Implementation of NEP/LOCF/CBCS / ECS

Minutes of Meetings (MoM) of Board of Studies (BoS)

Academic Year : 2023-24		
School	:	***School of Studies of Engineering and Technology***
Department	:	***Electronics and Communication Engineering***
Date and Time	:	***June 28, 2023 – 10.33 AM***
Venue	:	***Online Platform***

The scheduled meeting of member of Board of Studies (BoS) of Department of Electronics and Communication Engineering, School of Studies of Engineering and Technology, Guru Ghasidas Vishwavidyalaya, Bilaspur was held to design and discuss the B. Tech. 4th year, M.Tech. 1st and 2nd year and Pre-Ph.D. scheme and syllabus.

The following members were present in the meeting:

1. Dr. Soma Das, (Chairman & Member, BOS, Department of ECE, GGV)
2. Prof. Kavita Thakur, (Pt. Ravi Shankar Shukla University, Raipur & External expert Member of BOS)
3. Dr. Anita Khanna, (Member, BOS, Department of ECE, GGV)

The members approved the following documents after received the same online as listed below:

1. The Vision and Mission of the department in line with the Vision and Mission of the School of Studies of Engineering & Technology;
2. The scheme and syllabus of B.Tech. 4th year to be started from academic session 2023-24;
3. The scheme and syllabus of M.Tech. 1st and 2nd year to be started from academic session 2023-24;
4. The scheme and syllabus of Pre-phd course work to be started from academic session 2023-24.

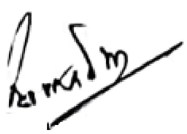
The committee discussed and approved the scheme and syllabi. The following courses were revised in the of M.Tech. 1st and 2nd year and Pre-Ph.D.:

- ECPBTP4 Pattern Recognition & Machine Learning
- ECDATP23 Digital Image Processing

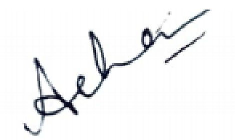
The following new courses were introduced in the of B. Tech. 4th year, M.Tech. 1st and 2nd year and Pre-Ph.D.:

- EC207TPE07 Analog CMOS IC Design

- EC208TPE18 Low Power VLSI Design
- EC208TOE03 Introduction to IoT
- EC207TOE02 CMOS Digital VLSI Design
- ECPATP5 Solid State Devices
- ECPATP7 Analog CMOS VLSI Design
- ECPATP10 Network Security & Cryptography
- ECPATP12 Satellite Communication
- ECPBTT1 Estimation and Detection Theory
- ECPBTP1 Low Power VLSI Design
- ECPBTP3 Optical Instrumentation
- ECPBLT1 Semiconductor Device Design and Simulation Lab
- ECDATP8 Tunnel Field Effect Transistor
- ECDATP9 MIMO Communication System
- ECDATP24 Medical Image Processing
- ECDATP25 Convex Optimization
- ECDATP10 Deep Learning



Dr. Soma Das
(Chairman & Member,
BOS)



Dr. Anita Khanna,
(Member, BOS)

[Consent taken through e-mail]
Dr. Kavita Thakur
(External Subject Expert)

Minutes of Meetings (MoM) of Board of Studies (BoS)

Academic Year : 2023-24	
School	: ***School of Studies of Engineering and Technology***
Department	: ***Electronics and Communication Engineering***
Date and Time	: ***October 08, 2023 – 08.45 AM***
Venue	: ***Online Platform***

The scheduled meeting of member of Board of Studies (BoS) of Department of Electronics and Communication Engineering, School of Studies of Engineering and Technology, Guru Ghasidas Vishwavidyalaya, Bilaspur was held to design and discuss the B.Tech. 1st and 2nd year NEP-2020 scheme and syllabus.

The following members were present in the meeting:

1. Dr. Soma Das, (Chairman & Member, BOS, Department of ECE, GGV)
2. Prof. Kavita Thakur, (Pt. Ravi Shankar Shukla University, Raipur & External expert Member of BOS)
3. Dr. Anita Khanna, (Member, BOS, Department of ECE, GGV)

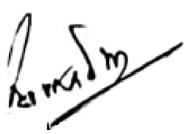
The members approved the following documents after received the same online as listed below:

1. The vision and Mission of the department in line with the vision and Mission of the School of Studies of Engineering & Technology;
2. The scheme and syllabus of NEP-2020 B. Tech. 1st year to be started from academic session 2023-24;
3. The scheme and syllabus of NEP-2020 B. Tech. 2nd year to be started from academic session 2023-24;

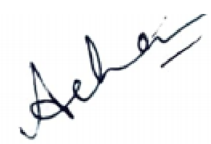
The following new courses were introduced in the of B.Tech. 1st and 2nd year NEP-2020:

- ECUBTE7 Introduction to Electronics & Communication Engineering
- ECUCTE1 Engineering Economics
- ECUCTT1 Electronic Devices
- ECUCTT2 Digital Logic Design
- ECUCTT3 Networks, Signals and Systems
- ECUCTK1 Transmission Line & Electromagnetic Waves
- ECUCTK2 Electronic Measurements and Instrumentation
- EC UCTO1 Data Communication
- CSUCTO1 Data Structure with C++
- ITUCTO1 Computer Organization & Architecture
- CEUCTO1 Green Buildings
- CHUCTO1 Engineering Materials

- MEUCTO1 Introduction to Thermodynamics
- IPUCTO1 I.C. Engine
- ECUCLT1 Electronics Devices Lab
- ECUCLT2 Digital Logic Design Lab
- ECUDTT1 Analog Circuits
- ECUDTT2 Analog and Digital Communication
- ECUDTT3 Control Systems
- ECUDTK1 Probability Theory & Random Process
- ECUDTK2 Sensors & Actuators
- ECUDTK3 Antenna & Wave Propagation
- ECUDTO1 Introduction to Electronics Devices and Circuits
- ITUDTO1 Computer Network
- ITUDTO2 Fundamentals of Python Programming
- CSUDTO1 Introduction to Information Science
- CEUDTO1 Remote Sensing & GIS
- CHUDTO1 Fluidization Engineering
- MEUDTO1 Introduction to Fluid Mechanics
- IPUDTO1 Automobile Engineering
- ECUDLT1 Analog Circuits Lab
- ECUDLT2 Analog and Digital Communication Lab
- ECUDPV1 Mini Project



Dr. Soma Das
(Chairman & Member, BOS)



Dr. Anita Khanna,
(Member, BOS)

[Consent taken through e-mail]
Dr. Kavita Thakur
(External Subject Expert)

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING SCHOOL OF STUDIES OF ENGINEERING & TECHNOLOGY

GURU GHASIDAS VISHWAVIDYALAYA, (A CENTRAL UNIVERSITY) BILASPUR (C.G.)

EVALUATION SCHEME

B. TECH. FOURTH YEAR (W.E.F. SESSION 2023-24)

SEMESTER- VII

S.N.	COURSE No.	SUBJECT	PERIODS			EVALUATION SCHEME			CREDITS
			L	T	P	IA	ESE	TOTAL	
1.	**Program Elective-2**		3	-	-	30	70	100	3
	EC207TPE05	Mobile Communication & Network							
	EC207TPE06	Digital Image Processing							
	EC207TPE07	Analog CMOS IC Design							
2.	**Program Elective-3**		3	-	-	30	70	100	3
	EC207TPE08	Fiber Optic Communication							
	EC207TPE09	Microwave Theory & Techniques							
	EC207TPE10	Power Electronics							
3.	**Program Elective-4**		3	-	-	30	70	100	3
	EC207TPE11	Estimation and Detection Theory							
	EC207TPE12	Radar & Satellite Communication							
	EC207TPE13	Pattern Recognition & Machine Learning							
4.	**Open Elective-2**		3	-	-	30	70	100	3
1.	EC207PPC11	Design & Simulation Lab	-	-	2	30	20	50	1
2.	EC207PPS01	Seminar on Industrial Training	-	-	-	30	20	50	1
3.	EC207PPS02	Project-I	-	-	10	60	40	100	5
		GRAND TOTAL	**12**	**-**	**12**	**240**	**360**	**600**	**19**

Total Credits: **19** Total Contact Hours: **24** Total Marks: **600**

SEMESTER- VIII

S.N.	COURSE No.	SUBJECT	PERIODS			EVALUATION SCHEME			CREDITS
			L	T	P	IA	ESE	TOTAL	
1.	**Program Elective-5**		3	-	-	30	70	100	3
	EC208TPE14	VLSI Fabrication Methodology							
	EC208TPE15	Millimeter Wave Technology							
	EC208TPE16	Video Processing							
	EC208TPE17	Wireless Sensor Networks							
2.	**Program Elective-6**		3	-	-	30	70	100	3
	EC208TPE18	Low Power VLSI Design							
	EC208TPE19	Biomedical Instrumentation							
	EC208TPE20	Neural Network & Fuzzy Logic							
	EC208TPE21	Next Gen. Comm. Technology							
3.	**Open Elective-3**		3	-	-	30	70	100	3
1.	EC208PPS03	Project-II	-	-	18	120	80	200	9
2.	EC208PPS04	Comprehensive Viva	-	-	-	30	20	50	1
		GRAND TOTAL	**09**	**0**	**18**	**240**	**310**	**550**	**19**

Total Credits: **19** Total Contact Hours: **27** Total Marks: **550**

L:LECTURE, T:TUTORIAL, P:PRACTICAL, IA: INTERNAL ASSESSMENT, ESE:END SEMESTER EXAMINATION

*INTERNAL ASSESSMENT- Two Class Test of 15 Marks each will be conducted.

