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

Programme Outcomes:

Graduates will be able to:

PO1: Fundamentals: Apply knowledge of mathematics, science and engineering.

PO2: Problem analysis: Identify, formulate and solve real time engineering problems using first principles.

PO3: Design: Design engineering systems complying with public health, safety, cultural, societal and environmental considerations

PO4: Investigation: Investigate complex problems by analysis and interpreting the data to synthesize valid solution.

PO5: Tools: Predict and model by using creative techniques, skills and IT tools necessary for modern engineering practice.

PO6: Society: Apply the knowledge to assess societal, health, safety, legal and cultural issues for practicing engineering profession.

PO7: Environment: Understand the importance of the environment for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics, and responsibilities and norms of the engineering practice.

PO9: Teamwork: Function effectively as an individual and as a member or leader in diverse teams and multidisciplinary settings.

PO10: Communication: Communicate effectively by presentations and writing reports.

PO11: Management: Manage projects in multidisciplinary environments as member or a team leader.

PO12: Life-long learning: Engage in independent lifelong learning in the broadest context of technological change.

Programme Specific Outcomes:

PSO1: Identify, formulate and apply concepts acquired through Electronics & Communication Engineering courses to the real-world applications.

PSO2: Design and implement products using the cutting-edge software and hardware tools to attain skills for analyzing and developing subsystem/processes.

PSO3: Ability to adapt and comprehend the technology advancement in research and contemporary industry demands with demonstration of leadership qualities and betterment of organization, environment and society.

Sub Code	L	T	P	Duration	IA	ESE	Total	Credits
EC207TPE05	3	1	-	4 hours	30	70	100	4

MOBILE COMMUNICATION & NETWORK

Course Objectives:

1. To know the evolution of Mobile communication and cell concept
2. To know the fading mechanism and types of fading and effect of fading on Mobile communication.
3. To know the role of Equalization and diversity techniques in Mobile communication
4. To know the various types of multiple access techniques .
5. To know the higher generation cellular standards

UNIT-I:

Introduction to Mobile Communication

Evolution of mobile communications, Mobile radio around the world, Types of Wireless communication system. Second generation Cellular Networks, GSM, The Cellular Concept-System design Fundamentals: Cellular System, Hexagonal geometry cell and frequency reuse concept, channel assignment strategies, Distance to frequency reuse ratio, channel & Co-channel interference reduction factor, S/I ratio consideration and calculation for minimum Co-channel and adjacent interference, Handoff strategies, Umbrella Cell Concept, Improving Coverage & Capacity in cellular System : splitting, cell sectorization, Repeaters, Micro cell zone concept.

UNIT-II:

Mobile Radio Propagation

Free space propagation model, The three basic propagation Mechanism: reflection, diffraction, scattering, Practical link budget design, Outdoor Propagation models, Indoor propagation models, Small scale Multipath propagation, Impulse response model of a Multipath Channel, Small scale Multipath measurements, parameters of Mobile multipath channels, types of small scale fading, Time Delay Spread; Flat, Frequency selective, Doppler Spread; Fast and Slow fading Rayleigh and Ricean Distributions.

UNIT-III:

Receiver Structure

Diversity receivers- selection and MRC receivers, RAKE receiver. Modulation Techniques: Minimum Shift Keying, Gauss ion MSK, M-ary QAM, M-ary FSK, Orthogonal Frequency Division Multiplexing, Performance of Digital Modulation in Slow-Flat Fading Channels and Frequency Selective Mobile Channels. Equalization: Survey of Equalization Techniques, Linear Equalization, Non-linear Equalization, Algorithms for Adaptive Equalization. Diversity Techniques, RAKE receiver. . Performance measures- Probability of Outage, average SNR, average symbol/bit error rate.

UNIT-IV:

Multiple Access Techniques for Wireless Communication

Introduction, FDMA, TDMA, CDMA:DS-SS, FH-SS, Space division multiple access.
Capacity of a cellular systems. Contention-based multiple access schemes (ALOHA and CSMA).

UNIT-V:

Higher Generation Cellular Standards

Evolution of Wireless LANs, Wireless LAN Topologies, IEEE 802.11 Standards, Wireless LAN Applications. Trunking and Grade Of Service(GOS). Enhancements in 3G Standards, Architecture and representative protocols in 4G standard, Introduction to 5G and 6G.

Text/Reference Books:

1. Wireless Communication, Theodore S. Rappaport, Prentice hall
2. Wireless Communications and Networking, Vijay Garg, Elsevier
3. Wireless digital communication, Kamilo Feher, PHI
4. Mobile Communications Engineering, William C. Y. Lee, Mc Graw Hill Publications
5. Wireless Communications, A. J. Goldsmith, Cambridge Univ. Press, 2005

6. Fundamentals of Wireless Communications, D. Tse and P. Vishwanath, ,Cambridge Univ. Press, 2005.
7. Mobile & Personal Communication System, Pandya R., PHI
8. 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 basic concepts of the cellular concept and Assess practical handoff considerations, interference and system capacity.

CO2: Compare mobile radio propagation with large-scale path loss and Demonstrate types of Small-Scale Fading

CO3: Analyze the fundamentals of Equalization and diversity in a communication Receiver.

CO4: Demonstrate an ability to explain multiple access techniques for Wireless Communication.

CO5: Explain the architecture, functioning, protocols, capabilities and application of various wireless communication networks.

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
EC207TPE06	3	-	-	4 hours	30	70	100	3

DIGITAL IMAGE PROCESSING

Course Objectives:

1. To provide the fundamental knowledge on digital image processing. 2. To develop the ability to understand and implement various digital image processing algorithms. 3. To facilitate the students for analyze and implement 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, 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. R. C. Gonzalez, R. E. Woods, Digital Image Processing, 3rd Edition, Pearson Education 2010.
2. Anil K Jain, Fundamentals of Digital Image Processing, Prentice Hall of India,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 and Costas Petrou, Image Processing: The Fundamentals, 2nd Ed., John Wiley & Sons, Ltd, 2010.

