservice, Broad network access, Location independent resource pooling ,Rapid elasticity , Measured service, Comparing cloud providers with traditional IT service providers, Roots of cloud computing.

Module II	Insights Architectural influences	(10 Hrs.)

High-performance computing, Utility and Enterprise grid computing, Cloud scenarios – Benefits: scalability ,simplicity ,vendors ,security, Limitations – Sensitive information - Application development-security level of third party - security benefits, Regularity issues: Government policies.

Module III	Cloud Architecture	(10 Hrs.)

Layers and Models Layers in cloud architecture, Software as a Service (SaaS), features of SaaS and benefits, Platform as a Service (PaaS), features of PaaS and benefits, Infrastructure as a Service (IaaS), features of IaaS and benefits, Service providers, challenges and risks in cloud adoption. Cloud deployment model: Public clouds – Private clouds – Community clouds - Hybrid clouds - Advantages of Cloud computing.

Module IV	Cloud Simulators	(10 Hrs.)

CloudSim and GreenCloud Introduction to Simulator, understanding CloudSim simulator, CloudSim Architecture(User code, CloudSim, GridSim, SimJava) Understanding Working platform for CloudSim, Introduction to GreenCloud

Simulator Basics of VMWare, advantages of VMware virtualization, using Vmware workstation, creating virtual machines-understanding virtual machines, create a new virtual machine on local host, cloning virtual machines, virtualize a physical machine, starting and stopping a virtual machine.

Learning Resources

Text Books:

1. Anthony T.Velte , Toby J. Velte Robert Elsenpeter,"Cloud computing a practical approach", TATA McGraw- Hill , 2010.
2. Cloud Computing: Web-Based Applications That Change the Way You Work and Collaborate Online - Michael Miller - Que 2008

Reference Books:

1. Judith Hurwitz , Robin Bloor , Marcia Kaufman ,Fern Halper, "Cloud computing for dummies", Wiley Publishing, Inc, 2010
2. RajkumarBuyya, James Broberg, AndrzejGoscinski, "Cloud Computing (Principles and Paradigms)", John Wiley & Sons, Inc. 2011.
3. Reese.G,"Cloud Application Architectures: Building Applications and Infrastructure in the Cloud", Sebastopol, CA: O'Reilly Media, Inc. (2009).
4. John Rhoton,"Cloud Computing Explained: Handbook for Enterprise Implementation" 2013 Recursive Press
5. Rajkumar Buyya, Christian Vecchiola, S.Thamarai Selvi,, ,MorganKaufmann,, "Mastering Cloud Computing: Foundations and ApplicationsProgramming", Elsevier publication, 2013
6. Thomas Erl, ZaighamMahmood, and Ricardo Puttini,"Cloud Computing Concepts,Technology& Architecture", PRENTICE HALL,2013

List of Experiments

1. Building a 'Hello World' app for the cloud
2. Deploying the 'Hello World' app for the cloud
3. Hands on containerization using Docker
4. Deployment and Configuration options in Amazon (AWS

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M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course

(With effect from Academic Year 2020-21)

504810: IoT Architecture and Protocols

Teaching Scheme	Credit	Examination Scheme
Theory: 04 Hrs. / Week	**04**	**In-Sem: 50 Marks** **End Sem: 50 Marks**

Course Objective:

1. To Understand the Architectural Overview of IoT
2. To Understand the IoT Reference Architecture and Real World

Course Outcome: Students will be able to

CO1: To Understand the various IoT Protocols (Datalink, Network,Transport, Session, Service)

Course Contents

Module I	Overview	(10 Hrs.)

IoT-An Architectural Overview– Building an 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.

Module II	Reference Architecture	(10 Hrs.)

IoT Architecture-State of the Art – Introduction, State of the art, Reference Model and architecture, IoT reference Model - IoT Reference Architecture- Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views. Real-World Design Constraints- Introduction, Technical Design constraints-hardware is popular again, Data representation and visualization, Interaction and remote control.

Module III	IoT Data Link Layer & Network Layer Protocols	(10 Hrs.)

PHY/MAC Layer(3GPP MTC, IEEE 802.11, IEEE 802.15), Wireless HART, ZWave, Bluetooth Low Energy, Zigbee Smart Energy, DASH7 - Network Layer-IPv4,IPv6, 6LoWPAN, 6TiSCH,ND, DHCP, ICMP, RPL, CORPL, CARP

Module IV	Transport , Session & Service Layer Protocols	(10 Hrs.)

Transport Layer (TCP, MPTCP, UDP, DCCP, SCTP)-(TLS, DTLS) – Session Layer-HTTP, CoAP, XMPP, AMQP, MQTT

Service Layer –oneM2M, ETSI M2M, OMA, BBF.

Learning Resources

Reference Books:

1. Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand,StamatisKarnouskos, David Boyle, “From Machine-to-Machine to the Internet ofThings: Introduction to a New Age of Intelligence”, 1st Edition, Academic Press,2014.
2. Peter Waher, “Learning Internet of Things”, PACKT publishing, BIRMINGHAM –MUMBAI
3. Bernd Scholz-Reiter, Florian Michahelles, “Architecting the Internet of Things”,ISBN 978-3-642-19156-5 e-ISBN 978-3-642-19157-2, Springer
4. Daniel Minoli, “Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications”, ISBN: 978-1-118-47347-
5. VijayMadisetti and ArshdeepBahga, “Internet of Things (A Hands-on-Approach)”, Wiley Publications 1st Edition, VPT, 2014.
6. http://www.cse.wustl.edu/~jain/cse570-15/ftp/iot_prot/index.html

List of Experiments
1. Understanding and connectivity of Raspberry-Pi /Beagle board with a Zigbee module. Write a network application for communication between two devices using Zigbee to on and off remote led. 2. Create a simple web interface for Raspberry-Pi/Beagle board to control the connected LEDs remotely through the interface. 3. Internet of things enabled real time water quality monitoring system. 4. Implement a weather monitoring system using humidity, temperature and raindrop sensor and Raspberry Pi/Arduino board

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M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course

(With effect from Academic Year 2020-21)

504811(A): Fiber Optic Sensors & Photonics (Elective-II)

Teaching Scheme	Credit	Examination Scheme
Theory: 05 Hrs. / Week	05	In-Sem: 50 Marks End Sem: 50 Marks

Course Objectives:

1. To learn the basic elements of optical fiber transmission link, fiber modes configurations and structures.
2. To learn the various optical sensors and its characteristics.
3. To introduce the students the field of photonic sensors and its applications.

Course Outcome:

CO1: To understand optical fiber communication link, structure, propagation and transmission properties of an optical fiber

CO2: To understand the various optical sensors and analyze it's characteristics.

CO3: Learn about the construction and working principle of high speed optoelectronics and photonics devices

Course Contents

Module I	Basics of Optics	(10 Hrs.)