Open Elective – 2 (for other branches)		**Open Elective – 3 (for other branches)**	
EC207TOE02	CMOS Digital VLSI Design (For students other than ECE)	**EC208TOE03**	Introduction to IoT (For students other than ECE)
Open Elective – 2 (for ECE branch)		**Open Elective – 3 (for ECE branch)**	
CE207TOE02A	Green Building and Sustainable Materials	CE208TOE03	Infrastructure Planning and Management
ME207TOE02	Principles of Management	ME208TOE0	Supply Chain Management
CH207TOE02	Waste to Energy	CH208TOE03	Plant Engineering Economics and Management
IT207TOE01	Machine Learning	IT208TOE01	Soft Computing
CS207TOE01	GIS & Remote sensing	CS208TOE01	Artificial Intelligence

MASTER OF TECHNOLOGY (SEMESTER- I)									
SN	**COURSE No.**	**SUBJECT**	**PERIODS**			**EVALUATION SCHEME**			**CREDITS**
			L	**T**	**P**	**IA**	**ESE**	**TOTAL**	
1.	ECPATT01	Linear Algebra	3	-	-	40	60	100	3
2.		**Elective-1**	3	-	-	40	60	100	3
	ECPATP01	Wireless Communication & Network							
	ECPATP02	Introduction to Embedded System & IoT							
	ECPATP03	Microstrip Antenna							
3.		**Elective-2**	3	-	-	40	60	100	3
	ECPATP04	Optoelectronic Devices							
	ECPATP05	Solid State Devices							
	ECPATP06	Antenna for Modern Wireless Communication							
4.		**Elective-3**	3	-	-	40	60	100	3
	ECPATP07	Analog CMOS VLSI Design							
	ECPATP08	Digital Image Processing							
	ECPATP09	Modern Digital Communication							
5.		**Elective-4**	3	-	-	40	60	100	3
	ECPATP10	Network Security & Cryptography							
	ECPATP11	Introduction to Signal Processing							
	ECPATP12	Satellite Communication							
6.	ECPATC01	Research Methodology & IPR	2	-	-	-	50	50	2
7.	ECPALT01	Adv Simulation Lab	-	-	4	30	20	50	2
		TOTAL	**17**	**0**	**4**	**230**	**370**	**600**	**19**

MASTER OF TECHNOLOGY (SEMESTER- II)									
SN	**COURSE No.**	**SUBJECT**	**PERIODS**			**EVALUATION SCHEME**			**CREDITS**
			L	**T**	**P**	**IA**	**ESE**	**TOTAL**	
1.	ECPBTT01	Estimation and Detection Theory	3	-	-	40	60	100	3
2.		**Elective-5**	3	-	-	40	60	100	3
	ECPBTP01	Low Power VLSI Design							
	ECPBTP02	Adv Digital Signal Processing							
	ECPBTP03	Optical Instrumentation							
3.		**Elective-6**	3	-	-	40	60	100	3
	ECPBTP04	Pattern Recognition & Machine Learning							
	ECPBTP05	Optical Communication System							
	ECPBTP06	Next Gen. Comm. Technology							
4.		**Elective-7**	3	-	-	40	60	100	3
	ECPBTP07	Computer Vision							
	ECPBTP08	Digital Communication Receiver							
	ECPBTP09	Millimeter Wave Technology							
5.		**Open Elective**	3	-	-	40	60	100	3
6.		**Audit Course/Value Added Course**	2	-	-	40	60	100	2
7.	ECPBLT01	Semiconductor Device Design and Simulation Lab	-	-	4	30	20	50	2
8.	ECPBLT02	RF & Microwave Component Design Lab	-	-	4	30	20	50	2
		TOTAL	**17**	**0**	**08**	**300**	**400**	**700**	**21**

SEMESTER- III									
S.No.	COURSE No.	SUBJECT	PERIODS			EVALUATION SCHEME			CREDITS
			L	T	P	IA	ESE	TOTAL	
1.	ECPCPT01	Dissertation Stage-I	-	-	28	100	100	200	14
		TOTAL	-	-	28	100	100	200	14

SEMESTER- IV									
S.No.	COURSE No.	SUBJECT	PERIODS			EVALUATION SCHEME			CREDITS
			L	T	P	IA	ESE	TOTAL	
1.	ECPDPT01	Dissertation Stage-II	-	-	32	100	200	300	16
		TOTAL	-	-	32	100	200	300	16

Total Credits for the Program= 19+21+14+16=70

Open Elective	
MSPBTO1	Business Analysis
IPPBTO2	Industrial Safety
IPPBTO3	Operations Research
CEPBTO4	Cost Management of Engineering Projects
MEPBTO5	Composite Materials
CHPBTO6	Waste to Energy
ECPBTO7	Internet of Things
ITPBTO9	Software Engineering Techniques
MCPBTO8	MOOCs
Audit Course/Value Added Course	
ELPBTX1	English for Research Paper Writing
PEPBTX2	Stress Management by Yoga
CEPBTX3	Disaster Management
LAPBTX4	Constitution of India

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING SCHOOL OF STUDIES OF ENGINEERING & TECHNOLOGY

GURU GHASIDAS VISHWAVIDYALAYA, (A CENTRAL UNIVERSITY)BILASPUR (C.G.)

SCHEME

Pre-PhD Course Work (W.E.F. SESSION 2022-23)

S.N.	SUBJECT CODE	SUBJECT NAME	PERIODS /WEEK			ESE DURATION	ESE MARKS		CREDIT
			L	T	P		MAX	MIN	
1.	ECDATT1	Research Methodology in Engineering	3	1	0	3Hrs	100	40	4
2.		Elective-I	3	1	0	3Hrs	100	40	4
3.		Elective-II	3	1	0	3Hrs	100	40	4

S.N.	SUBJECT CODE	SUBJECT NAME	S.N.	SUBJECT CODE	SUBJECT NAME
1.	ECDATP1	Vacuum Technology	8.	ECDATP11	Machine Learning
2.	ECDATP2	Antenna For Modern Wireless Communication	9.	ECDATP13	Introduction to IoT
3.	ECDATP3	Microstrip Antenna	10.	ECDATP14	Satellite Communication
4.	ECDATP4	Wireless Communication & Network	11.	ECDATP23	Digital Image Processing
5.	ECDATP8	Tunnel Field Effect Transistor	12.	ECDATP24	Medical Image Processing
6.	ECDATP9	MIMO Communication System	13.	ECDATP25	Convex Optimization
7.	ECDATP10	Deep Learning	14.	ECDATP26	Introduction to Signal Processing

ESE: End Semester Examination, **L**: Lecture, **T**: Theory, **P**: Practical
Max: Maximum Marks in ESE
Min: Minimum Pass Marks in each subject as 40%

- Duration of the semester will be 6 months.
- Candidate has to score minimum 55% of aggregate marks to qualify in ESE.

Two subjects as Electives (4 credits each) can be taken from the list of Electives

Sub Code	L	T	P	Duration	IA	ESE	Total	Credits
EC207TPE07	3	-	-	4 hours	30	70	100	3

ANALOG CMOS IC DESIGN

Course Objectives:

1. To demonstrate the ability to analyze and design the basic & advance analog integrated circuit.
2. To gain knowledge of strengths and weaknesses of basic CMOS circuit building blocks and feedback concepts
3. To develop skills in designing CMOS operational amplifier and reference circuits.
4. To study the frequency response of the amplifier.
5. To design analog IC circuits for a given specification.

UNIT-I: Basic MOSFET Physics: General consideration, MOS I/V characteristics, Second order effects and MOS small & large signal models.

UNIT-II: CMOS Amplifier and Current Sources: Single Stage Amplifier: CS stage with resistance load, Diode connected load, Current source load, Triode load, CS stage with source degeneration, Source follower, Common-gate stage, Cascade stage, current sources, Basic current mirrors, Cascode Current Mirrors.