Course Outcome:

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

1. Acquire the knowledge of basic image processing concept and image enhancement techniques involved.
2. Demonstrate 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**

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
EC207TPE08	3	1	-	4 hours	30	70	100	4

FIBER OPTIC COMMUNICATION

Course Objectives:

1. To introduce the concept of signal propagation through the optical fiber.
2. Discuss the channel impairments like losses and dispersion
3. To learn the various components of optical fiber Communication system.
4. Discuss the concept of optical networking and signal booster devices.
5. To familiar with the concept of advance optical communication system.

UNIT-I:

Introduction to optical communication, principle of light transmission, propagation of light in to fiber, mode theory of a cylindrical waveguide, Ray model.

UNIT-II:

Different types of optical fibers, Modal analysis of a step index fiber.
Signal degradation on optical fiber due to dispersion and attenuation. Fabrication of fibers and measurement techniques like OTDR.

UNIT-III:

Optical sources - LEDs and Lasers, Photo-detectors - pin-diodes, APDs, detector responsitivity, noise, optical receivers, Optical link design - BER calculation, power penalties.

UNIT-IV:

Optical switches - coupled mode analysis of directional couplers, electro-optics switches. Optical amplifiers - EDFA, Raman amplifier.WDM and DWDM systems. Principles of WDM networks.

UNIT-V:

Nonlinear effects in fiber optic links. Concept of self-phase modulation, group velocity dispersion and solition based communication.

Text/Reference Books:

1. J. Keiser, Fibre Optic communication, McGraw-Hill, 5th Ed. 2013 (Indian Edition).
2. T. Tamir, Integrated optics, (Topics in Applied Physics Vol.7), Springer-Verlag, 1975.
3. J. Gowar, Optical communication systems, Prentice Hall India, 1987.
4. S.E. Miller and A.G. Chynoweth, eds., Optical fibres telecommunications, Academic Press, 1979.
5. G. Agrawal, Nonlinear fibre optics, Academic Press, 2nd Ed. 1994.
6. G. Agrawal, Fiber optic Communication Systems, John Wiley and sons, New York, 1997
7. F.C. Allard, Fiber Optics Handbook for engineers and scientists, McGraw Hill, New York (1990).

Course Outcome:

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

1. Demonstrate the optical fiber communication system, fiber structure, propagation and transmission properties of an optical fiber.
2. Analyze the losses and propagation characteristics of an optical signal in different types of fibers.
3. Demonstrate the functionality of elements of optical fiber system and analyse the performance of the elements.
4. Estimate the power budget of the system and can understand the designing of the link.
5. Apply different techniques to improve the efficiency of the system.

Course Outcomes and their mapping with Programme Outcomes:

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

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

Sub Code	L	T	P	Duration	IA	ESE	Total	Credits
EC207TPE09	3	-	-	4 hours	30	70	100	3

MICROWAVE THEORY & TECHNIQUES

Course Objectives:

1. To understand the concepts of waveguides and modes.
2. To understand the basic concept of various types of Guiding Structure and Passive Components at Microwave.
3. To understand the concepts and working principles of Microwave Active Components.
4. To understand the concepts and working principles of Microwave System Design and Antenna
5. To understand the applications and effect of microwave in various system

UNIT-I:

Introduction to Microwaves-History of Microwaves, Microwave Frequency bands; Applications of Microwaves, Mathematical Model of Microwave Transmission-Concept of Mode, Features of TEM, TE and TM Modes in Rectangular and Circular waveguide, Losses associated with microwave transmission, Concept of Impedance in Microwave transmission. Introduction of Microwave Systems.

UNIT-II:

Analysis of RF and Microwave Transmission Lines- Coaxial line, Strip line, Micro strip line. Microwave Network Analysis- Equivalent voltages and currents for non-TEM lines, Network parameters for microwave circuits, Scattering Parameters. Passive Microwave Devices- Microwave passive components: Directional Coupler, Power Divider, Magic Tee, Resonator.

UNIT-III:

Microwave active components: Microwave Semiconductor Devices: Gunn Diodes, IMPATT diodes, Schottky Barrier diodes, PIN diodes. Microwave Tubes: Klystron, Travelling Wave Tube Amplifier, Magnetron.

UNIT-IV:

icrowave Design Principles-Impedance transformation, Impedance Matching, Introduction of Microwave Filter Design, Microwave Antennas Antenna parameters, Introduction of Antennas for ground based systems, airborne and satellite systems, Introduction of Planar Antennas for Microwave frequency.

UNIT-V:

Microwave Measurements- Power, Frequency and impedance measurement at microwave frequency, Noise at microwave frequency and measurement of noise figure. Electromagnetic interference and Electromagnetic Compatibility (EMI & EMC), Modern Trends in Microwaves Engineering, microwave imaging, Effect of Microwaves on human body.

Text/Reference Books:

1. R.E. Collins, Microwave Circuits, McGraw Hill
2. K.C. Gupta and I.J. Bahl, Microwave Circuits, Artech house
3. S.Y. Liao, Microwave Devices and circuits, Pearson Education
4. David M. Pozar, Microwave Engineering, John Wiley & Sons
5. R.K. Shevgaonkar, Electromagnetic Waves, Tata McGraw Hill, 2005

Course Outcome:

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

1. Analyze the need of various microwave system components and their properties.
2. Evaluate the various Guiding structures and passive components along with their properties.
3. Analyze the microwave active systems and different mathematical treatment for comparison of general circuit analysis.
4. Analyze to design the Microwave Devices.
5. Evaluate the Measurement of Microwave Properties and will learn latest development in Microwave Technology.

