UNIVERSITYOF KERALA

DEPARTMENT OF OPTOELECTRONICS

MSc DEGREE PROGRAMME IN ELECTRONICS
(Artificial Intelligence)

SYLLABUS

MSc. Degree program (from 2022-23 academic year)

1. Aim of the program

MSc. Electronics with specialization in Artificial Intelligence forms the formal training of Electronics and hence the program aims at providing an in-depth knowledge of Electronics and Artificial Intelligence to the student. After the successful completion of the program, a student should be capable of pursuing research in theoretical/ experimental or related areas.The program also aims at enhancing the employability of the student. Rigorous training requires phased teaching. With this intention credit and semester system is followed in this program.An M.Sc. student should be capable of doing research at least in the preliminary way.To accomplish this,research-oriented project is made part of this curriculum.

2. Eligibility for admissions

Bachelor's degree in Physics/Electronics/Photonics with an aggregate minimum of 50%marksin optional subjects or 2.0 CGPA (s) out of 4.0 or 5.0 CCPA(s) out of 10.0 subject to the usualconcessions allowed for backward classes and other communities as specified from time to time.

3. Admission

The admission to the MSc degree course shall be as per the rules and regulations of the University.Students admitted under this programme are governed by the Regulations in force.

4. Medium of instruction and assessment

English

5. Faculty under which the degree is awarded

Applied Science and Technology

6. Specialization offered if any

(1) Artificial Intelligence

7. Note on compliance with the UGC minimum standards for the conduct and award of postgraduate degrees.

MSc Electronics is a two-year program in which credit and semester system is followed. An M.Sc. student should be capable of doing research at least in the preliminary way. To accomplish this,research-oriented project is made part of this curriculum.There are 18 weeks in a semester and in each week there are16 lecture hours and 8 laboratory hours and 1 tutorial hour. In each semester there are 288 lecture hours, 144 practical hours and 18 tutorial hours. Thus, the total calendar hours in each semester are 450 which is in compliance with the minimum 390 hours stipulated by the UGC.

CHAPTER-I

1. GENERAL SCHEME OF THE SYLLABI

1.1 Theory Courses:

There are twelve theory courses in all four semesters in the M.Sc. Program. Distribution of theory courses is as follows. There are nine core courses common to all students. Semester I will have four core courses and Semester II will have three core courses and Semester III will have two core courses. In the fourth semester there will be one main project and one seminar. One elective course is in semester II and two elective courses are in semester III. There are two Elective Group offered in this syllabus. An Elective Group has three theory coursesand one laboratory course.

1.2 Practical:

All four semesters will have courses on laboratory practicals. A minimum of 10 experiments should be done and recorded in each semester. The practical examinations will be conducted at the respective examination centers by two examiners (one internaland one external appointed by the University) at the end of each semester.

1.3 Project:

The project of the PG program should be relevant to the Elective Group and innovative in nature. The type of project can be decided by the student and the guide (a faculty of the department or other department/college/university/institution). The project work should be taken up seriously by the student and the guide. The project should be aimed to motivate the inquisitive and research aptitude of the students. The students may be encouraged to present the results of the project in seminars/symposia. The project is evaluated by the external examiners. The project guide or a faculty member deputed by the head of the department may be present at the time of project evaluation. This is to facilitate the proper assessment of the project.

1.4 Viva - Voce:

A viva - voce examination will be conducted by the two examiners (one internaland one external appointed by the University)at the time of evaluation of the project. The components of viva consist of project related (60%), topics covering all semesters and awareness of current and advanced topics (40%).

1.5 Course Structure of M.Sc. Electronics Program:

The detailed structure of the Core courses common to all students of the program is given in Table 1.1

Table 1.1: Course Structure of M.Sc. Electronics

Sem. No.	CourseCode	Name of the Course	Credits	Total Credit per Semester
I	**Core Courses (CC)**			
	OPE-CC-511	Mathematical Methods in Electronics	4	**22**
	OPE-CC-512	Analog and Digital Circuits	4	
	OPE-CC-513	Solid State Electronics and Optoelectronics	4	
	OPE-CC-514	Electromagnetic Theory and Antennas	4	
	OPE-CC-515	Analog & Digital Circuits Lab	3	
	OPE-CC-516	General Lab	3	
II	**Core Courses (CC)**			
	OPE-CC-521	Communication Systems	4	**22**
	OPE-CC-522	Programming in Python	4	
	OPE-CC-523	Linear Control Systems	4	
	OPE-CC-524	Python Programming lab	3	
	OPE-CC-525	Communication, Signal Analysis and Circuit Design Lab	3	
	Discipline-Specific Electives (DE)			
		Elective I*	4	
III	**Core Courses (CC)**			
	OPE-CC-531	Digital Signal Processing	4	**22**
	OPE-CC-532	VLSI Design	4	
	OPE-CC-533	Digital Signal Processing Lab	3	
	OPE-CC-534	Elective Lab – Artificial Intelligence	3	
	Discipline-Specific Electives (DE)			
		Elective II*	4	
		Elective III*	4	
IV	**Core Courses (CC)**			
	OPE-CC-541	Project	12	**16**
	OPE-CC-542	Seminar	2	
	OPE-CC-543	Viva-Voce	2	
Generic Courses (GC)				
Any Semester (I-IV)		Open Elective I	2	**4**
		Open Elective II	2	
		MOOC/NPTEL Course	2	
	Total Credits			**86**

*The students will have to select Elective subject from list of Discipline-Specific Electives provided as given below:

List of Electives

Course Code	Discipline-Specific Electives (DE)	Credits
OPE-DE-501(A)	Machine Learning and Artificial Intelligence	4
OPE-DE-502(A)	RoboticsandIntelligentSystems	4
OPE-DE-503(A)	Image Processing	4
OPE-DE-504(A)	Pattern Recognition	4
OPE-DE-505(A)	Artificial Neural Networks	4
OPE-DE-506(A)	Fraud Analytics	4
OPE-DE-507(A)	Fuzzy Systems and Applications	4
OPE-DE-508(A)	Advanced Machine Learning	4
OPE-DE-509(A)	Information Theory and Coding	4
OPE-DE-5010(A)	Internet of Things	4
OPE-DE-5011(A)	Big Data Technologies	4
OPE-DE-5012(A)	Analog Integrated Circuits	4
OPE-DE-5013(A)	Microprocessor and Microcontroller	4
OPE-DE-5014(A)	Digital System Design	4
OPE-DE-5015(A)	Digital Communication	4
OPE-DE-5016(A)	Satellite and Mobile Communication	4
OPE-DE-5017(A)	Wireless Communication	4
OPE-DE-5018(A)	MicroElectroMechanicalSystems	4
OPE-DE-5019(A)	Biomedical Electronics	4

1.6 Distribution of Credit:

The total credit for the program is fixed at 86. The distribution of credit points in each semester and allocation of the number of credits for theory courses, practicals, project and viva is shown in Table 1.1.

CHAPTER - II

ASSESSMENT AND EVALUATION

2.1 Examinations

The evaluation of each course shall contain two parts such as Internal or Continuous Assessment (CA) and External or End-Semester Assessment (ESA).

2.2 Internal or Continuous Assessment (CA)

Internal evaluation is to be done by continuous assessments. The internal assessment should be fair and transparent. The evaluation of the components should be published and acknowledged by students. All documents of internal assessments are to be kept in the institution for 2 years and shall be made available for verification by the university. The responsibility of evaluating the internal assessment is vested on the teacher(s) who teach the course. The test papers should be in the same model as the end semester examination question paper. The duration and the number of questions in the paper may be adjusted judiciously for the sake of convenience. There shall be no separate minimum grade point for internal evaluation of Theory, Practical, Project, and Comprehensive viva-voce. No minimum is required for Internal evaluation for a pass, but a minimum is required for a pass in an external evaluation.

2.2.1Attendance, Assignment and Seminar

Attendance is not a component for the internal evaluation.But students with attendance less than 75% in a course are not eligible to attend external examination of that course. The performance of students in the seminar and assignment should also be documented.

2. 2.2 Project Evaluation

The internal evaluation of the project is done by the supervising guide of the department or the member of the faculty decided by the head of the department. The project work may be started at the beginning of the Semester IV.The supervising guide should keenly and sincerely observe the performance of the student during the course of project work. The supervising guide is expected to inculcate in student(s), the research aptitude and aspiration to learn and aim high in the realm of research and development. A maximum of three students may be allowed to perform one project work if the volume of the work demands it.Project evaluation begins with (i) the selection of problem, (ii) literature survey, (iii) work plan, (iv)experimental/theoretical setup/data collection, (v) characterization techniques/computation/analysis (vi) use of modern software for data analysis/experiments (Origin, LABView, MATLAB, etc) and (vi) preparation of dissertation.The project internal grades are to be submitted at the end of Semester IV.

2.2.3 General Instructions

i. The assignments/ seminars / test papers are to be conducted at regular intervals. These should be marked and promptly returned to the students.

ii. One teacher appointed by the Head of the Department will act as a coordinator for consolidating grade sheet for internal evaluation in the department in the format supplied by the University. The consolidated grade sheets are to be published in the department notice board, one week before the closing of the classes for end semester examinations. The grade sheet should be signed by the coordinator and counter signed by the Head of the Department.

iii. The consolidated grades in specific format supplied by the university areto be kept in the college for future references. The consolidated grades ineach course should be uploaded to the University Portal at the end of eachsemester as directed by the University.

iv. A candidate who fails to register for the examination in a particular semester is not eligible to continue in the subsequent semester.

2.3 External or End Semester Assessment (ESA)

The external examination of all semesters shall be conducted by the University on the close of each semester. There will be no supplementary examinations.

2.3.1 Question Paper Pattern for Theory Courses

All the theory question papers are of three-hour duration. All question papers will have two/three parts.

2.3.2 Practical, Project and Viva-Voce Examinations

Practical Evaluation: The practical examinations are conducted immediately after the semester theory examinations. All practical examinations will be of five hours duration. One examiner from the panel of examiners of the University will be deputed by the board chairman to each of the examination centers for the fair and transparent conduct of examinations. Practical examination is conducted in batches having a maximum of eight students. The board has the right to decide on the components of practical and the respective weights.

Project Evaluation: The project is evaluated by the two external examiners deputed from the board of practical examination. The dissertation of the project is examined along with the oral presentation of the project by the candidate. The examiners should ascertain that the project and report are genuine. Innovative projects or the results/findings of the project presented in national seminars may be given maximum advantage. The supervising guide or the faculty appointed by the Head of the Department may be allowed to be present at the time of project evaluation. This is only to facilitate proper evaluation of the project.

Viva-Voce Examination: Viva-voce examination is conducted by the two examiners (one internaland one external appointed by the University)of the board of practical examinations. The viva-voce examination is given a credit two.

2.3.3Generic (Open Elective) Courses:

The students should successfully complete two generic (open elective) courses offered by other departments during the programme. NPTEL/MOOC courses of more than three months duration also will be considered equivalent to the generic courses. The generic course credit will be added in Semester IV.

2.3.4 Reappearance/Improvement:

For reappearance/ improvement as per university rules, students can appear along with the next regular batch of students of their particular semester. A maximum of two chances will be given for each failed paper. Only those papers in which candidate have failed need be repeated.

CHAPTER III

M.Sc. ELECTRONICS SYLLABUS

3.1 INTRODUCTION

This chapter deals with the syllabi of all Core courses, Elective courses of the MSc. Electronics program. The semester wise distribution of the courses is given. The Programme Outcomes and Programme Specific Outcomes and Course Outcomes are described.

Programme Outcomes (POs)

PO1	Enhance knowledge by understanding, experimenting and co-relating information (existing and new) in the field of electronics.
PO2	Demonstrate ability to model, simulate and estimate the phenomenon and systems in the chosen areas of electronics.
PO3	Improve skills in solving scientific problems and designing devices.
PO4	Effectively communicate technical content through written reports/design documents, and presentations.
PO5	Students will become able to demonstrate a degree of mastery over the area as per the specialization of the program.

Programme Specific Outcomes (PSOs)

PSO1	Understand the principles and theoretical concepts in the fabrication of electronic devices and optoelectronic materials.
PSO2	Develop skills in designing electronic devices and artificial intelligent systems which are in tune with current technology and adaptable for future changes.
PSO3	Create an environment such that students develop a passion for hardware and software design using AI.
PSO4	Act as the part of the electronic design industry to become leaders in indigenous product development.
PSO5	Get mathematical background for theoretical analysis of modelling.

Course Outcomes

Semester: I	Course Code: OPE-CC-511
Course Title: MATHEMATICAL METHODS IN ELECTRONICS	Credits: 4

Prerequisite : Knowledge in complex analysis and probability.

Objective : To provide knowledge in Differential Equation, Fourier Series, Integral transforms, Complex variables and Probability distributions.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Analyze theoretically the differential equations and Special functions
CO2	Apply differential equations and Special functions
CO3	Remember the principles of Fourier series, infinite series, and transformations.
CO4	Understand Fourier transform, integral transform.
CO5	Understand the functions of a complex variable
CO6	Apply probability distribution functions

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Analyze theoretically the differential equations and Special functions	PSO5	An	M
CO2	Apply differential equations and Special functions	PSO5	Ap	P
CO3	Remember the principles of Fourier series, infinite series, and transformations.	PO3/PSO5	R	F and C
CO4	Understand Fourier transform, integral transform.	PO3/PSO5	U	C
CO5	Understand the functions of a complex variable	PO2/PSO5	U	C

CO6	Apply probability distribution functions	PO2/PSO5	Ap	P

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

ModuleI

PartialDifferentialEquations: Linear second order partial differential equations– solutions of partial differential equations-separation ofvariables- solutionof waveequations.

Legendre, Hermite and Laguerre's differential equations – Series solutions– Rodrigues formulae - Generatingfunctions –Orthogonality and associatepolynomials.

Bessel functions: Seriessolution- - secondkind–GeneratingfunctionforJn(x)–Bessel'sintegral representation – Recurrence formula for Jn(x) – Orthogonality of Jn(x)– SphericalBessel function

Green's function: Green' function in one dimension – motion of a particle in a resistive medium- motion of a damped harmonic oscillator – Green's function in three dimensions – solution of Poisson's equation.

Module II

Fourier analysis: Representation of periodic signals: Continuous Time Fourier Series, convergence of Fourier series, Gibbs phenomenon, Representation of aperiodic signals: Continuous Time Fourier Transform, The Fourier Transform for periodic signals, Properties of Fourier representations, Frequency Response of systems characterized by linear constant coefficient differential equations.