UNIT-III: Operational Amplifiers Design: Basic difference pair, Common mode response, Differential pair with MOS loads, Gilbert cell theory and design, Performance parameters, Design of 2-stage MOS operational amplifier, Gain boosting, Slew rate, Offset effects, PSRR.

UNIT-IV: Frequency Response and Feedback Amplifiers: Miller effect, Frequency response of all single stage amplifiers and cascade stage, General consideration of feedback circuits, Feedback topologies, Effect of loading.

UNIT-V: Voltage References and Noise: Different configurations of voltage references, Major issues, Supply independent biasing, Temperature independent references, Types of noise, Analysis and representation of noise in single stage amplifiers, cascode stage.

Text/Reference Books:

1. Behzad Razavi,"Design of Analog CMOS Integrated Circuits", Tata Mc Graw-Hill, 2001.
2. Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, and Robert G. Meyer, "Analysis and Design of Analog Integrated Circuits", 5th Edition, Wiley, 2009
3. Phillip Allen and Douglas R. Holberg, "CMOS analog Circuit Design", 3rd Edition, Oxford University Press, USA, 2011.
4. T. Carusone, D. Johns, K. Martin, Analog Integrated Circuit Design, 2nd Edition, Wiley, 2011.

Course Outcome:

At the end of the course, students will demonstrate the ability to:

CO1. Realize the concepts of analog IC design including small & large signal models.

CO2. Design different configuration of amplifiers for a given specification & current sources.

CO3. Illustrate the concept of op-amp and its design parameters and application.

CO4. Analyze the characteristics of frequency response of the amplifier and comprehend the feedback topologies.

CO5: Design band gap reference circuits providing constant dc voltage and immune to temperature variations and noise.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	1	1			1		2	1	1	1
CO2	3	3	3	3	3	1	1			1		2	2	2	2
CO3	3	3	3	3	3	1	1			1		2	3	2	2
CO4	3	3	3	3	3	1	1			1		2	3	2	2
CO5	3	3	3	3	3	1	1			1		2	3	2	2

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Sub Code	L	T	P	Duration	IA	ESE	Total	Credits
EC208TPE18	3	-	-	4 hours	30	70	100	3

LOW POWER VLSI DESIGN

Course Objectives:

- To understand the low voltage low power VLSI designs.
- To understand the impact of power on system performances.
- To realize different design approaches.
- To identify suitable techniques to reduce power dissipation in the circuits.

UNIT-I:

Introduction: Need for Low Power VLSI chips, Low power design methodology, Basic principal of low power design, Sources of power dissipation: Dynamic, Short-circuit and leakage power dissipation.

UNIT-II:

Supply Voltage Scaling for Low Power: Introduction, Device feature size scaling, Architectural-level approaches, Multilevel voltage scaling and challenges, Dynamic voltage and frequency scaling.

UNIT-III:

Switching Capacitance Minimization: Dynamic voltage and frequency scaling, Bus encoding, clock gating, Gated-clock FSM, Glitching power minimization, Logic style for low power.

UNIT-IV:

Leakage Power Minimization: Fabrication of multiple threshold voltages, VTCMOS approach, Transistor stacking, MTCMOS approach, Power gating.

UNIT-V:

Special Techniques: Low power clock distribution, Single driver vs distributed buffers, Various clock distribution networks, Power reduction in clock networks, Low power bus, CMOS floating nodes, and Adiabatic logic.

Text/Reference Books:

1. Ajit Paul, "Low Power VLSI Circuits & Systems", Springer, 2015.
2. Kaushik Roy, Sharat Prasad, "Low power CMOS VLSI circuit design", John Wiley sons Inc.,2000.
3. Gary Yeap, "Practical low power digital VLSI design", Kluwer, 1998.
4. J. B. Kulo and J. H. Lou, "Low voltage CMOS VLSI Circuits", Wiley, 1999.

Course Outcome:

At the end of the course, students will demonstrate the ability to:

CO1: Identify sources of power dissipation in VLSI systems.

CO2: Understand how to apply techniques at the device, circuit and architectural level to reduce power dissipation in an electronic design.

CO3: Illustrate and design switching capacitance & leakage power minimization techniques low voltage low power applications.

CO4: Learn and design special techniques for various low voltage low power applications.

CO5: Design and implementation of various structures for low power applications.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	1	1			1	1		2	3	1	2
CO2	3	3	2	1	1	1			1	1		2	3	1	2
CO3	3	3	3	1	1	1			1	1		2	3	3	2
CO4	3	3	3	1	1	1			1	1		2	3	3	2
CO5	3	3	1	1	1	1			1	1		2	3	1	1

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Sub Code	L	T	P	Duration	IA	ESE	Total	Credits
EC208TOE03	3	-	-	4 hours	30	70	100	3

INTRODUCTION TO IOT (OPEN ELECTIVE-03)

Course Objectives:

1. To understand the definition and significance of the Internet of Things.
2. To learn the architecture, operation, and business benefits of an IoT solution.
3. To examine the potential Security issues in IoT and explore the relationship between IoT, cloud computing, and big data.
4. Design and program IoT devices, use real IoT protocols for communication, Secure the elements of an IoT device.

UNIT-I:

Introduction to The Internet of Things

IoT Definition, Elements of an IoT ecosystem, IoT applications, trends and implications, sensing components and devices, Wearable sensors and their Applications, operating System for IoT, Industrial IoT: case study: Agriculture, Healthcare, Process Automation & monitoring etc.

UNIT-II:

Internet of Things– Architecture and Communication Protocol

Layered Architecture for IoT, Protocol Architecture of IoT, Infrastructure Protocols: MAC protocols for sensor network, S-MAC, IEEE 802.15.4, Near Field Communication (NFC), RFID, ZigBee, Bluetooth Low Energy (BLE),IPv6 over LowPower Wireless Personal Area Networks (6LoWPAN), Long Term Evolution-Advanced, Z-Wave, Components of ZWave Network, Protocols for IoT Service Discovery: DNS service discovery, multicast domain name system.

UNIT-III:

Internet of Things – Networking Protocol Constrained Application Protocol (CoAP), Message Queue Telemetry Transport (MQTT), Extensible Messaging and Presence Protocol (XMPP), Advanced Message Queuing Protocol (AMQP), Data Distribution Service (DDS), Service Discovery Protocols, Routing Protocol for Low Power and Lossy Networks (RPL), sensor networks, unique constraints and challenges, advantages of ad-hoc/sensor network, sensor network architecture, data dissemination and gathering protocol.

UNIT-IV:

Platforms for IOT Applications and Analytics

Role of the cloud and fog resources in the delivery of IoT services, The IoT Building Blocks, Connected Devices, IoT or Sensor Data Gateway, The IoT Data Analytics Platforms: IBM Watson IoT Platform, Splunk Software for IoT Data, Amazon Web Service IoT Platform, Azure IoT Hub, The IoT Data Virtualization Platforms, IoT Data Visualization Platform, Security and Privacy in IoT.

UNIT-V:

Design and Development

IoT Platforms, Arduino, Raspberry Pi Board, Other IoT Platforms; Data Analytics for Design Methodology,Embedded computing logic, Microcontroller, System on Chips , IoT system building blocks Arduino, Board details, IDE programming ,Raspberry Pi , Interfaces and Raspberry Pi with Python Programming Case Studies: Agriculture, Healthcare, and Activity Monitoring. Sensor-Cloud, Smart Cities and Smart Homes.

Text/Reference Books:

1. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press, 2017.
2. Simone Cirani, Gianluigi Ferrari, Marco Picone, Luca Veltri, "Internet of Things: Architectures, Protocols and Standards," Wiley, 2018.
3. Fei Hu, "Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations," CRC Press, 2016Fundamentals of Wireless Communications, D. Tse and P. Vishwanath, ,Cambridge Univ. Press, 2005.

4. R. Buyya and A.K. Dastjerdi (eds.), "Internet of Things: Principles and Paradigms," Cambridge, MA, USA: Morgan Kaufmann (Elsevier), 2016.
5. Modern Mobile Wireless Communication, Haykins S & Moher M, Pearson Ed.

Course Outcome:

At the end of the course, students will demonstrate the ability to:

CO1: Explain the concept of IoT.
CO2: Analyze the concept of data communications protocols and convergence of technologies.
CO3: Interpret the protocols to track, monitor and manage IoT devices.
CO4: Apply data analytics and use cloud offerings related to IoT..
CO5: Explain the principles and various research issues related to Internet of Things.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	1						2	1	1	1
CO2	3	3	3	3	3	1						2	2	2	2
CO3	3	3	3	3	3	1						2	3	2	2
CO4	3	3	3	3	3	1						2	3	2	2
CO5	3	3	3	3	3	1						2	3	2	2

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Sub Code	L	T	P	IA	ESE	Total	Credits
ECPBTP04	3	-	-	40	60	100	3

PATTERN RECOGNITION & MACHINE LEARNING

Course Objectives:

1- To study the fundamentals of pattern recognition.
2- To study the various parameter based estimation methods.
3- To study some dimensionality reduction methods.
4- To study the fundamentals of artificial neural networks.
5- To be able to choose and apply algorithms for pattern recognition.