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		3								3	2	
CO2	3	3	2	2	3								3	2	
CO3	3	3	2										3		
CO4	3	3	3	3	3								3	2	
CO5	3	1	1			1	1						3		3

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

Sub Code	L	T	P	Duration	IA	ESE	Total	Credits
EC207TPE10	3	-	-	4 hours	30	70	100	3

POWER ELECTRONICS

Course Objectives:

- To introduce students to the basic theory of power semiconductor devices and passive components, their practical applications in power electronics.
- To familiarize students to the principle of operation, design and synthesis of different power conversion circuits and their applications.
- To provide strong foundation for further study of power electronic circuits and systems.

UNIT-I:

Introduction: Concept & application of power electronics, uncontrolled converters, advantages and disadvantages of power electronics converters, power electronics switches. **Thyristors:** Thyristors, V-I characteristics and applications. Two transistor model of SCR, SCR turn on methods, switching characteristics, gate characteristics, ratings, SCR protection, series and parallel operation, gate triggering circuits, different commutation techniques of SCR.

UNIT-II:

Phase controlled converters: Principle of operation of single phase and three phase half wave, half controlled, full controlled converters with R, R-L and RLE loads, effects of freewheeling diodes and source inductance on the performance of converters. External performance parameters of converters, techniques of power factor improvement, single phase and three phase dual converters.

UNIT-III:

DC-DC converters: Principle of operation, control strategies, step up choppers, types of choppers circuits based on quadrant of operation, performance parameters, multiphase choppers and switching mode regulators.

UNIT-IV:

Inverters: Definition, classification of inverters based on nature of input source, wave shape of output voltage, method of commutation & connections. Principle of operation of single phase and three phase bridge inverter with R and R-L loads, performance parameters of inverters, methods of voltage control and harmonic reduction of inverters. Brief idea of Resonant Pulse inverters.

UNIT-V:

AC controllers: Principle of on-off and phase control, single phase and three phase controllers with R and R-L loads. Principle of operation of cycloconverters, circulating and non-circulating mode of operation, single phase to single phase step up and step down cycloconverters, three phase to single phase Cycloconverters, three phase to three phase Cycloconverter.

Text/Reference Books:

1. Ned Mohan, Tore M. Undeland and William P. Robbins, "Power Electronics – Converters, Applications and Design", John Willey & sons, Inc., 3rd ed., 2003.
2. Muhammad H. Rashid, "Power Electronics - Circuits, Devices and Applications", Prentice Hall of India, 3rd ed., 2009.
3. Power Electronics by P.S. Bhibmra, Khanna Publishers.
4. Modern Power Electronics and AC Drives –B. K. Bose-Pearson Publications, 2002.
5. L. Umanand, "Power Electronics Essentials and Applications", Wiley India Ltd., 2009
6. P.C Sen, 'Thyristor DC Drives', John wiely and sons, New York, 1981.

Course Outcome:

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

1. Relate basic semiconductor physics and mathematics to Describe basic operation of power semiconductor device and compare performance of various power semiconductor devices, passive components and switching circuits

2. Design and Analyze power converter circuits and learn to select suitable power electronic devices by assessing the requirements of application fields.
3. Formulate and analyze a DC-to-DC converter at the system level and assess the performance.
4. Design and analyse inverter circuits and derive for typical solutions to reduce harmonics to improve its efficiency s.
5. Demonstrate the working of voltage controllers and cyclo-converters and recognize the role of power electronics in domestic and industrial 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	1	3		2						1	2	3	1
CO2	3	3	1	3		2						1	2	3	1
CO3	3	3	1	3		2						1	2	3	1
CO4	3	3	1	3		2						1	2	3	1
CO5	3	3	1	3		2						1	2	3	1

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

Sub Code	L	T	P	Duration	IA	ESE	Total	Credits
EC207TPE11	3	-	-	4 hours	30	70	100	3

ESTIMATION AND DETECTION THEORY

Course Objectives:

1. To teach students the basics of estimation and detection theory.
2. To introduce the students to estimation bounds.
3. To introduce classical and Bayesian estimators like ML, LS, and MMSE to students.
4. To teach hypothesis testing and a number of detectors of signals in noise. And to introduce the likelihood ratio test and GLRT.
5. 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, 2nd 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: Learn 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: Compare and 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	2	2			1	1	2	3	2	2
CO2	3	3	3	3	3	2	2			1		2	3	2	2
CO3	3	3	3	3	3	2	2			1		2	3	2	2
CO4	3	3	3	3	3	2	2			1		2	3	2	2
CO5	3	3	3	3	3	2	2		1	1	1	2	3	2	2

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

Sub Code	L	T	P	Duration	IA	ESE	Total	Credits
EC207TPE12	3	-	-	4 hours	30	70	100	3

RADAR & SATELLITE COMMUNICATION

Course Objectives:

1.To know the evolution of Satellite communication and its concept
2. Understand the orbital and functional principles of satellite communication systems.
3. Analyse and evaluate a satellite link and suggest enhancements to improve the link performance.
4. Select an appropriate modulation, multiplexing and multiple access schemes for a given satellite communication link.
5. Understand the basics and functional principles of different types of RADAR.

UNIT-I:

Introduction to Satellite Communication: Principles and architecture of satellite Communication, Brief history of Satellite systems, advantages, disadvantages, applications and frequency bands used for satellite communication.

UNIT-II:

Orbital Mechanics: Orbital equations, Kepler's laws, Apogee and Perigee for an elliptical orbit, evaluation of velocity, orbital period, angular velocity etc. of a satellite, concepts of Solar day and Sidereal day. Satellite sub-systems: Study of Architecture and Roles of various sub-systems of a satellite system such as Telemetry, tracking, command and monitoring (TTC & M), Attitude and orbit control system (AOCS), Communication sub-system, power sub-systems etc.