Wave theory of optical waveguides, formation of guided modes, Slab waveguide, Rectangular waveguide, Radiation fields from waveguide, Effective index method, Marcatili's method, Beam propagation method. Basic characteristic of Optical Fiber Waveguides, Acceptance angle, Numerical aperture, skewrays- Electromagnetic Modes in Cylindrical Waveguides.

Module II	Optic Sensor Technology and Optical Sources	(10 Hrs.)

The Emergence of Fiber Optic Sensor Technology, Critical Components for Fiber Optic Sensors, Optical Modulators for Fiber Optic Sensors, Opto electronic devices, Optical modulators, modulation methods and modulators, transmitters, optical transmitter circuits, LED and laser diodes, LED Power and efficiency, double hetero structure LED, LED structures, LED characteristics, Organic LEDs, Principle of OLED, Multilayer OLED, Structure and characterization

Module III	Fiber Sensors-I	(10 Hrs.)

Intensity-Based and Fabry–Perot Interferometer Sensors, Multimode Grating Sensors, Multimode Polarization Sensors, Polymer Based waveguide in sensing, Interferometric sensors,

Module IV	Fiber Sensors-II	(10 Hrs.)

Fiber Optic Sensors Based on the Sagnac Interferometer and Passive Ring Resonator, Fiber Optic Sensors Based on the Mach–Zehnder and Michelson Interferometers , Distributed and Multiplexed Fiber Optic Sensor, Fiber Optic Magnetic Sensors, Fiber Grating Sensors, Fiber Optic Biosensors, Fiber optics Chemical Sensors, Industrial Applications of Fiber Optic Sensors.

Learning Resources

Text Books:

1. David A. Krohn, Trevor W. MacDougall, Alexis Mendez, "Fiber Optic Sensors: Fundamentals and Applications" SPIE Press, 4the Edition,2015.
2. Eric Udd , William B. Spillman Jr., "Fiber Optic Sensors: An Introduction for Engineers and Scientists", Wiley, 2nd Edition.

List of Experiments

1. Measurement of attenuation and bending loss in glass multimode fiber.
2. Measurement of numerical aperture.
3. Characteristics of LED & LASER Diodes.

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M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course

(With effect from Academic Year 2020-21)

504811(B): Smart Convergent System (Elective-II)

Teaching Scheme	Credit	Examination Scheme
Theory: 05 Hrs. / Week	05	In-Sem: 50 Marks End Sem: 50 Marks

Course Outcomes:

1) Describe the various technologies used in telecommunications
2) Explain the application of technologies, architectures, and protocols used in the telecommunications industry.
3) Describe 1G, 2G, 3G, 4G, LTE, WiMAX and their role in present and future Mobility

Course Contents

Module I	Introduction to Telecommunications and Transmission	(09 Hrs.)

Human–Machine Interactions - Embedded Devices - Intelligent Wearable - Traffic Patterns - The Electromagnetic Spectrum - Analog and Digital, Multiplexing Media: Twisted-Pair - Coaxial Cable- Microwave – Satellites - Fiber Optics - Data Communication Traffic - Data Transmission - OSI and TCP/IP Reference Models.

Module II	Introduction to the Internet And IP Telephony	(09 Hrs.)

Internet and Routing Protocols- Internet Architecture, and Infrastructure - Subnetting: IPv4, IPv6; DNS, QoS- Service Providers - IPT Network Architecture, QoS - VoIP Call Signaling Protocols - Digital Voice, ENUM- VPNs: Layer 3, 2, Security- Unified communications- IP voice and IPTV- The Broadband Infrastructure - Quality of Service-Virtualization- Cloud Computing

Module III	Fibre Optic Networks, Wired and Wireless Broadband	(09 Hrs.)

Optical Networking Elements : Switches, Edge, Core - DSL - Cable TV Networks,Packet Cable- Fiber Solutions- Wireless Broadband- HANs PANs, CANs, MANs- Broadband PLT - Antennas- Wireless Bandwidth - Spectrum Utilization Spread Spectrum. Cellular: 2G, 2,5G, 3G, 4G. 5G - WiMax,LTE - mobile security - Digital Cellular Radio - Enhanced Data Services - Broadband Wireless 3G Standards :UMTS, TDSCDMA,CDMA Solutions

Module IV	Wireless Network Architecture, Wireless and Mobility	(09 Hrs.)

BFWA- WLANs -IEEE 802.11a,b,g,n - IEEE 802.16, WiMax, WiBro and Mobile-Fi - VoWLAN - Integration of WLANs and Cellular Networks, RFID Mesh Networks - Mobile IP, IP Multimedia Subsystem - Applications, Mobile Video, Mobile TV, and Content

Learning Resources

Reference Books:

1. Lillian Goleniewski, "LIDO Telecommunications Essentials",Addison-Wesley Professional, Copyright, 2nd Edition,2007.

List of Experiments
1. Simulating a WiMAX Network using suitable network simulator 2. On any (Static/Dynamic stationary nodes) topology change the Network layer/Transport layer/MAC layer protocol and monitor the changes between any two protocols/ test bed using Network Simulator.

Savitribai Phule Pune University, Pune

M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course

(With effect from Academic Year 2020-21)

504811(C): Energy and Power Management for IoT Devices (Elective-II)

Teaching Scheme	Credit	Examination Scheme
Theory: 05 hrs. / week	05	In-Sem: 50 Marks End Sem: 50 Marks

Prerequisite:

1. Concept of power and energy in three phase and single phase
2. Various electrical equipment's and specifications

Course Objectives:

1. Understand importance of energy and energy security.
2. Understand impact of use energy resources on environment and emission standards, different operating frame work.
3. Follow format of energy management, energy policy.
4. Learn various tools of Demand Control.
5. Calculate economic viability of energy saving option.

Course Outcome:

CO1: Analyze and understand energy consumption patterns and environmental impacts and mitigation method.

CO2: Listing various energy conservation measures for various processes.

CO3: Students can carry out preliminary audits.

CO4: Can work out economic feasibility of encon option. Industrial Visit: Preferable visit to nearby process industry/power plant/utility substation for energy conservation.

Course Contents

Module I	Energy Scenario	(08 Hrs.)

Classification of Energy resources, Commercial and non-commercial energy, primary and secondary sources, commercial energy production, final energy consumption, Energy needs of growing economy, short terms and long terms policies, energy sector reforms, distribution system reforms and up-gradation, energy security, importance of energy conservation, energy and environmental impacts, emission check standard, United nations frame work convention on climate change, Global Climate Change Treaty, Kyoto Protocol, Clean Development Mechanism, salient features of Energy Conservation Act 2001 and Electricity Act 2003. Indian and Global energy scenario. Introduction to IE Rules. Study of Energy Conservation Building Code (ECBC), Concept of Green Building.