UNIT-I:

Introduction to statistical pattern recognition, Bayes Decision Theory: Minimum-error-rate classification. Classifiers, Discriminant functions, Decision surfaces. Discrete features.

UNIT-II:

Parameter Estimation Methods: Maximum-Likelihood estimation, Bayesian estimation, Unsupervised learning and clustering - Criterion functions for clustering. Algorithms for clustering: K-Means, Hierarchical and other methods. Cluster validation.

UNIT-III:

Gaussian mixture models, Expectation-Maximization method for parameter estimation. Hidden Markov Models (HMMs). Discrete HMMs. Continuous HMMs.

UNIT-IV:

Dimensionality reduction: Principal component analysis - relationship to eigen analysis. Fisher discriminant analysis - Generalised eigen analysis.

UNIT-V:

Artificial neural networks: Multilayer perceptron - feedforward neural network. A brief introduction to deep neural networks, convolutional neural networks, recurrent neural networks.

Text Books/Reference Books:

1. J.I. Tou & R C Gonzalez, Pattern Recognition Principles, Addition-Wesley.
2. R Schalkoff, Pattern Recognition- Statistical, Structural and Neural Approaches, John Wiley, 1992.
3. P A Devijer & J Kittler, Pattern Recognition – A statistical Approach, Prentice Hall
4. R O Duda, P E Hart, D G Stork, Pattern Classification, Wiley Publication 2001.
5. D Mckay, Information Theory, Inference and Learning Algorithms, Cambridge University Press 2003.
6. C M Bishop, Pattern Recognition and Machine Learning, Springer, 2006
7. Christopher M Bishop, Pattern Recognition and Machine Learning, Springer, 2006

Course Outcome:

At the end of the course, students will demonstrate the ability to:

CO1: Summarize the various techniques involved in pattern recognition
CO2: Ability to analyse the various parameter based estimation methods.
CO3: Illustrate the artificial neural network based pattern recognition **CO4:** Discuss the applications of pattern recognition in various applications
CO5: Apply to choose and evaluate suitable algorithm given the application.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1	-	-	-	-	-	-	2	3	1	2
CO2	3	3	3	2	1	2	-	-	-	-	-	2	3	2	2
CO3	3	2	2	1	2	2	-	-	-	-	-	2	3	2	2
CO4	3	3	3	2	3	2	-	-	-	-	-	2	3	1	3
CO5	3	2	3	1	2	2	-	-	-	-	-	2	3	1	3

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Sub Code	L	T	P	IA	ESE	Total	Credits
ECPATP05	3	-	-	40	60	100	3

SOLID STATE DEVICES

Course Objectives:

The objectives of the course are to make the students:

- To develop strong background in semiconductor physics.
- To understand the importance of electrons and holes in semiconductors, the charge density and distribution, the charge transport mechanisms.
- To expose the physics of a p-n junction and semiconductor-metal junctions.
- To identify the internal workings of the most basic solid state electronic devices.

UNIT-I: Introduction: Review of electrons and energy band structures in crystals, density of states, effective density of states**,** Fermi function, Law of Mass action, Elemental and compound semiconductor, Electron & hole concentration in semiconductor, Temperature dependence of carrier concentration.

UNIT-II: Carrier Transport in Semiconductor: Drift and diffusion currents, Excess carriers in semiconductors-Generation & recombination, Basic equation for semiconductor device operation.

UNIT-III: PN Junctions: Abrupt & linearly graded junctions, V-I characteristics of an ideal diode, a real diode, C-V characteristics of reverse biased p-n junction, Electrical breakdown of a p-n junction in reverse bias- Zener & Avalanche Breakdown, Solar cell.

UNIT-IV: Bipolar Junction Transistor: Structure, Principle of operation, Ideal & real transistor, I-V characteristics, Small signal equivalent circuits, High frequency & switching transistors.

UNIT-V: MOSFETs: Basic operation & fabrication, Ideal MOS capacitor, Threshold voltage, C-V characteristics, I-V characteristics, Short channel MOSFET, Body effect, Subthreshold characteristics, Equivalent circuits, Short Channel effects, GIDL, DIBL.

Text/Reference Books:

1. M. S. Tyagi, Introduction to "Semiconductor Materials and Devices", John Wiley, 2004.
2. B. G. Streetman and S. K. Banerjee, "Solid State Electronic Devices", Prentice Hall India, 2014.
3. D. Neamen, "Semiconductors Physics and Devices", Tata Mc Graw Hill, 2003.
4. N. D. Gupta and A. D. Gupta, "Semiconductor Devices: Modeling and Technology", Prentice Hall, 2007.
5. R. Pierret, "Semiconductor Device Fundamentals", Pearson Education, 2006

Course Outcome:

At the end of the course, students will demonstrate the ability to:

CO1: Illustrate energy band structure of crystal and evaluate density of states.

CO2: Analyze carrier transport in semiconductor and basic equation for semiconductor.

CO3: Analyze ideal & real diode and establish I-V & C-V distribution of junction diode.

CO4: Describe the principle and analyze the operation of ideal & real bipolar junction transistor and their characteristics.

CO5: Analyze the operation of MOSFET and evaluate MOSFET performance at scaled gate lengths.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	2				3			3	3		2
CO2	3	3	1	1	2				3			3	3		2
CO3	3	3	1	1	2	1			3		1	3	3		3
CO4	3	3	1	1	2	1			3		1	3	3		3
CO5	3	3	1	1	2	1			3		1	3	3		3

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Sub Code	L	T	P	IA	ESE	Total	Credits
ECPATP07	3	-	-	40	60	100	3

ANALOG CMOS VLSI DESIGN

Course Objectives:

- To demonstrate the ability to analyze and design the basic & advance analog integrated circuit.
- To gain knowledge of strengths and weaknesses of basic CMOS circuit building blocks and feedback concepts
- To develop skills in designing CMOS operational amplifier and reference circuits.
- To study the frequency response of the amplifier.
- To design analog IC circuits for a given specification.

UNIT-I: Basic MOSFET Physics: General consideration, MOS I/V characteristics, second order effects and MOS small & large signal models.

UNIT-II: CMOS Amplifier and Current Sources: Single Stage Amplifier: CS stage with resistance load, Diode connected load, Current source load, Triode load, CS stage with source degeneration, Source follower, Common-gate stage, Cascade stage, current sources, Basic current mirrors, Cascode current Mirrors, Active current Mirrors.

UNIT-III: Operational Amplifiers Design: Basic difference pair, Common mode response, Differential pair with MOS loads, Gilbert cell, Performance parameters, Design of 2-stage MOS operational amplifier, Gain boosting, Slew rate, Offset effects, PSRR, Stability and Frequency compensation.

UNIT-IV: Frequency Response and Feedback Amplifiers: Miller effect, Frequency response of all single stage amplifiers and Cascade stage, General consideration of feedback circuits, Feedback topologies, Effect of loading.

UNIT-V: Voltage References and Noise: Different configurations of voltage references, Major issues, Supply independent biasing, Temperature independent references, Types of noise, Analysis and representation of noise in single stage amplifiers, cascode stage and Noise in differential pairs.

Text/Reference Books:

1. Behzad Razavi, "Design of Analog CMOS Integrated Circuits", Tata Mc Graw-Hill,2001.
2. Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, and Robert G. Meyer, "Analysis and Design of Analog Integrated Circuits", 5th Edition, Wiley, 2009
3. Phillip Allen and Douglas R. Holberg, "CMOS analog Circuit Design", 3rd Edition, Oxford University Press, USA, 2011.
4. T. Carusone, D. Johns, K. Martin, Analog Integrated Circuit Design, 2nd Edition, Wiley, 2011.

Course Outcome: At the end of the course, students will demonstrate the ability to:

CO1. Realize the concepts of analog IC design including small & large signal models.

CO2. Design different configuration of amplifiers for a given specification & current sources.

CO3. Illustrate the concept of op-amp and its design parameters and application.

CO4. Analyze the characteristics of frequency response of the amplifier and comprehend the feedback topologies.