UNIT-III:

Typical Phenomena in Satellite Communication: Solar Eclipse on satellite, its effects, remedies for Eclipse, Sun Transit Outage phenomena, its effects and remedies, Doppler frequency shift phenomena and expression for Doppler shift. Satellite link budget Flux density and received signal power equations, Calculation of System noise temperature for satellite receiver, noise power calculation, Drafting of satellite link budget and C/N ratio calculations in clear air and rainy conditions.

UNIT-IV:

Modulation and Multiple Access Schemes: Various modulation schemes used in satellite communication, Meaning of Multiple Access, Multiple access schemes based on time, frequency, and code sharing namely TDMA, FDMA and CDMA.

UNIT-V:

RADAR: Introduction, Radar block diagram and Operation, Radar Frequencies, Simple form of Radar Equation, Prediction of Range Performance, Minimum Detectable Signals, CW Radar, Tracking Radar, MTI Radar.

Text/Reference Books:

1. Timothy Pratt Charles W. Bostian, Jeremy E. Allnutt: Satellite Communications: Wiley India. 2nd edition 2002
2. Tri T. Ha: Digital Satellite Communications: Tata McGraw Hill, 2009
3. Dennis Roddy: Satellite Communication: 4th Edition, McGraw Hill,2009

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, modulation and multiple access schemes.
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.

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	Duration	IA	ESE	Total	Credits
EC207TPE13	3	-	-	4 hours	30	70	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:

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.

Reference Books

1. P A Devijer & J Kittler, Pattern Recognition – A statistical Approach, Prentice Hall
2. R O Duda, P E Hart, D G Stork, Pattern Classification, Wiley Publication 2001.
3. D Mckay, Information Theory, Inference and Learning Algorithms, Cambridge University Press 2003.
4. C M Bishop, Pattern Recognition and Machine Learning, Springer, 2006
5. 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	Duration	IA	ESE	Total	Credits
EC207TOE02	3	-	-	4 hours	30	70	100	3

CMOS DIGITAL VLSI DESIGN (Open Elective 02 for non-ECE branch)

Course Objectives:

1. To introduce the physics of MOSFETs.
2. To understand MOS inverter and switching characteristics.
3. To identify different sources of power dissipation in CMOS logic circuits.
4. To build upon the theoretical, mathematical and physical analysis of digital VLSI circuits, for proper understanding of concept, working, analysis and design.

UNIT-I: Introduction: Basic MOSFET characteristics-Threshold voltage, Substrate bias effect, Current voltage characteristics-Square-law model, MOSFET modeling-Drain-source resistance, MOSFET capacitances, Geometric scaling theory-Full-voltage scaling, Constant-voltage scaling, Challenges of MOSFET scaling.

UNIT-II: MOS Inverter & Switching Characteristics: Introduction, NMOS inverter with different loads, CMOS inverter, Delay-time definitions, Calculation of delay times, inverter design with delay constraints.

UNIT-III: Combinational & Sequential Logic Circuits: CMOS logic circuits, Complex logic circuits, CMOS transmission gates, Behavior of bi-stabile elements, The S-R latch circuit, Clocked latch & flip flop circuits, CMOS D latch.

UNIT-IV: Power Dissipation in CMOS Digital Circuits: Switching power dissipation, Short circuit power dissipation, Glitching power dissipation, Static power dissipation-Reverse leakage current, Subthreshold leakage current.

UNIT-V: VHDL: Introduction and use of VHDL, Entity and architecture declaration, Types of models of architecture, Data objects, Data types, Operators, concurrent and sequential statements, process statements, case, if, when statements, Design of sequential and combinational circuits.

Text/Reference Books:

1. S. Kang and Y. Leblebici, "CMOS Digital Integrated Circuits-Analysis and Design", 3rd ed. Tata McGraw Hill, 2008.

2. N.H.E. Weste and K. Eshraghian, "CMOS VLSI Design: A Circuits and Systems Perspective", 2nd ed. eddision Wesley, 1998.

3. J. M. Rabaey, A.P. Chandrakasen, and B. Nikolic, "Digital Integrated Circuits-A Design Perspective", 2nd ed. Pearson Education, 2007.

4. V. A. Pedroni, "Circuits Design with VHDL", 3rd ed. The MIT Press, 2000.

Course Outcome:

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

CO1: Comprehend the fundamental of MOS transistor and short channel effects.
CO2: Design a MOS inverter with different loads and analyze switching characteristics.
CO3: Illustrate and design CMOS combinational & sequential Circuits.
CO4: Identify sources of power dissipation in VLSI systems.
CO5: Design an application using VHDL.

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		3	3	1	2
CO2	3	3	2	1	1	1			1	1		3	3	1	2
CO3	3	3	3	1	1	1			1	1		3	3	3	2
CO4	3	3	3	1	1	1			1	1		3	3	3	2
CO5	3	3	1	1					1	1		3	3	1	1

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

Sub Code	L	T	P	Duration	IA	ESE	Total	Credits
EC207PPC11	-	-	2	4 hours	30	20	50	1

DESIGN & 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 PN Junction Diode.
3. Design and Simulation of 2D/3D NPN & PNP BJT.
4. Design and Simulation of 2D/3D NMOS Channel Length 20nm or higher.
5. Design and Simulation of 2D/3D PMOS Channel Length 20nm or higher.
6. Design and Simulation of 2D/3D CMOS using NMOS and PMOS.
7. Design and Simulation of SOI/Bulk Dual Gate FET & Dual Gate Junction less FET.
8. Design and Simulation of SOI/Bulk FINFET device using GDS2MESH and GENIUS.
9. Design and Simulation of SOI/Bulk 2D/3D Nanowire FET

Course Outcome:

At the end of the course, students will be able 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**

Sub Code	L	T	P	Duration	IA	ESE	Total	Credits
EC208TPE14	3	1	-	4 hours	30	70	100	3

VLSI FABRICATION METHODOLOGY

Course Objectives:

- To introduce the brief concept of fabrication technology of both BJT & MOS.
- To learn difficulties in single crystal development and wafer design.
- To learn different epitaxial growth techniques and their associated problems.
- To introduce the concept of Si atomic structure, atomic planes and structural defects.

