DEPARTMENT OF

ELECTRONICS AND COMMUNICATION ENGINEERING

Scheme of Instruction

and

Syllabus of

M.E. (E C E)
Microwave and Radar Engineering

Full Time & PTPG

2025-26

UNIVERSITY COLLEGE OF ENGINEERING
(Autonomous)
Osmania University
Hyderabad – 500 007, TS, INDIA

INSTITUTE

Vision

The Vision of the institute is to generate and disseminate knowledge through harmonious blending of science, engineering and technology. To serve the society by developing a modern technology in student's heightened intellectual, cultural, ethical and humane sensitivities, fostering a scientific temper and promoting professional and technological expertise.

Mission

- To achieve excellence in Teaching and Research
- To generate, disseminate and preserve knowledge
- To enable empowerment through knowledge and information
- Advancement of knowledge in Engineering, Science and Technology
- Promote learning in free thinking and innovative environment
- Cultivate skills, attitudes to promote knowledge creation
- Rendering socially relevant technical services to the community
- To impart new skills of technology development
- To inculcate entrepreneurial talents and technology appreciation programmes
- Technology transfer and incubation

DEPARTMENT

Vision

- To be in the forefront of advances in Electronics and Communication Engineering education and research to guide and motivate young engineers to face future technological challenges.

Mission

- To inculcate analysis and design for innovative problems in the field of Electronics and Communication Engineering with the help of state of art curricula.
- To impart practical training to face real life case studies and inter-disciplinary simple solutions to complex problems.
- To make engineering education an enjoyable learning experience through challenging tutorials, mini-projects, assignments and laboratory exercises.
- To build project team spirit for professional working environment with high ethical values
- To develop overall character that will care for the society and concerned for the nation through extra-curricular activities.

Programme Educational Objectives (PEO):

PEO1: To educate students with analytical and design skills in Microwave and Radar engineering applicable to Industries, R&D labs and Institutions involving Space Communications and Defense Electronics.

PEO2: To strengthen the basic knowledge in mathematical science and applied science with orientation in engineering applications.

PEO3: To develop overall personality and character with team spirit, professionalism, integrity, moral and ethical values with the support of humanities, social sciences and physical educational courses.

PEO4: To equip the students with laboratory training leading to solving real life practical Problems and project analysis of Microwave and Radar Engineering through case-studies, seminars, Miniprojects, internships and main projects.

Programme Outcomes (PO):

PO1: Ability to apply the knowledge of science, mathematics, and engineering principles for developing problems solving attitude.

PO2: Able to conceptualize and analyze problems in Microwave and millimeter wave Engineering , Radar and Advanced GNSS applications leading to research and development.

PO3: Able to develop and validate models to solve complex problems of Electromagnetic Engineering by using approximate numerical techniques, and experimental techniques to interpret the results.

PO4: An ability to independently carry out research/investigation and development work to solve practical problems.

PO5: Ability to function as a member of a multidisciplinary team with sense of ethics, integrity and Social responsibility.

Scheme of Instruction and Evaluation for M.E. (ECE)
Microwave and Radar Engineering Programme

S.No.	Type of Course	Course Code	Course Name	Contact hours per week		Scheme of Evaluation		Credits
				L	P	CIE	SEE	
			SEMESTER-I					
1.	Core-I	EC301	Advanced Electromagnetic Engineering	3	-	40	60	3
2.	Core-II	EC302	Microwave Antennas	3	-	40	60	3
3.	Core-III	EC303	Satellite Radio Navigation	3	-	40	60	3
4.	Programme Elective-I	EC311	Electromagnetic Interference and Compatibility	3	-	40	60	3
		EC312	Adhoc Wireless Networks					
		EC313	Computational Electromagnetics					
5.	Programme Elective-II	EC321	RF MEMS	3	-	40	60	3
		EC322	IoT and Applications					
		EC323	Remote Sensing – Ground Stations					
6.	Programme Elective-III	EC331	Optical Communications and Networks	3	-	40	60	3
		EC332	Optimization Techniques					
		EC333	Software Defined Radio					
7.	Laboratory-I	EC361	Microwave Systems Lab	0	2	50	-	1
8.		EC371	Seminar	0	2	50	-	1
			TOTAL	**18**	**4**	**340**	**360**	**20**
			SEMESTER-II					
1.	Core-IV	EC304	Microwave Circuits and Systems	3	-	40	60	3
2.	Core-V	EC305	Radar Systems Engineering	3	-	40	60	3
3.	Core-VI	EC306	GNSS Augmentation Systems	3	-	40	60	3
4.	Programme Elective-IV	EC341	Phased Array Radar	3	-	40	60	3
		EC342	Radar Signal Processing					
		EC343	Microwave Solid State Devices and Applications					
5.	Programme Elective-V	EC351	Wireless and Mobile Communications	3	-	40	60	3
		EC352	Artificial Intelligence and Machine Learning					
		EC353	Unmanned Aerial Vehicle Systems					

6.	Open Electives	OE941BM	Medical Assistive Devices	3	-	40	60	3
		OE942BM	Medical Imaging Techniques					
		OE941CE	Green Building Technology					
		OE942CE	Cost Management of Engineering Projects					
		OE941CS	Business Analytics					
		OE941EC	Elements of Embedded Systems					
		OE941EE	Waste To Energy					
		OE942EE	Power Plant Control and Instrumentation					
		OE941ME	Operation Research					
		OE942ME	Composite Materials					
		OE943ME	Industrial Safety					
		OE941LA	Intellectual Property Rights					
7.		EC372	Mini Project	-	4	50	-	2
8.	Laboratory-II	EC362	Microwave Systems Simulation Lab	-	2	50	-	1
9.	Laboratory-III	EC363	GNSS Lab	-	2	50	-	1
			TOTAL	**18**	**8**	**390**	**360**	**22**
			SEMESTER-III					
1.	Audit Course-I	AC030EC	Research methodology	2	-	40	60	0
2.	Audit Course-II	AC031	English for Research Paper Writing	2	-	40	60	0
		AC032	Disaster Mitigation and Management					
		AC033	Sanskrit for technical Knowledge					
		AC034	Value Education					
		AC035	Stress Management by Yoga					
		AC036	Personality Development through Life Enlightenment Skills					
		AC037	Constitution of India					
		AC038	Pedagogy Studies					
		AC039	E-Waste Management					
3.	Dissertation-I	EC181	Dissertation Phase-I	-	20	100		10
			TOTAL	**4**	**20**	**180**	**120**	**10**
			SEMESTER-IV					
1.		EC382	Dissertation Phase-II	-	**32**	**100**	**100**	**16**
			GRAND TOTAL	**40**	**64**	**1010**	**940**	**68**

Note:

i. Dissertation-II has two parts, CIE - I and CIE – II, at the end of 8th week and 16th week respectively for evaluation of 50 marks each.

ii. Audit Courses will be offered in ONLINE mode and SEE will be conducted in Computer Based Test Mode.

iii. Research Methodology and IPR will be offered as an Audit Course for all PG Programs.

iv. Engineering Research Methodology Workshop will be conducted for one week for Ph.D scholars.

EC301	**ADVANCED ELECTROMAGNETIC ENGINEERING**					
(CORE – I)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60Marks	**CIE**		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To become familiar with the basic Electromagnetic Theory, Theorems and Concepts
2	To acquaint with theoretical analysis of the characteristics of electromagnetic waves in a wide variety of practical mediums
3	To be aware of commercially available EM Simulation Software

Course Outcomes:	
On completion of this course, the student will be able to:	
CO-1	Understand fundamental electromagnetic concepts.
CO-2	Apply Electromagnetic theorems and concepts to various practical applications.
CO-3	Analyze Maxwell's equations for complex electromagnetic media.
CO-4	Derive the propagation parameters for electromagnetic waves in various practical mediums.
CO-5	Acquire the knowledge on EM Simulation Software.

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	3	2	1	1	-
CO-2	3	2	2	2	-
CO-3	2	2	2	3	-
CO-4	1	2	3	2	-
CO-5	1	1	1	2	1

Correlation rating: Low/Medium/High:1/2/3respectively.

Unit- I
Fundamentals: Review of Basic Electromagnetic Theory, Maxwell's equations, Wave Equation, Time-Harmonic Fields, Plane waves in lossless and lossy media, Poynting's Theorem, Reflection and Transmission of waves.

Unit-II
Theorems and Concepts:The Generalized Current Concept, Circuit-Field Relations, Auxiliary Vector potentials, The source concept, Duality, Uniqueness, Image Theory, The Equivalence Principle, Induction and Reciprocity theorems, Green's Functions.

Unit –III
Guidance of Waves in Rectangular Cross section: The Parallel Plate Waveguide, The Rectangular Waveguide, Partially Filled Waveguide, The Dielectric Slab Guide, Surface Guided Waves.

Unit-IV
Guidance of Waves in Circular Cross section: Circular wave guide, Radial wave guide. Resonance of Waves - Resonators, Radiation of waves - Antennas.

Unit- V
Introduction to Metamaterials: EBG Structures and Frequency Selective Surfaces, Survey of Commercially available EM Simulation Software.

Suggested Reading:

1	CR.F. Harrington, Time- Harmonic Electromagnetic Fields, McGraw-Hill, 1961,reissued by IEEE Press,2001.
2	C.A.Balanis, Advanced Engineering Electromagnetics, John Wieley& Sons, 1989.
3	R.E.Collin, Field Theory of Guided Waves, IEEE Press, 1991, 2nd Ed.
4	J.A.Kong, Electromagnetic wave Theory, EMW Publishing, 2008.

EC302	**MICROWAVE ANTENNAS**					
(CORE – II)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60Marks	**CIE**		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To familiarize the basic concepts of antenna parameters and radiation mechanism.
2	To analyze aperture antennas with the knowledge of various theorems and study the principles of frequency independent antenna design.
3	To understand, analyze and synthesize printed antennas, array antennas and familiarize the concepts of smart antennas and modern antennas.

Course Outcomes :	
On completion of this course, the student will be able to:	
CO-1	Understand different types of aperture antennas with the help of basic antenna fundamentals.
CO-2	Understand the operating principles of microwave antennas.
CO-3	Apply the knowledge in the design of array antennas.
CO-4	Acquire knowledge of printed antenna and its design procedure
CO-5	Acquire basic knowledge of modern antenna technology

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	1	3	-	-	1
CO-2	2	2	-		1
CO-3	3	-	3	3	1
CO-4	2	-	3	3	2
CO-5	2	1	-	2	1

Correlation rating: Low/Medium/High:1/2/3respectively.

UNIT- I
Fundamental parameters and definitions related to antennas, Theories of radiation, Image theory, Schelkunoff's equivalence theorem, Huygen's principle, Babinet's principle.

UNIT-II
Radiation from rectangular and circular apertures, design considerations, Fourier transform method in aperture antenna theory. Broadband antenna concept, Log periodic antennas, Frequency independent antennas.

UNIT –III
Linear arrays: Uniform and Non uniform amplitude distribution, Planar arrays, Synthesis of antenna arrays: Schelkunoff polynomial method, Fourier transform method and Woodward-Lawson method, Concept and benefits of smart antennas.

UNIT-IV
Printed antennas: Rectangular and circular patch antenna design, Feeding techniques for micro strip antennas, Methods of analysis, Printed antenna arrays, Bandwidth enhancement techniques, Compact and Tunable Microstrip antenna.

UNIT- V
Advanced antennas and arrays for aerospace and defense applications. Modern antenna technologies: Metamaterial based antennas, Leakywave antennas, Dielectric resonator antenna.

Suggested Reading:

1	Constantine Balanis, "Modern Antenna Handbook", John wiley, 2008.
2	Stutzman, W.L. and Thiele, H.A., "Antenna Theory and Design", 2nd Ed., John Wiley & Sons.
3	Bahl IJ, and Bhartia, "Microstrip Antennas", Artech House, 1982.
4	D.G.Fang , "Antenna Theory and Microstrip Antennas", CRC press 2010
5	James.JR.Hall PS.wood.C., "Micro strip Antenna-Theory and Design", Peter Peregrinu.1981

EC 303	**SATELLITE RADIO NAVIGATION**					
(CORE-III)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To explore the basics of Satellite Communications.
2	To sensitize about the GNSS signal structure, errors and the RINEX data
3	To analyse GPS III system, new signals and other GNSS constellations.
4	To analyze GPS III system, new signals and other GNSS constellations
5	To explore the Indian regional navigation system and to analyse the parameters

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the properties of Satellite systems.
CO-2	Study about the GPS, DOP and various coordinate systems
CO-3	Explore the RINEX data formats and DGPS principles
CO-4	Estimate the various errors and their effect on position estimation.
CO-5	Experimental analysis of IRNSS signals

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	-	1	-	-
CO-2	2	-	1	-	-
CO-3	2	3	3	3	-
CO-4	2	3	3	3	2
CO-5	2	3	3	3	2

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
Introduction to Satellites, History of Satellites, Satellite systems, basic principles and properties of satellite communication, Launch Vehicles and their types, Earth Stations and their types, Types of Satellites and Future Satellite based applications.

UNIT – II
Introduction to Satellite Navigation Systems, GPS fundamentals: Principle of Trilateration, Transit, History of GPS, GPS Operating Principle, and Architecture: Space, Control and User Segments and its Frequencies, GPS signal structure, Types of GPS receivers - Single and Dual frequency GPS receivers, desired GPS signal properties. **GPS Coordinate Systems:** Earth Centered Earth Fixed (ECEF) and Earth Centered Inertial (ECI) Coordinate systems and World Geodetic System (WGS 84) datum, Required Navigation Performance (RNP) safety standards, SPS and PPS services.

UNIT – III
Data Formats: RINEX Observation and Navigation Data formats, GPS user position calculation, Selective Availability, Spoofing and Anti spoofing, Dilution of Precision (DOP).

UNIT – IV
GRNSS Errors: Ionospheric error, Tropospheric error, Ephemeris error, Clock errors, Satellite and receiver instrumental biases, Multipath, GPS Modernization – Necessity, Objectives, New Signals and their benefits, GPS III Satellites, New Operational Control system and Future applications. Other Satellite Radio Navigation Systems: Russian GLONASS, European GALILEO, Japanese QZNSS, Chinese Beidou and Indian NavIC Systems: Principle of Operation, Features and their Current Status.

UNIT – V
Case Studies: IRNSS Signals behaviour at various static and dynamic scenarios, modeling of Ionospheric Delay, Analysis on Ionospheric Scintillations, Real time SRN applications.

Suggested Reading:

1	B.Hofmann Wollenhof, H.Lichtenegger, and J.Collins, “GPS Theory and Practice”, Springer Wien, new York, 2000.
2	Pratap Misra and Per Enge, “Global Positioning System Signals, Measurements, and Performance,” Ganga-Jamuna Press, Massachusetts, 2001.
3	Ahmed El-Rabbany, “Introduction to GPS,” Artech House, Boston, 2002.

EC 311	**ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY**					
(PROGRAM ELECTIVE – I)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To understand the principles and history of Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC)
2	To develop the ability to identify and analyze conducted and radiated emissions and susceptibility in electronic systems, and to understand the commercial and military EMI standards for measurement.
3	To equip students with the knowledge and practical skills necessary to implement EMI mitigation strategies, including grounding, shielding, filtering, bonding etc.
4	To enable students to design analog and digital sub-systems by applying effective PCB layout techniques for improved EMC, integrating A/D and D/A converters, DC-DC converters, and power supplies to minimize EMI and maintain signal integrity.
5	To introduce students to numerical EMI and EMC simulation techniques and tools, explore commercially available EMC simulation software.