CO5: Design band gap reference circuits providing constant dc voltage and immune to temperature variations and noise.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	1	1			1			2	3	1	1
CO2	3	3	2	1	1	1			1			2	3	2	2
CO3	3	3	2	1	1	1			1			2	3	1	1
CO4	3	3	2	1	1	1			1			2	3	1	1
CO5	3	3	2	1	1	1			1			2	3	2	2

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Sub Code	L	T	P	IA	ESE	Total	Credits
ECPATP10	3	-	-	40	60	100	3

NETWORK SECURITY & CRYPTOGRAPHY

Course Objectives:

- To provide deeper understanding into cryptography, its application to network security, threats/vulnerabilities to networks and countermeasures.
- To explain various approaches to Encryption techniques, strengths of Traffic Confidentiality, Message Authentication Codes.
- To familiarize Digital Signature Standard and provide solutions for their issues.
- To familiarize with cryptographic techniques for secure communication of two parties over a public channel; verification of the authenticity of the source of a message.
- Understand Intrusions and intrusion detection.
- Generate and distribute a PGP key pair and use the PGP package to send an encrypted email message.
- Discuss Web security and Firewalls

UNIT-I: INTRODUCTION:

Security trends, The OSI Security Architecture, Security Attacks, Security Services and Security Mechanisms, A model for Network security. CLASSICAL ENCRYPTION TECHNIQUES: Symmetric Cipher Modes, Substitute Techniques, Transposition Techniques, Rotor Machines, Stenography**.** key range and key size, possible types of attacks.

UNIT-II: BLOCK CIPHER AND DATA ENCRYPTION STANDARDS:

Block Cipher Principles, Data Encryption Standards, the Strength of DES, Differential and Linear Crypt Analysis, Block Cipher Design Principles.
Analysis, Block Cipher Design Principles.

ADVANCED ENCRYPTION STANDARDS: Evaluation Criteria for AES, the AES Cipher. MORE ON SYMMETRIC CIPHERS: Multiple Encryption, Triple DES, Block Cipher Modes of Operation, Stream Cipher and RC4

UNIT-III:

Introduction to Number Theory Principles of public key cryptosystems, RSA Algorithm, Key management, Diffie-Hellman key exchange algorithm, Elliptic Curve Cryptography (ECC).

AUTHENTICATION AND HASH FUNCTION: Authentication requirements – Authentication functions Message Authentication Codes – Hash Functions – Security of Hash Functions and MACs, MD5 message Digest algorithm, Secure Hash Algorithm, RIPEMD, HMAC Digital Signatures, Authentication Protocols – Digital Signature Standard.

UNIT-IV: NETWORK AND SYSTEM LEVEL SECURITY:

Authentication Applications: Kerberos – X.509, Authentication Service, Electronic Mail Security – PGP – S/MIME - IP Security – Web Security, Intrusion detection – password management – Viruses and related Threats – Virus Counter measures – Firewall Design Principles – Trusted Systems, Hardware trojan.

UNIT-V:

WEB SECURITY: Requirements, Secure Socket Layer (SSL) and Transport Layer Security (TLS), Secure Electronic Transaction (SET), Intruders, Viruses and related threats.

FIREWALL: Firewall Design principles, Trusted Systems.

Text/Reference Books:

1. Cryptography and Network Security: Principles and Practice by William Stallings, Pearson Education.
2. Cryptography: Theory and Practice by D Stinson, Chapman & Hall.
3. Network Security by C. Kaufman, R. Perlman and M. Spenser, Prentice Hall of India.
4. Internet Security and Firewalls by S. Bellovin and W. Chesvick, Addison-Wesley, Reading.
5. Introduction to Cryptography with Coding Theory by Wade Trappe and Lawrence C.

Washington, Prentice-Hall.
6. Cryptography & Network Security by Behrouz A. Forouzan, McGraw Hill Education

Course Outcome:

At the end of the course, students will demonstrate the ability to:
CO1: Apply block cipher and stream cipher algorithms.
CO2: Employ Public key cryptographic techniques . CO3:
Explain the authentication and hash algorithms .
CO4: Analyze the digital signature concepts and applications . CO5:
Apply the Network and System level security measures

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2			1	2						3	3	1	1
CO2	3	2			1	2						3	3	2	2
CO3	3	2										3	3	2	2
CO4	3	2	2	2	1							3	3	2	2
CO5	3	2			1	2						3	3	2	2

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Sub Code	L	T	P	IA	ESE	Total	Credits
ECPATP12	3	-	-	40	60	100	3

SATELLITE COMMUNICATION

Course Objectives:

1. recall the basic concepts, frequency allocations and applications of satellite communication system
2. To know the role of different factors affecting satellite and link budget equation.
3. explain satellite sub system .
4. compare various multiple access schemes used in satellite communications.
5. To know the basics and details of Earth station

UNIT-I:

An overview of satellite communication, Satellite orbits, Kepler's law, Orbital Elements, Eclipse effect, Sun transit outage, Placement of a satellite in a geostationary orbit, Station keeping and Stabilization.

UNIT-II:

Satellite Link Design: Basic transmission theory, Friss transmission equation, EIRP, Completion Link design, System noise temperature G/T ratio, Noise figure and Noise temperature.

UNIT-III:

Communication Satellite Subsystems: Space Platform (Bus) and Communication Subsystem (Payload), Satellite Antennas, Frequency reuse Antennas.

UNIT-IV:

Earth Stations: Earth station antennas, Tracking, Equipment for earth stations, Equipment Reliability and Space qualification.

UNIT-V:

Analogue Satellite Communication Vs Digital Satellite Communication, Multiple Access Techniques : FDMA Concept, MCPC & SCPC, TDMA frame efficiency and super frame structure, Frame Acquisition and Synchronisation, CDMA concept, PN system, Spread spectrum, DSSS, DS CDMA, FHSS, FH CDMA.

Text/Reference Books:

"1. "Satellite Communication", T. Pratt & C. W. Bostian.
2. "Digital Satellite communication", Tri T. Ha, McGraw Hill.

Course Outcome:

At the end of the course, students will demonstrate the ability to:

1. Visualize the architecture of satellite systems as a means of high speed, high range communication system.
2. State various aspects related to satellite systems such as orbital equations, sub-systems in a satellite, link budget.
3. Solve numerical problems related to orbital motion and design of link budget for the given parameters and conditions.
4. Explain how satellite is controlled to become stationary w.r.t a point on the earth.
5. Explain how a single satellite is shared by large number of earth stations on the earth by using multiple access schemes

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1									2	3		1
CO2	3	3	1									2	3		1
CO3	3	3	2	2								2	3		1
CO4	3	2	1									2	3		3
CO5	3	2	1									2	2		1

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Sub Code	L	T	P	IA	ESE	Total	Credits
ECPBTT01	3	-	-	40	60	100	3

ESTIMATION AND DETECTION THEORY

Course Objectives:

- To teach students the basics of estimation and detection theory.
- To introduce the students to estimation bounds.
- To introduce classical and Bayesian estimators like ML, LS, and MMSE to students.
- To teach hypothesis testing and a number of detectors of signals in noise. And to introduce the likelihood ratio test and GLRT.
- Exposing the students to applications of estimation and detection is another important goal.

UNIT-I: Introduction: Recap of probability and linear algebra, Introduction of estimation in signal processing, Minimum variance unbiased estimation, Unbiased estimators, Minimum variance criterion, Existence of minimum variance unbiased estimator, Cramer-Rao lower bound (CRLB), scalar parameters, Signal in white Gaussian noise.

UNIT-II: Linear model and Estimation: Linear models, General minimum variance unbiased estimation, Sufficient statistic, finding minimum variance unbiased estimators, Best linear unbiased estimators (BLUE), Finding the BLUE, Signal processing example.

UNIT-III: Likelihood Estimation: Maximum Likelihood estimators (MLE), finding the MLE, Properties of the MLE, MLE for transformed parameters, Extension to a vector parameter, Introduction to Least Square (LS) Approach, Linear least square estimation, Geometrical interpretations of LS estimation, Some examples.

UNIT-IV: Bayesian Estimation: Bayesian estimators, Priors and Posteriors probabilities, Choosing a Prior PDF, General Bayesian estimators, Minimum mean square estimators (MMSE), Maximum A Posteriori (MAP) Estimators, Linear MMSE Estimation.

UNIT-V: Detection and Decision: Basics of statistical decision theory, Simple hypothesis testing, Likelihood ratio testing, Neyman-Pearson detectors, Detection of known signals in noise, Composite hypothesis testing, Generalized likelihood ratio tests (GLRTs), Deterministic signals with unknown parameters.

Text/Reference Books:

1. S. M. Kay, "Fundamentals of Statistical Signal Processing: Estimation Theory, vol. I" Prentice-Hall, 1993 & "vol. II" Prentice-Hall, 1998.
2. H. Vincent Poor, "An Introduction to Signal Detection and Estimation" Springer, 2^{nd} Ed, 1998
3. H. L. Van Trees, "Detection, Estimation, and Modulation Theory, Part I," John Wiley, 1968

Course Outcome: At the end of the course, students will demonstrate the ability to:

CO1: Explain the principle of estimation and detection.

CO2: Learn different estimation and detection techniques like ML, LS, MMSE.

CO3: Solve problems that involve estimation of the signal parameters or detection of the presence of a signals.