UNIT-I: Introduction to VLSI

Brief overview of processing steps of BJT & MOSFET fabrication; Concept of photolithography; Epitaxy; Self-aligned Technique, Polysilicon & its advantages etc.

UNIT-II: Silicon Crystal Structure

Basics of Crystal structure and its types and different formations, Hard sphere model of Diamond lattice and its Packing densities, Concept of misfit factor and its importance, Details of Crystal plane-Miller's indices, packing densities, interplane distances and angles between the planes, V-groove etching concept, Direction of line on Si-wafer.

Defects in Crystal structure: Point defects, Line defects, Area dislocation, Volume defects.

UNIT-III: Crystal growth of Si

Carbothermic Reduction process, Bridgemann Technique and its problems, Czochralski technique, its thermodynamics and effect of Pull rate on wafer size. Dopant incorporation in Si crystal: Segregation coefficient, O_2 incorporation and its removal.

UNIT-IV: Crystal refinement & wafer preparation

Zone refining technique and its advantages, Wafer preparation, Gettering process and Metallic contaminant removal. **Epitaxy:** Types, 3 cardinal rules and their importance, Liquid phase epitaxy, Vapour Phase Epitaxy, Reactor configuration.

UNIT-V: Chemical Vapour Deposition for Si epitaxy

Silane route, Doping during epitaxy- auto doping, Molecular Beam epitaxy.

Text/Reference Books:

1. VLSI Technology, S. M. Sze, McGraw Hill Book Co.
2. VLSI Fabrication Principles, S.K.Gandhi, John Wiley and Sons, NY.
3. VLSI Technology, Chen, Wiley, March.
4. Principles of Microelectronics Technology, D. Nagchoudhary, Wheeler (India).
5. Silicon VLSI Technology: Fundamentals, Practice & Modeling, Plummer, Deal , Griffin, PH, 2001.
6. Microchip Fabrication, P. VanZant, MH, 2000.

Course Outcome:

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

1. Explain the concept of fabrication technology.
2. Analyze the challenge of single crystal development and wafer design.
3. Apply the epitaxial growth techniques and their associated problems.
4. Explain the concept of Si atomic structure, atomic planes.
5. Explain the structural defects and their effects on wafer quality.

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	1								3	3	1	2
CO2	3	3	1	1								3	3	1	2
CO3	3	2	1	1								3	3	1	2
CO4	3	2	1	1								3	3	1	2
CO5	3	2	1	1								3	3	1	2

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

Sub Code	L	T	P	Duration	IA	ESE	Total	Credits
EC208TPE15	3	-	-	4 hours	30	70	100	3

MILLIMETER WAVE TECHNOLOGY

Course Objectives:

1. To understand the Characteristics of Millimeter Wave Technology
2. To understand the concepts and working principles of various guiding Structures at Millimeter Wave Technology.
3. To design the Antenna for Millimeter Wave Applications.
4. To perform analysis of passive Components at Millimeter Wave
5. To understand the basic concept of Active Devices and Link Design at Millimeter Wave.

UNIT-I:

Introduction to Millimeter wave Technology: Advantages and Challenges of Millimeter Wave Technology, Millimeter Wave Applications, Sources of losses at Millimeter wave; Dielectric Loss, Conduction Loss, Radiation Surface wave losses, Wave propagation, Phase and Group Velocity, Slow and Fast waves.TEM, TE and TM modes.

UNIT-II:

Guiding Structure: Transmission Lines, Surface Wave in Grounded Dielectric Slab, Parallel Plate Guide, Rectangular Wave Guide, Circular Waveguides, Microstrip Lines, High Frequency Limitation of Microstrip Lines, Microstrip Coupled Lines, Conductor Backed CPW, Substrate Integrated Waveguide (SIW), SIW Losses, Design of SIW.

UNIT-III:

Antennas at Millimeter wave Frequency: Antennas Parameters, Printed Millimeter Wave Antennas, Dipole and Slot Antenna, Loop Antennas, Printed Millimeter Wave Array Antennas, Waveguide Slot Arrays, On Chip Antennas: Design and Challenges.

UNIT-IV:

Passive Components: Dielectric Resonators, Dielectric Resonators Antenna and its modes, filters, Different types of couplings, Power divider, Directional Coupler, Hybrid Coupler.

UNIT-V:

Active Components: PIN Diode, Gunn Diode, IMPATT Diode**,** FET, MOSFET, HEMT, Comparison of Solid State Devices **,** Noise and Link Budget, Friss Transmission Equation, Millimeter Wave Systems, Noise Figure for Cascaded System Elements.