Course Outcomes:	
On completion of this course, the student will be able to:	
CO-1	Explain the requirement of EMI & EMC concept and impart knowledge on different units and standards used for Electromagnetic compatibility in electronic/electric system.
CO-2	Analyze and evaluate the impact of EMI mitigation techniques such as shielding and grounding etc.
CO-3	Analyze, measure and evaluate radiated and conducted emissions to examine the compatibility.
CO-4	Find solution to EMI Sources, EMI problem in Subsystem and system level design.
CO-5	Find solution to EMI Sources, EMI problems in PCB level design

Course outcome	Program outcomes				
	PO-1	PO-2	PO-3	PO-4	PO-5
CO-1	-	-	3	1	-
CO-2	-	1	3	1	-
CO-3	2	2	3	2	-
CO-4	-	2	2	2	-
CO-5	1	2	3	1	1

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
Introduction and History of EMI-EMC, Sources & effects of EMI – Intersystem & Intra system, Electromagnetic Environment Effects (E3), Common EMI measurement units. Time domain & frequency domain representation of periodic, non-periodic and digital waveforms.

UNIT – II
Conducted Emission & Susceptibility, Radiated Emission & Susceptibility, ESD, Introduction of Commercial & Military EMI Standards, Measurement of EMI, Shielded Enclosure, Antennas, Probes Equipment & Accessories used in EMI measurement.

UNIT – III
EMI Mitigation Techniques, Grounding, Shielding, Filtering & Bonding, EMI Suppression Components like EMI Filters (DC/AC), RFI Filters, EMI Gaskets, RF absorbing material, Transient Voltage Suppressors, Honey-comb vents etc., Cables, Connectors.

UNIT – IV
Sub-system and System level EMC, EMC Design of analog and digital Sub-systems, Mixed Signal PCB layout for better EMC, Analog and Digital grounds, EMC of A/D & D/A Converters, EMC of DC-DC Converters and Power Supplies, EMC Design Guidelines, Introduction to Signal Integrity.

UNIT – V
Introduction to Numerical EMI & EMC Simulation Techniques, Survey of Commercially available EMC Software, Introduction to Intentional EMI, EMP, Electromagnetic Weapons.

Suggested Reading:

1	Clayton R. Paul “Introduction to Electromagnetic Compatibility” Wiley Publication.
2	Dr. V.P. Kodali, “Engineering Electromagnetic Compatibility” IEEE Press, 1996.
3	Henry W. Ott, “Electromagnetic Compatibility Engineering” Wiley Publication.
4	Mark I. Montrose, “Printed Circuit Board Design Techniques for EMC Compliance: A Handbook for Designers”, IEEE Press ,2000.
5	Eric Bogatin, “Signal and Power Integrity – Simplified”, Signal Integrity Library, 3rd Edition,2018.

EC 312	**ADHOC WIRELESS NETWORKS**					
(PROGRAM ELECTIVE – I)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	**SEE**	**60 Marks**	**CIE**		**40 Marks**	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	An overview of ad hoc wireless networks, issues and applications.
2	The design issues of MAC layered protocols for adhoc networks and finding the solutions and various routing mechanisms for adhoc wireless networks
3	Designing issues at Transport layer of wireless network model and study of network security issues, key management and their solutions.

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Understand the various ad hoc wireless networks and their standards.
CO-2	Know the design issues and applications of various ad hoc wireless networks.
CO-3	Analyze and design the MAC protocols for different applications of adhoc wireless networks.
CO-4	Analyze and design different routing protocols for different adhoc networks.
CO-5	Know and analyze the transport layered issues and security management for adhoc networks.

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	1	-	-	2	-
CO-2	2	-	-	2	1
CO-3	1	-	-	2	1
CO-4	1	-	-	2	1
CO-5	1	-	-	2	1

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
Ad-hoc Wireless Networks: Fundamentals of Wireless Communication Technology, Characteristics of the Wireless Channel, IEEE 802 Networking Standard, Wireless networks overview Introduction to Ad-hoc wireless networks, Cellular and Ad-hoc wireless networks, Applications of Ad-hoc wireless networks, Issues in Ad-hoc wireless networks, Adhoc wireless Internet.

UNIT – II
MAC Protocols for Ad-hoc wireless networks: Issues in Designing a MAC protocol for Adhoc Wireless Networks, Design goals of a MAC protocol for Ad Hoc Wireless Networks, Classifications of MAC protocols, Contention –based protocols, Contention-based protocols with reservation Mechanisms, Contention –based MAC protocols with Scheduling Mechanisms, MAC protocols that use Directional Antennas, Other MAC protocols.

UNIT – III
Routing protocols for Ad-hoc wireless networks: Issues in Designing a Routing protocol for Ad Hoc Wireless Networks, Classification of Routing protocols, Table-Driven Routing protocols, On-Demand Routing protocols, Hybrid Routing protocols, Routing protocols with Efficient Flooding Mechanisms, Hierarchical Routing protocols, Power –Aware Routing protocols.

UNIT – IV
Transportation Layer Protocols for Ad-hoc wireless networks: Introduction, Issues in Designing a Transport Layer protocol for Ad-hoc Wireless Networks, Design goals of a Transport Layer Protocol for Ad hoc Wireless Networks, Classification of Transport Layer Solutions, TCP over Ad-hoc Wireless networks, Other Transport Layer protocol for Ad hoc Wireless Networks.

UNIT – V
Security Protocols for Ad-hoc wireless networks: Security in Ad-hoc wireless networks, Network security requirements, Issues and challenges in Security provisioning, Network Security attacks, Key management, Secure routing in Ad-hoc wireless networks.

Suggested Reading:

1	C. Siva Ram Murthy and B.S. Manoj, "Ad Hoc Wireless Networks: Architectures and protocols", 2004, PHI
2	George Aggelou, "Mobile Ad Hoc Networks", Tata McGraw-Hill, 2009.
3	C.K.Toh , "Ad hoc Mobile Wireless Networks: Protocols & Systems", 1st Ed. Pearson Education. 2002.
4	Jagannathan and Sarangapani, "Wireless Ad-hoc and Sensor Networks: Protocols, Performance and Control", 1st Edition, CRC Press, 2007.
5	Ozan K. Tonguz, Gianluigi Ferrari, "AD HOC Wireless Networks: A Communication-Theoretic Perspective", Wiley Student Edition, 2009

EC 313	**COMPUTATIONAL ELECTROMAGNETICS**					
(PROGRAM ELECTIVE – I)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To understand the basics of finite difference methods for solving Maxwell equations, both static and electrodynamics
2	To understand the basics of finite element methods for solving scalar Helmholtz equation.
3	To understand the determination of Green's function.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Utilize contemporary numerical approaches in Electromagnetics.
CO-2	Formulate, and solve engineering problems related to RF-microwave circuits.
CO-3	Formulate, and solve engineering problems of high-speed interconnects
CO-4	MEMS, antenna analysis and design.
CO-5	Apply Green's functions for free space and transmission lines like wave guide and microstrip.

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	3	3	-	1	-
CO-2	3	3	3	2	-
CO-3	3	3	3	3	-
CO-4	3	3	3	1	-
CO-5	3	3	3	1	-

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
Fundamental Concepts: Integral equations versus differential equations, radiation and edge conditions, modal representation of fields in bounded and unbounded media.

UNIT – II
Green's Functions: Green's function technique for the solution of partial differential equations, classification of Green's functions, various methods for the determination of Green's functions including Fourier transform technique and Ohm-Rayleigh technique, dyadic Green's functions, determination of Green's functions for free space, transmission lines, waveguides, and microstrips.

UNIT – III
Integral Equations: Formulation of typical problems in terms of integral equations: wire antennas, scattering, apertures in conducting screens and waveguides, discontinuities in waveguides and microstrip lines; Solution of Integral equations: General Method of Moments (MoM) for the solution of integral-differential equations, choice of expansion and weighting functions, application of MoM to typical electromagnetic problems.

UNIT – IV
Finite Element Method: Typical finite elements, Solution of two-dimensional Laplace and Poisson's equations, solution of scalar Helmholtz equation.

UNIT – V
Finite-difference Time-domain Method: Finite differences, finite difference representation of Maxwell's equations and wave equation, numerical dispersion, Yee's finite difference algorithm, stability conditions, programming aspects, absorbing boundary conditions.

Suggested Reading:

1	Peterson, A.F, Ray, S.L.and Mittra, R.,"Computational Methods for Electromagnetics", Wiley-IEEE Press. 1998
2	Harrington, R.F., "Field Computation by Moment Methods", Wiley- IEEE Press. 1993.
3	Sadiku, M.N.O., "Numerical Techniques in Electromagnetics", 2nd Ed., CRC Press-2.
4	Ramesh Garg," Analytical and Computational Methods in Electromagnetics" House, 2008.

EC 321	**RF MEMS**					
(PROGRAM ELECTIVE – II)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To explore MEMS concepts and MEMS devices.
2	To introduced to mechanical concepts.
3	To gain the physical knowledge underlying the operation principles and design of micro and nano- systems.

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Understand the basic structures of MEMS Devices
CO-2	Understand the operation of micro devices, micro systems and their applications
CO-3	Design the micro devices, micro systems using the MEMS fabrication process.
CO-4	Gain a knowledge of basic approaches for various sensor design, various actuator design
CO-5	Develop experience on micro/nano systems for photonics .Gain the technical knowledge required for computer-aided design, fabrication, analysis.

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	-	-	3	1	-
CO-2	-	1	3	1	-
CO-3	2	2	3	2	-
CO-4	-	2	2	2	-
CO-5	1	2	3	1	1

Correlation rating: Low / Medium / High: 1 / 2 / 3 respectively.

UNIT – I
Introduction, Basic Structures of MEMS Devices – (Canti Levers, Fixed Beams diaphragms). Broad Response of MEMS to Mechanical (force, pressure etc.) Thermal, Electrical, Optical and Magnetic stimuli, Compatibility of MEMS with VLSI Applications in Electronics, Broad Advantages and Disadvantages of MEMS from the point of Power Dissipation, Leakage.

UNIT – II
Review of Mechanical Concepts like Stress, Strain, Bending Moment, Deflection Curve. Differential equations describing the Deflection under Concentrated Force, Distributed Force, Deflection Curves for Canti Levers – Fixed beam. Electrostatic Excitation – Columbic Force between the Fixed and Moving Electrodes. Deflection with voltage in C.L, Deflection Vs Voltage Curve, Critical Deflection, Description of the above w.r.t. Fixed Beams. Fringe Fields – Field Calculations using Laplace Equation. Discussion on the Approximate Solutions – Transient Response of the MEMS.

UNIT – III
Two Terminal MEMS – capacitance Vs Voltage Curve – Variable Capacitor. Applications of Variable Capacitors. Two Terminal MEM Structures. Three Terminal MEM structures – Controlled Variable Capacitors – MEM as a Switch and Possible Applications.

UNIT – IV
MEM Circuits & Structures for Simple GATES – AND, OR, NAND, NOR, Exclusive OR, simple MEM Configurations for Flip-Flops Triggering, Applications to Counters, Converters. Applications for Analog Circuits like Frequency Converters, Wave Shaping. RF Switches for Modulation. MEM Transducers for Pressure, Force Temperature. Optical MEMS.

UNIT – V
MEM Technologies: Silicon Based MEMS – Process Flow – Brief Account of Various Processes and Layers like Fixed Layer, Moving Layers, Spacers etc., Etching Technologies. Metal Based MEMS: Thin and Thick Film Technologies for MEMS. Process flow and Description of the Processes. Status of MEMS in the Current Electronics scenario.

Suggested reading:

1	Gabriel.M. Reviez, R.F. MEMS Theory, Design and Technology, Thon Wiley & Sons, 2003.
2	Strength of Materials – by ThimoShenko, CBS Publishers & Distributors.
3	K. Pitt, M.R. Haskard – Thick Film Technology and Applications, 1997.
4	Wise K.D. (Guest Editor),"Special Issue of Proceedings of IEEE", Vol.86, No.8, Aug 1998.
5	Ristic L. (Ed.) Sensor Technology and Devices, Artech House, London 1994.

EC 322	**IOT AND APPLICATIONS**					
(PROGRAM ELECTIVE – II)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To understand the concepts of the Internet of Things and be able to build IoT Applications
2	To learn the programming and use of Arduino and Raspberry Pi boardsDesign and detail the deep beams.
3	To know about data handling and analytics in SDN

Course Outcomes:	
On completion of this course, the student will be able to:	
CO-1	Known basic protocols in sensor networks.
CO-2	Program and configure Arduino boards for various designs
CO-3	Python programming and interfacing for Raspberry Pi.
CO-4	Design IoT applications in different domains.
CO-5	Study the basics of Cloud Computing and different applications

Course outcome	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	1	2	2	2	2
CO-2	2	3	3	2	1
CO-3	1	3	3	3	2
CO-4	3	3	3	3	3
CO-5	2	3	3	3	3

UNIT – I
Introduction to the Internet of Things, Characteristics of IoT, Physical design of IoT, Functional blocks of IoT, Sensing, Actuation, Basics of Networking, Communication Protocols, Sensor Networks.

UNIT – II
Machine-to-Machine Communications, Difference between IoT and M2M, Interoperability in IoT, Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino.

UNIT – III

Introduction to Python programming, Introduction to Raspberry Pi, Interfacing Raspberry Pi with basic peripherals, Implementation of IoT with Raspberry Pi .

UNIT – IV
Implementation of IoT with Raspberry Pi, Introduction to Software-defined Network (SDN), SDN for IoT, Data Handling and Analytics

UNIT – V
Cloud Computing, Sensor-Cloud, Smart Cities and Smart Homes, Connected Vehicles, Smart Grid, Industrial IoT, Case Study: Agriculture, Healthcare, Activity Monitoring.

Suggested Reading:

1	"The Internet 'of Things: Enabling Technologies, Platforms, and Use Cases", by PethuruRaj and Anupama C. Raman (CRC Press).
2	"Make sensors": Terokarvinen, kemo, karvinen and villeyvaltokari, 1st edition, maker media, 2014.
3	"Internet of Things: A Hands-on Approach", by Arshdeep Bahga and Vijay Madisetti Vijay Madisetti
4	Arshdeep Bahga, "Internet of Things: A Hands-On Approach"
5	Waltenegus Dargie,Christian Poellabauer, "Fundamentals of Wireless Sensor Networks: Theory and Practice
6	Beginning Sensor networks with Arduino and Raspberry Pi – Charles Bell, Apress, 2013

EC323	**REMOTE SENSING – GROUND STATIONS**				
(PROGRAM ELECTIVE – II)					
Pre-requisites		**L**	**T**	**P**	**C**
		3	-	-	3
Evaluation		60 Marks		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To explain and make the students to understand the basic concepts of Remote sensing platforms and various satellite sensor technologies.
2	To understand the different types of satellites and various application in the present scenario
3	To understand the satellite ground station technology
4	To understand the RF systems, servo systems, Base sand systems
5	To demonstrate the satellite data quality evaluation and implement the quality assurance aspects

Course Outcomes:	
On completion of this course, the student will be able to:	
CO-1	Able to understand remote sensing and various applications
CO-2	Acquires knowledge related to design and development of RF systems, servo systems, Frame synchronizers etc
CO-3	Perform system verification and validation of satellite data quality parameters
CO-4	Understands environmental tests and EMI /EMC test standards related to various systems of ground station
CO-5	Can design and develop electronic hardware for components in the data reception chain

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	3	3	3	2	1
CO-2	3	3	3	2	2
CO-3	3	3	3	2	2
CO-4	3	3	3	2	1
CO-5	3	3	3	2	2

UNIT – I
Physics and principle of Remote Sensing: Electro Magnetic Spectrum, Different remote sensing platforms, Satellite sensors, active sensors and passive sensors, Introduction to space segment , ground segment and user segment, Space technology etc.

UNIT – II
Satellite orbital dynamics, satellite path and row concepts, reference schemes, Sun synchrounous satellites, geostationary satellites, Difference between Geo,MEO and LEO orbits and its requirements, Onboard satellite data conversion and modulation. Signal transmission and EIRP, satellite band L,S,X,Ku,Ka . Allocation of bands , Geostationary satellites constellations, IRNSS satellite , GPS constellations, Types and characteristics of different platforms –RESOURCESAT, OCEANSAT, LANDSAT, IRS, INSAT, TERRA, AQUA,NPP etc

UNIT – III
Noise survey for ground station, Link margin calculations, Ground station requirements for LEO ,MEO, GEO. Types os antenna mounts, Cassegranian configuration, Prime focus, astronomical mounts, Antenna systems for planetary missions, cross polarisation, isolation, Pointing and tracking accuracy, Auto tracking mechanism, Different tracking mechanisms step track, monopulse track etc, Antenna servo controller, Figure of merit of antenna systems, Front end electronics, Different RF feed systems, RF Downconverters , upconverters, Modulators, Configuration matrix, Demodulators, Frame synchronisers, Data acquisition systems.