Laplacetransform: Laplace Transform and its existence, Laplace Transform of standard functions, properties of Laplace Transform, Laplace Transform of periodic functions, Laplace Transform of some special functions, inverse Laplace Transform, circuit analysis using Laplace Transform (R, RC, LC, RLC circuits).Inverse Laplace Transform

Z-transform: Definition, Z-transform of elementary signals, Region of convergence, Properties of ROC and Z transform, Inverse Z-transform, Analysis and characterization of LSI systems, causality and stability, Transfer function and difference equations.

Module III

Complex variables: Functions of a complex variable-derivatives-Cauchy-Reimann equations-Cauchy's integral formula- derivatives of analytic functions- Taylor series- Laurent series- singular

points of an analytical function- poles –removable singularity- essential singularity- point at infinity- residues- calculation of residues- the residue theorem – evaluation of residues- evaluation of definite integrals.

Probability: Laws of probability – discrete probability distributions – theory of combinations and permutations – Stirling approximation for the factorial – continuous distributions – moments and standard deviations– Binomial distribution – Poisson distribution – normal distribution – distribution of a sum of normal variates.

References:

1. Alan V. Oppenheim Alan S. Willsky and S. Hamid Nawab, "Signals and Systems", 2nd Edition, Pearson Education India, 2015.
2. Simon Haykin and Barry V. Veen, "Signals & Systems", John Wiley, 2nd Edition, 2007.
3. B. P. Lathi, "Linear Systems and Signals", Oxford University Press, 2004.
4. Taylor F. H., "Principles of Signals & Systems", McGraw Hill, 1994.
5. Mathematical Methods for Physicists 4^{th} Edn by Arfken & Weber, Academic Press.
6. Applied Mathematics for Engineers and Physicists- L.A. Pipes and L. R. Harvill, McGraw-Hill.

Semester: I	Course Code: OPE-CC-512
Course Title: ANALOG AND DIGITAL CIRCUITS	Credits: 4

Prerequisite : Knowledge in basic electronics.

Objective : To understand the operations of various electronic circuits, and develop the circuits for the hardware design.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Understand the concept of feedback and oscillators
CO2	Understand the fundamental principles of linear electronic systems
CO3	Analyze electronic circuits using active devices
CO4	Design the electronic circuits using linear devices
CO5	Understand and analyse different modelling circuits

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand the concept of feedback and oscillators	PO1/PSO1	U,	C
CO2	Understand the fundamental principles of linear electronic systems	PO1/PSO1	U	F and C
CO3	Analyze electronic circuits using active devices	PSO2	An, Ap and Cr	P and M
CO4	Design the electronic circuits using linear devices	PO3/PSO5	Cr, Ap	M
CO5	Understand and analyse different modelling circuits	PO5/PSO5	U, An and Ap	C

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KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	

Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I

Operational amplifiers: Characteristics, op-amp architecture, Offset and Bias Voltages and Current, Slew Rate, Finite Frequency Response, Gain-bandwidth product, Linear op- amp circuits, Non-Linear Op-amp Circuits: Open Loop Comparator, Polarity Indicator, Schmitt Trigger; astable and monostable circuits, Active filters: LPF & HPF using Sallen-Key configuration, Simulation of circuits using LTSPICE.

Linear circuits: UJT relaxation oscillator, time base generators -bootstrap, miller; blocking oscillators, transient switching and characteristics., voltage regulators, VCO and emitter coupled VCO, Basic PLL topology and principle, transient response of PLL, Linear model of PLL, Major building blocks of PLL – analog and digital phase detector, VCO, filter, Applications of PLL Monolithic PLL - IC LM565 and CD4046 CMOS PLL.

Module II

Combinational Circuits: Multiplexers, decoders, encoders, buffers, code converters, adder, subtractor, Programmable Devices - Read Only Memory, Programmable Logic Array, Programmable Array Logic, Complex Programmable Logic Devices.

Sequential Circuits: Latches, Flip-Flops, Analysis of clocked sequential circuits, Mealy and Moore Models, state reduction and assignment, design procedures, excitation tables, state-transition table, state diagram, Finite State Machine design, Registers and Counters, Counter Design using flip flops.

Module III

Hardware Description Languages, Verilog, Rules and Syntax, Modules, Ports, Variables, Datatypes, Operators, Assignments, Procedural Assignments, Always block, Delays, Dataflow modeling, Behavioral modeling, Structural modeling, Tasks and functions. Modeling combinational and sequential circuits using verilog – arithmetic and logic circuits, registers, counters, sequential machines, tristate buffers, Mealy and Moore finite state machines, Simulation and verification - Verilog test bench, Memory, File read and write.

References:

1. Sergio Franco, “Design with Operational Amplifiers and Analog Integrated Circuits”, McGraw Hill Book Company 1998.
2. Millman J. and C. Halkias, “Integrated Electronics”, 2/e, TMH, 2010.
3. Gaykward, “Operational Amplifiers”, Pearson Education, 1999.
4. Coughlin R. F. and Driscoll F. F., “Operational Amplifiers and Linear Integrated Circuits”, Pearson Education 2002.
5. P. S. Bimbhra, “Power Electronics”, Khanna publishers, 2012.
6. Sen P. C., “Power Electronics”, Tata Mc Graw Hill,2003.
7. Rashid, “Power Electronics”,Prentice Hall India,1993.
8. G. K. Dubey et.al, “Thyristorised Power Controllers”, Wiley & Sons, 2001.
9. Dewan and Straughen, “Power Semiconductor Circuits”, Wiley & Sons, 1984.
10. Singh M. D. & Khanchandani K. B., Power Electronics, Tata Mc Graw Hill, 1998.

11. Charles H. Roth Jr. “Fundamentals of Logic Design”, 5th edition, Cengage Learning 2009.
12. Charles H. Roth Jr. Lizy Kurian John, Beyeong Kil Lee, “Digital Systems Design Using Verilog”, CL Engineering, 1st edition, 2015.
13. Samir Palnitkar, “Verilog HDL”, Pearson Education, 2nd edition, 2004.
14. Morris Mano, “Digital Logic Design”, Fourth Edition, Pearson Publication,2008.
15. NripendraN.Biswas“LogicDesignTheory”PrenticeHallofIndia,2001.
16. ParagK.Lala“DigitalsystemDesignusingPLD”BSPublications,2003.
17. John F. Wakerly, “Digital Design - Principles and Practices”, Pearson, 4th edition, 2008.
18. Victor P. Nelson, H. Troy Nagle, J. David Irvin, Bill D. Carol, “Digital logic Analysisanddesign”,1stedition,Prentice HallPublications.

Semester: I	Course Code: OPE-CC-513
Course Title: SOLID STATE ELECTRONICS AND OPTOELECTRONICS	Credits: 4

Prerequisite : Basic knowledge aboutelectronics.

Objective : To enhance the knowledge in optoelectronic materials and semiconductor electronics.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Understand the concept of quantum theory and wave equations.
CO2	Understand the fundamental concepts and properties of energy band.
CO3	Understand the distribution of carrier concentration and charge density
CO4	Analyse the carrier transportation mechanism in semiconductors
CO5	Understand the electronic properties of optoelectronic devices.

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand the concept of quantum theory and wave equations.	PO1	U,	C
CO2	Understand the fundamental concepts and properties of energy band.	PO1/PSO1	U and E	F, P and C
CO3	Understand the distribution of carrier concentration and charge density	PO2/PSO2	U, An and Ap	P and M
CO4	Analyse the carrier transportation mechanism in semiconductors	PO3	An, Cr and Ap	P and M
CO5	Understand the electronic properties of optoelectronic devices.	PO5/PSO4	U, An and Ap	P and M

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KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I:
Quantum Mechanics-Wave nature of particles-uncertaintyPrinciple-Wave motion-SuperpositionPrinciple-De-Broglie Hypothesis-Time dependent and independent Schrodinger wave Equation-Planck'sconcept of energy & Quantization particle in one dimensional infinite potential well-Finite and infinitesquare well-Particle in Box-Square potential –Barrier and quantum mechanical Tunneling.

Module II
Energy Bands in Solids: Energy Band Diagram, Direct and Indirect band gap semiconductors, Effective mass. Semiconductors- Intrinsic and Extrinsic. Carrier Concentration-Fermi-Dirac distribution function, Electron and Hole concentration at equilibrium, Temperature dependence of intrinsic carrier concentration & majority carrier concentration in extrinsic semiconductor, Equilibrium electron hole concentration. Carrier transport in semiconductors - mobility and conductivity. Variation of mobility with temperature & doping. Constancy of Fermi level at equilibrium. Hall Effect. Quasi Fermi level, Diffusion of charge carriers. Einstein relation. Continuity equation. PN junction under thermal equilibrium, Equilibrium energy band diagram - Distribution of carrier concentration, potential, electric field and charge density.

Module III
Optoelectronic materials, Semiconductors, compound semiconductors, III-V and II-VI compounds, ZnO, ITO, GaN, direct and indirect band gap, electronic properties of semiconductors, Fermi level, density of states, life time and mobility of carriers, invariance of Fermi level at equilibrium, diffusion, continuity equation, excess carriers, Quasi-Fermi levels.
LED, Blue LED, Laser diodes. Quantum well lasers, VCSEL, DFB and DBR lasers. Photodetectors, photoconductors and photodiodes, PIN diodes, heterojunction diodes and APDs, photomultiplier tube, Solar cell materials and their properties.

References:

1. AmnonYariv, Optical Electronics, Holt Rine hart & Winston, Philadelphia, 1991
2. Ben G. Streetmann& Sanjay Banerjee, Solid State Electronic Devices, 5thEdn, 2000.
3. Bhattacharya P., Semiconductor Optoelectronic Devices, PHI, New Delhi.1995
4. Martin A. Green, Solar Cells: Operating principles, Technology and System Applications, Prentice-Hall Inc, Englewood Cliffs, NJ, USA, 1981.
5. Poortmans J and Arkhipov V Thin Film Solar Cell: Fabrication, Characterizations and

Applications, John Wiley & Sons, England 2006.
6. W.R Fahrner: Nanotechnology&Nanoelectronics, (Springer 2005)
7. M S Tyagi: Introduction to semiconductor materials and devices (Wiley India)
8. D A Neeman: Semiconductor Physics& Devices (Tata Mc-Graw-Hill).

Semester: I	Course Code: OPE-CC-514
Course Title: ELECTROMAGNETIC THEORY AND ANTENNAS	Credits: 4

Prerequisite : Basic knowledge aboutelectricity and magnetism.

Objective : To enhance the knowledge in propagation of EM waves and design of antennas.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Understand the various theorems related to Electrostatics, Magnetostatics and Electromagnetism
CO2	Learn all basic terminologies and applications of Electric field and Magnetic field.
CO3	Study the behaviour of charges with respect to different mediums and Time varying fields.
CO4	Grasp the concepts of Transmission Lines, Waveguides and their applications.
CO5	Know the Types of Antennas and Identify the advance applications of Antennas.

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand the various theorems related to Electrostatics, Magnetostatics and Electromagnetism	PO1	U,	C
CO2	Learn all basic terminologies and applications of Electric field and Magnetic field.	PO2	U and E	F, P and C
CO3	Study the behaviour of charges with respect to different mediums and Time varying fields.	PO2/PSO1	U, An and Ap	P and M
CO4	Grasp the concepts of Transmission Lines, Waveguides and their applications.	PO3/PSO5	An, Cr and Ap	P and M
CO5	Know the Types of Antennas and Identify the advance applications of Antennas.	PO5/PSO5	Ap, An and Cr	P and M

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I:
Electrostatic fields in matter and Electrodynamics
Review of Electrostatics and Magnetostatics, Time varying fields and Maxwell's equations, Potential formulations-Scalar and Vector Potential, Gauge transformations, boundary conditions, wave equations and their solutions, Poynting theorem, Maxwell's stress tensor.

Electromagnetic waves
Maxwell's equations in phasor notation. Plane waves in conducting and non-conducting medium, Polarization, Reflection and transmission (Normal and Oblique incidence), Dispersion in Dielectrics, Superposition of waves, Group velocity.

Module II
Propagation of Electromagnetic Waves in conducting medium and non- conducting medium

Electromagnetic Radiation
Retarded potentials, Point charges, Lienard-Wiechert potential, Fields of a moving point charge, Electric dipole radiation, Magnetic dipole radiation, Power radiated by point charge in motion. Radiation reaction, Physical basis of radiation reaction, Radiation resistance of a short dipole, Radiation from quarter wave monopole or half wave dipole.

Module III
Wave Guides and Antenna
Antenna parameters. Waves between parallel conducting plane TE, TM and TEM waves, TE and TM waves in Rectangular wave guides, Impossibility of TEM waves in rectangular wave guides. Dipole arrays, Folded Dipole and Yagi-Uda Antenna (VHF).
Microwave Antennas: Antenna with parabolic reflectors, Horn antenna, Microwave detectors - PIN and Schottky diodes.

Transmission Lines-Principles-Characteristic impedance, Classification of Transmission lines: Coaxial Cable, Twin wire line, Strip and Microstrip line, standing waves-quarter and half wavelength lines.
.

References:

1. Electromagnetic Fields T.V.S.Arun Murthy (S.Chand Publications)
2. Electronics Communications Systems George Kennedy (McGraw Hill International Edition.,N.Y., USA)
3. Electromagnetism (Theory and Applications) Ashutosh Pramanik (Prentice Hall of India Pvt. Ltd., New Delhi, INDIA)
4. Elements of Electromagnetics Matthew N.O.Sadiku (Oxford Publication)
5. Microwave Engineering and Applications O.P.Gandhi (Maxwell Macmillan International Edition.)
6. Classical electrodynamics J.D.Jackson (Willey Eastern Ltd., New Delhi, INDIA)
7. Classical Electrodynamics S.P.Puri (Tata McGraw Hill Publishing Co. Ltd., New Delhi, INDIA)
8. Introduction to Electrodynamics David J. Griffith (Prentice Hall of India Pvt. Ltd., New Delhi, INDIA)
9. Modern Microwave technology Victor F. Velley (Prentice Hall Inc. N.Y., USA)
10. Electromagnetic Field Theory Fundamentals Bhag Guru (Cambridge Publications)
11. Electromagnetic Field theory and Transmission Lines G.S.N.Raju (Pearson Education, South Asia)
12. Antenna Handbook Joseph J.Carr (Galgotia Publication pvt.ltd.
13. Electromagnetic Concepts and Applications Stanley V. Marshall, Gabriel G.Skitek (Prentice-Hall International Editions)Martin A. Green, Solar Cells: Operating principles, Technology and System Applications, Prentice-Hall Inc, Englewood Cliffs, NJ, USA, 1981.