Module II	Energy Management	(07 Hrs.)
Definition and Objective of Energy Management, Principles of Energy management, Energy Management Strategy, Energy Manager Skills, key elements in energy management, force field analysis, energy policy, format and statement of energy policy, Organization setup and energy management. Responsibilities and duties of energy manager under act 2001. Energy Efficiency Programmes. Energy monitoring systems. Introduction to SCADA and Automatic meter reading in utility energy management.		
Module III	**Demand Management**	**(08 Hrs.)**
Supply side management (SSM), various measures involved such as use of FACTS, VAR Compensation, Generation system up gradation, constraints on SSM. Demand side management (DSM), advantages and Barriers, implementation of DSM, areas of development of demand side management in agricultural, domestic and commercial consumers. Demand management through tariffs (TOD). Power factor penalties and incentives in tariff for demand control. Apparent energy tariffs. Role of renewable energy sources in energy management, direct use (solar thermal, solar air conditioning, biomass) and indirect use (solar, wind etc.)		
Module IV	**Energy Audit**	**(08 Hrs.)**
Definition, need of energy audit, types of audit, procedures to follow, data and information analysis, energy audit instrumentation, energy consumption – production relationship, pie charts. Sankey diagram, Cusum technique, least square method and numerical based on it. Outcome of energy audit and energy saving potential, action plans for implementation of energy conservation options. Bench- marking energy performance of an industry. Energy Audit Report writing as per prescribed format. Audit case studies of sugar, steel, paper and cement industries.		

Learning Resources

Text Books:

1. Guide books for National Certification Examination for Energy Managers/Energy Auditors Book 1,
2. Guide books for National Certification Examination for Energy Managers/Energy Auditors Book 2
3. Guide books for National Certification Examination for Energy Managers/Energy Auditors Book 3
4. Guide books for National Certification Examination for Energy Managers/Energy Auditors Book 4
5. Amlan Chakrabarti, “Energy Engineering and Management”, PHI Learning Private Limited
6. W R Murphy, G Mckay, “Energy Management”, B.S. Publications

Reference Books:

1. Success stories of Energy Conservation by BEE (www. Bee-india.org)

2. C. Tripathi, “Utilization of Electrical Energy”,STata McGraw Hill.

3. W.R. Murphy and Mackay, “Energy Management”, B.S. Publication.

4. B.R. Gupta, “Generation and utilization of Electrical Energy”, S. Chand Publication.

5. Balasubramanian, “ Energy Auditing made simple”, Bala Consultancy Services.

List of Experiments

1. Write a case study of Power management Algorithms.
2. How to design system for Low Power. Address the power challenges for IOT devices.

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(With effect from Academic Year 2020-21)

504811 (D): Cloud Storage and Computing (Elective-II)

Teaching Scheme	Credit	Examination Scheme
Theory: 05 Hrs. / Week	05	In-Sem (Theory): 50Marks End Sem (Theory): 50 Marks

Prerequisite Courses, if any: Could Computing

Companion Course, if any:

Course Objectives:

1. This course gives students an insight into the basics of cloud computing along with virtualization
2. This course will provide students basic understanding about cloud and virtualization along with it how one can migrate over it

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

CO1: Analyze the trade-offs between deploying applications in the cloud and over the local infrastructure.
CO2: Compare the advantages and disadvantages of various cloud computing platforms.
CO3: Deploy applications over commercial cloud computing infrastructures such as Amazon Web Services, Windows Azure, and Google App Engine.
CO4: Analyze the performance, scalability, and availability of the underlying cloud technologies and software. CO5: Identify security and privacy issues in cloud computing.
CO5: Explain recent research results in cloud computing and identify their pros and cons.

Course Contents

Module-I	Basic Concepts, Cloud Infrastructure & Business Values	(12 Hrs)

Collaborative to Cloud- A Short History, Functioning of Cloud Computing, Cloud Architecture, Computer Network Basics. Concepts of Distributed Systems. Concepts of Cloud Computing and its Necessity. Cloud Service Providers in use and their Significance. Industrial Applications. Service Modeling, Infrastructure as a Service, Platform as a Service, Software as a Service, Massively Scaled Software as a Service. Cloud Pros and Cons. Cloud Delivery Models. Cloud Deployment Models

Module-II	Cloud Storage Management, Building Cloud Networks & Service Administration	(12 Hrs)

Concept of Virtualization and Load Balancing. Overview on Virtualization used for Enterprise Solutions. Key Challenges in managing Information. Identifying the problems of scale and management in big data. Platforms, Web Applications, API in Cloud Computing, Browsers for Cloud Computing, Designing and Implementing a Data Center-Based Cloud Installing Open Source Cloud service. Service Level Agreements and Monitoring, Support Services, Accounting Services, Resource Management, Service Management, Untangling Software Dependencies.

Module-III	Cloud Security	(12 Hrs)
Infrastructure Security Network level security, Host level security, Application level security. Data privacy and security Issues. Access Control and Authentication in cloud computing. Need for Privacy, Comparing Public, Private and Hybrid, Examining the Economics of the Private Cloud.		
Module- IV	**Cloud Application & IT Model**	**(12 Hrs)**
Programming Models for Cloud Computing - Software Development in Cloud - Service creation environments to develop cloud based applications. Development environments for service development; Amazon, Azure, Google App. Cloud based service, applications and development platform deployment so as to improve the total cost of ownership (TCO)		

Learning Resources

Text Books:

1.Anthony T.Velte , Toby J. Velte Robert Elsenpeter, "Cloud computing a practical approach,", TATA McGraw- Hill , 2010

2. Cloud Computing: Web-Based Applications That Change the Way You Work and Collaborate Online - Michael Miller - Que 2008

Reference Books:

1. Judith Hurwitz , Robin Bloor , Marcia Kaufman ,Fern Halper, "Cloud computing for dummies", Wiley Publishing, Inc, 2010.
2. Rajkumar Buyya, James Broberg, AndrzejGoscinski, "Cloud Computing (Principles and Paradigms)", John Wiley & Sons, Inc. 2011.
3. Barrie Sosinsky, "Cloud Computing Bible", Wiley-India, 2010.
4. Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, "Cloud Computing: Principles and Paradigms", Wiley, 2011.
5. Nikos Antonopoulos, Lee Gillam "Cloud Computing: Principles, Systems and Applications", , Springer, 2012.
6. Ronald L. Krutz, Russell Dean Vines , "Cloud Security: A Comprehensive Guide to Secure Cloud Computing", Wiley-India, 2010.

MOOC / NPTEL Courses:

1.**NPTEL Course "Cloud Computing and Distributed Systems"**
https://onlinecourses.nptel.ac.in/noc21_cs15/preview

List of Experiments

1. Case study on Google App Engine, Amazon
2. Software Case study-Hadoop MAPReduce, HDFS

Savitribai Phule Pune University, Pune

M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course

(With effect from Academic Year 2020-21)

504811 (E): Wearable Computing, Mixed Reality and Internet of Everything (Elective-II)

Teaching Scheme	Credit	Examination Scheme
Theory: 05 Hrs. / Week	05	In-Sem: 50 Marks End Sem: 50 Marks

Course Contents

Module I	Introduction	(12 Hrs.)