Text/Reference Books:

1. S. Rappaport, R.W. Heath, R.C. Daniels and J.N. Murdock,Millimeter Wave Wireless Communication, Prentice Hall
2. NPTEL Lectures by Dr M K Mondal IIT Kharagpur on Millimeter Wave Technology

Course Outcome:

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

1. Explain the Need of Millimeter Wave Technology for Communication
2. Apply the suitable Guiding Structure at Millimeter Wave Technology
3. Design of Antenna for Millimeter wave Frequency
4. Analyze the various Passive Devices at MM Wave Systems
5. Explain the principle of Active Devices and Design of MM Wave System

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								2	3		2
CO2	3	3	2	3								2	3		2
CO3	3	2	2	3	3							1	3	2	2
CO4	3	1	2	1	3							1	3	2	2
CO5	3	2	1	1	3							1	3		2

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

Sub Code	L	T	P	Duration	IA	ESE	Total	Credits
EC208TPE16	3	-	-	4 hours	30	70	100	3

VIDEO PROCESSING

Course Objectives:

- To acquire fundamental knowledge of digital video processing.
- To develop the ability to understand and implement various digital video processing and estimation algorithms.
- To facilitate the students for analyzing and implementing various real-time digital video processing applications.

UNIT-I:

Basic concepts of Video Processing: Video capture and display, Analog video, Digital Video, Time-varying Image Formation models-3D motion models, Geometric Image formation, Photometric Image formation, sampling of video signals, filtering operations

UNIT-II:

Video modeling: Camera Model-Pinhole Model, CAHV Model, Camera Motions. Object Model-Shape Model, Motion Model. Scene Model, Two-Dimensional Motion Models.

UNIT-III:

2-D Motion Estimation: Optical flow, general methodologies, pixel-based motion estimation, Block matching algorithm, multi-resolution motion estimation, Application of Motion Estimation in Video Coding.

UNIT-IV:

Video Coding: Waveform-based coding, Block based transform coding-Unitary Transform, Discrete Cosine Transform, Bit Allocation and Transform Coding Gain, DCT-Based Image Coders and the JPEG Standard, predictive coding, Video Coding Using Temporal Prediction and Transform Coding.

UNIT-V:

Video Compression: H.261, H.263, MPEG-1, MPEG-2, and MPEG-4.

Text/Reference Books:

1. The Essential Guide to Video Processing, Al Bovik (Alan C Bovik), Academic Press, Second Edition, 2009
2. Handbook of Image and Video processing, Al Bovik (Alan C Bovik), Academic Press, Second Edition, 2005.
3. Digital Video Processing - A. Murat Tekalp, Prentice Hall, 1995.
4. Yao Wang, Jorn Ostermann, Ya-Qin Zhang, "Video Processing and Communications", First Edition, Prentice Hall, 2002
5. Video Coding for Mobile Communications, David Bull et al, Academic Press.

Course Outcome:

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

1. Identify the fundamental concept of video signals.
2. Explain the various video models.
3. Apply appropriate motion estimation model for the specific application
4. Illustrate the video coding techniques for input video
5. Interpret the various video compression techniques and their 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	2	1	1	1	1						3	3	1	2
CO2	3	3	1	1	1	1						3	3	1	2
CO3	3	3	1	1	1	1						3	3	2	3
CO4	3	3	1	1	1	1						3	3	2	3
CO5	3	3	1	1	1	1						3	3	2	3

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

Sub Code	L	T	P	Duration	IA	ESE	Total	Credits
EC208TPE17	3	-	-	4 hours	30	70	100	3

WIRELESS SENSOR NETWORKS

Course Objectives:

- To understand the fundamentals of wireless sensor networks and its application to real time scenarios.
- To study the various protocols at various layers and its differences with traditional protocols.
- To understand the issues pertaining to sensor networks and the challenges involved in managing a sensor network.
- 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:

OVERVIEW OF WIRELESS SENSOR NETWORKS

SingleNode Architecture , Hardware Components , Network Characteristics, unique constraints and challenges, Enabling Technologies for Wireless Sensor Networks Types of wireless sensor networks.

UNIT-II:

ARCHITECTURES

Network Architecture, Sensor Networks Scenarios, Design Principle, Physical Layer and Transceiver Design Considerations, Optimization Goals and Figures of Merit, Gateway Concepts, Operating Systems and Execution Environments introduction to Tiny OS and nesC Internet to WSN Communication.

UNIT-III:

NETWORKING SENSORS

MAC Protocols for Wireless Sensor Networks, Low Duty Cycle Protocols And Wakeup Concepts – SMAC, BMAC Protocol, IEEE 802.15.4 standard and ZigBee, the Mediation Device Protocol, Wakeup Radio Concepts, Address and Name Management, Assignment of MAC Addresses, Routing Protocols, EnergyEfficient Routing, Issues in designing a routing protocol,classification of routing protocols,table driven,on-demand,hybrid,flooding,hierarchical and power aware routing protocols.

UNIT-IV:

INFRASTRUCTURE ESTABLISHMENT

Topology Control, Clustering, Time Synchronization, Localization and Positioning, Sensor Tasking and Control.

UNIT-V:

SENSOR NETWORK PLATFORMS AND TOOLS

Sensor Node Hardware – Berkeley Motes, Programming Challenges, Nodelevel software platforms, Node level Simulators, Statecentric programming.

Text/Reference Books:

1. Holger Karl & Andreas Willig, "Protocols And Architectures for Wireless Sensor Networks", John Wiley, 2005
2. Feng Zhao & Leonidas J.Guibas, "Wireless Sensor Networks An Information Processing Approach", Elsevier, 2007
3. Waltenegus Dargie , Christian Poellabauer, "Fundamentals of Wireless Sensor Networks Theory and Practice", John Wiley & Sons Publications, 2011
4. Kazem Sohraby, Daniel Minoli and Taieb Znati, " Wireless Sensor Networks Technology, Protocols, and Applications", John Wiley & Sons, 2007.

Course Outcome:

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

CO1: Explain the challenges and technologies for wireless sensor networks

CO2: Explain the architecture and sensors

CO3: Describe the communication, energy efficiency, computing, storage and transmission
CO4: Establishing infrastructure and simulations.
CO5: Explain the concept of programming the in WSN environment.