Semester: I	Course Code: OPE-CC-515
Course Title: ANALOG AND DIGITAL CIRCUITS LAB	Credits: 3

Prerequisite : Basic knowledge in electronic circuits.

Objective : To empower the students with hands-on experience and to providepracticalknowledge about analog and digital circuits and its design and characteristics.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Design and construct different electrical circuits using Op-amp.
CO2	Analyse the various parameters of circuits using Op-amp.

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Design and construct different electrical circuits using Op-amp.	PSO1	E, Cr	P,M
CO2	Analyse the various parameters of circuits using Op-amp.	PO3/PSO5	Cr, E, An	P, M

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT (List of Experiments)

1. Differential amplifier- inverting, non-inverting- operational amplifier parameters (IC 741)
2. Op-amp - Adder, Integrator, Differentiator, Clipper and Clamper circuits
3. Voltage regulator using op-amp
4. Series pass voltage regulator with short circuit protection
5. RC coupled CE amplifier
6. Wien bridge oscillator using op-amp
7. First order low pass and high pass filter
8. Second order low pass and high pass filter
9. Waveform generators using op-amp
10. Schmitt trigger using op-amp
11. Instrumentation amplifier
12. AC DC milli-voltmeter construction and calibration.
13. Study of the I-V Characteristics of UJT and relaxation oscillator
14. Design of astable multivibrator
15. Design of monostable multivibrator
16. Study of single slope ADC
17. Study the operation of frequency synthesizer using PLL
18. Study of 8-bit DAC.
19. Design D/A and A/D Converters IC.
20. Design and Verify the Truth Table for Half Adder and Full Adder Logic Circuits.
21. Study of Multiplexer and De-multiplexer.
22. Flipflops using gates
23. Shift Registers

(At least 10 experiments should be provided)

Semester: I	Course Code: OPE-CC-516
Course Title: GENERAL LAB	Credits: 3

Prerequisite : Basic knowledge in Semiconductors, Antennas and Lasers.

Objective : To empower the students with hands-on experience and to providepracticalknowledge about semiconductor devices, sensors, antennas and lasers.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Understand the characteristics of solar cell and laser beam properties.
CO2	Analyzethe arc spectra.
CO3	Evaluateband gap, fermi energy, resistivity of semiconductors.
CO4	Verify hysteresis

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand the characteristics of solar cell and laser beam properties.	PSO1	U	P
CO2	Analyzethe arc spectra.	PO4/PSO2	An, Ap	P
CO3	Evaluateband gap, fermi energy, resistivity of semiconductors.	PO2/PSO1	E	P
CO4	Verify hysteresis	PO3/PSO5	Cr, E	P, M

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	

Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT (List of Experiments)

1. Characteristics of solar cell
2. Energy bandgap of Silicon
3. Fermi energy of Copper and fermi temperature
4. Determination of Planck's constant using LED
5. Hall effect – carrier concentration, mobility and hall coefficient
6. Antennas – parameters
7. Resistivity- Four Probe and determination of bandgap
8. Constant Deviation Spectrometer:Arc spectra- Iron, Copper, Brass
9. Constant Deviation Spectrometer:Arc spectra- Identification of elements
10. Ultrasonics- Acoustic grating – Compressibility of liquids
11. e/m – Thomson's method
12. Measurement of beam characteristics of lasers
13. Goniometer – Angle of contact
14. Pull – Frich refractometer
15. Hysteresis- BH Curve using CRO
16. Particle Size Analyzer (Using Diode Laser)
17. Calibration of Scale Using He-Ne Laser
18. Michelson's Interferometer - wavelength of the laser source

(At least 10 experiments should be provided)

Semester: II	Course Code: OPE-CC-521
Course Title: COMMUNICATION SYSTEMS	Credits: 4

Prerequisite : Basic knowledge in signals and systems.

Objective : To familiarize students on basic concepts of a communication system, the signals and its transmission.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Understand the elements of an electrical communication system.
CO2	Develop modulators and demodulators.
CO3	Understand the multiplexing technique.
CO4	Analyse signals and its transmission
CO5	Understand the effect of noise on the different modulation schemes and describe an optimum receiver.

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand the elements of an electrical communication system.	PO1	U	C
CO2	Develop modulators and demodulators.	PO2/PSO4	Ap, An and Cr	C, P and M
CO3	Understand the multiplexing technique.	PSO1	U, Ap and An	P and M
CO4	Analyse signals and its transmission	PO2/PSO4	U, Ap, An and E	P and M
CO5	Understand the effect of noise on the different modulation schemes and describe an optimum receiver.	PO3/PSO4	U, Ap, An and E	P and M

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I

Elements of an electrical communication system, Primary communication resources, communication channels and their characteristics, mathematical models for communication channels.

Analog signal transmission and reception: Amplitude Modulation-Double sideband suppressed carrier AM, Conventional AM, Single sideband AM, Vestigial sideband AM, Implementation of AM modulators and demodulators. Angle Modulation-Representation of FM and PM signals, Spectral characteristics of angle modulated signals, Implementation of angle modulators and demodulators. Radio & Television broadcasting. Mobile communication: basic principles of cellular communications, principle and block diagram of GSM. Effects of noise on linear and angle modulation systems.

Module II

Pulse Modulation-Sampling theorem, Nyquist rate, Aliasing, Pulse amplitude modulation and other forms of analog pulse modulation, Quantisation process, Pulse code modulation, Transmission bandwidth in a PCM system, Noise considerations in PCM systems, Delta modulation, Differential PCM, Adaptive DPCM.

Multiplexing: Time division multiplexing, Frequency division multiplexing, PAM/TDM system. Digital multiplexing, bit rate, bit error rate, transmission band width and bandwidth efficiency, PCM-TDM system. Various Line coding formats.

Module III

Digital Transmission: Matched filter and inter symbol interference, Optimum filter, Bit timing recovery, Eye diagram. Concept of Additive White Gaussian Noise channel, Optimum receiver, geometric representation of signals.

Digital modulation formats: Coherent binary modulation techniques-Generation, Signal space diagram and demodulation of Binary amplitude shift keying, Generation, Signal space diagram and demodulation of Binary phase shift keying, Generation, Signal space diagram and demodulation of Binary frequency shift keying. Noncoherent binary modulation techniques. Quadrature phase shift keying. Minimum phase shift keying. Error control coding: Parity coding, Linear block codes, Hamming codes.

References:

1. John G. Proakis, Masoud Salehi, "Communications Systems Engineering", 2nd edition, Pearson Education.
2. Simon Haykin, "Communication Systems", 4th edition, John Wiley & Sons, Inc.

3. Dennis Roddy, John Coolen, “Electronic Communictions”, 4th edition, Prentice Hall of India Pvt. Ltd.
4. Sanjay Sharma, “Communication Systems”, 4th edition, S. K. Kataria & Sons, New Delhi.

Semester: II	Course Code: OPE-CC-522
Course Title: PROGRAMMING IN PYTHON	Credits: 4

Prerequisite : Basic knowledge in programming.

Objective : To enhance the knowledge in Python.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Understand programming syntax of Python.
CO2	Demonstrate handling different type of data in Python
CO3	Write Python programs
CO4	Apply various regressions in Python
CO5	Evaluate different regression methods and its implementation in Python

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand programming syntax of Python.	PO1/PSO1	U	C
CO2	Demonstrate handling different type of data in Python	PO2	Ap, An and E	C, P and M
CO3	Write Python programs	PO3/PSO2	Cr and E	P and M
CO4	Apply various regressions in Python	PO5	Ap, An and E	P and M
CO5	Evaluate different regression methods and its implementation in Python	PO5/PSO5	Ap, An and E	P and M

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's	Continuous Assessment Tests	Terminal

Category	1	2	3	Examination
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I

Identifiers, Keywords, Variables, Input, Output and Import Functions, Operators, Numbers, String, Built-in Functions and Methods - List, Tuple, Set and Dictionary. Running Python Programs-Writing Python Code.

Loops, Nested Loops, Control Statements, Types of Loops, Comprehensions – List, Set and Dictionary, Nested Dictionaries. Function Definition - Function Calling, Function Arguments, Anonymous (Lambda) Functions, *filter()* function, *reduce()* function, Recursive Functions, Function with more than one return value. Built-in Modules, Creating Modules, *import* Statement, Locating Modules, Namespaces and Scope, The *dir()* function, The *reload()* function.

Module II

Opening a file, closing a file, writing to a File, *with* statement, reading from a file, file methods, renaming a file, deleting a file, directories in Python. Object Oriented Programming advantages. Class definition, Creating objects, Built-in attribute methods, Built-in class attributes, Destructors, Encapsulation, Data hiding, Inheritance, Method overriding, Polymorphism. Built-in Exceptions, Handling Exceptions, Exception with arguments, Raising an Exception, User- defined Exception, Assertions in Python.

Expressions:Introduction, *match()* function, *search()* function, search and replace, regular expression modifiers, regular expression patterns, Character classes, special character classes, repetition cases, *findall()* method, *compile()* method.

Module III

Introduction to numpy – Creating arrays, indexing, data types. Plotting with matplotlib – bar plot, histogram, pie chart, scatterplot.

Pandas Series, Data Frames, Multi-index and index hierarchy, Working with Missing Data, Group by Function, Merging, Joining and Concatenating Data Frames, Pandas Operations, Reading and Writing Files

Regression Analysis using Python: Linear regression, Logistic regression, Ridge regression, Lasso regression, Polynomial regression, Stepwise regression

References:

1. McKinney, Wes. Python for Data Analysis. " O'Reilly Media, Inc.", 2013.
2. Sweigart, Al. Automate the boring stuff with Python: practical programming for total beginners. No Starch Press, 2015.
3. Albon, Chris. Machine learning with python cookbook: Practical solutions from preprocessing to deep learning. " O'Reilly Media, Inc.", 2018.
4. Beazley, David, and Brian K. Jones. Python Cookbook: Recipes for Mastering Python 3. " O'Reilly Me- dia, Inc.", 2013.
5. Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and

Techniques to Build Intelligent Systems
6. Jeeva Jose, Taming Python by Programming, Khanna Publishers, New Delhi,2016.

Semester: II	Course Code: OPE-CC-523
Course Title: LINEAR CONTROL SYSTEMS	Credits: 4

Prerequisite : Basic knowledge in signals and systems.

Objective : To develop skill in analysis and modeling of control systems.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Understand models and components of control systems.
CO2	Analyse various techniques for analysis of control systems.
CO3	Analyse the stability of discrete time systems.

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand models and components of control systems.	PSO1	U	C
CO2	Analyse various techniques for analysis of control systems.	PO3	Ap, An and E	C, P and M
CO3	Analyse the stability of discrete time systems.	PSO5	Cr, E and An	P and M

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I

Introduction to open and closed loop systems-Mathematical models of control systems. Linear time invariant systems-Electrical analogies of mechanical systems-Transfer function- block diagram algebra-signal flow graphs- Mason's gain formula - characteristic equation.

Components of control systems: Servo motors (DC & AC) – synchro - gyroscope - stepper motor - Tacho generator.

Time domain analysis: Specifications, first and second order systems and their step responses.

Module II

Performance analysis: Steady state error analysis - static error coefficient of type 0,1, 2 systems - Dynamic error coefficients.

Stability: Time response for various pole locations - stability of feedback system - Routh's stability criterion

Root locus Techniques: Construction of Root loci – stability from root loci - effect of addition of poles and zeros.

Module III

Frequency domain analysis: Specifications- Correlation between time and frequency responses- Bode plot - Log magnitude vs. phase plot.

Polar plot: Nyquist stability criterion-Nichols chart - Non-minimum phase system - transportation lag.

References:

1. Ogata K., Modern Control Engineering, Prentice Hall of India, New Delhi, 2010.
2. Dorf R. C. and R. H. Bishop, Modern Control Systems, Pearson Education, 2011.
3. Kuo B. C., Automatic Control Systems, Prentice Hall of India, New Delhi, 2002.
4. Nagarath I. J. and Gopal M., Control System Engineering, Wiley Eastern, 2008

Semester: II	Course Code: OPE-CC-524
Course Title: PYTHON PROGRAMMING LAB	Credits: 3

Prerequisite : Basic knowledge in Python.

Objective : To empower the students with hands-on experience and to implement the basic concepts of python programming like math function, Strings, List.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Learn basics of PYTHON.
CO2	To implement the programs using conditional and loop statements.
CO3	To implement file handling techniques.
CO4	To implement concepts of OOPS

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Learn basics of PYTHON.	PSO1	U	P
CO2	To implement the programs using conditional and loop statements.	PO4/PSO2	An, Ap	P
CO3	To implement file handling techniques.	PSO1	E	P
CO4	To implement concepts of OOPS	PO3/PSO2	Cr, E	P, M

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15

Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT (List of Experiments)

Write a program to

1. Demonstrate different number data types in Python.
2. Perform different Arithmetic Operations on numbers in Python.
3. Create, concatenate and print a string and accessing sub-string from a given string.
4. Print the current date in the following format "Mon June 20 02:26:23 IST 2022"
5. Create, append, and remove lists in python.
6. Demonstrate working with tuples in python.
7. Demonstrate working with dictionaries in python.
8. Find largest of three numbers.
9. Convert temperatures to and from Celsius, Fahrenheit. [Formula: c/5 = f-32/9]
10. Construct the stars(*) pattern, using a nested for loop
11. Print prime numbers less than 20.
12. Find factorial of a number using Recursion.
13. Accept the lengths of three sides of a triangle as inputs.
14. Define a module to find Fibonacci Numbers and import the module to another program.
15. Calculate the multiplication of two matrices
16. Search the given number in the list of numbers by using binary search
17. Convert the given decimal number into binary number by using recursion.
18. Sort the list of records in a file.

(At least 10 experiments should be provided)

Semester: II	Course Code: OPE-CC-525
Course Title: COMMUNICATION, SIGNAL ANALYSIS AND CIRCUIT DESIGN LAB	Credits: 3

Prerequisite : Basic knowledge in signals and systems.

Objective : To empower the students with hands-on experience and to providepracticalknowledge about signal generation and its analysis.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Generation of AM, FM signals
CO2	Analysethe modulation and demodulation schemes.
CO3	Analyse the signals from various spectral sources.