Introduction – History - Creative Coding Platforms - Open Source Platforms PIC -Arduino, Sketch, Raspberry Pi, Iterative coding methodology – Python Programming Mobile phones and similar devices - Arm Devices - Basic Electronics (circuit theory,measurements, parts identification) Sensors and Software: Understanding ProcessingCode Structure, variables and flow control, Interfacing to the Real World

Module II	Softwares	(12 Hrs.)

Software: openFrameworks as our IDE (C/C++) - "Arduino" Language (C/C++) Hardware: Desktop / Laptop / Raspberry Pi - How to approach a programming problem Representing "reality" with computers.Digital vs. Analog circuits, audio,communication, etc.Analog to Digital Conversion (ADC) - Digital to Analog Conversion(DAC)– Microcontrollers - Communication – Serial& Parallel - Hardware to HardwareCommunication - I2C/IIC (Inter-Integrated Circuit) - SPI (Serial Peripheral Interface) Serial UART Communication

Module III	Augmented Reality and Mixed Reality	(12Hrs.)

Wearables - Augmented Reality – Mixed Reality.Case studies, Oculus Rift (2012,2013), AR versus VR - IoT and Wearables: Smart Cites and Wearable Computing as aform of urban design - Advanced I/O – openFrameworks:Live Network feeds (push andpull) - Data persistence (saving data and preferences) - Database interface (MySQL,sqLite, XML, PHP/Web) - Arduino:Wired/Wireless Networking (hardware vs. USBproxy) - Software serial (RS-232) talking to other devices - Advanced sensor/device communication SPI - Advance IC interfacing / Bitbanging (bitwise operators) - Linux GPIO

Module IV	Wearable Computing and IoT	(10 Hrs.)

Humanistic Intelligence, Mann 1998. Wearable Computing and IoT (Internet of Things)The scale space theory; surveillance; integrity; Vigilance Contract; Humanistic Intelligence; Modality Axis Overview of Mobile and Wearable Computing, Augmented Reality, and Internet of Things. The fundamental axes of the Wearables + IoT + ARspace - Free-roaming AR: Wearable Computing, Wireless, Sensing, and Metasensingwith light bulbs Phenomenal Augmented Reality: Real world physical phenomena as the fundamental basis of mobile and wearable AR.

Learning Resources

Reference Books:

1. Paul Scherz and Simon, “Practical Electronics for Inventors, Third Edition”, Monk. 2016.
2. Intel Galileo and Intel Galileo Gen 2API Features and Arduino Projects for Linux Programmers, Ramon, Manoel 2014 (Open Access)
3. Woodrow Barfield , “Fundamentals of Wearable Computers and Augmented Reality”, 2nd Edition,2015.
4. OmeshTickoo, Ravi Iyer, “Making Sense of Sensors: End-to-End Algorithms and Infrastructure Design”,2016.
5. Josha Noble, “Programming Interactivity”, 2nd Edition, 2012.
6. “Programming the Raspberry Pi: Getting Started with Python”, 2nd Edition, 2016.

List of Experiments

1. Cast study of Wearable Antenna for IoT applications.
2. Cast study of IoT Based Wearable Instruments for Biomedical Applications.

Savitribai Phule Pune University M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course (With effect from Academic Year 2020-21) 504812: Mini Project / Seminar-I		
Teaching Scheme:	**Credit**	**Examination Scheme**
Practical: 04 Hrs. / Week	**04**	**TW: 50 Marks** **OR: 50 Marks**

Course Objectives:

1. To explore the basic principles of communication (verbal and non-verbal) and active, empathetic listening, speaking and writing techniques.
2. To Identify, understand and discuss current, real-world issues, new technologies, research, products, algorithms and services relevant to latest trends in the field of concerned branch.

Course Outcomes: On completion of the course, student will be able–

CO1: To use multiple thinking strategies to examine real-world issues and explore creative avenues of expression.

CO2: To acquire, articulate, create and convey intended meaning using verbal and non-verbal method of communication.

CO3: To learn and integrate, through independent learning in sciences and technologies, with disciplinary specialization and the ability to integrate information across.

Course Contents

Seminar I, shall be on the topic relevant to latest trends in the field of concerned branch, preferably on the topic of specialization based on the electives selected by him/her approved by authority. The student shall submit the seminar report in standard format, duly certified for satisfactory completion of the work by the concerned guide and head of the Department / Institute.

Savitribai Phule Pune University M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course (With effect from Academic Year 2020-21) 504813: Lab Practice-II		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 08 Hrs. / Week	**04**	**TW: 50 Marks** **OR: 50 Marks**

Course Contents

Lab Practice II: The laboratory work will be based on completion of minimum two assignments/experiments confined to the courses of the semester.

SEMESTER –III

Savitribai Phule Pune University, Pune
M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course
(With effect from Academic Year 2020-21)
604801: Micro System Fabrication

Teaching Scheme	Credit	Examination Scheme
Theory: 04 Hrs. / Week	04	In-Sem: 50 Marks End Sem: 50 Marks

Course Objectives:

1. Introduce to the students the essentials of micro-electronics fabrication technology required for the realization of integrated circuits and transducers & actuators.
2. Introduce the basic concepts of MEMS design, fabrication process integration and advanced micro-machining techniques for high aspect ratio MEMS structures.

Course Outcomes:

CO1: Understand the unit fabrication processes for ICs and MEMS.

CO2: Design and fabricate MEMS based sensors and actuators.

Course Contents

Module I	Processes in fabrication of ICs and MEMS	(8 Hrs.)

Processes in fabrication of ICs and MEMS: Clean room practices, Crystal growth techniques, wafer preparation and shaping, chemical cleaning, thermal oxidation, diffusion, ion implantation, photolithography, Thin film deposition, Etching.

Module II	Processes specific to MEMS	(8 Hrs.)

Processes specific to MEMS: Surface and bulk micro-machining, DRIE, LIGA, andpackaging

Module III	Case studies of MEMS	(8 Hrs.)

Case studies of MEMS: Basic concepts of Beam/diaphragm mechanics, electrostatic actuationand fabrication, 'process design' for selected MEMS based sensors and actuators such as Combdrives, touch sensor, pressure sensor, RF MEMS Switches, Electric / Magnetic Field sensor etc.(12 lectures)

Module IV	Case studies of MEMS	(8 Hrs.)

Learning Resources

Text Books:

1. Tai-Ran Hsu, " MEMS & Microsystems Design and Manufacture", Indian Edition,Tata McGraw-Hill
2. M. Bao, " Analysis and Design Principles of MEMS Devices",Elsevier,1st Edition.
3. J. D. Plummer, M. D. Deal, and P. B. Griffin, "Silicon VLSI technology:Fundamentals, Practice, and Modelling", Prentice Hall, 1st Edition

Self Learning Material:

1. Marc J. Madou, "Fundamentals of Microfabrication and Nanotechnology: TheScience of Miniaturization, CRC Press, 3rd Edition.
2. M.Sze, "VLSI Technology", McGraw Hill Education, 2nd Edition.