UNIT – IV
Satellite Data receive chain verification and validation, testing of End-end satellite receive chain for high data rate satellites, Servo control systems tests for performance evaluation, Satellite time importance, TCG, Interfacing of ECL,LVDS,TTL signals. Coding mechanisms, phase keying mechanisms and advantages, High speed fiber links for data transfers, RAID controllers and data acquisition systems.

UNIT –V
Quality assurance of ground station systems, KPI monitoring of RF signal parameters, Eb/N0, C/No, IF level. Improving signal to noise, RF performance tuning and signal level monitoring, Servo parameters tuning, tracking gradients, BER verification of satellite data receive chain, IS 9000 environmental test standards for systems/sub systems qualification. CISPR-22 ,IEC 61000 standards for EMI/EMC tests qualification for ground station systems. Overview of ISO 9001:2015 standard

Suggested Reading:

1	Bruce Elbert " The satellite communication Ground segment and earth station hadbook", Artech house- 2014, 2nd edition.
2	Louis J.Ippolito,Jr"Satellite Communications Systems Engineering" Wiley- 1st Edition, 2008.
3	William F. Egan "Practical RF System Design (IEEE Press) Hardcover", Wiley-IEEE Press, 1st edition 2003
4	Warren L.Stutzman, Gary A.thiele " Antenna theory and design" Wiley , 2012 3rd edition
5	Bureau of Indian standards BIS" Basic Environmental testing procedures for electronic and electrical items, Part 32, " BIS , 2006.

EC331	**OPTICAL COMMUNICATIONS AND NETWORKS**					
(PROGRAM ELECTIVE – III)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To know the basic geometric structures of Optical fibers, Light laws, modes of operation and losses in fibers.
2	To know the physical principles of optical sources and optical detectors and develop the design models and design the analog and digital optical links.
3	To understand, the noise effects and error control techniques, working of various optical components, Optical networks and their applications.

Course Outcomes :	
On completion of this course, the student will be able to:	
CO -1	Understand and analyze the design principles of Optical fibers and their losses.
CO-2	Analyze the design aspects of various types of Optical sources and detectors.
CO-3	Analyze and design the optical links for different applications.
CO-4	Know the working of WDM systems and various optical components for different applications.
CO-5	Choose the optical networks for various applications.

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	1	2	1	-
CO-2	2	1	-	-	-
CO-3	1	1	-	2	-
CO-4	1	-	-	-	-
CO-5	1	-	-	-	-

Correlation rating: Low/Medium/High:1/2/3respectively.

UNIT- I
Optical Fibers: Overview of Optical fiber communications, Elements of an Optical fiber transmission Link, Nature of light, Basic optical laws and definitions, Modes and configurations, Single & Multi mode step index and Graded index Fibers, Fibre materials. **Signal degradation in Optical fibers:** Attenuation, Signal Distortion in Optical Waveguides Dispersion, Pulse broadening in graded index fibers, Mode coupling, Design optimization of single mode fibers.

UNIT-II
Optical Sources: Semiconductors physics, LEDs and Laser diodes, Linearity of sources, Modal, Partition and reflection noise. **Photo detectors:** Physical principles of PIN and APD, Photo detector noise, detector response time, Avalanche multiplication noise, Temperature effect on avalanche gain, Comparison of Photo detectors.

UNIT –III
Optical Receiver Operation: Fundamental Receiver operation, Digital receiver performance calculations, Preamplifiers types, Analog receivers. **Digital Transmission Systems**: Point to point links, Line coding, Error correction, Noise effects on system performance, Overview of Analog links, Carrier-to-noise ratio

UNIT-IV
WDM: Concepts and components, Operational principles of WDM, Passive components, Tunable sources, Tunable filters, Introduction of optical amplifiers, Solution Pulses.

UNIT- V
Optical Networks: Basic Networks, SONET/SDH, Broadcast and select WDM networks, Wavelength Routed Networks, Nonlinear effects on Network Performance, Performance of EDFA+WDM systems, Optical CDMA, Ultrahigh capacity Networks.

Suggested Reading:

1	Djafar K.mynbaev Lowell l.Scheiner, Fibre Optic Communications Technology, Pearson Education Asia, 2006.
2	Senior John M. Optical Fibre Communications Principles and Practice, Prentice Hall India, second edition, 1996.
3	Keiser Gerd, Optical Fibre Communications, Mc GrawHill, Third edition,1991.
4	Govind P.agarwal, Fiber-Optic Communication Systems, Third edition, John Wiley & Sons, 2002.
5	Joseph C. Palais, Fibre Optic Communications, Fifth edition, Pearson Education, 2004.

EC 332	**OPTIMIZATION TECHNIQUES**					
(PROGRAM ELECTIVE – III)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To introduce various optimization techniques i.e., classical, linear programming, transportation problem, simplex algorithm, dynamic programming.
2	Constrained and unconstrained optimization techniques for solving and optimizing an electrical and electronic engineering circuits design problems in real world situations.
3	To explain the concept of Dynamic programming and its applications to project implementation.

Course Outcomes:	
On completion of this course, the student will be able to:	
CO-1	Explain the need of optimization of engineering systems.
CO-2	Understand optimization of electrical and electronics engineering problems.
CO-3	Apply classical optimization techniques, linear programming, simplex algorithm, transportation problem.
CO-4	Apply unconstrained optimization and constrained non-linear programming and dynamic programming.
CO-5	Formulate optimization problems.

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	1	-	2	-
CO-2	2	1	-	1	-
CO-3	2	1	1	2	-
CO-4	1	-	-	1	-
CO-5	1	-	-	1	-

Correlation rating: Low / Medium / High: 1 / 2 / 3 respectively.

UNIT - I
Use of optimization methods, Introduction to classical optimization techniques, motivation to the simplex method, simplex algorithm, sensitivity analysis.

UNIT - II
Search methods - Unrestricted search, exhaustive search, Fibonocci method, Golden section method, Direct search method, Random search methods, Univariate method, simplex method, Pattern search method.

UNIT - III
Descent methods, Gradient of function, Steepest decent method, Conjugate gradient method, Characteristics of constrained problem, Direct methods, The complex method, Cutting plane method.

UNIT - IV
Review of a global optimization techniques such as Monte Carlo method, Simulated annealing and Tunneling algorithm.

UNIT - V
Generic algorithm - Selection process, Crossover, Mutation, Schema theorem, comparison between binary and floating-point implementation.

Suggested Reading:

1	SS Rao, “Optimization techniques”, PHI, 1989
2	Zhigmiew Michelewicz, “Genetic algorithms + data structures = Evaluation programs”, Springer Verlog - 1992.
3	Merrium C. W., “Optimization theory and the design of feedback control systems”, McGraw Hill, 1964.
4	Weldo D.J., “Optimum seeking method”, PHI, 1964.

EC 333	**SOFTWARE DEFINED RADIO**					
(PROGRAM ELECTIVE – III)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To provide fundamental concepts in SDR.
2	To explore the reconfigurable features of modern radio communication systems.
3	To Explore various components for SDR.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the basic architecture and design principles of SDR.
CO-2	Analyze the parameters of analog RF components as front end block in implementation of SDR.
CO-3	Understand the concepts of analog& digital converters and frequency converter fundamentals.
CO-4	Understand the digital hardware & software architectures
CO-5	Understand the various applications of SDR.

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	1	-	2	-
CO-2	2	1	-	1	-
CO-3	2	1	1	2	-
CO-4	1	-	-	1	-
CO-5	1	-	-	1	-

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT - I
Introduction to Software Defined Radio: A Traditional Hardware Radio Architecture, Signal Processing Hardware History, Software Defined Radio Project Complexity. A Basic Software Defined Radio Architecture: 2G Radio Architectures, Hybrid Radio Architecture, Basic Software Defined Radio Block Diagram, System Level Functioning Partitioning, Digital Frequency Conversion Partitioning.

UNIT - II
RF System Design: Introduction- Noise and Channel Capacity, Link Budget, Receiver Requirements, Multicarrier Power Amplifiers, Signal Processing Capacity Tradeoff.

UNIT - III
Analog-to-Digital and Digital-to-Analog Conversion: Digital Conversion Fundamentals, Sample Rate, Band pass Sampling, Oversampling- Anti alias Filtering, Quantization, ADC Techniques-Successive Approximation, Figure of Merit-DACs, DAC Noise Budget, ADC Noise Budget.

UNIT - IV
Digital Frequency Up- and Down Converters: Introduction- Frequency Converter Fundamentals, Digital NCO, Digital Mixers, Digital Filters, Half band Filters, CIC Filters, Decimation, Interpolation, and Multi rate Processing, DUCs, Cascading Digital Converters and Digital Frequency Converters.

UNIT - V
Hardware and Software Components: SDR Requirements for Processing Power- DSPs- DSP Devices- DSP Compilers Reconfigurable Processors-Adaptive Computing Machine- FPGAs, Major Software Architecture Choices, Hardware – Specific Software Architecture, Software Standards for Software Radio, Software Design Patterns, Component Choices, Real Time Operating Systems, High Level Software Languages, Hardware Languages.

Suggested Reading:

1	Paul Burns, “Software Defined Radio for 3G”, Artech House, 2002
2	Tony J Rouphael, “RF and DSP for SDR”, Elsevier Newnes Press, 2008
3	Jouko Vanakka, “Digital Synthesizers and Transmitter for Software Radio”, Springer, 2005.
4	Sofie Pollin, Michael Timmers, Liesbet Van der Perre, “Software Defined Radios”, Springer Publications, 2011.
5	Walter Tuttlebee, “Software Defined Radio: Enabling Technologies”, Wiley Series in Software radio, June 2002 .

EC 361	**MICROWAVE SYSTEMS LABORATORY**					
	(LABORATORY –I)					
Pre-requisites			L	T	P	C
			-	-	2	1
Evaluation	**SEE**	--	**CIE**		50 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To become familiar with microwave bench set up and source characterization.
2	To understand the antenna radiation characteristics, input impedance using microwave bench setup
3	To study and understand the analog and digital communication using fiber optic cables.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Demonstrate the characteristics of Microwave sources.
CO-2	Energize microwave bench and study the characteristics of antenna impedance
CO-3	Understand the principles of optical fiber communications.
CO-4	Measure the radiation pattern characteristics of Horn antenna
CO-5	Measure power characteristics of frequency scanned array antenna

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	-	1	1	-
CO-2	1	2	2	-	-
CO-3	1	-	1	1	-
CO-4	1	2	2	1	-
CO-5	1	1	1	1	-

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

LIST OF EXPERIMENTS

1. Study of microwave source characteristics-Reflex Klystron
2. Study of microwave source characteristics- Gunn oscillator
3. Measurement of the Directional Coupler characteristics
4. Measurement of the Magic Tee characteristics
5. Impedance of Waveguide Discontinuities-Inductive and Capacitive Diaphrams
6. Radiation pattern measurement of Aperture antenna.
7. Characterization of Radiation pattern of all Wired Antenna.
8. Measure the characteristics of Standing Wave.
9. Measure the characteristics of open & short load.
10. Measurement of S-parameters (S11,S12, S21, S22).
11. Measurement in co-polarization and cross polarization of the antenna.

Note: The experiments will be decided and modified if necessary and conducted by the teacher.

EC 371	**SEMINAR**					
Pre-requisites			L	T	P	C
			-	-	2	1
Evaluation	**SEE**	60 Marks	**CIE**		50 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Identify appropriate topic of relevance.
2	Update literature on technical articles of selected topic and develop comprehension.
3	Prepare a technical report.
4	Deliver presentation on specified technical topic.

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Develop the habit of referring the journals for literature review.
CO-2	Understand the gist of the research paper.
CO-3	Identify the potential for further scope.
CO-4	Present the work in an efficient manner.
CO-5	Write the documentation in standard format.

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	3	-	1	1	-
CO-2	3	-	1	2	1
CO-3	-	3	1	3	-
CO-4	3	-	1	3	-
CO-5	-	-	1	1	1

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

Seminar topics may be chosen by the students with advice from the faculty members and the student shall read further relevant articles in the domain.

The seminar must be clearly structured and the power point presentation shall include following aspects:

1. Introduction to the field
2. Literature survey
3. Consolidation of available information
4. Summary and Conclusions
5. References

Each student is required to:

1. Deliver the seminar for a maximum duration of 30 minutes, where the presentation should be for 20 minutes in PowerPoint, followed by Question and Answers session for 10 minutes.
2. Submit the detailed report of the seminar in spiral bound in a précised format as suggested by the Department.

Guidelines for awarding marks		
S. No.	Description	Max. Marks
1	Contents and relevance	10
2	Presentation skills	10
3	Preparation of PPT slides	05
4	Questions and answers	05
5	Report in a prescribed format	20

Note:

1. The seminar presentation should be a gist of at least five research papers from Peer-reviewed or UGC recognised journals.

The seminar report should be in the following order: Background of work, literature review, techniques used, prospective deliverables, discussion on results, conclusions, critical appraisal and references.

EC304	**MICROWAVE CIRCUITS AND SYSTEMS**					
	(CORE – IV)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60Marks	**CIE**		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To become familiar with the characterization of microwave networks
2	To acquaint with theoretical analysis of the characteristics of electromagnetic waves in planar transmission lines.
3	To know impedance matching concepts and become familiar with microwave passive circuit analysis and design.

Course Outcomes :	
On completion of this course, the student will be able to:	
CO-1	Characterize the reciprocal networks, lossless networks in terms of S-Parameters
CO-2	Understand the behavior of most commonly used planar transmission lines such as microstrip line and strip line etc.
CO-3	Design impedance matching networks
CO-4	Understand the operation and design of passive microwave devices such as power dividers, couplers and filters
CO-5	Understand the microwave propagation in ferrites and use them in various applications

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	3	2	1	1	-
CO-2	2	2	2	2	1
CO-3	2	3	2	2	-
CO-4	2	3	2	3	-
CO-5	1	1	1	1	1

Correlation rating: Low/Medium/High:1/2/3respectively.

UNIT- I
Introduction to micro wave circuit concept: one port junction, scattering matrix, Properties of [S] matrix, Relationship between [S], [Z] and [Y] parameters, Wave amplitude transmission matrix[A], Relation between [A] and [S].

UNIT-II
Analysis of microstrip line and strip line, Method of conformal Transformation, Characteristic parameters of Microstrip, Strip line, **Introduction to slot line and coplanar waveguide, Impedance matching:** Stub matching - Single and double stub using Smith chart solutions, Quarter wave transformer, Multi section transformer design, tapered lines - Exponential taper, triangular taper.

UNIT -III
Introduction to Coupled microstrip, Even and odd mode analysis, Theory of coupled microstrip Directional couplers, Calculations for a coupled pair of microstrip, Branch line couplers, Eigen value method and its applications to branch line couplers, hybrid ring couplers and the Wilkinson power dividers/combiners.

UNIT-IV
Lumped Elements for MIC design and fabrication of lumped elements, circuits using lumped elements, Impedance transformers. **Microwave Planar Filters:** Periodic structures, Filter design by the Image Parameter method, Filter design by the Insertion Loss method, Filter transformations, Filter implementation.

UNIT- V
Microwave propagation in ferrites, Principles of faraday rotation, Microstrip on Ferromagnetic substrates, Microstrip circulators, Isolators and phase shifters, Applications of MICs.

Suggested Reading:

1	Collins. RE, Foundations for Microwave Engineering, McGraw Hill, 2nd edn,1992.
2	Pozer.DM, Microwave engineering,2nd edn., John Wiley Andsons, inc.,1999.
3	Gupta KC, and Amarjit Singh, Microwave Integrated circuits, Wiley Eastern,1974.
4	Hoffman R.K. "Hand Book of Microwave integrated Circuits", Artech House, Boston, 1987.