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Generation of AM, FM signals	PO4/PSO2	An, Ap	P
CO2	Analysethe modulation and demodulation schemes.	PSO1	E	P
CO3	Analyse the signals from various spectral sources.	PO3/PSO5	Cr, E	P, M

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35

Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT (List of Experiments)

1. AM generation using discrete components
2. AM generation using envelope detector
3. AM detection using envelope detector
4. IF tuned amplifier
5. FM using 555 IC
6. Study of 565 PLL – measurement of lock range and capture range
7. FM generation and demodulation using 565
8. Frequency multiplier using 565
9. PAM modulator and demodulator
10. PWM generation and demodulation using 555 IC
11. PPM generation and demodulation using 555 IC
12. Pseudo Random Binary Sequence generator
13. Delta modulation and demodulation
14. ASK modulation and demodulation
15. FSK modulation and demodulation
16. Digital pulse detector
17. TDM generation
18. BPSK modulation and demodulation
19. Determination of band gap from UV
20. Determination of a compound and its crystalline size from XRD
21. Determination of morphological and structural parameters of a compound from XRD
22. FFT and wavelet analysis of biomedical signals
23. Determination of CIE coordinates and colour parity from PL
24. Curve fitting

(At least 10 experiments should be provided)

Semester: III	Course Code: OPE-CC-531
Course Title: DIGITAL SIGNAL PROCESSING	Credits: 4

Prerequisite : Basic knowledge in signals and systems.

Objective : To enhance the knowledge in analysis and design of various digital Filters associated with DSPs and DSP processor architecture.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Apply linear and circular convolution.
CO2	Evaluate DFT of discrete signals.
CO3	Design a digital filter.
CO4	Understand the architecture of a DSP processor

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Apply linear and circular convolution.	PSO1	U and Ap	C and P
CO2	Evaluate DFT of discrete signals.	PO3	Ap, An and E	C, P and M
CO3	Design a digital filter.	PO5/PSO4	Cr and E	P and M
CO4	Understand the architecture of a DSP processor	PO5/PSO5	U, Ap, An and E	P and M

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35

Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I

Discrete Fourier Series, Discrete Time Fourier Transform, Convolution; Linear and circular convolution, Practical implementation, Overlap-save and overlap-add methods.

Approximation of Fourier transform through DFT, Fast algorithms for DFT -The FFT algorithm – DIT & DIF algorithms, inverse DFT using FFT

ModuleII

Digital filter design:FIR Filters: Impulse response, Transfer function, Linear phase properties, Design: window-based design, frequency sampling design. IIR Filters: Impulse response, Transfer function, Pole-zero representation; Butterworth, Chebyshev, elliptic filter concepts, Approximation problem for IIR filter design - Impulse in variance method, bilinear transform method, matched z-transform method. Frequency transformations, Realization structures: Direct form 1 and 2, parallel and cascade

Module III

Digital Signal Processors:TMS320C6x Architecture, Functional units, Linear and circular addressing modes, TMS320C6x instruction set, Changing the sampling rate using discrete time processing, Sampling rate reduction by an integer factor, Compressor, Time and frequency domain relations, Sampling rate increase by an integer factor, Expander, Time and frequency domain relations, Changing the sampling rate by a rational factor

References:

1. John G. Proakis, Dimitris G. Manolakis, “Digital Signal Processing: Principles, Algorithms and Applications,” Pearson Education, 4th edition, 2007.
2. Rulph Chassaing, “Digital Signal Processing and Applications with the C6713 and C6416 DSK", John Wiley & Sons, Inc., 2005
3. Mitra S. K., “Digital Signal Processing: A Computer Based Approach,” McGraw-Hill Publishing Company, 1998.
4. Oppenheim A. V., Schafer R. W., “Discrete-Time Signal Processing,” Prentice Hall India, 1996.
5. Chi-Tsong Chen, “Digital Signal Processing: Spectral Computation and Filter Design,” Oxford University Press, 2001.
6. Lonnie C. Ludeman, “Fundamentals of Digital Signal Processing,” John Wiley& Sons, NY, 1986.
7. R. E. Bogner, A. G. Constantinidis, (Editors), “Introduction to Digital Filtering,” John Wiley & Sons, NY, 1975.
8. Emmanuel C. Ifeacher, Barry W. Jervis, “Digital Signal Processing: A Practical Approach,” 2nd edn., Pearson Education, 2004.
9. Boaz Porat, “A Course in Digital Signal Processing,” Prentice Hall Inc, 1998.

Semester: III	Course Code: OPE-CC-532
Course Title: VLSI DESIGN	Credits: 4

Prerequisite : None.

Objective : To provide knowledge in VLSI design, fabrication of CMOS circuits and Lithographic technique.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Understand the VLSI design methodologies
CO2	Understand the basic complementary CMOS circuits and their fabrication
CO3	Explain Dynamic Logic Designs
CO4	Discuss the material preparation techniques
CO5	Understand and apply lithographic technique

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand the VLSI design methodologies	PO1	U	F, C
CO2	Understand the basic complementary CMOS circuits and their fabrication	PO2/PSO1	U, Ap	F, C, P
CO3	Explain Dynamic Logic Designs	PO3	U, Ap	P, M
CO4	Discuss the material preparation techniques	PSO5	Ap, An	P, M
CO5	Understand and apply lithographic technique	PSO5	U, Ap, An	C, P, M

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I

VLSI Design Methodologies: Moore's law. Introduction to ASIC design-Full custom ASICs, Standard cell-based ASICs, Gate array-based ASICs, SoCs. Introduction to FPGA technology. Comparison between ASIC and FPGA solutions. ASIC Design flow- Logical and Physical design. Speed, power and area considerations in VLSI design.

MOSFET Logic Design - NMOS logic (Static analysis of Basic gates only), CMOS logic, Static (Static analysis of Basic gates only). Transient analysis and Switching power dissipation of CMOS inverter. Realization logic functions in static CMOS logic, Pass transistor logic, and transmission gate logic (Static analysis only)

Module II

Dynamic Logic Design- Pre-charge- Evaluate logic, Domino Logic, NP domino logic. Read Only Memory-4x4 MOS ROM Cell Arrays (OR, NOR, NAND). Random Access Memory –SRAM-Six transistor CMOS SRAM cell, DRAM –Three transistor and One transistor Dynamic Memory Cell.

Module III

Material Preparation (qualitative analysis only), Purification and Crystal growth (CZ process), wafer preparation. Thermal Oxidation- Growth mechanisms, Dry and Wet oxidation. Diffusion and ion implantation techniques. Epitaxy: molecular beam epitaxy.

Lithography- Photo lithographic sequence, Electron Beam Lithography, Etching and metal deposition techniques. MOSFET Fabrication techniques (qualitative analysis only). Twin-Tub fabrication sequence, Fabrication process flow.

References:

1. Michael John Sebastian Smith, Application Specific Integrated Circuits, Pearson Education,2001.
2. Sung –Mo Kang & Yusuf Leblebici, CMOS Digital Integrated Circuits- Analysis & Design, McGraw-Hill, Third Ed., 2003
3. Wayne Wolf, Modern VLSI design, Third Edition, Pearson Education,2002.
4. S.M. SZE, VLSI Technology, 2/e, Indian Edition, McGraw-Hill,2003.

Semester: III	Course Code: OPE-CC-533
Course Title: DIGITAL SIGNAL PROCESSING LAB	Credits: 3

Prerequisite : Basic knowledge in signal processing.

Objective : To empower the students with hands-on experience in signal and image processing using MATLAB.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Generate elementary waveforms in signal processing.
CO2	Simulate systems related to Digital Signal Processing
CO3	Analyse the biomedical signals.
CO4	Apply histogram analysis and edge detection using image processing

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Generate elementary waveforms in signal processing.	PSO1	U	P
CO2	Simulate systems related to Digital Signal Processing	PO3/PSO5	An, Ap	P
CO3	Analyse the biomedical signals.	PSO1	E	P
CO4	Apply histogram analysis and edge detection using image processing	PO3/PSO5	Cr, E	P, M

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15

Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT (List of Experiments)

Using MATLAB

1. Generation of standard waveforms
   a) Unit Impulse
   b) Unit Step
   c) Ramp
   d) Sine Wave
   e) Cosine wave
   f) Square Wave
2. Analog modulation schemes (a) AM (b) FM (c) PM (d) PAM(e)PWM(f)PPM
3. Digital modulation schemes (a) ASK (b) FSK (c) PSK
4. Design and simulation of various PSK systems-BPSK,DPSK,M-Ary PSK
5. Design and simulation of Channel Coding theorems
6. DFT & IDFT
7. Convolution (with & without conv)
8. Scaling & Shifting
9. Digital Butterworth filters
10. Digital Chebyshev filters
11. Digital filters using FIR
12. Radon transforms
13. Histogram analysis of image
14. Image compression and resizing
15. Edge detection
16. Filtering of images
17. Image encryption and decryption using transforms
18. Image coding using ANN
19. Pattern classification using ANN
20. Loss measurements in image compression

(At least 10 experiments should be provided)

Semester: III	Course Code: OPE-CC-534
Course Title: ELECTIVE LAB – ARTIFICIAL INTELLIGENCE	Credits: 3

Prerequisite : Basic knowledge in AI and machine learning.

Objective : To empower the students with hands-on experience and to providepracticalknowledge in machine learning and implementation using AI.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Understand the implementation procedures for the machine learning algorithms.
CO2	Design Java/Python programs for various Learning algorithms
CO3	Apply appropriate data sets to the Machine Learning algorithms.
CO4	Identify and apply Machine Learning algorithms to solve real world problems

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand the implementation procedures for the machine learning algorithms.	PSO1	U	P
CO2	Design Java/Python programs for various Learning algorithms	PO4/PSO2	An, Ap	P
CO3	Apply appropriate data sets to the Machine Learning algorithms.	PSO3	E	P
CO4	Identify and apply Machine Learning algorithms to solve real world problems	PO3/PSO5	Cr, E	P, M

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15

Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

List of AI Experiments

1. Implement and demonstrate the FIND-S algorithm for finding the most specific hypothesis based on a given set of training data samples. Read the training data from a .CSV file.
2. For a given set of training data examples stored in a .CSV file, implement and demonstrate the Candidate-Elimination algorithm to output a description of the set of all hypotheses consistent with the training examples.
3. Write a program to demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.
4. Implement A* search algorithm. *Hint: Missionaries and Cannibals Problem: Three missionaries and three cannibals are all together on one side of a river. There is one boat that can carry either one or two persons. How can they all cross the river such that there are never less missionaries than cannibals on either side of the river? Implement A*-search procedure traverses the search-space*
5. Implement water-jug problem. *Hint:* For example, there are two jugs of 4 litre and 3 litre capacities. Neither has any markings made on it. There is a pump which issued to fill the jugs with water. How to obtain exactly two litres of water in the 4 litre jug.
6. Implement Knight tour problem. *Hint: In chess game, a knight can move two squares either horizontally or vertically followed by one square in an orthogonal direction as long as it does not move on the board. Find out the series of legal moves in which the knight lands on each square of a chess board exactly once. Given a 3x 3 chess board. Write a program to implement Knight tour problem*
7. Solve 8-Queen problem. *Hint: The goal of Eight Queens problems is to place 8 Queens on a chess board such that no queens attacks any other (A queen attacks any piece 'n' the same row, column or diagonal). Write a program to implement 8 queen problem.*
8. Implement Minimax procedure for Tic-Tac-Toe game. *Hint: Tic-Tac-Toe is a game for two players. The board is a square of 3 x 3 fields. Each player is assigned a type of token (O or X).*

Initially the board is empty. The players play in turn and place a token on an empty Field. A player wins, if she/he has first aligned three of her/his tokens either in a row, a column, or on one of the two diagonals. The game ends when a player wins or when there are no emptier fields. Develop an evaluation function for the Tic-Tac-Toe game. Indicate the values of your evaluation function for each node of the search tree at level 2. Use these values to compute the values of nodes on level 1 and 0 using the Minimax algorithm.

List of Experiments -ML

1. Build an Artificial Neural Network by implementing the Back propagation algorithm and test the same using appropriate data sets.
2. Write a program to implement the naïve Bayesian classifier for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering few test data sets.
3. Assuming a set of documents that need to be classified, use the naïve Bayesian Classifier model to perform this task. Built-in Java classes/API can be used to write the program. Calculate the accuracy, precision, and recall for your data set.
4. Write a program to construct a Bayesian network considering medical data. Use this model to demonstrate the diagnosis of heart patients using standard Heart Disease Data Set. You can use Java/Python ML library classes/API.
5. Apply EM algorithm to cluster a set of data stored in a .CSV file. Use the same data set for clustering using k-Means algorithm. Compare the results of these two algorithms and comment on the quality of clustering. You can add Java/Python ML library classes/API in the program.
6. Write a program to implement k-Nearest Neighbour algorithm to classify the iris data set. Print both correct and wrong predictions. Java/Python ML library classes can be used for this problem.
7. Implement the non-parametric Locally Weighted Regression algorithm in order to fit data points. Select appropriate data set for your experiment and draw graphs.

(At least 10 experiments should be provided from the list)

Semester: IV	Course Code: OPE-CC-541
Course Title: PROJECT	Credits: 12

Prerequisite : None.

Objective :To enable the students to develop deep knowledge, understanding, capabilities in the specialization subject. It should improve their subject knowledge level, experimental and report making skills. It should also enhance aptitude for research and assist career growth.

Learning Outcomes :At the end of 4thsemester, each student has to submit a project report consistingof the work they have done and findings obtained during their project.

Semester: IV	Course Code: OPE-CC-542
Course Title: SEMINAR	Credits: 2

Prerequisite : None.

Objective : To perform a seminar relevant to the field of specialization.

Learning Outcomes : To carry out a seminar presentation relevant to the field of specialization. The students have to submit a report, exhibit (if any) and have to make a presentation before the expert committee.

Semester: IV	Course Code: OPE-CC-543
Course Title: VIVA-VOCE	Credits: 2

Prerequisite **:** None.

Objective **:**To enable the students to develop deep knowledge, understanding, capabilities in the project and with all the core courses. It should improve their subject knowledge level, experimental and communication skills. It should also enhance aptitude for research and assist career growth.

Learning Outcomes **:**At the end of 4thsemester, each student has to prepare for the viva-voce based on theproject report consistingof the work they have done and findings obtained during their project and the topics covering all semesters and awareness of current and advanced topics.

ELECTIVES–ARTIFICIAL INTELLIGENCE

Semester:	Course Code: OPE-DE-501(A)
Course Title: MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE	Credits: 4

Prerequisite : Basic knowledge in Artificial Intelligence.