List of Experiments
1. Familiariztion of unit processes. 2. Familiarization of analytical characterization techniques: thin film thickness measurement , 4-point probe for sheet resistance measurement, micro-stylus step height measurement, AFM, FTIR, XRD, SEM, ,LDV, Nanoindentation 1. Fabrication of MEMS structures such as Microcantilever beam/suspended membrane etc. 2. Familiarization of Microfabrication environment in clean room 3. Electrical characterization: High frequency capacitance-voltage measurement (HFCV) and High frequency capacitance-voltage measurement (LFCV), I-V and reliability measurements, parameter extraction of MOS devices

Savitribai Phule Pune University, Pune
M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course
(With effect from Academic Year 2020-21)
604802: IoT Applications & Web Development

Teaching Scheme	Credit	Examination Scheme
Theory: 04 Hrs. / Week	04	In-Sem: 50 Marks End Sem: 50 Marks

Course Objectives:

1. To acquire specific scripting knowledge to develop interactive applications.
2. To understand the basics of android application development.
3. To apply the programming skills in developing application pertaining to Industrial, medical, agricultural, etc.

Course Outcome: Students will be able to

CO1: Design dynamic web forms to acquire and process user & sensor data.
CO2: Interactive forms using Java Script with a focus on internet of things.
CO3: Implement mobile application using android SDK.
CO4: Solve the need for smart systems in a distributed environment
CO5: Understand the IoT architecture and building blocks for various domains
CO6: Devise multidisciplinary case to case modelling and execute wide range of application

Course Contents

Module I	Markup & Scripting Language	(14 Hrs.)

Introduction to Markup language, HTML document structure, HTML forms, Style (CSS), Multiple CSS style sheets, DHTML, Tools for image creation and manipulation, User experience design, IoT development using charts
Introduction to JavaScript, Functions, DOM, Forms, and Event Handlers, Object Handlers, Input validation, J2ME, application design using J2ME , IoT development using Real time rules, platforms, alerts.

Module II	Programming Framework	(6 Hrs.)

Mobile app development: Android Development environment, Simple UI Layouts and layout properties, GUI objects, Event Driven Programming.

Module III	4SQLite Database	(8 Hrs.)

Basics of SQLite DB, Various Data Types, SQLite Queries, SQLite Connections, Adding/Updating/Deleting Contents of SQLite

Module IV	Application in Industrial Internet & smart cities	(12 Hrs.)

IIoT Fundamentals and Components, Industrial Manufacturing, Monitoring, Control, Optimization and Autonomy, Introduction to Hadoop and big data analytics
Energy Consumption Monitoring, Smart Energy Meters, Home automation, Smart Grid and Solar Energy Harvesting, Intelligent Parking, Data lake services scenarios.

Learning Resources

Text Books:

1. John Dean, Web Programming with HTML5, CSS and JavaScript, 2018, Jones and Bartlett Publishers Inc., ISBN-10: 9781284091793
2. DiMarzio J. F., Beginning Android Programming with Android Studio, 2016, 4th ed., Wiley, ISBN-10: 9788126565580

Reference Books:

1. Fadi Al-Turjman, "Intelligence in IoT- enabled Smart Cities, 2019", CRC Press, 1st Edition.
2. Giacomo Veneri, and Antonio Capasso, "Hands-on Industrial Internet of Things: Create a powerful industrial IoT infrastructure using Industry 4.0", Packt Publishing.
3. Subhas Chandra Mukhopadhyay,"Smart Sensing Technology for Agriculture and Environmental Monitoring", Springer, 2012.

List of Experiments

1. Study of MIT App Inverter/Kodular/Arduino Cloud.
2. Design the android app for Following applications
   a) Home Automation
   b) Weather Monitoring System
   c) Energy Consumption Monitoring
   d) Automated guided Vehicle System from remote server

Savitribai Phule Pune University, Pune
M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course
(With effect from Academic Year 2020-21)
604803 (AA): Value Education, Human rights and Legislative Procedures (Elective – III)

Teaching Scheme	Credit	Examination Scheme
Theory: 03 Hrs. / Week	03	In-Sem: 50 Marks End Sem: 50 Marks

Course Contents

Module I	Values and Self Development	(08 Hrs.)

Values and Self Development: Social values and individual attitudes, Work ethics, Indian vision of humanism, Moral and non moral valuation, Standards and principles, Value judgments. Importance of cultivation of values, Sense of duty, Devotion, Self reliance, Confidence, Concentration, Truthfulness, Cleanliness, Honesty, Humanity, Power of faith, National unity, Patriotism, Love for nature, Discipline.

Module II	Personality and Behavior Development	(08 Hrs.)

Personality and Behavior Development: Soul and scientific attitude, God and scientific attitude, Positive thinking, Integrity and discipline, Punctuality, Love and kindness, Avoiding fault finding, Free from anger, Dignity of labor, Universal brotherhood and religious tolerance, True friendship, Happiness vs. suffering love for truth, Aware of self destructive habits, Association and cooperation, Doing best, Saving nature.

Module III	Human Rights	(08 Hrs.)

Human Rights: Jurisprudence of human rights nature and definition, Universal protection ofhuman rights, Regional protection of human rights, National level protection of human rights, Human rights and vulnerable groups. Legislative Procedures- Indian constitution, Philosophy, fundamental rights and duties, Legislature, Executive and Judiciary, Constitution and function of parliament, Composition of council of states and house of people, Speaker, Passing of bills, Vigilance, Lokpal and functionaries References.

Learning Resources

Reference Books:

1. Chakraborty, S.K., " Values and Ethics for Organizations Theory and Practice", Oxford University Press, New Delhi, 2001.
2. Kapoor, S.K., "Human rights under International Law and Indian Law", Prentice Hall of India, 2002.
3. Basu, D.D., "Indian Constitution", Oxford University Press, 2002.
4. Frankena, W.K., "Ethics", Prentice Hall of India, New Delhi, 1990.
5. Meron Theodor, "Human Rights and International Law Legal Policy Issues, Vol. 1 and 2", Oxford University Press,2000.

Savitribai Phule Pune University, Pune
M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course
(With effect from Academic Year 2020-21)
604803(AB): Environmental Studies (Elective – III)

Teaching Scheme	Credit	Examination Scheme
Theory: 03 Hrs. / Week	03	In-Sem: 50 Marks End Sem: 50 Marks

Course Contents

Module I	Introduction and Natural Resources	(08 Hrs.)