EC305	**RADAR SYSTEMS ENGINEERING**					
(CORE – V)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60Marks	**CIE**		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To familiarize the basic concepts of a radar system in target detection.
2	To know the features of radar target models and clutter.
3	To understand various types of radar systems and their applications.

Course Outcomes :	
On completion of this course, the student will be able to:	
CO-1	Understand the radar fundamentals
CO-2	Understand the principle of operation of various radar systems
CO-3	Apply the knowledge in the design of a radar system
CO-4	Characterize the target fluctuation
CO-5	Understand the concepts of phased array radar

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	1	1	-	1	-
CO-2	1	2	-	1	-
CO-3	2	3	2	2	-
CO-4	2	-	-	1	-
CO-5	2	2	2	2	1

Correlation rating: Low/Medium/High:1/2/3respectively.

UNIT- I
The radar range equation: Radar fundamentals, Derivation of range equation, Search radar equation, Jamming and radar range with jamming, Radar clutter and radar range with clutter.

UNIT-II
The theory of target detection: Noise and false alarms, Detection of one sample of signal with noise, Integration of pulse trains, Detection of fluctuating targets, CFAR, Optimum and matched filter Theory, Loss factors in detection

UNIT –III
Targets and interference: Definition of radar cross section, Radar cross section of simple and complex objects, Spatial distribution of cross section, Bistatic cross section. **CW and FM Radar:** Doppler Effect. CW and FMCW Radar, Airborne Doppler Navigation, Multi frequency CW Radar.

UNIT-IV
MTI Radar: Delay line cancellers, Sub clutter Visibility, MTI using range gates and filters, Pulse Doppler radar, Non-coherent MTI radar, Tracking Radar: Different types of tracking techniques. Tracking in range, Tracking in Doppler. Search Acquisition radar, Comparison of Trackers.

UNIT- V
Introduction to Synthetic Aperture Radar (SAR) - Principles of SAR, Range resolution, azimuthal resolution, backscattering coefficient. Range compression, azimuth compression, Doppler centroid, Doppler rate, range migration, range curvature, range ambiguities, azimuth ambiguities, Modes of SAR operation -Strip mode, Scansar mode, Spot mode.

Suggested Reading:

1	David Barton .K, “Modern radar system analysis”, Artech house, 1988.
2	Fred Nathanson E, “Radar design principles signal processing and the environment”, McGraw Hill.1969.
3	John C. Curlander, Robert N. McDonough, "Synthetic Aperture Radar Systems and Signal Processing, John Wiley & Sons Inc.
4	Giorgio Franceschetti, Riccardo Lanari, "Synthetic Aperture Radar Processing'", CRC Press.
5	Skolnik, “Introduction to radar systems”, McGraw hill, 2nd Edition 2003.

EC306	**GNSS AUGMENTATION SYSTEMS**					
	(CORE – VI)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To review about the GPS, DGPS and its applications..
2	To make the students to understand about SBAS, its operations and applications
3	To make the students appreciate about the LAAS, its operations and their applications.
4	To make the students appreciate about the LAAS, its operations and their applications
5	To understand the applications of Applications of GPS and Augmentation systems

Course Outcomes :	
On completion of this course, the student will be able to:	
CO-1	Understand about the review GNSS and DGPS
CO-2	Compare various GRNSAS being developed across the world
CO-3	Appreciate about LASS, its architecture and applications
CO-4	Appreciate about LASS, its architecture and applications
CO-5	Use GPS and augmentation systems in various fields such as navigation, GIS etc

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	3	2	2	-
CO-2	1	1	2	2	-
CO-3	1	1	2	2	-
CO-4	-	2	3	3	-
CO-5	-	2	3	3	-

Correlation rating: Low/Medium/High:1/2/3respectively.

UNIT- I
Overview of GPS, Various GNSS across the world, Comparison of Global and Regional Satellite Systems, advantages and GNSS threats, Limitations of GNSS, DGPS – Principle of operation of DGPS, architecture, advantages, limitations and GRNSS Applications.

UNIT-II
Augmentation Systems: Introduction, Satellite Based Augmentation Systems (SBAS), SBAS features and Principle of operation of US based Wide area augmentation system (WAAS), architecture, advantages, limitations and applications.

UNIT –III
Indian SBAS: Introduction to Indian GAGAN, Implementation, Technology demonstration, Technology integration, Effective flight management, GAGAN satellites, developments, GAGAN applications in India.

UNIT-IV
The European Geostationary Navigation Overlay Service (EGNOS) system, Japan's Multi-functional Satellite Augmentation System (MSAS), Russian The System for Differential Corrections and Monitoring (SDCM) system, The Chinese BeiDou Satellite-Based Augmentation System (BDSBAS)- Operation, features and applications.

UNIT- V
LAAS: Categories of Precision Approach requirements of Civil Aviation for various phases of flight, Integral components of LAAS, LAAS architecture,operating principle, Protection Levels and Alert limits, LAAS Benefits, advantages, limitations, Error Sources in LAAS and its current status, LAAS Services, LAAS: International Status, LAAS National status, LAAS applications.

Suggested Reading:

1	Elliot D. Kaplan, "Understanding GPS Principles and Applications", Artech House Boston, 1996.
2	Bradford W. Parkinson and James J. Spilker, "Global Positioning System: Theory and Applications," Volume II, American Institute of Aeronautics and Astronautics, Inc., Washington,1996.
3	B.Hofmann Wollenhof, H.Lichtenegger, and J.Collins, "GPS Theory and Practice", Springer Wien, Newyork, 2000.

EC 341	**PHASED ARRAY RADAR**					
(PROGRAM ELECTIVE – IV)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To understand the principle of electronic scanning and its application to a phased-array radar system
2	To understand the concepts of cell, grid and feeding techniques.
3	To familiarize with the design of frequency scanned array and concepts of beam positioning

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the basic concepts of radar beam steering and determine the direction of a resultant beam.
CO-2	Identify the advantage and applications of an electronically scanned system.
CO-3	Understand the concepts of frequency scanned array
CO-4	Be aware of the role of phase shifters and feed networks in the frequency scanned array design.
CO-5	Design planar array antenna with scanning capabilities.

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	2	-	-	-
CO-2	1	3	1	1	-
CO-3	1	1	-	-	-
CO-4	1	2	1	-	-
CO-5	2	3	3	1	-

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT - I
Conventional scanning techniques, Mechanical versus electronic scanning, Techniques of Electronic scanning, Frequency, Phase and time delay scanning principle, Hybrid scanning techniques.

UNIT - II
Array Theory, Linear and Planner arrays, various grid configuration, Concept of cell and grid, Calculation of minimum number of elements, Radiation pattern, Grating lobe formation, Rectangular and triangular grid design of arrays.

UNIT - III
Feed Networks for phased Arrays, Corporate Feed, Lens and Reflect feed Techniques, Optimum f/d ratio basic building block for corporate feed network, Series, Parallel feed networks, Comparison of various feeding techniques, Antenna Array Architecture, Brick/ Tile Type construction.

UNIT - IV
Frequency scanned array design, Snake feed, Frequency-phase scanning, Phase scanning, Digital phase shifter PIN diode and Ferrite phase shifters for phased arrays, Beam pointing errors due to digitalization, Beam pointing accuracy.

UNIT - V
Search patterns, Calculation of search frame time, Airborne phased array design, Electronic scanning radar parameter calculation, Application of phased arrays, Phased Array Radar Systems, Active Phased Array, TR/ATR Modules.

Suggested Reading:

1	Olliner & knittel, “Phased Array Radar”, Artech House, 1972.
2	Kahrilas, PJ, “Electronic Scanning Radar Systems Design Handbook”, Artech House, 1976.
3	Skolnik, MI, “Radar Handbook”, McgrawHillso, NY, 1970.
4	Hansen, RC, “Significant Phased Array” Papers.
5	Galati, G, “Advanced Radar Technique and Systems”, Peter Peregrims Ltd, London,1993.

EC 342	**RADAR SIGNAL PROCESSING**					
(PROGRAM ELECTIVE – IV)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To review the Radar fundamentals.
2	To know the sampling criteria of Pulsed radar signals and learn about various radars like MTI, Doppler and tracking radars and their comparison
3	To analyze the radar signals using ambiguity function and understand various technologies involved in the design of radar transmitters and receivers.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Explain the fundamental concepts of radar signal processing
CO-2	Describe the basic radar signal, noise and clutter models
CO-3	Explain the matched filter and ambiguity function concepts
CO-4	Explain radar detection techniques
CO-5	Use numerical tools to calculate radar performance and to simulate the signal processing in a radar.

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	3	2	1	-	-
CO-2	1	-	3	2	-
CO-3	1	3	2	-	-
CO-4	-	1	2	3	-
CO-5	-	1	3	-	2

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
A Preview of Basic Radar Signal Processing, Radar Literature, Signal Models, components of a Radar Signal, Amplitude Models, clutter, Noise Model and Signal -to -Noise Ratio, Jamming, Frequency Models-The Doppler Shift, Spatial Models, Spectral Model.

UNIT – II
Sampling and Quantization of Pulsed Radar Signals, Domains and Criteria for Sampling Radar Signals, Sampling in the Fast Time Dimension, Sampling in Slow Time – Selecting the Pulse Repetition Interval, Sampling the Doppler Spectrum, Sampling in the Spatial and Angle Dimensions, Quantization, I/Q Imbalance and Digital I/Q.

UNIT – III
Radar waveforms: The waveform Matched filter, Matched filter for Moving Targets, Radar Ambiguity Function and Ambiguity Diagram - Principles and Properties; Specific Cases - Ideal Case, Single Pulse of Sine Wave, Periodic Pulse Train, Single Linear FM Pulse.

UNIT – IV
Doppler Processing, Alternate forms of the Doppler Spectrum, Moving Target Indication (MTI), Pulse Doppler Processing, Pulse Pair Processing, Additional Doppler Processing Issues, Clutter Mapping and the Moving Target Detector, MTI for moving platforms.

UNIT – V
Pulse Compression in Radar Signals: Introduction, Significance, Types, Frequency Modulated Pulse compression wave forms, Range side lobe control for FM waveforms, Phase modulated pulse compression wave forms, Costas Frequency codes.

Suggested Reading:

1	Mark A. Richards, “Fundamentals of Radar Signal Processing”, McGraw Hill
2	M.I. Skolnik, “Introduction to Radar Systems”, 3rd Edition, 2001, TMH.
3	R. Nitzberg, “Radar Signal Processing and Adaptive Systems”, 1999, Artech House.
4	F.E. Nathanson, “Radar Design Principles”, 1st Edition, 1969, McGraw Hill.

EC 343	**MICROWAVE SOLID STATE DEVICES AND APPLICATIONS**					
(PROGRAM ELECTIVE – IV)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To analyze the working principles, applications, and biasing of Microwave BJTs and GaAs FETs, including impedance matching techniques.
2	To develop and characterize RF switches, attenuators, and phase shifters using FETs for efficient microwave signal processing.
3	To study S-parameters, power gain equations, stability criteria, and impedance matching for designing various microwave amplifiers.
4	To investigate the negative resistance concept, oscillator conditions, and different oscillator designs, including YIG, Gunn, and IMPATT oscillators.
5	To examine diode and FET-based mixers, including single, balanced, and double-balanced designs, and their characterization in RF applications.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the working principles of the Microwave solid state devices (Microwave BJTs. GaAs FETs, low noise and power GaAs FETs, IMPATT Diodes)
CO-2	Choose a suitable microwave solid state device for a particular application.
CO-3	Understand the use of microwave semiconductor devices in RF Switches, Phase shifter and attenuators.
CO-4	Understand the use of microwave semiconductor devices in microwave amplifiers and oscillators.
CO-5	Understand the use of microwave semiconductor devices in design of microwave, mixers.

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	3	1	1	-	1
CO-2	3	1	1	-	-
CO-3	1	2	2	3	-
CO-4	2	2	2	3	-
CO-5	2	2	2	3	-

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
Introduction to two terminal microwave devices: Microwave BJTs, GaAs FETs, low noise and power GaAs FETs and their applications. DC biasing, Z and Y smith charts and impedance matching circuits.

UNIT – II
RF Switches, Phase shifter and attenuators: SPST and SPDT design using FETs, FET based attenuators and phase shifters. Characterization of Switches, attenuators and phase shifters.

UNIT – III
Amplifiers - Microwave transistor, S parameters, Power gain equations, stability, impedance matching, constant gain and noise figure circles; Small signal, low noise, high-power and broadband amplifier designs, Characterization of amplifiers.

UNIT – IV
Oscillators: Negative resistance concept, types of resonators, oscillator condition, One port, two port, YIG dielectric oscillators, broad band oscillator, Gunn diode oscillator design, and wave guide cavity IMPATT oscillator design, FET oscillator design, Characterization of oscillators.

UNIT – V
Microwave Mixers design: Diode mixer theory, single diode mixers; single balanced, double balanced mixers.FET mixer theory, balanced FET mixers, and special mixer circuits. Characterization of Mixers.

Suggested Reading:

1	S.Y. Liao, “Microwave Circuit Analysis and Amplifier Design”, Prentice Hall, 1987.
2	G.D. Vendelin, A.M. Pavio, U.L. Rohde, “Microwave Circuit Design, Using Linear and Non-linear Techniques”, John Wiley, 1990.
3	S.Y.Liao, “Microwave Devices and Circuits”, Third addition, , Prentice Hall.
4	Guillermo and Gonzalez, “Microwave Transistor Amplifiers: Analysis and Design”, (2nd Edition), 1996
5	Stephen A.Mass, “Microwave Mixers” , Artech House Publishers , 2nd edition,1993.

EC 351	**WIRELESS AND MOBILE COMMUNICATIONS**					
(PROGRAM ELECTIVE – V)						
Pre-requisites	Analog communications and Digital communications		L	T	P	C
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	An overview of key wireless technologies: Various generations of mobile communications for voice and data, 5G networks, Multicarrier Modulation, OFDM, MIMO.
2	Wireless system design fundamentals: channel assignment, Outdoor, Indoor propagation models and Various statistical models for small-scale fading study.
3	Various Diversity techniques, Equalizers used in communication receivers, Multiple Access techniques and their applications in wireless networks.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Develop design models for cellular systems.
CO-2	Analyze the various Large-scale fading effects in designing propagation models for Mobile communications in Outdoor environments.
CO-3	Analyze the various types of Small-scale fading, measurement techniques, Parameters of multi-path radio and Statistical models.
CO-4	Understand Various Diversity techniques and Equalizers used in communication receivers.
CO-5	Develop the design models for various multiple access techniques and understand their spectral efficiencies.

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	1	-	1	-
CO-2	2	1	1	1	-
CO-3	2	1	1	1	-
CO-4	1	-	-	1	-
CO-5	2	1	-	2	-

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I

Introduction to Wireless Communication Systems and the Cellular Concept: Evolution of Mobile Radio Communications, Examples of Wireless Communication Systems, Overview of 1G,2G, 2.5G,3G, 4G and 5G Cellular networks.

The Cellular Concept: Introduction, Frequency Reuse, Channel Assignment Strategies, Handoff Strategies, Interference and System Capacity, Improving Coverage and Capacity in cellular systems.

UNIT – II

Mobile Radio Propagation: Large-Scale Path Loss Introduction to Radio wave propagation, Free space propagation model, Relating Power to Electric Field, The three basic propagation mechanisms-Reflection, Ground Reflection (Two Ray) model, Diffraction, Scattering.

Outdoor propagation models: Longley-Rice model, Okumura model, Hata model, PCS Extension to Hata model, Walfisch and Bertoni Model, Wideband PCS Microcell model.

Indoor propagation models: Partition losses (same floor), Partition losses between floors, Logdistance path loss model, Ericsson multiple breakpoint model, Attenuation factor model, Signal penetration into buildings.