Objective : To develop knowledge in big data technologies.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Understand the basic knowledge on machine learning.
CO2	Apply regression and classification analysis.
CO3	Understand the concepts of deep learning.
CO4	Carry out clustering analyses.
CO5	Understand the search and control strategies used in AI.

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand the basic knowledge on machine learning.	PO1	U	C
CO2	Apply regression and classification analysis.	PO2	Ap, An and E	C, P and M
CO3	Understand the concepts of deep learning.	PSO1	U	C
CO4	Carry out clustering analyses.	PSO4	An, Cr and Ap	P and M
CO5	Understand the search and control strategies used in AI.	PO4/PSO5	U, Ap, An and Cr	P and M

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I

Supervised Learning, Unsupervised Learning, Semi-supervised Learning, Reinforcement Learning, Active Learning. Applications of Machine Learning, Challenges in Machine Learning, Vapnik - Chervonenkis (VC) Dimension, Probably Approximately Correct (PAC) Learning, Noise, Learning Multiple Classes.

Regression - Linear Regression, Multiple Linear Regression, Polynomial Regression and Logistic Regression, Dimensions of a Supervised Machine Learning Algorithm, Bayesian Decision Theory: Introduction, Classification, Losses and Risks, Discriminant Functions, Utility Theory, Association Rules. Parametric Methods: Introduction, Maximum Likelihood Estimation, Evaluating an Estimator-Bias and Variance, The Bayes' Estimator, Parametric Classification, Regression, Tuning Model Complexity: Bias/Variance Dilemma.

Module II

Clustering: Introduction, Mixture Densities, k-Means Clustering, Expectation- Maximization Algorithm, Mixtures of Latent Variable Models, Supervised Learning after Clustering, Hierarchical Clustering, Choosing the Number of Clusters

Advanced multivariate analysis – Introduction-Dimensionality Reduction - Principal Component Analysis, Linear Discriminant Analysis, Principal Component Analysis Vs. Linear Discriminant Analysis. Factor Analysis, Multidimensional scaling. Semi-supervised, Reinforcement & Active Learning- Introduction - Semi-supervised Learning, Pseudo Labelling. Reinforcement Learning Concepts and Terminologies, Implementation, ϵ (epsilon)-Greedy Algorithm. Active Learning - Concepts of Active Learning, Query Strategies, Steps in Active Learning. Introduction to Deep learning, Applications of Deep Learning, Deep Learning Process, Types of Deep Learning Networks, Limitations of Deep Learning.

Module III

The importance of Artificial Intelligence, Knowledge: Definition and Importance of knowledge, Knowledge–Based Systems, Representation of Knowledge, Knowledge Organization, Knowledge Manipulation, Acquisition of Knowledge. Formalized Symbolic Logics: Introduction, Syntax and Semantics for Propositional Logic and FOPL, Properties of WFFs, Conversion to Clausal Form, Inference Rules, The Resolution Principle; Structured Knowledge: Associative Networks, Frame Structures, Conceptual Dependencies and Scripts.

Search and Control Strategies: Preliminary concepts, Examples of Search Problems, Uniformed or blind

Search, Informed Search, Searching And-Or graphs; Matching Techniques: Introduction, Structures Used in Matching, Measures for Matching, Partial Matching, The RETE Matching Algorithm.

References:

1. Dan W. Patterson, Introduction to Artificial Intelligence and ExpertSystems,PHILearning2014
2. Alpaydin, E. (2009). Introduction to machine learning. MIT press.
3. Trevor, H., Robert, T., & JH, F. (2009). The elements of statistical learning: data mining, inference, and prediction.
4. Jeeva Jose, Introduction to MACHINE LEARNING using PYTHON, Khanna Publishers, New Delhi
5. Vinod Chandra S S, Anand H S, Artificial Intelligence and Machine Learning, Prentice Hall of India, New Delhi,2014
6. C. Bishop, Pattern Recognition and Machine Learning, Springer, 2007.
7. K. Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012.
8. Vinod Chandra S S, Anand H S, Machine Learning: A Practitioners Approach, Prentice Hall of India, New Delhi,2020

Semester:	Course Code: OPE-DE-502(A)
Course Title: ROBOTICS AND INTELLIGENT SYSTEMS	Credits: 4

Prerequisite :Basic knowledge in Artificial Intelligence

Objective : To enhance the knowledge in intelligent systems and its applications in Robotics.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Understand various locomotion techniques in mobile robot
CO2	Describe the various aspects of robot motion control
CO3	Understand challenges in robot motion planning and navigation.
CO4	Use various Localization methods to locate a mobile robot
CO5	Analyse the various techniques involved in robot vision

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand various locomotion techniques in mobile robot	PSO1	U	F
CO2	Describe the various aspects of robot motion control	PO2	U	F, C
CO3	Understand challenges in robot motion planning and navigation.	PSO2	U, Ap	F, C and P
CO4	Use various Localization methods to locate a	PO3	Ap	P and M

	mobile robot			
CO5	Analyse the various techniques involved in robot vision	PSO3	Cr, An	P and M

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

ModuleI
Mobile Robots: Introduction to Wheeled Robots, Classification of wheels, Fixed wheel, Centered Oriented Wheel, Off-centered oriented wheel, Swedish wheel, Mobile robot locomotion, Differential Wheel, Tricycle, Synchronous drive, Omni-directional, Ackerman Steering, Kinematics models of WMR. Robot Motion Control: Robot Motion Planning, Path Planning, Geometric path, Obstacle avoidance, shortest path, Trajectory planning, The boundary conditions, Control Methods- Conventional Joint PID control, Computed torque, Nonlinear feedback, Adaptive Control, Variable Structure Control.

ModuleII
Motion planning and Navigation: Basics, Configuration Space, Obstacles, Motion Planning Methods, Roadmap Approaches, Visibility graphs, Voronoi diagram, Cell Decomposition, Trapezoidal Decomposition, Potential Fields, Bug Algorithms, RRT. Localization and Mapping: Introduction to localization – challenges in localization – localization and navigation, Mapping: map representation, Indoor and outdoor mapping, SLAM, Bayes rule, Passive and active Beacons sensors. Global Positioning System, DGPS, Laser Range Scanner.

ModuleIII
Robot Vision: Introduction, Image acquisition, Illumination Techniques, Image Conversion, Frame Buffers and Grabbers, Image sampling and Quantization, Basic Relationship between pixels, Image enhancement in Spatial and Frequency domain, Image Processing and Analysis Data Reduction: Edge detection, Feature Extraction and Object Recognition Algorithm and its applications.

References:

1. Fu,K.S. ,et al "Robotics- Control, Sensing, Vision and Intelligence ", McGraw – Hill,1987.

2. H.R.Everett, “Sensors for Mobile Robots – Theory and Applications”, A.K.Peteres Ltd. 1995. ISBN 1-56881-048-2.
3. Roland Siegwart, Illah R, Nourbakhsh, “Introduction to Autonomous Mobile Robots”, The MIT Press, 2004. ISBN 0-262-19502-X.
4. “Robotics and Automation Handbook”, Edited: Thomas R. Kurfees,, CRC Press 2005.

Additional References:

1. “Where am I? Sensors and Methods for Mobile Robot Positioning”, J. Borenstein, et al., The University of Michigan, 1996.
2. “Applying Machine Vision”, Zuech, Nello, John Wiley and Sons, 1988. 7. “Robotics and Image Processing”, Janakiraman P.A, Tata McGraw-Hill, 1995.

Semester:	Course Code: OPE-DE-503(A)
Course Title: IMAGE PROCESSING	Credits: 4

Prerequisite :Basic knowledge in digital image processing.

Objective : To provide basic of digital image representation and processingtechniques.

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

CO No.	CO Statement
CO1	Remember the fundamentals and concepts in signal processing.
CO2	Discuss about various transforms of two-dimensional sequences.
CO3	Discuss about the two-dimensional transform coding.
CO4	Design and development of spatial filtering
CO5	Design and development of wiener filtering
CO6	Apply software practice for designing of image compression technique.

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Remember the fundamentals and concepts in signal processing.	PO1	R	C
CO2	Discuss about various transforms of two-dimensional sequences.	PO2	U	F
CO3	Discuss about the two-dimensional transform coding.	PO2	Ap,Cr	C
CO4	Design and development of spatial filtering	PSO2	Cr	M
CO5	Design and development of wiener filtering	PSO2	Cr	P

CO6	Apply software practice for designing of image compression technique.	PSO5	Ap	M

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I

Introduction, Digital Image Fundamentals: elements of visual perception, light and electromagnetic spectrum, image sensing and acquisition, image sampling and quantization, some basic relationship between pixels. Intensity Transformations: Basics of intensity transformations, some basic intensity transformation functions, histogram processing.

Module II

Spatial Filtering: fundamentals of spatial filtering, smoothing and sharpening filters. Frequency domain Filtering: Background, preliminary concepts, sampling, Fourier transforms and DFT, 2-D DFT and properties, frequency domain filtering, low pass filters, high pass filters, implementation.

Module III

Image restoration and Reconstruction: Noise models, restoration in the presence of noise, linear positive invariant degradations, inverse filtering, Wiener filtering, constrained least square filtering, geometric mean filter.

Image Compression: fundamentals, basic compression methods. Morphological Image Processing: preliminaries, erosion and dilation, opening and closing, basic morphological algorithms. Image Segmentation: fundamentals, point, line and edge detection, thresholding, region based segmentation, use of motion in segmentation.

References:

1. Jain, A. K. (1989). Fundamentals of digital image processing. Englewood Cliffs, NJ: Prentice Hall.
2. Pratt, W. K. (2007). Digital image processing: PIKS Scientific inside (Vol. 4). Hoboken, New Jersey: Wiley-interscience.
3. Aggarwal, C. C., &Zhai, C. (Eds.). (2012). Mining text data. Springer Science & Business Media.
4. Jurafsky, D. (2000). Speech & language processing. Pearson Education India.
5. Gonzalez, R. C., & Woods, R. E. (2002). Digital image processing.

Semester:	Course Code: OPE-DE-504(A)
Course Title: PATTERN RECOGNITION	Credits: 4

Prerequisite :Basic knowledge in digital image processing.

Objective : To provide an idea about pattern recognition.

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

CO No.	CO Statement
CO1	Remember the fundamentals and concepts in signal processing.
CO2	Discuss about the image enhancement technique.
CO3	Discuss about the shape analysis.
CO4	Design and development of Hough transform.
CO5	Apply software practice for designing of pattern recognition.

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Remember the fundamentals and concepts in signal processing.	PSO1	R	C
CO2	Discuss about the image enhancement technique.	PO1	U	F
CO3	Discuss about the shape analysis.	PO1/PSO2	Ap, Cr	C
CO4	Design and development of Hough transform.	PSO2/PSO3	Cr	M
CO5	Apply software practice for designing of pattern recognition.	PSO1	R	C

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create, **KC- Knowledge Category**: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

MODULE I:

Introduction to pattern recognition, pattern recognition methods, pattern recognition system design, statistical pattern recognition – classification, principle, classifier learning, neural networks for pattern classification.

Introduction to shape analysis, shape representation, irregular shape representation, shape representation in image processing , shape representation by convex hull, SPCH algorithm for convex hull finding, stair-climbing method for simple polygon finding, properties of the simple polygon, Sklansky's algorithm for convex hull finding, convex hull based shape representation, boundary and convex hull, description function, feature extraction and shape classification, measurements, feature extraction, shape classification, examples of shape analysis, fractals, self-similarity, fractal dimension, multi-fractals, fractals based shape representation, boundary and fractal dimension, region and fractal dimension.

MODULE II:

Introduction to roundness / sharpness analysis, problem of roundness analysis, problem of circle and arc detection, Hough transform, definition of Hough transform, algorithm of Hough transform, circular, Hough transform, algorithms for circular Hough transform curve detection, basic method, directional gradient method, centre method, gradient centre method, radius method, threshold function , sharp corners, examples of roundness/sharpness analysis.

Introduction to orientation analysis, problem of orientation analysis, development of orientation analysis, directed vein method, directed vein image, orientation of a vein, algorithm, convex hull method, principal component transformation, theory of principal component transformation, orientation by principal component transformation, theory of moments, central moments, orientation by moments, examples of orientation analysis

MODULE III:

Introduction to arrangement analysis, aggregates, examples of arrangements, extended Hough transform, Hough transform, extension of Hough transform, simplified extended Hough transform, arrangement features, orientation and position, description in Hough space, feature extraction, more arrangement, measurements, more features description and classification of arrangements.

REFERENCES

1. Daisheng Luo, Pattern Recognition and Image Processing, Horwood Publishing, England, 1998.
2. Milam Sonka, Vaclav HLAVAC, Roger Boyle, Image Processing, Analysis and Machine Vision, 2ndEdn, Thomson Learning, 2001.

ADDITIONAL REFERENCES

1. Jr. Parker, Algorithms for Image Processing and Computer Vision, John Wiley.

2. Francis T.S YU and Suganda Jutamulia (Eds), Optical Pattern Recognition, Cambridge University Press, 1998

3. Conelius T Leondes (Ed), Image Processing and Pattern Recognition, Academic Press, 1998.

Semester:	Course Code: OPE-DE-505(A)
Course Title: ARTIFICIAL NEURAL NETWORKS	Credits: 4

Prerequisite : Basic knowledge in computing.

Objective : To familiarize the concept of biological neural network and implementation of neural networking for problem solving in real life.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Deals with the principle and working of biological neural network, adaptation of various paradigms and learning principles.
CO2	Describes fundamental theorems and their applications
CO3	Deals with Radial basis function network for modelling applications, multilayer perceptrons and associative learning rules
CO4	Deals with Self organized maps with unsupervised learning, winner networks and adaptive resonance theory for computational applications
CO5	Deals with self-organizing maps and issues regarding linearly separable and non-linearly separable patterns.
CO6	Deals with Hopfield network, Boltzmann machine and applications.

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Deals with the principle and working of biological neural network, adaptation of various paradigms and learning principles.	PSO1	R, U	F, C
CO2	Describes fundamental theorems and their applications	PO2	Ap, E	C, P
CO3	Deals with Radial basis function network for modelling applications, multilayer perceptrons and	PO2	Ap, Cr	P

	associative learning rules			
CO4	Deals with Self organized maps with unsupervised learning, winner networks and adaptive resonance theory for computational applications	PSO3	E, Cr	P, M
CO5	Deals with self-organizing maps and issues regarding linearly separable and non-linearly separable patterns.	PSO3	Cr, An	M
CO6	Deals with Hopfield network, Boltzmann machine and applications.	PSO3	Ap, Cr	P, M

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I

Introduction – uses of neural networks, Biological neural networks- neuro physiology, models of a neuron- McCulloch & Pitts model, Activation functions- types, multiple input neurons. Learning processes- learning paradigms- supervised and unsupervised learning.