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	1								2	2	1	2
CO2	3	2	2	1								2	2	2	2
CO3	3	2	2	1								2	2	2	2
CO4	3	2	2	1								2	2	2	2
CO5	3	2	2	1								2	2	1	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.
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	Duration	IA	ESE	Total	Credits
EC208TPE19	3	-	-	4 hours	30	70	100	3

BIOMEDICAL INSTRUMENTATION

Course Objectives:

- To introduce an fundamentals of transducers as applicable to physiology
- To explore the human body parameter measurements setups
- To measure non electrical parameter of human body.
- To make the students understand medical imaging techniques.
- To make the students understand the devices used in diagnosing the disease.

UNIT-I: Physiology and transducers

Cell and its structure, Resting and Action Potential, Nervous system: Functional organization of the nervous system, Structure of nervous system, neurons, transmitters and neural communication, Cardiovascular system, respiratory system, Basic components of a biomedical system, Transducers, selection criteria, Piezo-electric, ultrasonic transducers, Temperature, measurements.

UNIT-II: Electro – Physiological measurements

Electrodes: Limb electrodes, floating electrodes, Micro, needle and surface electrodes, Amplifiers: Preamplifiers, differential amplifiers, chopper amplifiers, ECG, EEG, EMG, ERG, Lead systems and recording methods, Typical waveforms. Electrical safety in medical environment: leakage current-Instruments for checking safety parameters of biomedical equipment.

UNIT-III: Non-electrical parameter measurements

Measurement of blood pressure, Cardiac output, Heart rate, Heart sound Pulmonary function measurements, Blood Gas analyzers : pH of blood, measurement of blood pCO2, finger-tip oximeter, measurements.

UNIT-IV: Medical Imaging

Radiographic and fluoroscopic techniques, X rays, Computer tomography, Mammography, MRI, Ultrasonography, Endoscopy, Different types of biotelemetry systems and patient monitoring.

UNIT-V: Assisting and therapeutic equipments

Pacemakers, Defibrillators, Ventilators, Nerve and muscle stimulators, Diathermy, Heart Lung machine, Audio meters, Dialyzers.

Text/Reference Books:

1. R.S.Khandpur, 'Hand Book of Bio-Medical instrumentation', Tata McGraw Hill Pub., 2003.
2. Leslie Cromwell, Fred J.Weibell, Erich A.Pfeiffer, 'Bio-Medical Instrumentation and Measurements', II edition, Pearson Education, 2002 / PHI.
3. J.Webster, 'Medical Instrumentation', John Wiley & Sons, 1995.
4. L.A. Geddes, L.E.Baker, 'Principles of Applied Bio-Medical Instrumentation', John Wiley & Sons, 1975

Course Outcome:

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

- Explain the physiology of biomedical system.
- Describe biomedical and physiological information.
- Determine the non electrical parameter of human body.
- Illustrate the devices used in medical imaging and biotelemetry
- Discuss the application of electronics in therapeutic area

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	1							2	3	2	3
CO2	3	3	2	3	1							2	3	3	3
CO3	3	3	2	3	1							2	3	3	3
CO4	3	3	2	3	1							2	3	3	3
CO5	3	3	2	3	1							2	3	3	3

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

Sub Code	L	T	P	Duration	IA	ESE	Total	Credits
EC208TPE20	3	-	-	4 hours	30	70	100	3

NEURAL NETWORK & FUZZY LOGIC

Course Objectives:

- To introduce the origin and terminology of the Neural Network.
- To understand the basic structure of the Artificial Neural Network (ANN).
- To understand the single layer Neural Network and concept of perceptrons.
- To introduce the concept of back propagation and deep learning at an elementary level.
- To introduce basic concepts and terminology of Fuzzy logic and systems.

UNIT-I:

Introduction to Neural Networks: Introduction, Humans and Computers, Organization of the Brain, Biological Neuron, Biological and Artificial Neuron Models, Hodgkin-Huxley Neuron Model, Integrate-and-Fire Neuron Model, Spiking Neuron Model, Characteristics of ANN, McCulloch-Pitts Model, Historical Developments, Potential Applications of ANN.

UNIT-II:

Essentials of Artificial Neural Networks Artificial Neuron Model, Operations of Artificial Neuron, Types of Neuron Activation Function, ANN Architectures, Classification Taxonomy of ANN – Connectivity, Neural Dynamics (Activation and Synaptic), Learning Strategy (Supervised, Unsupervised, Reinforcement), Learning Rules, Types of Application.

UNIT-III:

Single Layer Feed Forward Neural Networks, Introduction, Perceptron Models: Discrete, Continuous and Multi-Category, Training Algorithms: Discrete and Continuous Perceptron Networks, Perceptron Convergence theorem, Limitations of the Perceptron Model, Applications.

UNIT-IV:

Multilayer Feed forward Neural Networks Credit Assignment Problem, Generalized Delta Rule, Derivation of Backpropagation (BP) Training, Summary of Backpropagation Algorithm, Kolmogorov Theorem, Learning Difficulties and Improvements.

Introduction of RBF Neural Network, MLP Network, Self-organizing Feature Map, counter-propagation neural network, recurrent neural network, deep learning(Introductory).

Applications of Neural Networks: Pattern classification/Handwritten character recognition/ Face recognition/Image compression and decompression.

UNIT-V:

Fuzzy Logic & System: Basic Fuzzy logic theory, sets and their properties, Operations on fuzzy sets, Fuzzy relation and operations on fuzzy relations and extension principle, Fuzzy membership functions and linguistic variables, Fuzzy rules and fuzzy reasoning, Fuzzification and defuzzification and their methods, Fuzzy inference systems, Mamdani Fuzzy models, and Fuzzy knowledge based controllers

Basic applications of Fuzzy Logic and Fuzzy Systems: In controllers /Fuzzy pattern recognition/ Fuzzy image processing/popular applications of fuzzy sets, namely fuzzy reasoning and fuzzy clustering.