UNIT – III

Mobile Radio Propagation: Small Fading and Multipath Small scale multipath propagation, Factors influencing small scale fading, Doppler shift, Small scale multipath Measurements-Direct RF Pulse System, Spread Spectrum Sliding correlator Channel Sounding, Frequency Domain Channels Sounding, Parameters of Mobile multipath channels, Types of Small Scale Fading, Statistical models for multipath Fading Channels-Clarke's model for flat fading, spectral shape due to Doppler, Level Crossings and Fading Statistics, Two-ray Rayleigh Fading model.

UNIT – IV

Equalization and Diversity : Introduction, Fundamentals of Equalization, Training a Generic Adaptive Equalizer, Equalizers in a communication Receiver, Linear Equalizers, Non linear Equalization-Decision Feedback Equalization (DFE), Maximum Likelihood Sequence Estimation (MLSE) Equalizer, Algorithms for adaptive equalization.

Diversity Techniques: Practical Space Diversity Considerations, Selection Diversity, Scanning Diversity, Maximal Ratio Combining, Equal Gain Combining, Polarization Diversity, Frequency Diversity, Time Diversity, RAKE Receiver.

UNIT – V
Multiple Access Techniques for Wireless Communications FDMA, TDMA, Spread Spectrum Multiple Access- FHMA and CDMA, SDMA, Spectral efficiency analysis for Multiple Access Technologies: FDMA, TDMA and CDMA Comparison of these technologies based on their signal separation techniques, advantages, disadvantages and application areas.

Suggested Reading:

1	Theodore, S.Rappaport , Wireless Communications, Principles and Practice, 2nd Ed.,2002,PHI.
2	Andrea Goldsmith, Wireless Communications, 2005, Cambridge University Press.
3	Kaveh pah Laven and P.Krishna Murthy, Principles of Wireless networks, 2002,PE.
4	P. Nicopolitidis, M.S. Obaidat, G.I. Papadimitriou, A.S.Pomportsis, Wireless Networks, 2003, John Wiley & Sons Pte Ltd.
5	Ashok Raj, Wireless Communication, First Edition, 2014, Khanna Publishers.

EC 352	**ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING**					
(PROGRAM ELECTIVE – V)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Study the concepts of Artificial Intelligence.
2	Learn the methods of solving problems using Artificial Intelligence.
3	Introduce the concepts of Expert Systems and machine learning.
Course Outcomes:	
On completion of this course, the student will be able to do :	
CO-1	To identify problems that are amenable to solutions by AI methods.
CO-2	To identify appropriate AI methods to solve a given problem & implement basic AI algorithms.
CO-3	To formalize a given problem in the language/framework of different AI methods.
CO-4	To study the basics of Machine learning. Usage of Python packages for Machine Learning.
CO-5	To evaluate the performance of various Machine Learning algorithms on a dataset.

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	1	1	2	1	-
CO-2	1	3	2	3	-
CO-3	2	2	2	2	-
CO-4	2	3	3	2	-
CO-5	3	2	2	2	-

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
Introduction: Machine learning, Terminologies in machine learning, Types of machine learning: supervised, unsupervised, semi-supervised learning.

UNIT – II
Discriminative Models: Least Square Regression, Gradient Descent Algorithm, Univariate and Multivariate Linear Regression, Prediction Model, probabilistic interpretation, Regularization, Logistic regression, multi-class classification, Support Vector Machines- Large margin classifiers, Nonlinear SVM, kernel functions, SMO algorithm. Model evaluation and improvement, Regularization, Bias Variance, Hyperparameter Tuning. Computational Learning theory- Sample complexity, exhausted version space, PAC Learning, agnostic learner, VC dimensions, Sample complexity - Mistake bounds.

UNIT – III
Gaussian models: Multivariate Gaussian distributions, Maximum Likelihood Estimate, inferring parameters, Mixture models, EM algorithm for clustering and learning with latent variables.

UNIT – IV
Generative models: Linear Discriminative Analysis, Nave Bayes classifier, Decision trees, Ensemble models – Bagging and Boosting. Unsupervised Learning.

UNIT – V
Algorithms: Dimensionality Reduction Principal Component Analysis (PCA), Singular Value Decomposition (SVD).Clustering – Hierarchical, Partitioned clustering: K-means, PAM, explainable AI (XAI), Approaching an ML problem.

Suggested Reading:

1	Tom Mitchell, “Machine Learning”, McGraw Hill, 1997
2	E. Alpaydin, “Introduction to Machine Learning”, PHI, 2005.
3	Andrew Ng, Machine learning yearning, https://www.deeplearning.ai/machinelearningyearning/
4	Aurolien Geron , “Hands-On Machine Learning with Scikit-Learn and Tensor Flow, Shroff/O’Reilly”,2017
5	Andreas Muller and Sarah Guido, “Introduction to Machine Learning with Python: A Guide for Data Scientists”, Shroff/O’Reilly, 2016.

EC353	**UNMANNED AERIAL VEHICLE SYSTEMS**					
(PROGRAM ELECTIVE – V)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To explain and make the students to understand the basic concepts of UAV/DRONE systems and its applications.
2	To understand the different hardware configurations for UAV.
3	To understand the designing, integration and testing of UAV.
4	To understand the GCS Software & applications.
5	To demonstrate the flight configurations and Practical implementation.

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Able to identify different hardware for UAV.
CO-2	Prepare preliminary design requirements for an unmanned aerial vehicle.
CO-3	Perform system testing for unmanned aerial vehicles.
CO-4	Integrate various systems of unmanned aerial vehicle.
CO-5	Design micro aerial vehicle systems by considering practical limitations.Understanding of GCS Software & Practical implementation.

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	3	3	3	2	1
CO-2	3	3	3	2	2
CO-3	3	3	3	2	2
CO-4	3	3	3	2	1
CO-5	3	3	3	2	2

UNIT – I
Introduction to Unmanned Aerial Vehicle Systems -- evolution of UAV – classification – models and prototypes – System Composition-applications.

UNIT – II
Introduction to Design and Selection of the System- Aerodynamics and Airframe Configurations- Characteristics of Aircraft Types- Regulations of DGCA- Fixed Wing Operations and Aerodynamics - Drone Piloting-Weather and Meteorology- ATC Procedures & Radio Telephony.

UNIT – III
Basic Components of Drone - Different Types of Drones- Assembling of Drone, Artificial Intelligence in Drone -Drone Mapping.

UNIT – IV
Theory of Flight-Three Axes of Fight-Take –Off - Landing – Hover- Turning- Forwards and Sideway-Aerodynamic of Drone.

UNIT –V
Waypoints Navigation-Introduction to Ground Control software (GCS) - System Ground Testing-System In-flight Testing of Mini and Micro UAVs- Case study on the usage of UAV/DRONE.

Suggested Reading:

1	Paul G Fahlstrom, Thomas J Gleason, “Introduction to UAV Systems”, UAV Systems, Inc, 1998.
2	Reg Austin “Unmanned Aircraft Systems UAV design, development and deployment”, Wiley, 2010.
3	Dr. Armand J. Chaput, “Design of Unmanned Air Vehicle Systems”, Lockheed Martin Aeronautics Company, 2001.
4	Kimon P. Valavanis, “Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy”, Springer, 2007.
5	Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, Inc, 1998.

OE 941 BM	**MEDICAL ASSISTIVE DEVICES**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To extend knowledge of the amputee, of lost and remaining functions affecting locomotion, and to collect information on the best possible medical treatment.
2	To improve fitting techniques and practices, including training, so that existing devices might be used with greater comfort and function.
3	To develop improved lower-extremity devices

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Apply fundamental knowledge of engineering in rehabilitation
CO-2	Apply analytical skills to assess and evaluate the need of the end-user
CO-3	Develop self-learning initiatives and integrate learned knowledge for problem solving
CO-4	Understand the basics of robotics and apply their principles in developing prosthetics
CO-5	Apply the knowledge of computers in solving rehabilitation problems

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	-	-	2	1
CO-2	3	-	-	1	2
CO-3	2	-	-	3	2
CO-4	1	-	-	2	1
CO-5	1	-	-	3	2

UNIT – I
Introduction to Rehabilitation Engineering, Measurement and analysis of human movement, Disability associated with aging in the workplace and their solutions, clinical practice of rehabilitation engineering.

UNIT – II
Assistive Technology, Seating Biomechanics and systems. Wheeled Mobility: Categories of Wheelchairs. Wheelchair Structure and Component Design. Ergonomics of Wheel chair propulsion. Power Wheelchair Electrical Systems. Control. Personal Transportation. Auxiliary devices and systems.

UNIT – III
Sensory augmentation and substitution: Visual system: Visual augmentation. Tactual vision substitution, Auditory vision substitution; Auditory system: Auditory augmentation. Cochlear implantation, Visual auditory substitution, Tactual auditory substitution, Tactual system: Tactual augmentation. Tactual substitution. Measurement tools and processes: fundamental principles, structure, function; performance and behavior. Subjective and objective measurement methods.

UNIT – IV
Rehabilitation Robotics, Major Limb Prosthetic Devices, Orthotic Devices, Types of orthotics and prosthetics, Intelligent prosthetic Knee, Prosthetic Hand, Controlled orthotics and prosthetics FES system, Restoration of Hand function, Restoration of standing and walking, Myo-electric Hand.

UNIT – V
Augmentative and Alternative communication technology, Computer applications in Rehabilitation Engineering, telecommunications, and Web Accessibility.

Suggested Reading:

1	Robinson C.J., *Rehabilitation Engineering*, CRC Press, 1995.
2	Ballabio E., et al., *Rehabilitation Technology*, IOS Press, 1993.
3	Rory A Cooper, Hisaichi Ohnabe, Douglas A. Hobson, *Series in medical physis and biomedical engineering: An introduction to rehabilitation engineering*, Taylor and Francis Group, London, 2007.
4	Joseph D. Bronzino *The biomedical engineering handbook -biomedical engineering fundamentals*, 3rdEd., CRC Press, Taylor & Francis Group, London, 2006.

OE 942 BM	**MEDICAL IMAGING TECHNIQUES**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To familiarize the students with various medical imaging modalities.
2	To make learners understand the principles, detectors and operating procedures of X-ray, CT, MRI, ultrasound, PET and SPECT.
3	To make the students learn the advantages, disadvantages and hazards of various medical imaging equipment.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Interpret the working principle and operating procedure and applications of X-ray equipment.
CO-2	Understand the image reconstruction techniques and applications of CT.
CO-3	Summarize the image acquisition and reconstruction techniques in MRI.
CO-4	Comprehend the working principle, modes and medical applications of ultrasound imaging.
CO-5	Examine the operation and applications of PET, SPECT and radio nuclide instrumentation.

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	-	-	2	1
CO-2	3	-	-	1	2
CO-3	2	-	-	3	2
CO-4	1	-	-	2	1
CO-5	1	-	-	3	2

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UNIT – I
X ray Imaging: Electromagnetic spectrum, Production of X-rays, X-ray tubes- Stationary and Rotating Anode types, Block diagram of an X-Ray Machine, Collimators and Grids, Timing and Exposure controls. X-Ray Image visualization-Films, Fluorescent screens, Image Intensifiers. Dental X-Ray machines, Portable and mobile X-Ray units, Mammographic X-Ray equipment, Digital Radiography and flat panel detectors. Radiation safety, ALARA principle, Dose units and dose limits, Radiation dosimeters and detectors.

UNIT – II
Computed Tomography: Basic principles, CT number scale, CT Generations. Major sub systems- Scanning system, processing unit, viewing unit, storage unit. Need and Principle of sectional imaging, 2D image reconstruction techniques - Iteration and Fourier methods. Applications of CT - Angio, Osteo, Dental, Perfusion (Body & Neuro), Virtual Endoscopy, Coronary Angiography.

UNIT – III
Magnetic Resonance Imaging: Principles of NMR imaging systems, Image reconstruction techniques-Relaxation processes, imaging/ pulse sequences. Sub systems of an NMR imaging system, NMR detection system, types of coils, biological effects and advantages of NMR imaging. Functional MRI - The BOLD effect, intra and extra vascular field offsets, source of T2* effects, Creating BOLD contrast sequence optimization sources and dependences of physiological noise in fMRI.

UNIT – IV
Ultrasound Imaging: - Principles of image formation -Imaging principles and instrumentation of A-mode, B-Mode, Gating Mode, Transmission mode and M-mode. Basics of multi-element linear array scanners, Digital scan conversion. Doppler Ultrasound and Colour Doppler imaging, Image artifacts, Biological effects, Ultrasound applications in diagnosis, therapy and surgery.

UNIT – V
Nuclear Medicine–Radioisotopes in medical diagnosis, Basic instrumentation- Radiation detectors, Pulse height analyzer, Rectilinear scanner, Gamma camera. Emission Computed Tomography (ECT), Principle and instrumentation of Single Photon Emission Computed Tomography(SPECT) and Positron Emission Tomography (PET). Comparison of SPECT, PET and combined PET/ X-ray CT.

Suggested Reading:

1	Khandpur R.S., *Handbook of Biomedical Instrumentation*, Tata McGraw Hill, 2016.
2	S Webb, "*The Physics of Medical Imaging*", Adam Highler, Bristol Published by CRC Press, 1988.
3	A C Kak, "*Principle of Computed Tomography*", IEEE Press New York, 1988.
4	Hykes, Heorick, Starchman, *Ultrasound physics and Instrumentation* MOSBY year book, 2nd Ed. 1992.
5	Stewart C. Bushong, *Magnetic Resonance Imaging- physical and biological principles*, MOSBY, 2nd Ed., 1995.

OE 941 CE	**GREEN BUILDING TECHNOLOGY**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Exposure to the green building technologies and their significance.
2	Understand the judicial use of energy and its management.
3	Educate about the Sun-earth relationship and its effect on climate.
4	Enhance awareness of end-use energy requirements in the society.
5	Develop suitable technologies for energy management

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the fundamentals of energy use and energy processes in building.
CO-2	Identify the energy requirement and its management.
CO-3	Know the Sun-earth relationship vis-a-vis its effect on climate.
CO-4	Be acquainted with the end-use energy requirements.
CO-5	Be familiar with the audit procedures of energy

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	-	-	2	1
CO-2	3	-	-	1	2
CO-3	2	-	-	3	2
CO-4	1	-	-	2	1
CO-5	1	-	-	3	2

c

UNIT – I
Overview of the significance of energy use and energy processes in building - Indoor activities and environmental control - Internal and external factors on energy use and the attributes of the factors - Characteristics of energy use and its management - Macro aspect of energy use in dwellings and its implications.

UNIT – II
Indoor environmental requirement and management - Thermal comfort - Ventilation and air quality – Air-conditioning requirement - Visual perception - Illumination requirement - Auditory requirement.

UNIT – III
Climate, solar radiation and their influences - Sun-earth relationship and the energy balance on the earth's surface - Climate, wind, solar radiation, and temperature - Sun shading and solar radiation on surfaces - Energy impact on the shape and orientation of buildings.

UNIT – IV
End-use, energy utilization and requirements - Lighting and day lighting - End-use energy requirements - Status of energy use in buildings Estimation of energy use in a building. Heat gain and thermal performance of building envelope - Steady and non-steady heat transfer through the glazed window and the wall - Standards for thermal performance of building envelope - Evaluation of the overall thermal transfer.

UNIT – V
Nuclear Medicine–Radioisotopes in medical diagnosis, Basic instrumentation- Radiation Energy management options - Energy audit and energy targeting - Technological options for energy management.

Suggested Reading:

1	Bryant Edwards (2005): Natural Hazards, Cambridge University Press, U.K.
2	Carter, W. Nick, (1991): Disaster Management, Asian Development Bank, Manila.
3	Sahni, Pardeep et.al. (eds.) (2002), Disaster Mitigation Experiences and Reflections, Prentice Hall of India, New Delhi.
4	Bryant Edwards (2005): Natural Hazards, Cambridge University Press, U.K.