Single layer perceptrons-Architecture-learning rule- Perceptron convergence theorem. Performance learning-Quadratic functions-performance optimization-steepest descent algorithm, learning rates, Widrow-Hoff learning- ADALINE networks, LMS algorithm, linear separability- The XOR problem, Multilayer perceptrons (MLPs) – Backpropagation algorithm.

Module II

RBF networks- Cover's theorem on separability of patterns, comparison of RBF networks and MLPs. Associative learning- Unsupervised Hebb rule, Instar and outstar rules.

Competitive learning- Winner –Take-All networks, Learning Vector Quantizers, Counter propagation networks, Adaptive Resonance Theory (ART) - ART1 clustering algorithm, ART1 network architecture.

Module III

Self-organizing maps (SOM), Support vector machines: optical hyperplane for linearly separable and

non-separable patterns, design of support vector machines. Principal component analysis (PCA) networks. Hopfield networks – Discrete Hopfield networks- energy function- storage capacity of Hopfield networks, Optimization using Hopfield networks- Travelling salesperson problem, solution of simultaneous linear equations, character retrieval. Boltzmann machines. Simulated annealing.

References:

1. Martin T. Hagan, Howard B. Demuth & Mark Beale, Neural Network Design,Vikas Thomson learning, 2014.
2. Mohamad H. Hassoun, Fundamentals of Artificial Neural Networks, 1995.
3. Simon Haykin,Neural Networks,A Comprehensive Foundation, Pearson Education, 1999.

Additional References:

1. Bose &Liang,Neural Network Fundamentals, McGraw Hill, 1995.
2. James A Freeman, David M. Skapura,Neural Networks, Algorithms, Applications and Programming Techniques,Pearson Education, 1991.
3. KishanMehrotra, Chilukuri K. Mohan, Sanjay Ranka: Elements of Artificial Neural Networks, Penram International Publishing (India), 2009.

Semester:	Course Code: OPE-DE-506(A)
Course Title: FRAUD ANALYTICS	Credits: 4

Prerequisite :None.

Objective : To provide basic knowledge on analysis of fraud and fraud detection models.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Understand the basic knowledge on analysis of fraud
CO2	Understand fraud detection models
CO3	Develop automation process of fraud detection
CO4	Compare different models
CO5	Formulate and evaluate fraud detection

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand the basic knowledge on analysis of fraud	PO1	U	C
CO2	Understand fraud detection models	PSO1	U	C
CO3	Develop automation process of fraud detection	PSO2	Ap	P
CO4	Compare different models	PO2	An	P, M
CO5	Formulate and evaluate fraud detection	PSO5	Cr	P, M

(**CL- Cognitive Level:** R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, C- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I

Formulation and evaluation of fraud detection - Fraud detection using data analysis. Obtain and cleanse the data for fraud detection-preprocess data for fraud detection - sampling, missing values, outliers, categorization etc.- Explain characteristics and components of the data and assess its completeness

Module II

Identify known fraud symptoms -and use digital analysis to identify unknown fraud symptoms— Fraud detection models using supervised analytics (logistic regression, decision trees, neural networks, ensemble models, etc.

Automating fraud detection process -Fraud detection models using unsupervised analytics (hierarchical clustering, non-hierarchical clustering, k-means, self-organizing maps, etc.

ModuleIII

Fraud detection models using social network analytics (homophily, featurization, egonets, PageRank, bigraphs etc. -Verification of results and understand how to prosecute fraud. Fraud detection and prevention-case studies.

References:

1. Nigrini, M. J. (2011). Forensic analytics: methods and techniques for forensic accounting investigations (Vol. 558). John Wiley & Sons.
2. Baesens, B., Van Vlasselaer, V., & Verbeke, W. (2015). Fraud analytics using descriptive, predictive, and social network techniques: a guide to data science for fraud detection. John Wiley & Sons.

Semester:	Course Code: OPE-DE-507(A)
Course Title: FUZZY SYSTEMS AND APPLICATIONS	Credits: 4

Prerequisite :None.

Objective : To provide basic knowledge on fuzzy systems.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Understand the concept of fuzzy set and its properties
CO2	Explain Extension Principle and its application
CO3	Discuss the operation on fuzzy relation
CO4	Understand the fuzzy logic controllers
CO5	Develop a system with fuzzy logic.

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand the concept of fuzzy set and its properties	PSO1	U	F and C
CO2	Explain Extension Principle and its application	PO2	U, Ap	C and P
CO3	Discuss the operation on fuzzy relation	PO3	Ap, An	P and M
CO4	Understand the fuzzy logic controllers	PSO3	U, E	P and M
CO5	Develop a system with fuzzy logic.	PSO5	Ap, An, Cr	P and M

(**CL- Cognitive Level:** R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, C- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I

Introduction to fuzzy sets and systems – crispness, vagueness- uncertainty and fuzziness. Basics fuzzy sets, membership functions, support of a fuzzy set height, normalized fuzzy set, α cuts. Properties of Fuzzy set. Operation on fuzzy set – complement, intersection, union, equality & subset hood.

Module II

Law of excluded middle, law of contradiction, concentration, dilation, contrast intensification. Type -2 fuzzy sets, Extension Principle and its application. Fuzzy relation, operation on fuzzy relation, Projection, max – mini composition, cylindrical extension. Reflexivity, symmetry and Transitivity. Fuzzy prepositions, fuzzy connectives, linguistic variables, linguistic hedges. Fuzzy quantifiers.

ModuleIII

Approximate reasoning or fuzzy inference, generalized modus ponens (GMP), generalized diagram of fuzzy logic controllers, Multi input multi output control system. Automatic train operating system.

References:

1. Timothy J. Ross, Fuzzy logic with Engineering applications, 2ndedn, McGraw Hill.
2. Zimmerman H.J, Fuzzy set theory and its applications, 4thed, Springer, 2001.
3. Ganesh M, Introduction to fuzzy sets and Fuzzy logic, PHI, 2006.

Semester:	Course Code: OPE-DE-508(A)
Course Title: ADVANCED MACHINE LEARNING	Credits: 4

Prerequisite :None.

Objective : To provide basic knowledge on analysis of fraud and fraud detection models.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Explain advanced machine learning models
CO2	Explain deep learning
CO3	Understand CNN, reinforcement learning
CO4	Understand learning algorithms
CO5	Apply advanced machine learning techniques

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Explain advanced machine learning models	PO2	U	F, C
CO2	Explain deep learning	PO2	U, Ap	F, C
CO3	Understand CNN, reinforcement learning	PSO2	U, Ap	P
CO4	Understand learning algorithms	PSO3	Ap, An	P, M
CO5	Apply advanced machine learning techniques	PSO5	Ap, Cr	P, M

(**CL- Cognitive Level:** R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, C- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15

Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I

Multilayer Perceptrons: Introduction, The Perceptron, Training a Perceptron, Learning Boolean Functions, Multilayer Perceptrons, Backpropagation Algorithm, Training Procedures, Competitive Learning, Radial Basis Function, Introduction to Kernel Machines, Optimal Separating Hyperplane, The Nonseparable Case-Soft Margin Hyperplane, ν-SVM, Kernel Trick, Vectorial Kernels, Defining Kernels
What is deep learning? DL successes -Intro to neural networks (Kate) cost functions, hypotheses and tasks; training data; maximum likelihood-based cost, cross entropy, MSE cost; feed -forward networks; MLP, sigmoid units; neuroscience inspiration; Learning in neural networks (Kate) output vs hidden layers; linear vs nonlinear networks.

Module II

Back propagation (Kate) learning via gradient descent; recursive chain rule (backpropagation); if time: bias-variance trade off, regularization; output units: linear, softmax; hidden units: tanh, RELU V Deep learning strategies I (Brian) (e.g., GPU training, regularization,etc); Deep learning strategies II (Brian) (e.g., RLUs, dropout, etc)-SCC/TensorFlow overview (Katia Oleinik) How to use the SCC cluster; introduction to Tensor flow.

Module III

CNNs (Kate) Convolutional neural networks -CNNs II (Kate) -Deep Belief Nets I (Brian) probabilistic methods-Deep Belief Nets II (Brian) -RNNs I (Sarah) Recurrent neural networks - RNNs II (Kate)-Other DNN variants (Kate) (e.g. attention, memory networks, etc.)
Overview of reinforcement learning: the agent environment framework, successes of reinforcement learning-Bandit problems and online learning-Markov decision processes-Returns, and value functions-Solution methods: dynamic programming-Solution methods: Monte Carlo learning- Solution methods: Temporal difference learning-Eligibility Traces-Value function approximation (function approximation)-Models and planning (table lookup case).

References:

1. Learning, D. (2016). Ian Goodfellow, Yoshua Bengio, Aaron Courville.
2. Sutton, R. S., &Barto, A. G. (1998). Introduction to reinforcement learning (Vol. 135). Cambridge: MIT press.
3. Szepesvári, C. (2010). Algorithms for reinforcement learning. Synthesis lectures on artificial intelligence and machine learning, 4(1), 1-103.
4. Alpaydin, E. (2010). Introduction to machine learning.

Semester:	Course Code: OPE-DE-509(A)
Course Title: INFORMATION THEORY AND CODING	Credits: 4

Prerequisite :None.

Objective : To provide basic knowledge on coding.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Understand the concepts of information theory.
CO2	Discuss the types of coding
CO3	Discuss cryptography
CO4	Explain digital signatures and its applications

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand the concepts of information theory.	PO1	U	F and C
CO2	Discuss the types of coding	PO2	U, Ap	C and P
CO3	Discuss cryptography	PSO3	Ap, C	C and P
CO4	Explain digital signatures and its applications	PO5	Ap, An, E	P and M

(**CL- Cognitive Level:** R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, C- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15

Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I

Information – Entropy, information rate, classification of codes, Kraft McMillan inequality, source coding theorem, Shannon-Fano coding, Huffman coding, Extended Huffman coding – Joint and conditional entropies, Mutual information – Discrete memory less channels – BSC, BEC – Channel capacity, Shannon limit.

Module II

Definitions and principles: Hamming weight, Hamming distance, Minimum distance decoding – Single parity codes, Hamming codes, Repetition codes – Linear block codes, Cyclic codes- Syndrome calculation, Encoder and decoder - CRC.

ModuleIII

Convolutional codes – code tree, trellis, state diagram – Encoding – Decoding: Sequential search and Viterbi algorithm – Principle of Turbo coding, Cryptography: Secret key cryptography, block and stream ciphers, DES, Public key cryptography, digital signatures.

References:

1. Dr.P.SSathya Narayana: Concepts of Information Theory & Coding, Dynaram Publications
2. R Bose, “Information Theory, Coding and Cryptography”, TMH 2007.
3. Simon Haykin: Communication Systems, 4th ed., John Wiley & Sons Pvt. Ltd.
4. Taub& Schilling: Principles of Communication Systems, 2nd ed., TMH, New Delhi.
5. Ranjan Bose: Information Theory, Coding and Cryptography, TMH, New Delhi.

Semester:	Course Code: OPE-DE-5010(A)
Course Title: INTERNET OF THINGS	Credits: 4

Prerequisite :None.

Objective : To provide basic knowledge on analysis of fraud and fraud detection models.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Understand the various concepts, terminologies and architecture of IoT systems
CO2	Apply sensors and actuators for design of IoT
CO3	Understand and apply various protocols for design of IoT systems
CO4	Apply various techniques of data storage and analytics in IoT
CO5	Understand various applications of IoT

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand the various concepts, terminologies and architecture of IoT systems	PSO1	U	F, C
CO2	Apply sensors and actuators for design of IoT	PO5	U, Ap	F, C
CO3	Understand and apply various protocols for design of IoT systems	PSO3	U, Ap	P
CO4	Apply various techniques of data storage and analytics in IoT	PSO5	Ap, An	P, M
CO5	Understand various applications of IoT	PSO5	U, Ap	C, P, M

(**CL- Cognitive Level:** R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, C- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	

Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I

Fundamentals of IoT: Introduction, Definitions & Characteristics of IoT, IoT Architectures, Physical & Logical Design of IoT, Enabling Technologies in IoT, History of IoT, About Things in IoT, The Identifiers in IoT, About the Internet in IoT, IoT frameworks, IoT and M2M.

Sensors Networks: Definition, Types of Sensors, Types of Actuators, Examples and Working, IoT Development Boards: Arduino IDE and Board Types, RaspberriPi Development Kit, RFID Principles and components, Wireless Sensor Networks: History and Context, The node, Connecting nodes, Networking Nodes, WSN and IoT.

Module II

Wireless Technologies for IoT: WPAN Technologies for IoT: IEEE 802.15.4, Zigbee, HART, NFC, Z-Wave, BLE, Bacnet, Modbus. IP Based Protocols for IoT IPv6, 6LowPAN, RPL, REST, AMPQ, CoAP, MQTT. Edge connectivity and protocols

Data Handling& Analytics: Introduction, Bigdata, Types of data, Characteristics of Big data, Data handling Technologies, Flow of data, Data acquisition, Data Storage, Introduction to Hadoop. Introduction to data Analytics, Types of Data analytics, Local Analytics, Cloud analytics and applications.

Module III

Applications of IoT: Home Automation, Smart Cities, Energy, Retail Management, Logistics, Agriculture, Health and Lifestyle, Industrial IoT, Legal challenges, IoT design Ethics, IoT in Environmental Protection.

References:

1. Hakima Chaouchi, ― "The Internet of Things Connecting Objects to the Web" ISBN: 978-1-84821-140-7, Wiley Publications
2. Olivier Hersent, David Boswarthick, and Omar Elloumi, ― "The Internet of Things: Key Applications and Protocols", WileyPublications
3. Vijay Madisetti and ArshdeepBahga, ― "Internet of Things (A Hands-on-Approach)", 1 st Edition, VPT, 2014.
4. J. Biron and J. Follett, "Foundational Elements of an IoT Solution", O'Reilly Media, 2016.
5. Keysight Technologies, "The Internet of Things: Enabling Technologies and Solutions for Design and Test", Application Note, 2016.
6. Daniel Minoli, ― "Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications", ISBN: 978-1-118-47347-4, Willy Publications
7. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press.