CO4: Evaluate the performance of different estimation technique in different setups. CO5: Apply these skills to solve problems with practical context.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	2							3	3	2	2
CO2	3	3	3	3	3							3	3	2	2
CO3	3	3	3	3	3							3	3	2	2
CO4	3	3	3	3	3							3	3	2	2
CO5	3	3	3	3	3							3	3	2	2

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Sub Code	L	T	P	IA	ESE	Total	Credits
ECPBTP01	3	-	-	40	60	100	3

LOW POWER VLSI DESIGN

Course Objectives:

- To understand the low power low voltage VLSI design.
- To understand the impact of power on system performances.
- To realize different design approaches.
- To identify suitable techniques to reduce power dissipation in the circuits.

UNIT-I:

Introduction: Need for Low Power VLSI chips, Low power application, Low power design methodology, Basic principal of low power design, Low power figure of merits, Sources of Power dissipation: Dynamic, Short-circuit, Glitching and Leakage power dissipation, The load capacitance.

UNIT-II:

Supply Voltage Scaling for Low Power: Introduction, Device feature size scaling, Architectural-level approaches, Multilevel voltage scaling and challenges, Dynamic voltage and frequency scaling.

UNIT-III:

Switching Capacitance Minimization: Dynamic voltage and frequency scaling, Bus encoding, clock gating, Gated-clock FSM, Glitching power minimization, Logic style for low power, some related techniques for dynamic power reduction.

UNIT-IV:

Leakage Power Minimization: Fabrication of multiple threshold voltages, VTCMOS approach, Transistor stacking, MTCMOS approach, Power gating, DTCMOS, Dynamic V_{th} scaling.

UNIT-V:

Special Techniques: Low power clock distribution, Single driver Vs distributed buffers, Various clock distribution networks, Power reduction in clock networks, Low power bus, CMOS floating nodes, and Adiabatic logic.

Text/Reference Books:

1. Ajit Paul, “Low Power VLSI Circuits & Systems”, Springer, 2015.
2. Kaushik Roy, Sharat Prasad, “Low power CMOS VLSI circuit design”, John Wiley sons Inc.,2000.
3. Gary Yeap, “Practical low power digital VLSI design”, Kluwer, 1998.
4. J. B. Kulo and J. H. Lou, “Low voltage CMOS VLSI Circuits”, Wiley, 1999.
5. A. P. Chandrasekaran and R. W. Broadersen, “Low power digital CMOS design”, Kluwer, 1995.

Course Outcome:

At the end of the course, students will demonstrate the ability to:

CO1: Identify sources of power dissipation in VLSI systems.

CO2: Understand how to apply techniques at the device, circuit and architectural level to reduce power dissipation in an electronic design.

CO3: Illustrate and design switching capacitance & leakage power minimization techniques low voltage low power applications.

CO4: Learn and design special techniques for various low voltage low power applications. CO5: Design and implementation of various structures for low power applications.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	1	1			1	1		2	3	1	2
CO2	3	3	2	1	1	1			1	1		2	3	1	2
CO3	3	3	3	1	1	1			1	1		2	3	3	2
CO4	3	3	3	1	1	1			1	1		2	3	3	2
CO5	3	3	1	1	1	1			1	1		2	3	1	1

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Sub Code	L	T	P	IA	ESE	Total	Credits
ECPBTP03	3	-	-	40	60	100	3

OPTICAL INSTRUMENTATION

Course Objectives:

- To understand the measuring methods and instruments of electrical quantities.
- To understand the concept of optical instrumentation.
- To get the concept of optical switching and various instruments.
- To get the concept of optical fiber sensors.
- To get the measurement concept of optical instrumentation.

UNIT-I:

Performance characteristics of instruments: Static characteristics, accuracy, resolution, precision, expected value, error and sensitivity. Errors in measurement and dynamic characteristics: speed of response, fidelity, lag and dynamic error.

UNIT-II:

Optical Instruments: basic principles, interferometric configurations, MachZender, Michelson and FabriPerot configurations components and construction, OTDR and applications.

UNIT-III:

Fiber optic components and devices : Direction couplers, beam splitters, switches modulations, connectors, couplers, polarizer, polarization controllers, amplifiers, wavelength filters, polarizing beam splitters, wavelength division multiplexers, fiber optic isolators.

UNIT-IV:

Fibre optic sensors : general features, types of OFS, intrinsic and extrinsic sensors, intensity sensors, shutter based multimode OFS, simple fibre based sensors for displacement, temperature and pressure. Fibre Bragg grating based sensors.

UNIT-V:

Measurements methods in optical fiber : General experimental consideration, measurement of refractive index profile, numerical aperture, attenuation, pulse dispersion and bandwidth, Cut off wavelength, mode field diameter and birefringence of single mode fiber.

Text/Reference Books:

1. B. P. Pal : Fundamentals of Fibre Optics in Telecommunication and Sensor Systems, New Age, New Delhi.
2. A. K. Ghatak and K. Thyagarajan, Introduction to Fiber Optics, Cambridge.
3. S.M. Senior : Optical Fibre Communication: Principles and Practice, PHI, New Delhi.
4. A.K.Ghatak, M.R. Shenoy : Fibre Optics Measurements, Viva, New Delhi.

Course Outcome:

At the end of the course, students will demonstrate the ability to:

- Explain the measuring methods and instruments of electrical quantities.
- Apply the concept of optical instrumentation.
- Analyze the concept of optical switching and various instruments.
- Explain the concept of optical fiber sensors.
- Demonstrate the measurement concept of optical instrumentation.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1	3	1							3	2	2	
CO2	2	2	1	3	2							3	2	2	
CO3	3	2	3	3	2							3	2		3
CO4	3	2	1	2	3							3	2		2
CO5	3	2	1	2	3							3	2	2	2

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Sub Code	L	T	P	IA	ESE	Total	Credits
ECPBLT01	-	-	4	30	20	50	2

SEMICONDUCTOR DEVICE DESIGN AND SIMULATION LAB

Course Objectives:

- To give the exposure of TCAD tools.
- To develop skills in designing diodes and transistors using TCAD.
- To efficiently understand the various device parameters, working and characteristics.
- To provides an opportunity to design feature low power devices.

List of Experiments:

1. Introduction of VLSI TCAD tools.
2. Design and Simulation of 2D/3D NMOS Channel Length 20nm or higher.
3. Design and Simulation of 2D/3D PMOS Channel Length 20nm or higher.
4. Design and Simulation of 2D/3D CMOS using NMOS and PMOS.
5. Design and Simulation of SOI/Bulk Dual Gate FET & Dual Gate Junction less FET.
6. Design and Simulation of SOI/Bulk FINFET device using GDS2MESH and GENIUS.
7. Design and Simulation of SOI/Bulk 2D/3D Nanowire FET.
8. Design and simulation of dopingless FET.
9. Design and implementation of SRAM using CMOS & FINFET Process.
10. Desgn and implemenation of Tunnel Field Effect Transistor.

Course Outcome:

At the end of the course, students will demonstrate the ability to:

CO1. Familiar with sophisticated VLSI TCAD tools.

CO2. Design and implement any diode and transistor using TCAD tools.

CO3. Design and implement SOI based junction/junction less dual gate FET & FINFET using TCAD tools.

CO4. Understand the working of all devices and implement advanced device using TCAD tools.

CO5: Learn advanced features in device design & simulation.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	3		1		3			3	3	3	3
CO2	3	3	2	3	3		1		3			3	3	3	3
CO3	3	3	2	3	3		1		3			3	3	3	3
CO4	3	3	2	3	3		1		3			3	3	3	3
CO5	3	3	2	3	3		1		3			3	3	3	3

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

DIGITAL IMAGE PROCESSING

SUB CODE	L	T	P	DURATION	ESE	CREDITS
ECDATP23	03	01	0	4 HRS	100	4

Course Objectives:

- To provide fundamental knowledge on digital image processing.
- To develop the ability to understand and implement various digital image processing algorithms.
- To facilitate the students for analyze and implementing various real-time digital image processing applications.

UNIT-I: Image Representation and Image Processing Paradigm: Image, Elements of Image perception, image sensing and acquisition, image sampling and quantization, basic relationships between pixels

Image Enhancements: Point operations, Arithmetic operations, Logical operation, Gray level transformations, histogram equalization, histogram specifications, pixel-domain smoothing filters, pixel-domain sharpening filters, two-dimensional DFT and its inverse, and Cosine transform.

UNIT-II: Image Filtering and Restoration: Noise models, Restoration in the Presence of Noise Only using Spatial Filtering and Frequency Domain Filtering, Linear Position-Invariant Degradations, Estimating the Degradation Function, Inverse Filtering, Minimum Mean Square Error (Wiener) Filtering, Constrained Least Squares Filtering.