Introduction and Natural Resources: Multidisciplinary nature and public awareness, Renewable and nonrenewal resources and associated problems, Forest resources, Waterresources, Mineral resources, Food resources, Energy resources, Land resources, Conservation of natural resources and human role. Ecosystems: Concept, Structure and function, Producers composers and decomposers, Energy flow, Ecological succession, Food chains webs and ecological pyramids, Characteristics structures and functions of ecosystems such as Forest, Grassland, Desert, Aquatic ecosystems.

Module II	Environmental Pollution	(08 Hrs.)

Environmental Pollution: Definition, Causes, effects and control of air pollution, water pollution, soil pollution, marine pollution, noise pollution, thermal pollution, nuclear hazards, human role in prevention of pollution, Solid waste management, Disaster management, floods, earthquake, cyclone and landslides.

Module III	Social issues and Environment	(08 Hrs.)

Social issues and Environment: Unsustainable to sustainable development, Urban problems related to energy, Water conservation and watershed management, Resettlement and re- habitation, Ethics, Climate change, Global warming, Acid rain, Ozone layer depletion, Nuclear accidents, holocaust, Waste land reclamation, Consumerism and waste products, Environment protection act, Wildlife protection act, Forest conservation act, Environmental issues in legislation, population explosion and family welfare program, Environment and human health, HIV, Women and child welfare, Role of information technology in environment and human health.

Learning Resources

Reference Books:

1. Agarwal, K.C., "Environmental Biology", Nidi Publication Ltd., Bikaner, 2001.
2. BharuchaErach, "Biodiversity of India," Mapin Publishing Pvt. Ltd., Ahmadabad, 2002.
3. Bukhootsow, B.," Energy Policy and Planning", Prentice Hall of India, New Delhi, 2003.
4. Cunningham, W.P., " Environmental Encyclopedia", Jaico Publishing House, Mumbai, 2003.

Savitribai Phule Pune University, Pune
M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course
(With effect from Academic Year 2020-21)
604803(AC): Renewable Energy Studies (Elective – III)

Teaching Scheme:	Credit	Examination Scheme:
Lecture: 03 Hrs. / Week	03	In-Sem: 50 Marks End Sem: 50 Marks

Course Contents

Module I	Photovoltaic Systems	(08 Hrs.)

Photovoltaic Systems: Introduction to the Major Photovoltaic System Types, Current– Voltage Curves for Loads, Grid-Connected Systems: Interfacing with the Utility, DC andAC Rated Power, The "Peak-Hours" Approach to Estimating PV Performance, Capacity Factors for PV Grid Connected Systems, PV Powered Water Pumping, PV systems – off grid systems and scope for inclusive growth of rural India.

Module II	Wind Energy	(08 Hrs.)

Wind Energy: wind speed and power relation, power extracted from wind, wind distribution and wind speed predictions. Wind power systems: system components, Types of Turbine, Choice of generators, electrical load matching, power control, Effect of wind speed variations, tower height and its effect, Variable speed operation, maximum power operation, control systems, Design consideration of wind farms and control

Module III	Biomass	(08 Hrs.)

Biomass: various resources, energy contents, technological advancements, conversion of biomass in other form of energy – solid, liquid and gases. Gasifiers, Biomass fired boilers, Co-firing, Generation from municipal solid waste, Issues in harnessing these sources. Mini and micro hydel plants scheme layout economics. Tidal and wave energy, Geothermal and Ocean-thermal energy conversion (OTEC) systems – schemes, feasibility and viability. Fuel cell- types and operating characteristics, efficiency, energy output of fuel cell.

Learning Resources

Reference Books:

1. Renewable energy technologies - R. Ramesh, Narosa Publication.
2. Energy Technology – S. Rao, Parulkar
3. Non-conventional Energy Systems – Mittal, Wheelers Publication.
4. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response",CRC Press.
5. Renewable Energy Technologies – Chetan Singh Solanki, PHI Learning Pvt. Ltd.

Savitribai Phule Pune University, Pune
M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course
(With effect from Academic Year 2020-21)
604803 (AD): Disaster Management (Elective – III)

Teaching Scheme	Credit	Examination Scheme
Theory: 03 Hrs. / week	03	In-Sem: 50 Marks End Sem: 50 Marks

Course Contents

Module I	Introduction	(08 Hrs.)

Introduction: Concepts and definitions: disaster, hazard, vulnerability, risk, capacity, impact, prevention, mitigation). Disasters classification; natural disasters (floods, draught, cyclones, volcanoes, earthquakes, tsunami, landslides, coastal erosion, soil erosion, forest fires etc.); manmade disasters (industrial pollution, artificial flooding in urban areas, nuclear radiation, chemical spills etc); hazard and vulnerability profile of India, mountain and coastal areas, ecological fragility

Module II	Disaster Impacts	(08 Hrs.)

Disaster Impacts: Disaster impacts (environmental, physical, social, ecological, economical, political, etc.); health, psycho-social issues; demographic aspects (gender, age, special needs); hazard locations; global and national disaster trends; climate-change and urban disasters.

Module III	Disaster Risk Reduction (DRR)	(08 Hrs.)

Disaster Risk Reduction (DRR): Disaster management cycle – its phases; prevention, mitigation, preparedness, relief and recovery; structural and non-structural measures; riskanalysis, vulnerability and capacity assessment; early warning systems, Post-disaster environmental response (water, sanitation, food safety, waste management, disease control); Roles and responsibilities of government, community, local institutions, NGOs and otherstakeholders; Policies and legislation for disaster risk reduction, DRR programmes in India andthe activities of National Disaster Management Authority.

Learning Resources

Reference Books:

1. http://ndma.gov.in/ (Home page of National Disaster Management Authority).
2. http://www.ndmindia.nic.in/ (National Disaster management in India, Ministry of Home Affairs).
3. Pradeep Sahni, “Disaster Risk Reduction in South Asia”, Prentice Hall.
4. Singh B.K., “Handbook of Disaster Management: Techniques & Guidelines”, Rajat Publication.
5. Ghosh G.K., “Disaster Management,” APH Publishing Corporation.

Savitribai Phule Pune University, Pune
M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course
(With effect from Academic Year 2020-21)
604803 (AE): Knowledge Management (Elective-III)

Teaching Scheme	Credit	Examination Scheme
Theory: 03 Hrs. / Week	03	In-Sem: 50 Marks End Sem: 50 Marks

Course Contents

Module I	Introduction	(08 Hrs.)

Introduction: Definition, evolution, need, drivers, scope, approaches in Organizations, strategies in organizations, components and functions, understanding knowledge; Learning organization: five components of learning organization, knowledge sources, and documentation. Essentials of Knowledge Management; knowledge creation process, knowledge management techniques, systems and tools.

Module II	Organizational knowledge management	(08 Hrs.)

Organizational knowledge management: architecture and implementation strategies, building the knowledge corporation and implementing knowledge management in organization. Knowledge management system life cycle, managing knowledge workers, knowledge audit, and knowledge management practices in organizations, few case studies

Module III	Futuristic KM	(04 Hrs.)