Semester:	Course Code: OPE-DE-5011(A)
Course Title: BIG DATA TECHNOLOGIES	Credits: 4

Prerequisite : Nil.

Objective : To develop knowledge in big data technologies.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Understand the elements of big data.
CO2	Understand the analytics and big data models.
CO3	Understand the MapReduce framework.
CO4	Develop simple MapReduce application.
CO5	Analyse the high value big data use.

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand the elements of big data.	PO1	U,	C
CO2	Understand the analytics and big data models.	PSO1	U and E	F, P and C
CO3	Understand the MapReduce framework.	PSO1	U, An and Ap	P and M
CO4	Develop simple MapReduce application.	PO2	An, Cr and Ap	P and M
CO5	Analyse the high value big data use.	PSO3	Ap, An and Cr	P and M

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I

Big Data – Introduction, Structuring Big Data, Elements of Big data, Big data analytics, Big data applications. Big Data in business context, Technologies for handling big data –Distributed and Parallel computing for Big Data, Data Models, Computing Models, Introducing Hadoop – HDFS and MapReduce.

Understanding Analytics and Big data – Comparison of Reporting and Analysis, Types of Analytics, Analytical approaches. Hadoop Eco-System, Hadoop Distributed file system, HDFS architecture, MapReduce, Hadoop YARN, Introducing HBase, Hive and Pig

Module II

MapReduce framework, Techniques to Optimize MapReduce, Uses of MapReduce, Role of HBase in Big data processing, Processing Data with MapReduce – Framework, Developing simple MapReduce Application.

MapReduce execution and Implementing MapReduce Programs, YARN Architecture – Limitations of MapReduce, Advantages of YARN, Working of YARN, YARN Schedulers,Configurations,Commands, Containers.

Module III

Introduction to Mahout – Machine Learning, Clustering, Classification, Mahout Algorithms, Environment for Mahout. Introduction to NoSQL.

Overview of High Value BD Use Cases and Examples

References:

1. DTEditorialServices,"BigData,BlackBook:CoversHadoop2,MapReduce,Hive,YARN,Pig,RandDataVisualizationWileyIndia.
2. Lublinsky,B.,Smith,K.T.,&Yakubovich,A.(2013).Professionalhadoopsolutions.JohnWiley&Sons.
3. ChrisEaton, DirkDeroos (2012), "UnderstandingBigdata",McGrawHill.
4. SimaAcharya,SubhashiniChellappan,BigDataandAnalytics,Willey.
5. TomWhite (2012),"Hadoop:ThedefinitiveGuide",OReilly.
6. VigneshPrajapati(2013),"BigDataAnalyticswithRandHadoop",PacketPublishing.
7. Kulkarni,P.,Joshi,S.,&Brown,M.S.(2016).Bigdataanalytics.PHILearningPvt.Ltd.

Semester: I	Course Code: OPE-DE-5012(A)
Course Title: ANALOG INTEGRATED CIRCUITS	Credits: 4

Prerequisite : Basic knowledge in electronic circuits.

Objective :

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Understand the concepts of operational amplifiers
CO2	Apply the characteristics of OPAMPs in electronic circuit designs
CO3	Understand waveform generators
CO4	Explain about filter circuits
CO5	Use filter circuits in electronic applications

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand the concepts of operational amplifiers	PSO1	U	C
CO2	Apply the characteristics of OPAMPs in electronic circuit designs	PO2	Ap, Cr	P, M
CO3	Understand waveform generators	PSO1	U, Ap	C, P, M
CO4	Explain about filter circuits	PO2	Ap	P, M
CO5	Use filter circuits in electronic applications	PO4/PSO4	Ap, Cr, An	P, M

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I

Difference amplifiers: Differential amplifier using BJT, differential and common mode gains, CMRR, input and output resistance, Voltage gain.

Monolithic IC operational amplifiers, The 741 Op Amp-Block diagram, specifications, Ideal op-amp parameters and typical parameter. Equivalent circuit, slew rate and methods of improving slew rate. Open loop configurations, Op-amp with negative feedback, Virtual ground. Inverting and non-inverting amplifiers- gain, input and output resistances.

Module II

Applications: Summer, Voltage Follower, Differential and Instrumentation Amplifiers, Voltage to current and Current to voltage converters, Integrator, Differentiator, Precision rectifiers, Comparators, Schmitt Triggers, Log and antilog amplifiers.

Waveform generators: Phase Shift and Wien-bridge Oscillators, Triangular and Saw tooth waveform generators, Astable and monostable multivibrators.

Module III

Filter circuits: Passive and active filters. First and second order low pass, High pass, Band pass and band reject active filters, state variable filters

Timer IC 555- Functional diagram, Astable and monostable operations; Voltage Controlled Oscillator (LM566)-basic concept and application, Phase Locked Loop(PLL IC 565) – Basic building blocks, Operation, Lock and capture range and Applications.

Voltage Regulators: Fixed and Adjustable voltage regulators, IC 723, Data Converters: Digital to Analog converters, Specifications, Weighted resistor type and R-2R Ladder type. Analog to Digital Converters: Specifications, Flash type and Successive approximation type.

References:

1. Roy D. C. and S. B. Jain, Linear Integrated Circuits, New Age International, 3/e, 2010
2. D Franco S., Design with Operational Amplifiers and Analog Integrated Circuits, 3/e, Tata McGraw Hill, 2008
3. Gayakwad R. A., Op-Amps and Linear Integrated Circuits, Prentice Hall, 4/e, 2010
4. David A. Bell, Operational Amplifiers & Linear ICs, Oxford University Press, 2nd edition, 2010.

Semester:	Course Code: OPE-DE-5013(A)
Course Title: MICROPROCESSOR AND MICROCONTROLLER	Credits: 4

Prerequisite :None.

Objective : This course deals with the basic overview of microprocessor. It will also include discussion of architecture, programming and interfacing of 8051 microcontroller.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Understand basic computer system using 8086 microprocessor.
CO2	Identify the various features in microprocessors
CO3	Demonstrate the basic architecture of 8051
CO4	Write assembly language programs for 8051 microcontroller
CO5	Interface various input and output devices to design embedded systems using 8051 microcontroller

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand basic computer system using 8086 microprocessor.	PSO1	U	F and C
CO2	Identify the various features in microprocessors	PO2	U	F and C
CO3	Demonstrate the basic architecture of 8051	PO2	U, Ap	C and P
CO4	Write assembly language programs for	PSO4	Ap and Cr	P and M

	8051 microcontroller			
CO5	Interface various input and output devices to design embedded systems using 8051 microcontroller	PSO5	Ap and An	P and M

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I
Evolution of microprocessors and microcontrollers. Architecture of 8086/8088 Microprocessor, Pin assignments, minimum and maximum mode, addressing modes, interrupts, instruction format, instruction set and assembly language programming. Peripheral Devices and their Interfacing: Memory and I/O interfacing, data transfer schemes. Programmable peripheral interface (8255), Programmable DMA controller (8257), Programmable interrupt controller (8259), Programmable communication interface (8251).

Module II
Introduction to Microcontrollers and Embedded Processors. Architecture – Block diagram of 8051, Pin diagram, Special Function Registers (SFRs), Internal Memory, Timers, Port Structures, and Interrupts. Assembly Language Programming - Addressing Modes, Instruction set (Detailed study of 8051 instruction set is required).

Module III
Assembly languageprogramming of 8051 with simple examples. Interfacing with 8051 using Assembly language programming: LED, seven segment LED display. Programming in C - Declaring variables, Simple examples – delay generation, port programming and code conversion. Interfacing of – LCD display/Keyboard/Stepper Motor/DAC/ADC -- with 8051 and its programming.

References:

1. D.V.Hall, Microprocessors and Interfacing. TMGH, 2nd edition**.**
2. Liu and GA Gibson, "Micro computer system 8086/8088 family architecture, programming and design" PHI, 2nd Ed.,
3. Muhammed Ali Mazidi & Janice Gilli Mazidi, R.D. Kinley, The 8051 microcontroller and Embedded System, Pearson Education, 2nd edition.
4. K Uma Rao & Andhe Pallavi, "The 8051 Microcontrollers: Architecture Programming and Applications", Pearson, 2011.

Semester:	Course Code: OPE-DE-5014(A)
Course Title: DIGITAL SYSTEM DESIGN	Credits: 4

Prerequisite :Knowledge in designing complex, high speed digital systems.

Objective : To expertise students ondifferent methods for logic representation, manipulation and optimization for both combinational and sequential logic.

LearningOutcomes :On completion of the course, the student will be able to

CO No.	CO Statement
CO1	Understand the concepts of digital design by using combinational and sequential modules.
CO2	Analysis of combinational systemsimplementation with ROM's and PLA's.
CO3	Analysis of multi-module implementation of combinational and sequential systems.
CO4	Analysis of networks in the canonical implementation.
CO5	Discuss different sequential and combinational modular networks.
CO6	Discuss Synchronous and Asynchronous sequential circuits

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand the concepts of digital design by using combinational and sequential modules.	PSO1	U	F,C
CO2	Analysis of combinational systemsimplementation with ROM's and PLA's.	PO2	An,Ap	P
CO3	Analysis of multi-module implementation of combinational and sequential systems.	PO2	An,Ap	P

CO4	Analysis of networks in the canonical implementation.	PO2	An,Ap	P
CO5	Discuss different sequential and combinational modular networks.	PSO2	U	F, C
CO6	Discuss Synchronous and Asynchronous sequential circuits	PO4	U	F, C

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

ModuleI

IntroductiontocombinationalModulesandmodularnetworks.StandardcombinationalModules,designofarithmeticModules.ImplementationofcombinationalsystemswithROM'sandPLA's.Comparisonwith otherapproaches.

Implementation of multi-Module combinational systems – decoder networks,Multiplexertrees,demultiplexernetwork,encodernetwork,shifternetworkandbarrel shifters.

ModuleII

Canonicalimplementation–analysisandsynthesisofnetworksinthecanonical implementation. Flip flop Modules and networks. Modular sequential networks.Standardsequential Modules. Registers– shift register.

Counters–RAM–contentaddressablememoriesandprogrammablesequentialarrays(PSA)–

DesignofsequentialsystemswithsmallnumberofstandardModules- state register and combinational networks – RAM and combinational networks – SR andcombinationalnetworks.

Module III

Multi-Moduleimplementationofsequentialsystems–multi-Moduleregisters–shiftregistersandRAMs–multi-Modulecounters.Introductiontosynchronousdigitalsystems: state diagram, state tables, state reduction

methods, state assignments, Mealy andMooremachines.
Time behaviour of synchronous sequential systems. Minimization of numberofstates.Specificationofvarioustypesofsequentialsystem,sequentialcircuitdesign.Asynchronousseq uentialcircuits:derivationofexcitationtable,raceconditionsandcycles.

References:

1. MilosD.Ercegovac,TomasLang:DigitalSystemsandHardware/FirmwareAlgorithm,John Wiley.
2. WilliamIFletcher:AnEngineeringApproachtoDigitalDesign,Prentice Hall.
3. Hayes:DigitalSystemDesignand Microprocessors,McGrawHill.
4. JohnBPeatman:DigitalHardwareDesign,McGrawHill.
5. CharlesH. Roth,Jr., Fundamentals ofDigital Design,PWS Pub.Co. 1998.
6. KennethJ Breeding,DigitalDesignFundamentals,PrenticeHall,EnglewoodCliffs,NewJersey,1989.
7. JamesE.Palmer, IntroductiontoDigitalDesign, DavidE.Perlman,TataMcGrawHill, 1996.
8. JohnF.Wakerly,DigitalDesignPrinciplesandPractices,PrenticeHall,4thEdition,2001.

Semester:	Course Code: OPE-DE-5015(A)
Course Title: DIGITAL COMMUNICATION	Credits: 4

Prerequisite : Knowledge in signal processing.

Objective :To introduce basic theory and techniques in digital communication.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Remember the fundamentals and concepts in signal processing.
CO2	Design of different modulation techniques.
CO3	Evaluate the bit error rate for different modulation techniques.
CO4	Discuss multiple access techniques.
CO5	Construct of source coding.
CO6	Apply MATLAB for designing of various communication systems.

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Remember the fundamentals and concepts in signal processing.	PSO1	R	C
CO2	Design of different modulation techniques.	PO2/PSO2	Ap, Cr	M
CO3	Evaluate the bit error rate for different modulation techniques.	PO3	E	P
CO4	Discuss multiple access techniques.	PSO2	U	C

CO5	Construct of source coding.	PO1/PSO2	Cr	P
CO6	Apply MATLAB for designing of various communication systems.	PO4/ PSO4	Ap	M

(**CL- Cognitive Level**: R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, Cr- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

MODULE I:

Digital communication system (description of different Modules of the block diagram), Complex baseband representation of signals, Gram-Schmidt orthogonalization procedure. M-ary orthogonal signals, bi-orthogonal signals, simplex signal waveforms.

Pulse modulation – Sampling process – PAM – Quantization – PCM – Noise in PCM system - TDM – Digital multiplexers – Modifications of PCM – Delta modulation – DPCM – ADPCM – ADM. Base band pulse Transmission – Matched filter - Error rate due to noise – ISI – Nyquist criterion for distortion less transmission-MATLAB Practices for signal representation, Pulse modulation schemes.

MODULE II:

Application of pass band transmission – Voice band Modems – Multichannel modulation – Discrete multitone. Synchronization. Spread spectrum communication – Pseudo– noise sequences – Spread Spectrum – Direct sequence spread spectrum with coherent binary phase shift keying – Signal space dimensionality and processing gain – Probability of error – Frequency Hop spread spectrum – Maximum length and Gold codes.

Multiple Access Techniques. Statistical characterization of multi path channels. Binary signaling over a Rayleigh fading channel – Diversity techniques. TDMA and CDMA – RAKE receiver. Performance analysis of cellular DS-CDMA, power control, soft handoffs, IS-95A and 3G CDMA system.B3G systems, rate and power adaptation, LTE standard, its air interface. MATLAB practice: TDMA, Spread Spectrum Techniques.

MODULE III:

Introduction to Information Theory: Concept of amount of information, units-entropy, marginal, conditional and joint entropies - relation among entropies – mutual information, information rate. Source coding: Instantaneous codes- construction of instantaneous codes - Kraft's inequality, coding efficiency and redundancy, Noiseless coding theorem - construction of basic source codes - Shannon - Fano Algorithm. Channel capacity -redundancy and efficiency of a channel., binary symmetric channel (BSC), Binary erasure channel (BEC)- capacity of band limited Gaussian channels, Shannon- Hartley theorem - bandwidth - SNR trade off -capacity of a channel of infinite bandwidth, Shannon's limit. Quantum Error Correcting Codes, Coding for Cooperative Communication; Network Coding-MATLAB Practice: Channel coding theorem.