UNIT-III: Color Image Processing: Color models, Color transformations, Color image smoothing and sharpening; Color Segmentation. **Wavelets and Multi-resolution image processing**- Uncertainty principles of Fourier Transform, Time-frequency localization, continuous wavelet transforms, wavelet bases and multi-resolution analysis, wavelets and Sub-band filter banks, wavelet packets.

UNIT-IV: Image Compression: Redundancy–inter-pixel and psycho-visual; Lossless compression – predictive, entropy; Lossy compression- predictive and transform coding; Still image compression standards – JPEG and JPEG-2000.

UNIT-V: Image Segmentation: Detection of discontinuities, edge linking and boundary detection, thresholding, region-based segmentation, Segmentation Using Morphological Watersheds.

Text/Reference Books:

1. Rafael C. Gonzalez, R E. Woods, Digital Image Processing, 3rd Ed, Pearson Ed 2010
2. Anil Kumar Jain, Fundamentals of Digital Image Processing, Prentice Hall,2nd ed 2011
3. William K. Pratt, Digital Image Processing, 4th edition, John Wiley, 2007.
4. John C. Russ, The Image Processing Handbook, 6th edition, CRC Press,2011
5. Maria M. P. Petrou, C Petrou, Image Processing: The Fundamentals, 2nd Ed, Wiley 2010

Course Outcome:

At the end of the course, students will demonstrate the ability to:

1. Acquire the knowledge of basic image processing concepts and image enhancement techniques involved.
2. Demonstrate the image restoration process and its respective filters required.
3. Illustrate the color image processing and various multi-resolution techniques
4. Interpret the various image compression techniques and their applications.
5. Design the various image segmentation operations for a meaningful partition of objects.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	1	1			1		2	1	1	1
CO2	3	3	3	3	3	1	1			1		2	2	2	2
CO3	3	3	3	3	3	1	1			1		2	3	2	2
CO4	3	3	3	3	3	1	1			1		2	3	2	2
CO5	3	3	3	3	3	1	1			1		2	3	2	2

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

TUNNEL FIELD EFFECT TRANSISTOR

SUB CODE	L	T	P	DURATION	ESE	CREDITS
ECDATP8	03	01	0	4 HRS	100	4

Course objective:

- To introduce CMOS scaling and its limitations.
- To demonstrate the fundamental aspect of quantum tunneling.
- To gain the knowledge of principle working , characteristics and current improving techniques of TFET.
- To cognize the role of TFET in low power application.

UNIT-I:

CMOS Scaling: Introduction, Basics of MOSFET and CMOS, MOSFET structure and operation, Operation of MOSFET as a switch, Short-channel effects in a MOSFET, CMOS inverter, Power dissipation in a CMOS circuit, CMOS scaling, Types of CMOS scaling-Constant-field scaling, Constant- voltage scaling, Current trends in CMOS scaling, Challenges in continued CMOS scaling, Emerging research devices.

UNIT-II:

Quantum Tunneling: Quantum mechanics, Quantum mechanical tunneling, Solving the tunneling problems-Analytic Approximation methods, Numerical methods, Junction breakdown due to tunneling, Tunnel diode.

UNIT-III:

Basics of Tunnel Field Effect Transistors: Introduction, Device structure, Operation, Transfer characteristics-OFF state, Subthreshold region, Super-threshold region, Subthreshold swing, Tunneling current, Output characteristics, Threshold voltage, Impact of device parameters, Ambipolar current.

UNIT-IV:

Boosting ON-Current in Tunnel Field Effect Transistor: Introduction, Types of techniques to boost ON current, Gate Engineering, Tunneling junction engineering, Material engineering.

UNIT-V:

Application of Tunnel Field Effect Transistor: Introduction, Electrical characteristics of TFETs, Digital Circuits, Application in memories, Analog circuits, Future perspective of TFETs in circuits.

Text/Reference Books:

1. S. Saurabh and M. J. Kumar, "Fundamentals of tunnel field effect transistors", CRC Press, Taylor & Francis, 2016.
2. M. J. Kumar, R. Vishnoi and P. Pandey, "Tunnel Field Effect Transistor-Modelling & Simulation" Wiley, 2016.
3. N. Gupta, A. Makosiej, A. Amara, A. Vladimirescu and C. Anghel, "TFET Integrated Circuits", Springer, 2021.

Course Outcomes:

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

CO1: Develop an understanding for the scaling of CMOS and its future limitation.

CO2: Explore the fundamental aspect of quantum tunneling and the physical principle that forms the basis of TFET.

CO3: Comprehend the operating principle of TFET and analyze the characteristics of TFET. CO4: Discuss & explore various techniques to improve the ON current of TFET device.

CO5: Apply TFET based device in various low power application.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1			2			3	3	1	2
CO2	3	3	2	2	2	1			2			3	3	2	2
CO3	3	3	3	2	2	1			2			3	3	2	2
CO4	3	3	3	2	2	1			2			3	3	2	2
CO5	3	3	3	2	2	1			2			3	3	2	2

MIMO COMMUNICATION SYSTEM

SUB CODE	L	T	P	DURATION	ESE	CREDITS
ECDATP9	03	01	0	4 HRS	100	4

Course objective:

- To introduce the fundamentals need and limitations of MIMO communication systems.
- To demonstrate the different MIMO channel models.
- To identify the role of diversity and MIMO techniques in combating the effect of fading and maximizing the capacity.
- To cognize the most recent trends in the broad area of wireless communication.

Introduction: MIMO wireless communication, Need for MIMO systems, Multiple antennas in wireless communication systems, MIMO in wireless networks, Diversity-multiplexing trade-off, Transmit diversity schemes, advantages and applications of MIMO systems, MIMO channel and signal model, MIMO in wireless standards, Future challenges.

MIMO Channel Models: Analytical MIMO channel models: Uncorrelated, fully correlated, separately correlated and keyhole MIMO fading models, parallel decompositionof MIMO channel. **Capacity limits of MIMO systems,** Introduction, Single-user MIMO, Multi-user MIMO, MIMO Channel models, Capacity and information rates in MIMO channels: Capacity and Information rates in AWGN and fading channels, Capacity of MIMO channels, Capacity for deterministic and random MIMO channels, Capacity of i.i.d., separately correlated and keyhole Rayleigh fading MIMO channels, Single user MIMO Capacity, Single user capacity metrics, Multi-user capacity metrics.

Precoding Design: Channel state information at the transmitter (CSIT), Information-theoretic foundation for exploiting CSIT, A transmitter structure, Precoding design criteria, Linear precoder designs, Precoder performance results and discussion, Applications in practical systems.

Space Time-Coding for Wireless Communications: Principles and applications, Introduction, Space time coding principles, Alamouti space–time codes, SER analysis of Alamouti space-time code over fading channels, Space-time block codes, Space-time trellis codes, Performance analysis of Space-time codes over separately correlated MIMO channel.

Text/Reference Books:

1. E. G. Larsson, P. Stoica, "Space-Time Block Coding for Wireless Communications", Cambridge University Press, 2008.
2. E. Biglieri, R. Calderbank et al "MIMO Wireless Communications" Cambridge Univ Press, 2007.
3. D. Tse, P. Viswanath, "Fundamentals of Wireless Communication", Cambridge Univ Press, 2005.
4. H. Jafarkhani, "Space-Time Coding: Theory and Practice", Cambridge University Press 2005.
5. Paulraj, R. Nabar, and D. Gore, "Introduction to Space-Time Wireless Communications", Cambridge University Press, 2003.

Course Outcomes:

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

CO1: Understand the concept & working principle of MIMO communication systems.

CO2: Learn & design uncorrelated & correlated MIMO channel and its impact on system

capacity. CO3: Analyze the information theoretic capacity of MIMO system under different conditions.
CO4: Illustrate the concept of channel state information at the transmitter side and their impact on channel capacity.
CO5: Comprehend space time coding and design a suitable coding of structure for the improvement of bit error rate.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1			2			3	3	1	2
CO2	3	3	2	2	2	1			2			3	3	2	2
CO3	3	3	3	2	2	1			2			3	3	2	2
CO4	3	3	3	2	2	1			2			3	3	2	2
CO5	3	3	3	2	2	1			2			3	3	2	2

DEEP LEARNING

SUB CODE	L	T	P	DURATION	ESE	CREDITS
ECDATP10	03	01	0	4 HRS	100	4

Course objectives:

1. To introduce the basic concept of artificial neural network for deep learning.
2. To introduce techniques used for training artificial neural networks.
3. To understand practical aspects of deep neural networks.
4. To understand the Convolutional neural network and optimization algorithms.
5. To carry out design and implementation of deep learning models on signals and images.