Futuristic KM: Knowledge Engineering, Theory of Computation, Data Structure.

Learning Resources

Reference Books:

1. A Thohothathri Raman, “Knowledge Management – A Resource book”, Excel, 2004.
2. Elias M. AwadHasan M. Ghazri, “Knowledge Management”, Pearson Education
3. Amrit Tiwana,,“The KM Toolkit – Orchestrating IT, Strategy & Knowledge Platforms”, Pearson, PHI, 2nd Edition.
4. Peter Senge, Nicholas Brealey, “The Fifth Discipline Field Book–Strategies & Tools For Building A Learning Organization”, 1994.
5. Sudhir Warier, “Knowledge Management”, Vikas Publications.
6. Madanmohan Rao, “Leading with Knowledge”, Tata Mc-Graw Hill..

Savitribai Phule Pune University, Pune
M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017Course
(With effect from Academic Year 2020-21)
604803 (AF): Foreign Language (Elective-III)

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 Hrs. / Week	03	In-Sem: 50 Marks End Sem: 50 Marks

Course Contents

Module I	Pronunciation guidelines	(08 Hrs.)

Pronunciation guidelines: Single vowels, Accentuated vowels, Vowels and consonants combinations, Consonants; Numbers 1-10 Articles and Genders; Gender in French, Plural articles, Some usual expressions. Pronouns and Verbs; The verb groups, The pronouns,Present tense, Some color Adjectives and Plural ; Adjectives, Some adjectives, Our firstsentences, More Numbers.

Module II	Sentences Structures	(08 Hrs.)

Sentences Structures: Some Prepositions, Normal Sentences, Negative Sentences, Interrogative Sentences, Exercises The Family; Vocabulary ,Conversation, Notes on Pronunciation, Notes on Vocabulary, Grammar, Liaisons Guideline. D'oùviens-tu (Where do you come from); Vocabulary, Conversation, Notes on Vocabulary, Liaisons Guidelines . Comparer (Comparing); Vocabulary, Conversation, Notes on Vocabulary, Grammar Liaisons Guidelines, Ordinal Numbers

Module III	Le temps (Time)	(08 Hrs.)

Le temps (Time): Vocabulary, Grammar, Time on the clock Additional French Vocabulary; Vocabulary related to - The Family, Vocabulary related to - Where do you come from? French Expressions and Idioms; Day-to-day Life, At Work, The car, Sports, Specia Events Other French Flavours; Nos cousins d'Amérique - Québec et Accadie, Au pays de la bière et des frites, Mettez-vous à l'heure Suisse, Vé, peuchère, le françaisbien de chez nous

Learning Resources

Reference Books:

http://www.jump-gate.com/languages/french/index.html

Savitribai Phule Pune University, Pune
M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course
(With effect from Academic Year 2020-21)
604803 (AG): Economics for Engineers (Elective-III)

Teaching Scheme	Credit	Examination Scheme
Lecture: 03 Hrs. / Week	03	In-Sem: 50 Marks End Sem: 50 Marks

Course Contents

Module I	Introduction to the subject	(08 Hrs.)

Introduction to the subject: Micro and Macro Economics, Relationship between Science, Engineering, Technology and Economic Development. Production Possibility Curve, Nature of Economic Law, Time Value of Money: concepts and application. Capital budgeting; Traditional and modern methods, Payback period method, IRR, ARR, NPV, PI (with the help of case studies)

Module II	Meaning of Production and factors of production	(08 Hrs.)

Meaning of Production and factors of production: Law of variable proportions and returns to scale. Internal and external economies and diseconomies of scale. Concepts of cost of production, different types of costs; accounting cost, sunk cost, marginal cost, Opportunity cost. Break even analysis, Make or Buy decision (case study). Relevance of Depreciation towards industry. Meaning of market, types of market, perfect competition, Monopoly, Monopolistic, Oligopoly. (Main features). Supply and law of supply, Role of demand and supply in price determination.

Module III	Indian Economy, nature and characteristics	(08 Hrs.)

Indian Economy, nature and characteristics. Basic concepts; fiscal and monetary policy, LPG,Inflation, Sensex, GATT, WTO and IMF. Difference between Central bank and Commercial banks.

Learning Resources

Reference Books:

1. Jain T.R., “Economics for Engineers”, VK Publication
2. Singh Seema, “Economics for Engineers”, IK International
3. Chopra P. N., “ Principle of Economics”, Kalyani Publishers
4. Dewett K. K., “Modern Economic Theory”, S. Chand.
5. H. L. Ahuja., “Modern Economic Theory”, S. Chand

Savitribai Phule Pune University, Pune

M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course

(With effect from Academic Year 2020-21)

604803 (AH): Engineering risk – Benefit and Analysis (Elective-III)

Teaching Scheme	Credit	Examination Scheme
Theory: 03 Hrs. / Week	03	In-Sem: 50 Marks End Sem: 50 Marks

Course Contents

Module I	Introduction	(08 Hrs.)

Introduction: Knowledge and Ignorance, Information Uncertainty in Engineering Systems, Introduction and overview of class; definition of Engineering risk; overview of Engineeringrisk analysis. Risk Methods: Risk Terminology, Risk Assessment, Risk Management and Control, Risk Acceptance, Risk Communication, Identifying and structuring the Engineering risk problem; developing a deterministic or parametric model System Definition and Structure: System Definition Models, Hierarchical Definitions of Systems, and System Complexity.

Module II	Reliability Assessment	(08 Hrs.)

Reliability Assessment: Analytical Reliability Assessment, Empirical Reliability AnalysisUsing Life Data, Reliability Analysis of Systems

Module III	Reliability and probabilistic risk assessment (RPRA)	(08 Hrs.)

Reliability and probabilistic risk assessment (RPRA): decision analysis (DA), and cost- benefit analysis (CBA). All of these pertain to decision making in the presence of significant uncertainty. In ERBA, the issues of interest are: The risks associated with large engineering projects such as nuclear power reactors, the International Space Station, and critical infrastructures; the development of new products; the design of processes andoperations with environmental externalities; and infrastructure renewal projects.

Learning Resources

Reference Books:

1. B. M. Ayyub, “Risk Analysis in Engineering and Economics”, Chapman Hall/CRCPress.
2. Hoyland, Arnljot, and Rausand, Marvin , “System Reliability Theory”, Hoboken, NJ:Wiley Interscience..
3. Clemen, Robert, “Making Hard Decisions: An Introduction to Decision Analysis (Business Statistic)”, PHI publications

Savitribai Phule Pune University, Pune

M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017Course

(With effect from Academic Year 2020-21)

604803 (BA): Optimization Techniques (Elective- III)

Teaching Scheme:	Credit	Examination Scheme:
Theory: 02 Hr. / Week	2	In-Sem: 50 Marks End Sem: 50 Marks

Course Contents

Module I		(08 Hrs.)