OE 942 CE	**COST MANAGEMENT OF ENGINEERING PROJECTS**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Introduce the concepts of cost management
2	Fundamentals of cost overruns
3	Introduce the concepts of Quantitative techniques for cost management Linear Programming, PERT/CPM.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understanding of strategic cost management process, control of cost and decision making based on the cost of the project.
CO-2	Ability to appreciative detailed engineering activities of the project and execution of projects
CO-3	Preparation of project report and network diagram
CO-4	Able to plan Cost Behavior , Profit Planning , Enterprise Resource Planning, Total Quality Management.
CO-5	Applications of various quantitative techniques for cost management

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	-	-	2	1
CO-2	3	-	-	1	2
CO-3	2	-	-	3	2
CO-4	1	-	-	2	1
CO-5	1	-	-	3	2

UNIT – I
Introduction and Overview of the Strategic Cost Management Process-Cost concepts in decision-making; relevant cost, Differential cost, Incremental cost and OpportUNITy cost. Objectives of a Costing System- Inventory valuation- Creation of a Database for operational control; Provision of data for Decision-Making.

UNIT – II
Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning- Project execution as conglomeration of technical and non-technical activities- Detailed Engineering activities.

UNIT – III
Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process.

UNIT – IV
Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems- Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector- Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints- Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets- Performance budgets- Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

UNIT – V
Quantitative techniques for cost management, Linear Programming, PERT/CPM,- Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

Suggested Reading:

1	Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2	Charles T. Horngren and George Foster, Advanced Management Accounting
3	Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4	Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5	N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

OE 941 CS	**BUSINESS ANALYTICS**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Understanding the basic concepts of business analytics and applications
2	Study various business analytics methods including predictive, prescriptive and prescriptive analytics
3	Prepare the students to model business data using various data mining, decision making methods

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	To understand the basic concepts of business analytics
CO-2	Identify the application of business analytics and use tools to analyze business data
CO-3	Become familiar with various metrics, measures used in business analytics
CO-4	Illustrate various descriptive, predictive and prescriptive methods and techniques
CO-5	Model the business data using various business analytical methods and techniques

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	-	-	2	1
CO-2	3	-	-	1	2
CO-3	2	-	-	3	2
CO-4	1	-	-	2	1
CO-5	1	-	-	3	2

UNIT – I
Introduction to Business Analytics: Introduction to Business Analytics, need and science of data driven (DD) decision making, Descriptive, predictive, prescriptive analytics and techniques, Big data analytics, Web and Social media analytics, Machine Learning algorithms, framework for decision making, challenges in DD decision making and future.

UNIT – II
Descriptive Analytics: Introduction, data types and scales, types of measurement scales, population and samples, measures of central tendency, percentile, decile and quadrille, measures of variation, measures of shape-skewness, data visualization.

UNIT – III
Forecasting Techniques: Introduction, time-series data and components, forecasting accuracy, moving average method, single exponential smoothing, Holt's method, Holt-Winter model, Croston's forecasting method, regression model for forecasting, Auto regression models, auto-regressive moving process, ARIMA, Theil's coefficient

UNIT – IV
Decision Trees: CHAID, Classification and Regression tree, splitting criteria, Ensemble and method and random forest. **Clustering**: Distance and similarity measures used in clustering, Clustering algorithms, K-Means and Hierarchical algorithms, **Prescriptive Analytics**- Linear Programming(LP) and LP model building.

UNIT – V
Six Sigma: Introduction, introduction, origin, 3-Sigma Vs Six-Sigma process, cost of poor quality, sigma score, industry applications, six sigma measures, DPMO, yield, sigma score, DMAIC methodology, Six Sigma toolbox.

Suggested Reading:

1	U Dinesh Kumar, "Data Analytics", Wiley Publications, 1st Edition, 2017
2	Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, "Business analytics Principles, Concepts, and Applications with SAS", Associate Publishers, 2015
3	S. Christian Albright, Wayne L. Winston, "Business Analytics - Data Analysis and Decision Making", 5th Edition, Cengage, 2015

Web Resources:

1	https://onlinecourses.nptel.ac.in/noc18-mg11/preview
2	https://nptel.ac.in/courses/110105089/

OE 941 EC	**ELEMENTS OF EMBEDDED SYSTEMS**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Understanding various Embedded Design strategies
2	Designing Micro controller based Embedded Systems
3	Designing FPGA Based Embedded Systems

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand Embedded Design Strategies and architecture of Arduino Board
CO-2	Program using various onboard components of Arduino
CO-3	Design real time interfacing with Arduino
CO-4	Understand Design Flow of FPGA, programming FPGA using Verilog HDL
CO-5	Implement combinational and sequential circuits using verilog HDL

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	-	-	2	1
CO-2	3	-	-	1	2
CO-3	2	-	-	3	2
CO-4	1	-	-	2	1
CO-5	1	-	-	3	2

UNIT – I
Embedded Systems Design Strategies: Micro Controller, DSP, FPGA, Introduction to Arduino (Micro controller Board), Components of Arduino, Architecture and Pin Configuration of ATMega328, Ports of ATMega328.

UNIT – II
Interfacing: Interfacing Switches, LEDs, Analog to Digital Converter, Digital to Analog Converter, Interfacing and Programming I2C, SPI

UNIT – III
Real Time Programming: Interfacing Key Pad, 7-segment display, LCD, Interfacing Sensors, Interfacing Stepper Motor**,** USB programming

UNIT – IV
FPGA Based Embedded Design: FPGA Design flow, Introduction to Verilog HDL**,** Basic building blocks, Data types of Verolog HDL, Behavioral Modelling, Data Flow Modelling, Structural Modelling, Hierarchal Structural Modelling, Case Studies on Verilog HDL descriptions of Basic Circuits

UNIT – V
Modelling of Circuits: Verilog HDL Implementation of Combinational MSI Circuits, Verilog HDL Implementation of Sequential MSI Circuits, Finite Sate Machine Design, Tasks and Functions, Introduction to Test Benches

Suggested Reading:

1	Ming-Bo Lin, Digital System Designs and Practices Using Verilog HDL and FPGAs, Wiley India, 2008
2	Samir Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Pearson Education, 2005
3	Simon Monk, Programming Arduino: Getting Started with sketches, Mc.Hill, 2016

Web Resources:

1	www.arduino.cc
2	www.learn.sparkfun.com/tutorials/arduino

OE 941 EE	**WASTE TO ENERGY**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To know the various forms of waste
2	To understand the processes of Biomass Pyrolysis.
3	To learn the technique of Biomass Combustion.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the concept of conservation of waste
CO-2	Identify the different forms of wastage.
CO-3	Chose the best way for conservation to produce energy from waste.
CO-4	Explore the ways and means of combustion of biomass.
CO-5	Develop a healthy environment for the mankind.

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	-	-	2	1
CO-2	3	-	-	1	2
CO-3	2	-	-	3	2
CO-4	1	-	-	2	1
CO-5	1	-	-	3	2

UNIT – I
Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNIT – II
Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT – III
Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT – IV
Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNIT – V
Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Suggested Reading:

1	Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2	Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3	Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4	Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

OE 942 EE	**POWER PLANT CONTROL AND INSTRUMENTATION**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	The operation of different types of power plants.
2	The basic working principle of instruments for measurement of electrical and non-electrical quantities like Temperature Pressure flow level measurements.
3	The instrumentation and protection systems applied in thermal power plant.
4	The control techniques employed for the operation of modern power generation Plant

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Explain the different methods of power generation. Along with Piping and Instrumentation diagram of boiler.
CO-2	Select various measurements involved in power generation for measuring electrical and non-electrical parameters.
CO-3	Identify the different types of analyzers used for scrutinizing boiler steam and water.
CO-4	Model different types of controls and control loops in boilers.
CO-5	Illustrate the methods of monitoring and control of different parameters like speed, vibration of turbines

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	-	-	2	1
CO-2	3	-	-	1	2
CO-3	2	-	-	3	2
CO-4	1	-	-	2	1
CO-5	1	-	-	3	2

UNIT – I
Brief survey of methods of power generation, hydro, thermal, nuclear, solar and wind power, importance of instrumentation in power generation, thermal power plants, block diagram, details of boiler processes, Piping and Instrumentation diagram of boiler, cogeneration.

UNIT – II
Electrical measurements, current, voltage, power, frequency, power factor etc, non-electrical parameters, flow of feed water, fuel, air and steam with correction factor for temperature, steam pressure and steam temperature, drum level measurement, radiation detector, smoke density measurement, dust monitor.

UNIT – III
Flue gas oxygen analyzer: Analysis of impurities in feed water and steam, dissolved oxygen analyzer. Chromatography, pH meter, fuel analyzer, pollution monitoring instruments.

UNIT – IV
Combustion control, air / fuel ratio control, furnace draft control, drum level control, main steam and reheat steam temperature control, super heater control, air temperature, distributed control system in power plants, interlocks in boiler operation.

UNIT – V
Speed, vibration, shell temperature monitoring and control, steam pressure control, lubricant oil temperature control, cooling system.

Suggested Reading:

1	Sam G. Dukelow, The Control of Boilers, Instrument Society of America, 2nd Edition, 2010.
2	P.K. Nag, „Power Plant Engineering“, Tata McGraw-Hill, 1st Edition, 2001.
3	S.M. Elonka and A.L. Kohal, “Standard Boiler Operations”, Tata McGraw-Hill, 1st Edition, 1994.
4	R K Jain, “Mechanical and Industrial Measurements”, Khanna Publishers, 1st Edition, 1995.
5	E Al Wakil, “Power Plant Engineering”, Tata McGraw-Hill, 1st Edition, 1984.

OE 941 ME	**OPERATION RESEARCH**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Introduce the concepts of optimization techniques
2	Formulation of LPP models
3	Basic concepts of Non-linear programming, Dynamic programming, Game theory are introduced.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
CO-2	Students should able to apply the concept of non-linear programming
CO-3	Students should able to carry out sensitivity analysis
CO-4	Student should able to model the real world problem and simulate it.
CO-5	Student should able to apply graph theory, competitive models, and game theory simulations.

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	-	-	2	1
CO-2	3	-	-	1	2
CO-3	2	-	-	3	2
CO-4	1	-	-	2	1
CO-5	1	-	-	3	2

UNIT – I
Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models.

UNIT – II
Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming.

UNIT – III
Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT.

UNIT – IV
Scheduling and sequencing - single server and multiple server models deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

UNIT – V
Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

Suggested Reading:

1	H.A. Taha, Operations Research, An Introduction, PHI, 2008
2	H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3	J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008.
4	Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5	Pannerselvam, Operations Research: Prentice Hall of India 2010.
6	Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010.

OE 942 ME	**COMPOSITE MATERIALS**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*Study the concepts of composite construction.*
2	*Learn analysis and designs of composite beams, floors, columns and trusses as per the recommendations of IS codes of practice.*
3	*Apply the concepts for design of multi-storey composite buildings.*
4	*Scope of analysis is restricted to skeletal structures subjected to prescribed dynamic loads.*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Understand the fundamentals of composite construction, and analysis and designs of composite beams.*
CO-2	*Analyse and design the composite floors*
CO-3	*Select suitable materials for composite columns,*
CO-4	*Analyse composite trusses and understand connection details.*
CO-5	*Analyse and design the multi-storey composite buildings*

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	-	-	2	1
CO-2	3	-	-	1	2
CO-3	2	-	-	3	2
CO-4	1	-	-	2	1
CO-5	1	-	-	3	2

UNIT – I
Introduction of composite constructions: Benefits of composite construction - Introduction to IS - BS and Euro codal provisions. Composite beams: Elastic behaviour of composite beams - No and full interaction cases - Shear connectors - Ultimate load behaviour - Serviceability limits - Effective breadth of flange - Interaction between shear and moment - Basic design consideration and design of composite beams.

UNIT – II
Composite floors: Structural elements - Profiled sheet decking - Bending resistance - Shear resistance - Serviceability criterion - Analysis for internal forces and moments - Design of composite floors.

UNIT – III
Composite columns: Materials - Concrete filled circular tubular sections - Non-dimensional slenderness - Local buckling of steel sections - Effective elastic flexural stiffness - Resistance of members to axial compressions - Composite column design - Fire resistance.

UNIT – IV
Composite trusses: Design of truss - Configuration - Truss members - Analysis and design of composite trusses and connection details.

UNIT – V
Design of multi-storey composite buildings: Design basis - Load calculations - Design of composite slabs with profile decks - Composite beam design - Design for compression members - Vertical cross bracings - Design of foundation.

Suggested Reading:

1	R.P. Johnson, “Composite Structures of Steel and Concrete - Beams, Slabs, Columns and Frames in Buildings”, Blackwell Publishing, Malden, USA, 2004.
2	“INSDAG Teaching Resources for Structural Steel Design”, Vol-2, Institute for Steel Development and Growth Publishers, Calcutta, India.
3	“INSDAG Handbook on Composite Construction – Multi-Storey Buildings”, Institute for Steel Development and Growth Publishers, Calcutta, India.
4	“INSDAG Design of Composite Truss for Building”, Institute for Steel Development and Growth Publishers, Calcutta, India.
5	“INSDAG Handbook on Composite Construction – Bridges and Flyovers”, Institute for Steel Development and Growth Publishers, Calcutta, India.
6	IS: 11384-1985, “Code of Practice for Composite Construction in Structural Steel and Concrete”, Bureau of Indian Standards, New Delhi, 1985.

OE 943 ME	**INDUSTRIAL SAFETY**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Causes for industrial accidents and preventive steps to be taken.
2	Fundamental concepts of Maintenance Engineering.
3	About wear and corrosion along with preventive steps to be taken
4	The basic concepts and importance of fault tracing.
5	The steps involved in carrying out periodic and preventive maintenance of various equipments used in industry

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Identify the causes for industrial accidents and suggest preventive measures.
CO-2	Identify the basic tools and requirements of different maintenance procedures.
CO-3	Apply different techniques to reduce and prevent Wear and corrosion in Industry.
CO-4	Identify different types of faults present in various equipments like machine tools, IC Engines, boilers etc.
CO-5	Apply periodic and preventive maintenance techniques as required for industrial equipments like motors, pumps and air compressors and machine tools etc

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	-	-	2	1
CO-2	3	-	-	1	2
CO-3	2	-	-	3	2
CO-4	1	-	-	2	1
CO-5	1	-	-	3	2

UNIT – I
Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes, Fire prevention and firefighting, equipment and methods.

UNIT – II
Fundamentals of Maintenance Engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT – III
Wear and Corrosion and their Prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications of Screw down grease cup, Pressure grease gun, Splash lubrication, Gravity lubrication, Wick feed lubrication, Side feed lubrication, Ring lubrication, Definition of corrosion, principle and factors affecting the corrosion, Types of corrosion, corrosion prevention methods.

UNIT – IV
Fault Tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, any one machine tool, Pump, Air compressor, Internal combustion engine, Boiler, Electrical motors, Types of faults in machine tools and their general causes.

UNIT – V
Periodic and Preventive Maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of Machine tools, Pumps, Air compressors, Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance.

Suggested Reading:

1	H. P. Garg, "Maintenance Engineering", S. Chand and Company
2	Audels, "Pump-hydraulic Compressors", Mcgraw Hill Publication
3	Higgins & Morrow, "Maintenance Engineering Handbook", Da Information Services.
4	Winterkorn, Hans, "Foundation Engineering Handbook", Chapman & Hall London

OE 941 LA	**INTELLECTUAL PROPERTY RIGHTS**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Acquaint the students with basics of intellectual property rights with special reference to Indian Laws and its practices.
2	Compare and contrast the different forms of intellectual property protection in terms of their key differences and similarities.
3	Provide an overview of the statutory, procedural, and case law underlining these processes and their interplay with litigation.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the concept of intellectual property rights.
CO-2	Develop proficiency in trademarks and acquisition of trade mark rights.
CO-3	Understand the skill of acquiring the copy rights, ownership rights and transfer.
CO-4	Able to protect trade secrets, liability for misappropriations of trade secrets.
CO-5	Apply the patents and demonstration of case studies.

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	-	-	2	1
CO-2	3	-	-	1	2
CO-3	2	-	-	3	2
CO-4	1	-	-	2	1
CO-5	1	-	-	3	2

UNIT – I
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT – II
Trade Marks: Purpose and function of trademarks, acquisition of trade mark rights, protectable matter, selecting, and evaluating trade mark, trade mark registration processes.