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1. B. P. Lathi, Modern Digital and Analog Communication Systems, PHI, 1998.
2. Nielsen M.A. and Chuang I.L., Quantum Computation and Quantum Information, Cambridge University Press, 2006.
3. Sesia S., Toufik, I., Baker M., LTE – The UMTS Long Term Evolution, John Wiley and Sons, First Edn, 2009.
4. Simon Haykin - Communication Systems, 4th Edn. John-Wiley & Sons, 2001.
5. Yeung R.W., Information Theory and Network Coding, Springer,2008.

ADDITIONAL REFERENCES

1. Couch: Digital and Analog Communication Systems, 6th Edn, Pearson Education, 1997
2. Goldsmith A., Wireless Communications, Cambridge Univ. Press, First Edn, 2005.
3. Harold Kolimbris: Digital Communication Systems, 1st Edn, Pearson Education, 2000.
4. Marvin K. Simon, Sami M. Hinedi, William C. Lindsey: Digital Communication Techniques, PHI.

Semester:	Course Code: OPE-DE-5016(A)
Course Title: SATELLITE AND MOBILE COMMUNICATIONS	Credits: 4

Prerequisite :Knowledge in basic communication.

Objective :

(i) Tounderstand the engineering impact of the various satellite components and its performance.

(ii) To impart the fundamentals concepts of mobile communicationsystems.

(iii) To introduce various technologies and protocols involved in mobilecommunication.

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

CO No.	CO Statement
CO1	Understand about satellite orbits and launching methods.
CO2	Discuss the satellite links.
CO3	Understand the cellular concepts.
CO4	Apply the multiple access techniques in cellular communication.
CO5	Design a GSM.
CO6	Create CDMA in cellular environment.

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand about satellite orbits and launching methods.	PSO1	R,U	F, C
CO2	Discuss the satellite links.	PO1/PSO2	Ap	P
CO3	Understand the cellular concepts.	PSO2	U	C

CO4	Apply the multiple access techniques in cellular communication.	PO3/PSO5	Ap, Cr	P, M
CO5	Design a GSM.	PO5/PSO5	Ap, Cr	P, M
CO6	Create CDMA in cellular environment.	PO5/ PSO5	An, E	M

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KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

MODULE I:

Communication satellite-orbits & launching methods-Kepler's law-inclined orbits-geostationary orbits, effect of orbital inclination, azimuth and elevation, coverage angle and slant range, eclipse, satellite placement.

Space segment subsystems & description, earth station- antenna, high power amplifiers, up converter, down converters, monitoring and control. satellite link- basic link and interference analysis.

MODULE II:

Cellular concept: hand off strategies, interference and system capacity: cell splitting, sectoring, repeaters, micro-cells. Link budget based on path loss models. propagation models(outdoor)- Longely-Rice model, Okumura model.

Mobile propagation- fading and Doppler shift, impulse response model of multipath channel, parameters of multipath channel. Fading effect due to multipath time delay spread and Doppler shift. Multiple Access- TDMA overlaid on FDMA, SDMA, FHMA.

MODULE III:

GSM: architecture, radio subsystem, channel types, frame structure, introduction to ultra-wideband communication system, direct sequence modulation, spreading codes, the advantage of CDMA for

wireless, code synchronization, channel estimation, power control- the near-far problem.
FEC coding and CDMA, multiuser detection, CDMA in cellular environment. space division multiple access and smart antennas.

REFERENCES

1. Dennis Roody, Satellite Communication, 2/e, McGraw Hill.
2. Theodore S. Rappaport, Wireless Communication Principles and Practice, 2/e, Pearson Education.
3. William C Y Lee, Mobile Cellular Telecommunications,2/e, McGraw Hill.
4. Madhavendar Richharia, Mobile Satellite Communications: Principles and Trends, Pearson Education, 2004.

ADDITIONAL REFERENCES

1. Simon Haykin & Michael Mohar, Modern Wireless Communication, Pearson Education, 2008.
2. Tri. T. Ha, Digital Satellite Communication, 2/e, Mcgraw Hill.
3. M. Ghavami, L. D. Michael & K Rohino, Ultra-Wide Band Signals in Communication Engineering, Wiley Inc.
4. William Stallings, Wireless Communication and Networks, Pearson Education, 2006.

Semester:	Course Code: OPE-DE-5017(A)
Course Title: WIRELESS COMMUNICATION	Credits: 4

Prerequisite :Basic knowledge in communication.

Objective : The course provides details of the wireless propagation mechanisms. It gives an idea about the different multiple access techniques. It also discusses the 4G systems and the latest wireless technologies.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Understand propagation mechanisms and path loss models
CO2	Apply the concepts in communication to understand cellular communication design
CO3	Explain the effects of multipath on the propagation
CO4	Apply different multiple access schemes.
CO5	Familiarizing 4G systems and latest wireless technologies

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand propagation mechanisms and path loss models	PSO1	U	F, C
CO2	Apply the concepts in communication to understand cellular communication design	PO2	U, Ap	C, P
CO3	Explain the effects of multipath on the propagation	PSO2	U	C, P
CO4	Apply different multiple access schemes.	PSO4	Ap, An	C, P, M

CO5	Familiarizing 4G systems and latest wireless technologies	PSO5	U	C, P

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KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

ModuleI

Cellular Networks: Introduction – Concepts of cell- Frequency Reuse – Channel Assignment Strategies, Handoff strategies – Interference and System Capacity, Trunking and Grade of Service- Improving capacity- Cell splitting and Sectoring. GSM, CDMA UMTS, LTE standards and specifications,

Propagation and Path Loss: Free space Propagation Model, Basic propagation mechanisms, Ground reflection Model, Knife-edge diffraction model, Radar cross section model. Path-loss Model: Log Distance Path-Loss Model.

Module II

Multipath and Fading: Small Scale Multipath propagation, Impulse response Model, Parameters of Multipath Channel, Types of Small-scale fading: due to multipath time delay spread and Doppler spread.

Multiple Access Techniques: Introduction, FDMA, TDMA, Spread Spectrum Multiple Access: FHMA, CDMA, Hybrid Technique, SDMA. Packet Radio Protocols- Pure and Slotted ALOHA, CSMA. Capacity of CDMA networks.

Module III

Fourth Generation Systems and Wireless Technologies: Introduction – 4G Features and Challenges, Applications of 4G – 4G Technologies: Multi Carrier Modulation, Smart Antenna Techniques, OFDM MIMO systems, Adaptive modulation and coding with time slot scheduler, BLAST system, Software Defined Radio, Cognitive Radio.

References:

1. Theodore S. Rappaport, "Wireless Communications: Principles & Practice", Second Edition, Prentice Hall of India Pvt. Ltd. (Low Priced Edition – Pearson Education Asia), 2002.
2. Andrea Goldsmith, "Wireless Communications", Cambridge University press.
3. William C.Y. Lee, "Mobile Communication Engineering: Theory & Applications", Second Edition, McGraw Hill, 1998.

4. Gordon L. Stuber, “Principles of Mobile Communications”, Kluwer Academic Press, 1996.
5. John G. Proakis, “Digital Communications”, Fourth Edition, McGraw Hill, 2001.
6. Jochan Schiller, “Mobile communications”, Addison-Wesley (Low Priced Edition – Pearson Education Asia), 2002.
7. Simon Haykin and Michael Moher, “Modern Wireless Communications”, Pearson Education.

Additional References:

1. A. J. Viterbi, “CDMA- Principles of Spread Spectrum”, Addison Wesley, 1995.
2. Jerry R. Hampton, “Introduction to MIMO Communications”, Cambridge University Press, 2014
3. Vijay K. Garg, “Wireless Communications and Networking”, First Edition, Morgan Kaufmann Publications.

Semester:	Course Code: OPE-DE-5018(A)
Course Title: MICRO ELECTRO MECHANICAL SYSTEMS	Credits: 4

Prerequisite :Basic knowledge in smart materials and structures.

Objective : To provide basic of different methods of micromachining and how thesemethods can be used to produce a variety of MEMS, includingmicrostructures, microsensors, and microactuators.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Remember the fundamentals and concepts in smart materials and structures.
CO2	Discuss about material processing and device fabrication.
CO3	Discuss about the micro sensors.
CO4	Design and development of micro sensors.
CO5	Design and development of MEMS devices for different application.
CO6	Apply software practice for designing of microstructures and component modelling.

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Remember the fundamentals and concepts in smart materials and structures.	PO1	R	C
CO2	Discuss about material processing and device fabrication.	PO2/PSO1	U	F
CO3	Discuss about the micro sensors.	PSO2	Ap,Cr	C
CO4	Design and development of micro sensors.	PSO5	Cr	M

CO5	Design and development of MEMS devices for different application.	PO5/PSO5	Cr	P
CO6	Apply software practice for designing of microstructures and component modelling.	PSO5	Ap	M

(**CL- Cognitive Level:** R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, C- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I

Introduction to MEMS: historical background of micro electro mechanicalsystems, role of MEMS in improved efficiency, smart materials and structures, materialsprocessingsynthesis, multifunctional polymers.

Materialprocessing anddevicefabrication:lithography,ionimplantation,etching,waferbonding,integratedprocesses,bulksiliconmicromachining,surfacemicromachining, CVD oxide process. Enhanced CVD, physical vapor deposition, DRIE.

ModuleII

Microsensors-microactuators-microoptoelectromechanicalsystems,micromechanicalcomponents-springsbearings,gearsandconnectors,hightemperaturesensors,capacitivepressuresensor,bulkmicro-machinedaccelerometer,surfacemicro-machinedmicro-spectrometer.

Microoptoelectromechanicalsystems(MOEMS),opticalMEMScomponents, micro mirrors, micro lenses, optical sources and detectors for optical MEMSapplications, design and simulation of micro sensors, micro actuators and MOEMS- microfluidicdevices, microfluidicdevices usingphotoniccrystalfiber.

Module III

Applications of MEMS: blood pressure monitoring transducers, disposableblood pressure monitoring transducers. MEMS devices - infusion pumps, kidney dialysis,respirators, active noise and vibration control, intelligent structures, micro -robots, smartstructuresforaircraft,automotiverequirements,automobile,satellite,buildingsandmanufacturingsystems.

Simulation of microstructures and component modeling: general overview ofbasic processes (planar-

CMOS, bulk-Si,LIGA), physical-chemical determinated simulation ofselectedprocesssteps.SystematicofMEMScomponents,layoutsupport,examplesofelementmodeling(DAE, FEM).

References:

1. Tai-Ran Hsu, "MEMS & Microsystem, Design and Manufacture", McGraw Hill,2002.
2. BanksH.T.SmithR.C.andWangY.Smart,"MaterialStructures-Modeling,Estimation and Control", JohnWiley&Sons, NewYork, 1996.
3. MassoodTabib-Arar,"Microactuators-Electrical,MagneticThermal,Optical,Mechanical,ChemicalandSmartstructures",KlumerAcademicpublishers,NewYork1997.
4. M.Eluenspoek, R.Wiegerink, "Mechanical Microsensors", Springer, 2001. Mode ofevaluation:Written examination, Seminar, Assignments.

Semester:	Course Code: OPE-DE-5019(A)
Course Title: BIOMEDICAL ELECTRONICS	Credits: 4

Prerequisite :Basic knowledge in electronics and circuits.

Objective : To provide enhanced knowledge on biomedical electronic systems.

Learning Outcomes : On completion of the course the student will be able to

CO No.	CO Statement
CO1	Understand the electrical activity of heart.
CO2	Explain ECG, EEG, EMG
CO3	Discuss human respiratory system and its measurements
CO4	Demonstrate the Medical Imaging systems
CO5	Apply telemetry in patient care

Tagging Course Outcomes

CO	CO Statement	PO/ PSO	CL	KC
CO1	Understand the electrical activity of heart.	PSO1	U	F and C
CO2	Explain ECG, EEG, EMG	PO1/PSO3	U, An	C and P
CO3	Discuss human respiratory system and its measurements	PO3/ PSO2	Ap. An and E	C, P and M
CO4	Demonstrate the Medical Imaging systems	PO4/PSO3	Ap. An	P and M
CO5	Apply telemetry in patient care	PO5	Ap	P and M

(**CL- Cognitive Level:** R-remember, U-understand, Ap- Apply, An- analyses, E- evaluate, C- create,
KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

Assessment Pattern (Internal & External)

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	15	15	15
Understand	15	15	15	15
Apply	35	35	35	35
Analyse	15	15	15	15
Evaluate	10	10	10	10
Create	10	10	10	10

COURSE CONTENT

Module I

The Human Body-Overview. Principle of generation and propagation of bioelectric potentials. ECG, EEG, EMG. The heart and circulatory system. Electrical activity of heart. ECG machine, Biopotential Electrodes, Transducers, Lead and Electrodes, Pacemaker, Defibrillator, Blood pressure measurements Oscillometric and Ultrasonic Non-invasive pressure measurements. Bioelectric Amplifiers-Introduction Isolation and chopper stabilized Amplifiers.

Module II

Human respiratory system and its measurement. Respiratory therapy equipment-Ventilator. The human nervous system. Neuron, Propagation of action potential through nerves, EEG Machine, Instrumentation for measuring brain function-Intensive and coronary care units. Medical laboratory Instruments Hemodialysis Machine. Electrical Safety, Micro and Macro shock hazards.

ModuleIII

Medical Imaging systems: X-ray Imaging, Application of X-rays in medicine, Computed Tomography. Ultrasonic Imaging-A-Scan, B-Scan, M-Scan, Magnetic Resonance Imaging. Benefits, Risks and Limitations of MRI. Positron Emission Tomography. PET Instrumentation System. Advantages of PET scan. Biomedical Telemetry system –Components of Biotelemetry system, Application of telemetry in patient care.

References:

1. Joseph J Carr & John M Brown: Introduction to Biomedical Equipment Technology.4thEdn., Pearson Education.
2. R.S.Khandpur: Handbook of Biomedical Instrumentation, TMH, New Delhi.
3. T.K.Attuwood & D J Pary Smith: Introduction to Bioinformatics,1999, Pearson Education
4. John G.Webster : Medical Instrumentation-Application and Design, Houghton Mifflin Company, Boston.

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