First and second order conditions for local interior optima (concavity and uniqueness), Sufficient conditions for unique global optima; Constrained optimization with Lagrange multipliers; Sufficient conditions for optima with equality and inequality constraints.

Module II		(08 Hrs.)

Recognizing and solving convex optimization problems. Convex sets, functions, and optimization problems. Least-squares, linear, and quadratic optimization. Geometric and semidefinite programming. Vector optimization. Duality theory. Convex relaxations. Approximation, fitting, and statistical estimation. Geometric problems. Control and trajectory planning.

Learning Resources

Reference Books:

1. Stephen Boyd and Lieven Vandenberghe, " Convex Optimization", Cambridge UniversityPress.
2. D. P. Bertsekas, A. Nedic, A. E. Ozdaglar, "Convex Analysis and Optimization", , AthenaScientific.
3. D. P. Bertsekas, "Nonlinear Programming", Athena Scientific.
4. Y. Nesterov, Introductory, " Lectures on Convex Optimization: A Basic Course", Springer.
5. J. Borwein and A. S. Lewis, "Convex Analysis and Nonlinear Optimization:Theory and Examples", Springer.

Savitribai Phule Pune University, Pune

M.E. (Electronics & Telecommunications- IoT and Sensor System)2017 Course

(With effect from Academic Year 2020-21)

604803 (BB): Fuzzy Mathematics (Elective - III)

Teaching Scheme	Credit	Examination Scheme
Theory: 02 Hr. / Week	2	In-Sem: 50 Marks End Sem: 50 Marks

Course Contents

Module I	Definition of a Fuzzy set	(08 Hrs.)

Definition of a Fuzzy set: Elements of Fuzzy logic. Relations including, Operations, reflexivity, symmetry and transitivity; Pattern Classification based on fuzzy relations

Module II	Fuzzy Models	(06 Hrs.)

Fuzzy Models: Mamdani , Sugeno, Tsukamoto.

Learning Resources

Reference Book:

1. S.R.Jung, Sun, Mizutani , “Neuro-Fuzzy and Soft Computing”

Savitribai Phule Pune University, Pune

M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course

(With effect from Academic Year 2020-21)

604803 (BC): Design and Analysis of Algorithm (Elective - III)

Teaching Scheme	Credit	Examination Scheme
Theory: 0 2 Hr. / Week	2	In-Sem: 50 Marks End Sem: 50 Marks

Course Contents

Module I	Introduction	(08 Hrs.)

Introduction: Fundamental characteristics of an algorithm. Basic algorithm analysis – Asymptotic analysis of complexity bounds– best, average and worst-case behaviour, standard notations for expressing algorithmic complexity. Empirical measurements of performance, time and space trade-offs in algorithms.

Module II	Properties of big-Oh notation	(08 Hrs.)

Properties of big-Oh notation: Recurrence equations – Solving recurrence equations – Analysis of linear search. Divide and Conquer: General Method – Binary Search – Finding Maximum and Minimum – Merge Sort – Greedy Algorithms: General Method – Container Loading – Knapsack.

Learning Resources

Reference Book:

1. Jon Kleinberg , Eva Tardos and T.H. Corman, “Algorithm Design: Introduction to Algorithms”

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(With effect from Academic Year 2020-21)

604803 (BD): CUDA (Elective - III)

Teaching Scheme	Credit	Examination Scheme
Theory: 0 2 Hr. / Week	2	In-Sem: 50 Marks End Sem: 50 Marks

Course Contents

Module I	Fundamentals	(08 Hrs.)

History of GPUs leading to their use and design for HPC- The Age of Parallel Processing, The Rise of GPU Computing ,CUDA, Applications of CUDA, Development Environment,Introduction to CUDA C, Kernel call, Passing Parameters, Querying Devices, Using Device Properties

Module II	Programming and Memory	(08 Hrs.)

Parallel Programming in CUDA C - CUDA Parallel Programming, Splitting Parallel Blocks, Shared Memory and Synchronization, Constant Memory, Texture Memory, CUDA events, Measuring Performance with Events.

Learning Resources

Reference Books:

1. David B. Kirk, Wen-mei W. Hwu., "Programming Massively Parallel Processors: A Hands-on Approach", 2nd Edition.
2. Jason Sanders ,Edward Kandrot, "CUDA by Example - An Introduction to General-Purpose GPU Programming"
3. Wen-mei,W. Hwu, "GPU Computing Gems Emerald Edition -Applications of GPU Computing". Series
4. Shane Cook, "CUDA Programming: A Developer's Guide to Parallel Computing with GPUs".

Savitribai Phule Pune University
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604804: Industry Internship-I/ In-house Research Project-I / Seminar-II

Teaching Scheme	Credit	Examination Scheme
Practical: 04 Hrs. / Week	04	TW: 50 Marks OR: 50 Marks

Course Contents

Seminar II: shall be on the topic relevant to latest trends in the field of concerned branch, preferably on the topic of specialization based on the electives selected by him/her approved by authority. The student shall submit the seminar report in standard format, duly certified for satisfactory completion of the work by the concerned guide and head of the Department/Institute.

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604805: Dissertation Stage – I

Teaching Scheme	Credit	Examination Scheme
Practical: 08 Hrs. / Week	08	TW: 50 Marks OR: 50 Marks

Course Contents

Dissertation Stage – I: is an integral part of the project work. In this, the student shall complete the partial work of the project which will consist of problem statement, literature review, project overview, scheme of implementation (Mathematical Model/SRS/UML/ERD/block diagram/ PERT chart, etc.) and Layout & Design of the Set-up. As a part of the progress report of Project work Stage-I, the candidate shall deliver a presentation on the advancement in Technology pertaining to the selected dissertation topic.
The student shall submit the duly certified progress report of Project work Stage-I in standard format for satisfactory completion of thework duly signed by the concerned guide and head of the Department/Institute.

SEMESTER –IV

Savitribai Phule Pune University M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course (With effect from Academic Year 2020-21) 604807: Industry Internship-II/ In-house Research Project-II / Seminar-III		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 05 Hrs. / Week	**05**	**TW: 50 Marks** **OR: 50 Marks**
Course Contents		
Seminar III: shall be on the topic relevant to latest trends in the field of concerned branch, preferably on the topic of specialization based on the electives selected by him/her approved by authority. The student shall submit the seminar report in standard format, duly certified for satisfactory completion of the work by the concerned guide and head of the Department/Institute.		

Savitribai Phule Pune University M.E. (Electronics & Telecommunications- IoT and Sensor System) 2017 Course (With effect from Academic Year 2020-21) 604808: Dissertation Stage – II		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 20 Hrs. / Week	**20**	**TW: 150 Marks** **OR: 50 Marks**
Course Contents		
In **Dissertation stage – II,** the student shall complete the remaining part of the project which will consist of the fabrication of set up required for the project, work station, conducting experiments and taking results, analysis & validation of results and conclusions. The student shall prepare the duly certified final report of project work in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute.		