UNIT – III
Law of copy rights: Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration, notice of copy right, international copy right law. Law of patents: Foundation of patent law, patent searching process, ownership rights and transfer**.**

UNIT – IV
Trade Secrets: Trade secrete law, determination of trade secrete status, liability for misappropriations of trade secrets, protection for submission, trade secrete litigation. Unfair competition: Misappropriation right of publicity, false advertising.

UNIT – V
New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Suggested Reading:

1	Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd, 2007.
2	“Mayall, “Industrial Design”, McGraw Hill,1992
3	“Niebel, “Product Design”, McGraw Hill,1974.
4	“Asimov, “Introduction to Design”, Prentice Hall,1962.
5	“Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”,2016.
6	T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand,2008

EC372	**MINI PROJECT**					
Pre-requisites	-		**L**	**T**	**P**	**C**
			-	-	4	2
Evaluation	**SEE**	-	**CIE**	50 Marks		

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To review available literature and formulate structural engineering problems*
2	*To learn the technique of writing reports and prepare presentation*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Identify structural engineering problems reviewing available literature*
CO-2	*Study different techniques used to analyse complex structural systems.*
CO-3	*Able to work on the solutions given problem*
CO-4	*Present solution by using his/her technique applying engineering principles.*
CO-5	*Prepare technical report and presentation*

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	3	-	3	1	-
CO-2	-	1	3	1	-
CO-3	2	2	2	3	-
CO-4	-	2	2	2	-
CO-5	1	2	3	1	-

Syllabus Contents:

Mini Project will have mid semester presentation and end semester presentation. Mid semester Presentation will include identification of the problem based on the literature review on the topic referring to latest literature available.

End semester presentation should be done along with the report on identification of topic for the work and the methodology adopted involving scientific research, collection and analysis of data, determining solutions highlighting individuals' contribution. Continuous assessment of Mini Project at Mid Sem and End Sem will be monitored by the departmental committee

EC 362	**MICROWAVE SYSTEM SIMULATION LAB**					
	(LABORATORY –II)					
Pre-requisites			L	T	P	C
			-	-	2	1
Evaluation	SEE	--	**CIE**		50 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Get acquainted with RF test and measurement equipment
2	Get acquainted with EM Simulation Software
3	Become familiar with the Design and simulation of passive RF subsystems

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Acquire the Knowledge on RF Test and measurement instruments
CO-2	Acquire the knowledge to use RF CAD software
CO-3	Design RF subsystems
CO-4	Test the performance of RF components and systems
CO-5	Analyze and validate RF components and systems

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	-	-	3	1	-
CO-2	-	1	3	1	-
CO-3	2	2	3	2	-
CO-4	-	2	2	2	-
CO-5	1	2	3	1	1

Correlation rating: Low / Medium / High: 1 / 2 / 3 respectively.

LIST OF EXPERIMENTS:

1. Calibration with Vector Network Analyzer
2. Study of non-ideal behavior of lumped circuit components using Network Analyzer
3. Characterization of Microstrip Filters, Couplers and Resonators using Spectrum Analyzer and Network Analyzer.

4. Software simulation and design of passive Microwave Components and printed antennas using Ansys HFSS Agilent Advanced Design System (ADS).
5. Software simulation of Power divider and attenuator and amplifiers.

SUGGESTED READING:

1	Samuel Y. Liao, "Microwave Device and Circuits",PH1,3rd Edition.1994.
2	Pozar D.M., "microwave Engineering", John Wiley & Sons 3rd Edition,2005.

EC363	**GNSS LABORATORY**					
(LABORATORY –III)						
Pre-requisites			L	T	P	C
			-	-	2	1
Evaluation	**SEE**	--	**CIE**		50 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To get acquaint with Single, Dual and Triple, Frequency GNSS receiver equipment.
2	To analyse the usage of various GUIs and GNSS parameters
3	To become familiar with the constraints of various receivers
4	To become familiar with the various parameters of IGS Receiver.
5	To analyze the usage of various GUIs and IRNSS parameters

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Able to acquire the Knowledge on various GNSS receiver equipment
CO-2	Able to acquire the knowledge on various parameters.
CO-3	Able to compare all the receivers in terms of their GUI parameters
CO-4	Able to acquire the Knowledge on various IGS receiver equipment
CO-5	Able to compare all the receivers in terms of their GUI parameters of IGS Receiver

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	2	3	2	2
CO-2	2	2	3	2	2
CO-3	2	2	3	2	2
CO-4	2	2	3	2	2
CO-5	2	2	3	2	2

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

I
Study of basic Hardware and Software aspects of Dual Frequency ISRO IGS (IRNSS/GPS/SBAS) Receiver.

II
Tracking and comparative analysis of Standalone IRNSS and GPS satellites using IGS receiver in terms of Satellite visibility.

III
Estimation of True Range from Satellite to receiver for all the visible IRNSS satellites.

IV
Study of basic Hardware and Software aspects and selected GNSS parameters estimation using Triple frequency GPStation6 receiver.

V
Study of basic Hardware/Software aspects of NAVLAN IG3 Single frequency and selected GNSS parameters estimation using IRNSS/GPS/GLONASS Receiver.

Suggested Reading:

1	Elliot D. Kaplan, “Understanding GPS Principles and Applications”, ArtechHouse Boston, 1996.
2	Bradford W. Parkinson and James J. Spilker, “Global Positioning System: Theory and Applications,” Volume II, American Institute of Aeronautics and Astronautics, Inc., Washington, 1996.
3	B.HofmannWollenhof, H.Lichtenegger, and J.Collins, GPS Theory and Practice”, Springer Wien, Newyork, 2000.

SEMESTER –III

AC030EC	RESEARCH METHODOLOGY					
AUDIT COURSE-I						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

1.Learn to focus on research related activities.
2. Learn methods to devise and develop the various research designs
3. Learn basic principles of data collection and analysis techniques
4.Learn the style and format of writing a report for technical papers

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

1. Motivate the orientation towards research related activities
2. Formulate the research problem, analyze research related information
3. Identify various sources for literature review and design an experimentation set-up
4. Apply the basic principles of data collection and analysis techniques
5. Improve the style and format of writing a report for technical / Journal articles

Program Articulation Matrix

Course outcome	Program outcome					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1						
CO2						
CO3						
CO4						
CO5						

UNIT – I

Research Methodology: Objectives and Motivation of Research, Types of Research, Research Approaches, Significance of Research, Research Methods verses Methodology, Research and Scientific Method, Important of Research Methodology, Research Process, Criteria of Good Research, Problems Encountered by Researchers in India, Benefits to the society in general.

Defining the Research Problem: Definition of Research Problem, Problem Formulation, Necessity of Defining the Problem, Technique involved in Defining a Problem.

UNIT – II

Literature Survey: Importance of Literature Survey, Sources of Information, Assessment of Quality of Journals and Articles, Information through Internet. Literature Review: Need of Review, Guidelines for Review, Record of Research Review.

UNIT – III

Research Design: Meaning of Research Design, Need of Research Design, Feature of a Good Design Important Concepts Related to Research Design, Different Research Designs, Basic Principles of Experimental Design, Developing a Research Plan, Design of Experimental Set-up, Use of Standards and Codes.

UNIT – IV

Data Collection: Collection of primary data, Secondary data, Data organization, Methods of data grouping, Diagrammatic representation of data, Graphic representation of data. Sample Design, Need for sampling, some important sampling definitions, Estimation of population, Role of Statistics for Data Analysis, Parametric V/s Non Parametric methods, Descriptive Statistics, Measures of central tendency and Dispersion, Hypothesis testing, Use of Statistical software.

Data Analysis: Deterministic and random data, Uncertainty analysis, Tests for significance: Chi-square, student's t-test, Regression modeling, Direct and Interaction effects, ANOVA, F- test, Time Series analysis, Autocorrelation and Autoregressive modeling.

UNIT – V
Research Report Writing: Format of the Research report, Synopsis, Dissertation, Thesis its Differentiation, References/Bibliography/Webliography, Technical paper writing/Journal report writing, making presentation, Use of visual aids. Research Proposal Preparation: Writing a Research Proposal and Research Report, Writing Research Grant Proposal.

Suggested Reading:

1	C.R Kothari, Research Methodology, Methods & Technique; Revised Edition, New Age International Publishers, 2004.
2	R. Ganesan, Research Methodology for Engineers, 1st Edition, MJP Publishers, 2011.
3	RatanKhananabis and SuvasisSaha, Research Methodology, 1st Edition, Universities Press, Hyderabad, 2015.
4	Y.P. Agarwal, Statistical Methods: Concepts, Application and Computation, 1st Edition, Sterling Publs., Pvt., Ltd., New Delhi, 2004
5	Vijay Upagade and AravindShende, Research Methodology, 1st Edition, S. Chand & Company Ltd., New Delhi, 2009
6	G. Nageswara Rao, Research Methodology and Quantitative methods, 2nd Edition, BS Publications, Hyderabad, 2012.

AC031	**ENGLISH FOR RESEARCH PAPER WRITING**					
AUDIT COURSE-II						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

1. Features of Academic writing; different kinds of Academic writing
2. Some academic writing skills; the research process; the structure of a research document

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

1. Academic writing features; Academic writing kinds; Important academic writing skills
2. The process of research; general research document structure

Program Articulation Matrix

Course outcome	**Program outcome**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1						
CO2						
CO3						
CO4						
CO5						

UNIT – I
Features of Academic Writing Language: Clear, Correct, Concise, Inclusive; **Tone**: Formal, Objective, Cautious;**Style**: Appropriate, Accurate, Organized; **Ethics**: Honesty, Integrity, Responsibility, Accountability

UNIT – II
Kinds of Academic Writing Essays, Reports, Reviews, Abstracts, Proposals

UNIT – III
Academic Writing Skills Paraphrasing; Summarizing; Quoting; Rewriting; Expansion

UNIT – IV
Research Process Selection of Topic, Formulation of Hypothesis, Collection of Data, Analysis of Data, Interpretation of Data, Presentation of Data
UNIT – V
Structure of a Research Document Title, Abstract, Introduction, Literature Survey, Methodology, Discussion, Findings/Results, Conclusion, Documenting Sources (IEEE style)

Suggested Reading:

1	Bailey, S. (2014). Academic writing: A handbook for international students. Routledge.
2	Gillett, A., Hammond, A., &Martala, M. (2009). Inside track: Successful academic writing. Essex: Pearson Education Limited.
3	Griffin, G. (2006). Research methods for English studies. Edinburgh: Edinburgh University Press.
4	Silyn-Roberts, Heather. (2013). Writing for Science and Engineering: Papers, Presentations and Reports(2nd ed.). Elsevier.
5.	Lipson, Charles (2011). Cite right: A quick guide to citation styles; MLA,APA, Chicago, the sciences, professions, and more (2nd ed.). Chicago[u.a.]: University of Chicago Press.

AC032	**DISASTER MITIGATION AND MANAGEMENT**					
	AUDIT COURSE-II					
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

1. *To impart knowledge in students about the nature, causes, consequences and mitigation measures of the various natural disasters*
2. *To enable the students to understand risks, vulnerabilities and human errors associated with human induced disasters*
3. *To enable the students to understand and assimilate the impacts of any disaster on the affected area depending on its position/ location, environmental conditions, demographic, etc.*

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

1. *Learn to demonstrate a critical understanding of key concepts in disaster risk reduction*
2. *Humanitarian response*
3. *Critically evaluate disaster risk reduction and humanitarian response policy and Practice from multiple perspectives.*
4. *Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.*
5. *Critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in.*

Program Articulation Matrix

Course outcome	Program outcome					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1						
CO2						
CO3						
CO4						
CO5						

Row wise cumulative percentage weightage should be equal to 1.0.

UNIT – I
*Introduction:*Disaster: Definition, Factors and Significance; Difference between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT – II
Repercussions of Disasters and Hazards: Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. *Natural Disasters:*Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides and Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks and Spills, Outbreaks of Disease and Epidemics, War and Conflicts.

UNIT – III
*Disasters Prone Areas in India:*Study of Seismic Zones; Areas Prone to Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with Special Reference to Tsunami; Post-Disaster Diseases and Epidemics

UNIT – IV
*Disaster Preparedness:*Monitoring of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological and Other Agencies, Media Reports: Governmental and CommUNITy Preparedness.

UNIT – V
*Disaster Risk:*Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival. Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India.

References:

1	R. Nishith, Singh AK, *"Disaster Management in India: Perspectives, issues and strategies"*, New Royal Book Company.
2	Sahni, Pardeep (Eds.), *"Disaster Mitigation Experiences and Reflections"*, PHI, New Delhi.
3	Goel S. L., *"Disaster Administration and Management Text and Case Studies",* Deep & Deep Publication Pvt. Ltd., New Delhi.

AC033	**SANSKRIT FOR TECHNICAL KNOWLEDGE**					
AUDIT COURSE-II						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. To make the novice Learn the Sanskrit to develop the logic in mathematics, science & other subjects
3. To explore the huge knowledge from ancient Indian literature

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

1. Develop passion towards Sanskrit language
2. Decipher the latent engineering principles from Sanskrit literature
3. Correlates the technological concepts with the ancient Sanskrit history.
4. Develop knowledge for the technological progress
5. Explore the avenue for research in engineering with aid of Sanskrit

Program Articulation Matrix

Course outcome	**Program outcome**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1						
CO2						
CO3						
CO4						
CO5						

Row wise cumulative percentage weightage should be equal to 1.0.

UNIT – I
*Introduction to Sanskrit Language:*Sanskrit Alphabets-vowels-consonants- significance of Amarakosa-parts of Speech-Morphology-creation of new words-significance of synonyms-sandhi-samasa-sutras-active and passive Voice-Past/Present/Future Tense-Syntax-Simple Sentences (elementary treatment only)

UNIT – II
*Role of Sanskrit in Basic Sciences:*Brahmagupthas lemmas (second degree indeterminate equations), sum of squares of n-terms of AP- sulba, sutram or baudhayana theorem (origination of Pythagoras theorem)-value of pie-Madhava's sine and cosine theory (origination of Taylor's series). The measurement system-time-mass-length-temp, Matter elasticity-optics-speed of light (origination of Michaelson and Morley theory).

UNIT – III
Role of Sanskrit in Engineering-I (Civil, Mechanical, Electrical and Electronics Engineering): Building construction-soil testing-mortar-town planning-Machine definition-crucible-furnace-air blower- Generation of electricity in a cell-magnetism-Solar system-Sun: The source of energy, the earth-Pingala chandasutram (origination of digital logic system)

UNIT – IV
*Role of Sanskrit in Engineering-II (Computer Science Engineering & Information Technology):*Computer languages and the Sanskrit languages-computer command words and the vedic command words-analogy of pramana in memamsa with operators in computer language-sanskrit analogy of physical sequence and logical sequence, programming.

UNIT – V
*Role of Sanskrit in Engineering-III (Bio-technology and Chemical Engineering):*Classification of plants- plants, the living-plants have senses-classification of living creatures, Chemical laboratory location and layout- equipment-distillation vessel-kosthi yanthram

References:

1	M Krishnamachariar, "*History of Classical Sanskrit Literature",* TTD Press, 1937.
2	M.R. Kale, "*A Higher Sanskrit Grammar: For the Use of School and College Students*", Motilal Banarsidass Publishers, 2015.
3	Kapail Kapoor, "*Language, Linguistics and Literature: The Indian Perspective",* ISBN-10: 8171880649, 1994.
4	"*Pride of India*", Samskrita Bharati Publisher, ISBN: 81-87276 27-4, 2007.
5	Shri Rama Verma, "*Vedas the source of ultimate science",* Nag publishers, 2005.