Text/Reference Books:

1. Neural Networks: A comprehensive foundation, S. Haykin , 2nd Ed., Pearson Education Asia,1999.
2. Neural Networks and Fuzzy Systems: A dynamical systems approach to machine intelligence, .B. Kosko , Prentice Hall India 1994.
3. Fuzzy Logic with Engineering Applications‖, Thimothy J. Ross, Wiley India Publications
4. Fundamentals of Neural Networks‖,Laurence Fausett, Pearson Education
5. Neural Networks, Fuzzy Logic, and Genetic Algorithms‖,S.Rajasekaran andG. A. Vijaylakshmi Pai, PHI
6. Introduction to Neural Network Using MATLAB", S. N. Sivanandam, S. Sumathi, and S. N. Deepa, Tata McGraw-Hill Publications 2006.

7. Neural Networks – James A Freeman and Davis Skapura, Pearson Education, 2002.
8. Fuzzy Sets and Fuzzy Logic,' G.J. Klir and B. Yuan, Prentice Hall India 1997.

Course Outcome:

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

1. Describe artificial neurons and its role in ANN.
2. Explain learning types and elementary structures of ANN.
3. Describe perceptron model and single layer neural networks with application.
4. Identify and apply basic techniques of fuzzy logic and systems
5. Apply neural network and fuzzy based processing in pattern recognition and Image Processing.

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	1	1						1	3	3	2
CO2	3	3	3	2	3	2						1	3	3	2
CO3	3	3	3	2	3	2						1	3	3	2
CO4	3	3	3	2	3	1						1	3	3	2
CO5	3	3	3	3	3	2						2	3	3	2

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

Sub Code	L	T	P	Duration	IA	ESE	Total	Credits
EC208TPE21	3	-	-	4 hours	30	70	100	3

NEXT GEN. COMM. TECHNOLOGY

Course Objectives:

1. To learn the new communication technologies such as OFDM and MIMO used in Next Generation communication systems.
2. To understand and apply the fundamental concept of Coherence Time, Coherence Bandwidth.
3. To learn the different fading model and evaluate the SNR.
4. To learn and analyse the performance of a massive MIMO system.
5. To analysis the performance such as capacity/spectral efficiency and energy efficiency of the MIMO and massive MIMO system.

UNIT – I

Introduction and Preliminaries: Introduction to point-to-point Multi-input Multi-output (MIMO), multiuser MIMO, massive MIMO, Coherence Time, Coherence Bandwidth, Coherence Interval. TDD Coherence Interval structure, Coherence Interval in the context of OFDM modulation, Small-scale and Large-scale fading, Normalized signal model, and SNR.

UNIT –II

OFDM: Principle of Orthogonal Frequency Division Multiplexing (OFDM), Multiple access – OFDMA, Implementation of transceivers, Frequency-selective channels, Cyclic Prefix (CP), Performance in the frequency-selective channel, Pilot based channel estimation, Peak-to-average power ratio, Inter-carrier-interference, Parameter adaptation.

UNIT –III

MIMO Systems: Introduction to MIMO systems, Diversity in wireless channel, Introduction to fading distributions, Analytical MIMO channel models, Independent and identically distributed (uncorrelated) MIMO fading model, Fully correlated MIMO channel model, MIMO channel parallel decomposition.

UNIT –IV

MIMO Channel Capacity and Power Allocation: Power allocation in MIMO systems, Uniform power allocation, Adaptive power allocation, MIMO channel capacity, Capacity of i.i.d. Rayleigh fading MIMO channels, Capacity of separately correlated Rayleigh fading MIMO channel.

UNIT –V

Massive MIMO Systems: Definition of Massive MIMO, Correlated Rayleigh fading, Uplink, and downlink system model, Impact of Spatial channel correlation, Channel hardening and favorable propagation, Pilot transmission and channel estimation, Spectral Efficiency (SE), Transmit precoding and Receive decoding, Single-cell uplink and downlink SE expressions, Asymptotic analysis, Energy efficiency.

Suggested Books & References: -

1. D. Tse and P. Vishwanath, "Fundamentals of Wireless Communications," Cambridge Univ. Press, 2005.
2. A. J. Goldsmith, "Wireless Communications," Cambridge Univ. Press, 2005.
3. R. S. Kshetrimayum, "Fundamentals of MIMO Wireless Communications," Cambridge University Press, 2017.
4. T. L. Marzetta, E. G. Larsson, H. Yang, and H. Q. Ngo, "Fundamentals of Massive MIMO," Cambridge Univ. Press, 2016.
5. Emil Björnson, Jakob Hoydis, and Luca Sanguinetti, "Massive MIMO Networks: Spectral, Energy, and Hardware Efficiency," Foundations and Trends® in Signal Processing: Vol. 11: No. 3-4, pp 154-655 (2017).

Course Outcome:

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

CO1: Explain the different physical layer wireless communication technologies used in 4G and 5G communication systems.

CO2: Apply the concept of Coherence Bandwidth, Coherence Time, Coherence Interval, Small-

scale and Large-scale fading to analyze the physical layer performance of 4G and 5G communication systems.
CO3: Evaluate the channel capacity of the MIMO and massive MIMO Systems.
CO4: Analyze the communication system performance under OFDMA.
CO5: Evaluate the spectral efficiency and energy efficiency of massive MIMO technology used in 5G.

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	1							2	3	3	3
CO2	3	3	2	2	2							2	3	3	2
CO3	3	3	2	3	2							2	3	3	1
CO4	3	3	2	3	2							2	3	3	1
CO5	3	3	2	3	2							2	3	3	2

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**