UNIT I: Introduction: Introduction to deep learning, Machine learning vs and Deep learning, review of gradient descent; logistic regression; cost function- maximum likelihood based cost, cross entropy, MSE; perceptron learning; activation functions – softmax, logistic sigmoid, tanh, ReLU; types of neural networks – feed forward neural network, recurrent neural network, symmetrically connected network.

UNIT II: Deep Feed Forward Neural Networks: Gradient based learning; hidden units; architecture design; back-propagation; hyperparameters. output units: linear, softmax; hidden units: tanh, RELU; GPU training etc.

UNIT III: Regularization and Practical Aspects of Deep Learning: Regularization and under-constrained problems, dataset augmentation, noise robustness, early stopping, bagging, dropout, normalizing inputs; vanishing/exploding gradients, weight initialization for deep networks; numerical approximation of gradients; gradient checking; hyperparameter tuning; batch normalization.

UNIT IV: Convolutional neural networks , Fundamentals, architectures, pooling, visualization, Deep learning for spatial localization, Convolution operation, Transposed convolution, efficient pooling, object detection, semantic segmentation, Optimization Algorithms: mini-batch gradient descent; gradient descent with momentum; rmsprop, ADAM optimization algorithm.

UNIT V: Recurrent neural networks (RNN), long-short term memory (LSTM), language models, machine translation, image captioning, video processing, visual question answering, video processing, and learning from descriptions. Deep Learning Tools: Use of deep learning tools such as tensor flow, Keras for deep learning applications.

Reference books:

1. Goodfellow, Ian, Yoshua Bengio, Aaron Courville, Deep Learning (Adaptive Computation and Machine Learning Series), MIT Press, 2016.
2. Nielsen, Michael A., Neural Networks and Deep Learning, 2015.
3. Gibson, Adam, and Josh Patterson, Deep Learning: a Practitioner's Approach, O'Reilly Media, Inc 2016.
4. Chollet, Franois. Deep Learning with Python, 2017.
5. Buduma, Nikhil, and Nicholas Locascio, Fundamentals of Deep Learning: Designing Next-generation Machine Intelligence Algorithms, O'Reilly Media, Inc., 2017.

Course Outcomes (COs): At the end of the course, the students will be able to:

1. Explain the mathematics behind functioning of artificial neural network for deep learning.
2. Illustrate the basic concepts of Neural Networks based on architectures and learning rules.
3. Comprehend the practical aspects of Deep Neural Networks (DNN) with parameter tuning.
4. Design and implementation of deep learning models for signal/image processing applications
5. Design and deploy simple TensorFlow-based deep learning solutions to classification/ segmentation problems.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	2				2			3	3	1	3
CO2	3	2	2	1	2				2			3	3	1	3
CO3	3	2	2	2	2				2			3	3	2	3
CO4	3	2	2	2	2				2			3	3	2	3
CO5	3	2	2	2	2				2			3	3	2	3

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

MEDICAL IMAGE PROCESSING

Sub Code	L	T	P	Duration	ESE	Credits
ECDATP24	3	1	-	4 hours	100	4

Course Objectives:

2. To provide fundamental knowledge about images & their processing.
3. To understand & to know how an image model is developed and processed.
4. To develop a capacity to analyze the image through various segmentation techniques.
5. To develop a capacity to apply these processings in medical applications.

UNIT-1 Medical Imaging: fundamentals of medical imaging, Various Modalities of Medical Imaging: X-ray Imaging, Computed Tomography, magnetic resonance imaging, Ultrasound Imaging, Nuclear medicine imaging, Mammographic Imaging. Fundamental steps in Digital Image Processing, Components of Image processing system, Image Formation Model, Image Sampling and Quantization, Basic relationship between pixels, Image sensing, and acquisition.

UNIT-2: Medical Image Enhancement in spatial domain: Background, Point processing-Image negatives, Log transformation, Power law transformations, Contrast stretching, Intensity level slicing, Bit plane slicing, histogram processing-Histogram equalization, Histogram matching, Arithmetic/Logic operations-Image subtraction, Image averaging, Fundamentals of spatial filtering, Smoothing spatial filters, Sharpening spatial filters.

UNIT-3: Medical Image Enhancement in Frequency Domain: Background, 2D-Discrete Fourier Transform and its Inverse, Basic properties of the 2D-Discrete Fourier Transform, Basics of filtering in the frequency domain. Image smoothing using frequency domain filters-Ideal lowpass filters, Butterworth lowpass filters, Gaussian lowpass filters; Image sharpening using frequency domain filters- Ideal highpass filters, Butterworth highpass filters, Gaussian highpass filters, Homomorphic filtering.

UNIT-4: Medical Image restoration: Image degradation model, Image noise models, filtering techniques. Image Compression: Fundamentals, image compression models, basic compression methods- Huffman coding, Arithmetic coding, LZW coding, Run-length coding.

UNIT-5: Medical Image Segmentation: Fundamentals, Point detection, Line detection, Edge models, Edge detection, Canny edge detector, Thresholding, Region-based segmentation.

Text/Reference Books:

1. Digital Image Processing by Rafael C. Gonzalez & Richard E. Woods, 3rd Ed. Pearson Edu, 2012.
2. Medical Image Processing Concepts and Applications by G.R. Sinha, Bhagwati Charan Patel. PHI Learning, 2014
3. Handbook of Medical Image Processing and Analysis by Isaac Bankman, Academic Press
4. Anil Kumar Jain, Fundamentals of Digital Image Processing, Prentice Hall of India.2nd ed, 2011.
5. John C. Russ, The Image Processing Handbook, 6th edition, CRC Press,2011

Course Outcome:

Upon successful completion of the course, students will be able to

1. Acquire the knowledge of basic medical imaging and recognize the imaging modality from their visualization

2. Describe fundamental methods of medical image enhancement in the spatial domain.
3. Demonstrate the frequency domain image enhancement process and its respective filters required.
4. Interpret the various medical image restoration and compression techniques.
5. Design the various image segmentation operations for a meaningful partition of objects.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	1	3				3			3	3	1	2
CO2	3	1	1	1	3				3			3	3	1	2
CO3	3	2	2	1	3				3			3	3	2	3
CO4	3	2	2	2	3				3			3	3	2	3
CO5	3	2	2	2	3				3			3	3	2	3

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

CONVEX OPTIMIZATION

SUB CODE	L	T	P	DURATION	ESE	CREDITS
ECDATP25	**03**	**01**	**0**	**4 HRS**	**100**	**4**

Course Objective

1- To study the fundamentals of convex optimization.
2- To study the Unconstrained optimization methods.
3- To study Linear programming and its usability.
4- To study the fundamentals of Non-linear constrained optimization.
5- Learn to apply and convert real world problem in to convex optimization framework.

Prerequisites: Linear Algebra, Probability.

Unit I Background on linear algebra, Convex sets and Convex functions: examples of convex problems.

UNIT II Level sets and Gradients. Unconstrained Optimization: Search methods, Gradients Methods, Newton Method, Conjugate Direction Methods, Quasi-Newton Methods.

UNIT III Linear Programming: Standard Form Linear Programs, Simplex method, Duality and Non Simplex Methods, applicability in Communication domain.

UNIT IV Nonlinear Constrained Optimization: Problems with equality constraints, Problems with Inequality Constraints, Convex Optimization Problems.

UNIT V Algorithms for Constrained Optimization: Projected Gradient Methods and Penalty Methods.

References:

- Lieven Vandenberghe and Stephen P. Boyd, Convex Optimization, Cambridge University Press, 2004.
- Dimitris Bertsekas, John N. Tsitsiklis, Introduction to Linear Optimization, Athena Scientific Series, 1997.
- Aharon Ben-Tal and Arkadi Nemirovski, Lectures on Modern Convex Optimization: Analysis, Algorithms, and Engineering Applications, SIAM, 2001.
- Stephen Boyd and Lieven Vandenberghe, Convex Optimization, Cambridge University Press. [Online]. http://www.stanford.edu/~boyd/cvxbook/
- Convex Optimization in Signal Processing and Communications, D. P. Palomar, Y. C. Eldar. Cambridge Press, 2010.
- https://ocw.mit.edu/courses/6-079-introduction-to-convex-optimization-fall-2009/pages/readings/
- Dimitri P. Bertsekas, Convex Analysis and Optimization, Athena-Scientific, 2003.

Course Outcome

On the successful completion of this course Student are able to

CO1: Differentiate between non convex and convex functions and sets

CO2: Analyse the various algorithms and their convergence.

CO3: Formulate communication problems in convex optimization framework

CO4: Discuss the applications of convex optimization methods in various applications

CO5: Choose and apply suitable algorithm given the application.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	1	1			2			3	3	1	2
CO2	3	2	2	2	1	1			2			3	3	1	2
CO3	3	2	2	2	1	1			2			3	3	1	2
CO4	3	2	3	2	1	1			2			3	3	1	2
CO5	3	2	3	2	1	1			2			3	3	1	2

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**