AC034	**VALUE EDUCATION**					
AUDIT COURSE-II						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

1. *Understand the need and importance of Values for self-development and for National development.*
2. *Imbibe good human values and Morals*
3. *Cultivate individual and National character.*

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

1. *Gain necessary Knowledge for self-development*
2. *Learn the importance of Human values and their application in day to day professional life.*
3. *Appreciate the need and importance of interpersonal skills for successful career and social life*
4. *Emphasize the role of personal and social responsibility of an individual for all-round growth.*
5. *Develop a perspective based on spiritual outlook and respect women, other religious practices, equality, non-violence and universal brotherhood.*

Program Articulation Matrix

Course outcome	**Program outcome**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1						
CO2						
CO3						
CO4						
CO5						

Row wise cumulative percentage weightage should be equal to 1.0.

UNIT – I
*Human Values, Ethics and Morals:*Concept of Values, Indian concept of humanism, human values; Values for self-development, Social values, individual attitudes; Work ethics, moral and non- moral behaviour, standards and principles based on religion, culture and tradition.

UNIT – II
*Value Cultivation, and Self-management:*Need and Importance of cultivation of values such as Sense-of Duty, Devotion to work, Self-reliance, Confidence, Concentration, Integrity & discipline, and Truthfulness.

UNIT – III
*Spiritual outlook and social values:*Personality and Behavior, Scientific attitude and Spiritual (soul) outlook; Cultivation of Social Values Such as Positive Thinking, Punctuality, Love & Kindness, avoiding fault finding in others, Reduction of anger, forgiveness, Dignity of labour, True friendship, Universal brotherhood and religious tolerance.

UNIT – IV
*Values in Holy Books:*Self-management and Good health; internal & external cleanliness, Holy books versus Blind faith, Character and Competence, Equality, Nonviolence, Humility, Role of Women.

UNIT – V
*Dharma, Karma and Guna:*Concept of soul; Science of Reincarnation, Character and Conduct, Concept of Dharma; Cause and Effect based Karma Theory; The qualities of Devine and Devilish; Satwic, Rajasic and Tamasic gunas.

References:

1	Chakroborty, S.K., *"Values & Ethics for organizations Theory and practice*", Oxford University Press, New Delhi, 1998.
2	2. Jaya Dayal Goyandaka, "*Srimad Bhagavad Gita with Sanskrit Text*", Word Meaning and Prose Meaning‖, Gita Press, Gorakhpur, 2017.

AC035	**STRESS MANAGEMENT BY YOGA**					
	AUDIT COURSE-II					
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

1. *Creating awareness about different types of stress and the role of yoga in the management of stress.*
2. *Promotion of positive health and overall wellbeing (Physical, mental, emotional, social and spiritual).*
3. *Prevention of stress related health problems by yoga practice.*

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

1. *Understand yoga and its benefits.*
2. *Enhance Physical strength and flexibility.*
3. *Learn to relax and focus.*
4. *Relieve physical and mental tension through asanas.*
5. *Improve work performance and efficiency.*

Program Articulation Matrix

Course outcome	**Program outcome**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1						
CO2						
CO3						
CO4						
CO5						

Row wise cumulative percentage weightage should be equal to 1.0.

UNIT – I
Meaning and Definition of Yoga **-** Historical perspective of Yoga - Principles of Astanga Yoga by Patanjali.

UNIT – II
Meaning and Definition of Stress- Types of stress - Eustress and Distress. Anticipatory Anxiety and Intense Anxiety and depression. Meaning of Management- Stress Management.

UNIT – III
Concept of Stress According to Yoga- Stress assessment methods - Role of Asana, Pranayama and Meditation in the management of stress

UNIT – IV
Asanas- (5 Asanas in each posture) - Warm up - Standing Asanas - Sitting Asanas - Prone Asanas - Supine asanas - Surya Namaskar.

UNIT – V
Pranayama- Anulom and Vilom Pranayama - Nadishudhi Pranayama - Kapalabhati Pranayama - Bhramari Pranayama - Nadanusandhana Pranayama. *Meditation Techniques:*Om Meditation - Cyclic meditation: Instant Relaxation technique (QRT), Quick Relaxation Technique (QRT), Deep Relaxation Technique (DRT)

References:

1	Janardhan Swami Yogabhyasi Mandal, "*Yogic Asanas for Group Training - Part-I*", , Nagpur.
2	Advaita Ashrama, "*Swami Vivekananda, "Rajayoga or Conquering the Internal Nature",* (Publication Department), Kolkata.
3	Nagendra H.R and Nagaratna R, "*Yoga Perspective in Stress Management",* Swami Vivekananda Yoga Prakashan, Bangalore.

AC036	**PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS**					
AUDIT COURSE-II						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

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

1. Develop their personality and achieve their highest goal of life.
2. Lead the nation and mankind to peace and prosperity.
3. Practice emotional self-regulation.
4. Develop a positive approach to work and duties.
5. Develop a versatile personality.

Program Articulation Matrix

Course outcome	**Program outcome**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1						
CO2						
CO3						
CO4						
CO5						

Row wise cumulative percentage weightage should be equal to 1.0.

UNIT – I
Neetisatakam – Holistic Development of Personality- Verses 19, 20, 21, 22 (Wisdom) - Verses 29, 31, 32 (Pride and Heroism) - Verses 26,28,63,65 (Virtue)
UNIT – II
Neetisatakam – Holistic Development of Personality (cont'd) - Verses 52, 53, 59 (don'ts) - Verses 71,73,75 & 78 (do's) - Approach to day to day works and duties.
UNIT – III
Introduction to Bhagavadgeetha for Personality Development - Shrimad Bhagavadgeetha: CHAPTER 2 – Verses 41, 47, 48 - Chapter 3 – Verses 13,21,27,35 - Chapter 6 – Verses 5,13,17,23,35 - Chapter 18 –Verses 45, 46, 48 Chapter – 6: Verses 5, 13, 17, 23, 35; Chapter – 18: Verses 45, 46, 48
UNIT – IV
Statements of Basic Knowledge - Shrimad Bhagavadgeetha: Chapter 2- Verses 56, 62,68 - Chapter 12 – Verses 13, 14, 15, 16, 17, 18 - Personality of Role model from Shrimad Bhagawat Geeta.
UNIT – V
Role of Bhagavadgeetha in the Present Scenario **-** Chapter 2 – Verses 17 - Chapter 3 – Verses 36, 37, 42 - Chapter 4 – Verses 18, 38, 39 - Chapter 18 – Verses 37, 38, 63.

References:

1	Swami Swarupananda Advaita Ashram "*Srimad Bhagavad Gita",* (Publication Department), Kolkata
2	P.Gopinath, *"Bhartrihari's Three Satakam (Niti-sringar-vairagya*)", Rashtriya Sanskrit Sansthanam, New Delhi

AC037	**CONSTITUTION OF INDIA**					
AUDIT COURSE-II						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

1.	*Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective*
2.	*To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role*
3.	*Entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.*

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

1.	*Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.*
2.	*Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.*
3.	*Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru*
4.	*The eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.*
5.	*Discuss the passage of the Hindu Code Bill of 1956.*

Program Articulation Matrix

Course outcome	**Program outcome**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1						
CO2						
CO3						
CO4						
CO5						

Row wise cumulative percentage weightage should be equal to 1.0.

UNIT – I
History of Making of the Indian Constitution: History, Drafting Committee, (Composition & Working) Philosophy of the Indian Constitution: Preamble, Salient Features.

UNIT – II
Contours of Constitutional Rights & Duties: Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT – III
Organs of Governance: Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications. Powers and Functions.

UNIT – IV
Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative CEO of Municipal Corporation, Panchayat raj: Introduction, PRI: Zilla Panchayat, Elected officials and their roles, CEO Zilla Panchayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT – V
Election Commission: Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.

References:

1	*"The Constitution of India",* 1950 (Bare Act), Government Publication.
2	Dr. S. N. Busi, *"Dr. B. R. Ambedkar framing of Indian Constitution",* 1st Edition, 2015.
3	M. P. Jain, "*Indian Constitution Law",* 7th Edn., Lexis Nexis, 2014.
4	D.D. Basu, *"Introduction to the Constitution of India",* Lexis Nexis, 2015.

AC038	**PEDAGOGY STUDIES**					
AUDIT COURSE-II						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

1. To present the basic concepts of design and policies of pedagogy studies.
2. To provide understanding of the abilities and dispositions with regard to teaching techniques, curriculum design and assessment practices and familiarize various theories of learning and their connection to teaching practice.
3. To create awareness about the practices followed by DFID, other agencies and other researchers and provide understanding of critical evidence gaps that guides the professional development

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

1. Illustrate the pedagogical practices followed by teachers in developing countries both in formal and informal classrooms.
2. Examine the effectiveness of pedagogical practices.
3. Understand the concept, characteristics and types of educational research and perspectives of research.
4. Describe the role of classroom practices, curriculum and barriers to learning.
5. Understand Research gaps and learn the future directions.

Program Articulation Matrix

Course outcome	**Program outcome**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1						
CO2						
CO3						
CO4						
CO5						

Row wise cumulative percentage weightage should be equal to 1.0.

UNIT – I
*Introduction and Methodology:*Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions, Overview of methodology and Searching.

UNIT – II
*Thematic Overview:*Pedagogical practices followed by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education

UNIT – III
*Evidence on the Effectiveness of Pedagogical Practices***:** Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and Practicum) and the school curriculum and guidance material best support effective pedagogy? - Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches – Teachers attitudes and beliefs and pedagogic strategies.

UNIT – IV
*Professional Development:*alignment with classroom practices and follow up support - Support from the head teacher and the commUNITy – Curriculum and assessment - Barriers to learning: Limited resources and large class sizes.

UNIT – V
*Research Gaps and Future Directions:*Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment – Dissemination and research impact.

References:

1	Ackers J, Hardman F, *"Classroom Interaction in Kenyan Primary Schools, Compare*", 31 (2): 245 – 261, 2001.
2	2. Agarwal M, *"Curricular Reform in Schools: The importance of evaluation*", Journal of Curriculum Studies, 36 (3): 361 – 379, 2004.
3	Akyeampong K, "*Teacher Training in Ghana – does it count? Multisite teacher education research project (MUSTER)",* Country Report 1. London: DFID, 2003.
4	Akyeampong K, Lussier K, Pryor J, Westbrook J, *"Improving teaching and learning of Basic Maths and Reading in Africa: Does teacher Preparation count?"*International Journal Educational Development, 33 (3): 272- 282, 2013.
5	Alexander R J, *"Culture and Pedagogy: International Comparisons in Primary Education",* Oxford and Boston: Blackwell, 2001.
6	Chavan M, Read India: *"A mass scale, rapid, learning to read campaign",* 2003

AC039	**E-WASTE MANAGEMENT**					
AUDIT COURSE-II						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

1. Introduction to E-Waste management
2. Understanding on resource efficiency and circular economy
3. E-waste Management rules 2016
4. RoHS compliances/directives to EEE

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

1. Complete understanding on E-Waste management
2. Understanding on effective recycling methodologies for e-waste management
3. Overall understanding about E-waste Management rules 2016 and strategies for e-waste management
4. Understanding on RoHS compliances for EEE products

Program Articulation Matrix

Course outcome	**Program outcome**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1						
CO2						
CO3						
CO4						
CO5						

Row wise cumulative percentage weightage should be equal to 1.0.

UNIT – I
Waste Electrical and Electronic Equipment (WEEE): Flows, Quantities and Management, a Global Scenario; The Importance of Waste Management; Types of Waste- Solid and Liquid; Criteria for EEE/E-Waste Classification; Multivariate Model for E-Waste Estimation; Environmental and Health Effects of Waste Management, Inventorisation of E-Waste and Emerging trends in E-waste disposal with bench marks for depollution - global scenario; Dumping, Burning and Landfill: Impact on the Environment

UNIT – II
Effective Waste Management and Disposal Strategies; Legislative Influence on Electronics Recycling; Waste Management Rules and Their Amendments; Extended Producer Responsibility (EPR) in E-Waste Management; The Role of Collective versus Individual Producer Responsibility in E-Waste Management

UNIT – III
Electronic Waste: Public Health Implications; Restriction of Hazardous Substances (RoHS) Directives in Electrical and Electronic Equipment; Materials Used in Manufacturing Electrical and Electronic Products

UNIT – IV
Recycling and Resource Management: Ecological and Economical Valuation; Life Cycle Assessment (LCA) Approach to Waste Management System; Environmental Incentives for Recycling and Life Cycle Analysis of Materials Recycling Electronic Waste: Challenges and OpportUNITies for Sustainable Management; Resource Recovery from E-waste: Efficiency and Circular Economy; Integrated Approach to E-Waste Recycling: Recycling and Recovery Technologies, Recycling and Recovery Technologies.

UNIT – V
Cases studies: E-waste Generation, collection and recycling

References:

1	Electronic Waste Management and Treatment Technology, Editors: Majeti Narasimha Vara Prasad Meththika Vithanage
2	Electronic Waste Management, Edited by R. E. Hester, R. M. Harrison, RSC Publishing 2009
3	Solid Waste Technology & Management, Christensen, T., Ed., Wiley and Sons., 2011
4	Electronics Waste Management: An India Perspective. Front Cover. Sandip Chatterjee. Lap Lambert Academic Publishing GmbH KG, 2010 – Electronic
5	Handbook of Electronic Waste Management, International Best Practices and Case studies, Elsevier, 2019
6	E-waste: Implications, regulations, and management in India and current global best practices. Author(s): Rakesh Johri, TERI Press

EC381	**DISSERTATION-I**					
DISSERTATION PHASE-I						
Pre-requisites	-		**L**	**T**	**P**	**C**
			-	-	20	10
Evaluation	**SEE**	-	**CIE**	100 Marks		

Course Objectives :	
1	*Identification of the research problem*
2	*Discussion of literature survey.*

Course Outcomes :	
CO-1	*Identification of the objectives of the Research Problem.*
CO-2	*Ability to update the latest literature in chosen area of research & establishment of the scope of work.*
CO-3	*Development of the methodology for the chosen research problem and perform basic theoretical /experiment studies.*
CO-4	*Identification of the objectives of the Research Problem.*
CO-5	*Ability to update the latest literature in chosen area of research & establishment of the scope of work.*

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	-	-	3	3	-
CO-2	-	1	3	3	-
CO-3	2	2	3	3	-
CO-4	-	2	2	3	-
CO-5	1	2	3	3	-

Contents:

Each student will be attached to a faculty member/guide for project. The student will carry out the project which may be development of Software / Hardware / Simulation studies / Design analysis / Experimental related to his/her specialization. The work will be monitored regularly by the guide. At the end of the semester student will write the report on the work done and submit to the guide. Student has to present his/her work before two faculty members (one guide and other to be appointed by chairman BOS) on a fixed day during last week of the semester in which project is offered. The sessional marks will be awarded jointly by these examiners based on the report, presentation and viva voice

SEMESTER – IV

EC382	**DISSERTATION-II**					
DISSERTATION PHASE-II						
Pre-requisites	-		**L**	**T**	**P**	**C**
			-	-	32	16
Evaluation	**SEE**	100	**CIE**	100 Marks		

Course Objectives :	
1	*Identification of the research problem*
2	*Discussion of literature survey.*

Course Outcomes :	
CO-1	*Expand the defined Research Problem for the dissertation work.*
CO-2	*Conduct of Laboratory/analytical/ software studies*
CO-3	*Analysis of Data, development of models*
CO-4	*Offer solutions to the research problem and provide conclusions of the work.*
CO-5	*Validate the results*

Course outcome	**Program outcomes**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	-	-	3	3	-
CO-2	-	1	3	3	-
CO-3	2	2	3	3	-
CO-4	-	2	2	3	-
CO-5	1	2	3	3	-

Contents:

The student will carry out the project under allotted supervisor, which may be development of Software / Hardware / Simulation studies / Design analysis / Experimental related to his/her specialization. The work will be monitored regularly by the guide. At the end of the semester student will write the report on the work done and submit to the guide. Student has to present his/her work before two faculty members (one guide and other to be appointed by chairman BOS) on a fixed day during last week of the semester in which project is offered. The final marks will be allotted based on the report, presentation and viva voce conducted by the external examiner whose name is suggested by Chairman BOS