RV COLLEGE OF ENGINEERING®

(Autonomous Institution Affiliated to VTU, Belagavi)

R.V. Vidyaniketan Post, Mysore Road

Bengaluru – 560 059

Bachelor of Engineering (B.E.)
Scheme and Syllabus of VII & VIII Semesters

2016 SCHEME

ELECTRONICS & COMMUNICATION ENGINEERING

VISION

Leadership in Quality Technical Education, Interdisciplinary Research & Innovation, with a Focus on Sustainable and Inclusive Technology

MISSION

1. To deliver outcome based Quality education, emphasizing on experiential learning with the state of the art infrastructure.
2. To create a conducive environment for interdisciplinary research and innovation.
3. To develop professionals through holistic education focusing on individual growth, discipline, integrity, ethics and social sensitivity.
4. To nurture industry-institution collaboration leading to competency enhancement and entrepreneurship.
5. To focus on technologies that are sustainable and inclusive, benefiting all sections of the society.

QUALITY POLICY

Achieving Excellence in Technical Education, Research and Consulting through an Outcome Based Curriculum focusing on Continuous Improvement and Innovation by Benchmarking against the global Best Practices.

CORE VALUES

Professionalism, Commitment, Integrity, Team Work, Innovation

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2016 SCHEME

DEPARTMENT OF
ELECTRONICS & COMMUNICATION ENGINEERING

DEPARTMENT VISION

Imparting quality technical education through interdisciplinary research, innovation and teamwork for developing inclusive & sustainable technology in the area of Electronics and Communication Engineering.

DEPARTMENT MISSION

- To impart quality technical education to produce industry-ready engineers with a research outlook.
- To train the Electronics & Communication Engineering graduates to meet future global challenges by inculcating a quest for modern technologies in the emerging areas.
- To create centres of excellence in the field of Electronics & Communication Engineering with industrial and university collaborations.
- To develop entrepreneurial skills among the graduates to create new employment opportunities.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1. To apply concepts of mathematics, science and computing to Electronics and Communication Engineering

PEO2. To design and develop interdisciplinary and innovative systems.

PEO3. To inculcate effective communication skills, team work, ethics, leadership in preparation for a successful career in industry and R & D organizations.

PROGRAM SPECIFIC OUTCOMES (PSOS)

PSO	Description
PSO1	Should be able to clearly understand the concepts and applications in the field of Communication/networking, signal processing, embedded systems and semiconductor technology.
PSO2	Should be able to associate the learning from the courses related to Microelectronics, Signal processing, Microcomputers, Embedded and Communication Systems to arrive at solutions to real world problems.
PSO3	Should have the capability to comprehend the technological advancements in the usage of modern design tools to analyze and design subsystems/processes for a variety of applications.
PSO4	Should possess the skills to communicate in both oral and written forms, the work already done and the future plans with necessary road maps, demonstrating the practice of professional ethics and the concerns for societal and environmental wellbeing.

Lead Society: Institute of Electrical and Electronics Engineers (IEEE)

ABBREVIATIONS

SL. NO.	ABBREVIATION	MEANING
1.	VTU	Visvesvaraya Technological University
2.	BS	Basic Sciences
3.	CIE	Continuous Internal Evaluation
4.	SEE	Semester End Examination
5.	CE	Professional Core Elective
6.	GE	Global Elective
7.	HSS	Humanities and Social Sciences
8.	CV	Civil Engineering
9.	ME	Mechanical Engineering
10.	EE	Electrical & Electronics Engineering
11.	EC	Electronics & Communication Engineering
12.	IM	Industrial Engineering & Management
13.	EI	Electronics & Instrumentation Engineering
14.	CH	Chemical Engineering
15.	CS	Computer Science & Engineering
16.	TE	Telecommunication Engineering
17.	IS	Information Science & Engineering
18.	BT	Biotechnology
19.	AS	Aerospace Engineering
20.	PY	Physics
21.	CY	Chemistry
22.	MA	Mathematics

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RV COLLEGE OF ENGINEERING®
(Autonomous Institution Affiliated to VTU, Belagavi)
ELECTRONICS AND COMMUNICATION ENGINEERING

SEVENTH SEMESTER CREDIT SCHEME								
Sl. No	Course Code	Course Title	BOS	Credit Allocation				Total Credits
				Lecture	Tutorial	Practical	SS	
1	16EC71	Microwave & Radiating Systems	ECE	4	0	1	0	5
2	16EC72	Broadband Wireless –LTE 4G	ECE	4	0	0	0	4
3	16EC73P	Minor Project**	ECE	0	0	3	0	3
4	16EC7FX	Elective F (PE)	ECE	4	0	0	0	4
5	16EC7GX	Elective G(PE)	ECE	4	0	0	0	4
6	16G7HXX	Elective H (GE)*	Respective BOS	3	0	0	0	3
Total No. of Credits				**19**	**0**	**4**	**0**	**23**
No. Of Hrs/Week				**19**	**0**	**4**	**0**	

*Students should take other department Global Elective courses;

** Minor Project-6 hours per week;

EIGTH SEMESTER CREDIT SCHEME								
Sl. No.	Course Code	Course Title	BOS	Credit Allocation				Total Credits
				Lecture	Tutorial	Practical	SS	
1.	16EC81	Major Project	ECE	0	0	16	0	16
2.	16EC82	Technical Seminar	ECE	0	0	2	0	2
3.	16HS83	Innovation and Social Skills	HSS	0	0	2	0	2
Total No. of Credits				**0**	**0**	**20**	**0**	**20**
No. Of Hrs.				**0**	**0**	**40**	**0**	

VII Semester
GROUP F: PROFESSIONAL ELECTIVES

Sl. No.	Course Code	Course Title
1.	16EC7F1	Satellite Communications & GPS
2.	16EC7F2	ARM Programming & Optimization
3.	16EC7F3	Speech Processing
4.	16EC7F4	Radio Frequency Integrated Circuits Design
5.	16EC7F5	High Performance Computing
6.	16EC7F6	Integrated Photonics
7.	16EC7F7	Nanoelectronics

VII Semester
GROUP G: PROFESSIONAL ELECTIVES

Sl. No.	Course Code	Course Title
1.	16EC7G1	Radar & Navigation
2.	16EC7G2	Automotive Electronics
3.	16EC7G3	Multimedia Communication
4.	16EC7G4	VLSI Testing for ICs
5.	16EC7G5	High Speed digital design
6.	16EC7G6	MEMS and Smart Systems

OPEN ELECTIVES				
Sl. No.	Host Dept	Course Code	Course Title	Credits
1.	BT	16G7H01	Nanotechnology	3
2.	CH	16G7H02	Industrial Safety and Risk Management	3
3.	CV	16G7H03	Intelligent Transport System	3
4.	CS	16G7H04	Intelligent Systems	3
5.	EC	16G7H05	Image Processing and Machine Learning	3
6.	EE	16G7H06	Design of Renewable Energy Systems	3
7.	IM	16G7H07	Systems Engineering	3
8.	EI	16G7H08	MEMS and Applications	3
9.	IS	16G7H09	Introduction to Internet of Things	3
10.	ME	16G7H10	Industry 4.0 – Smart Manufacturing for The Future	3
11.	TE	16G7H11	Space Technology and Applications	3
12.	MA	16G7H12	Advanced linear Algebra	3
13.	PY	16G7H13	Thin Film Nanotechnology	3
14.	CY	16G7H14	Engineering Materials for Advanced Technology	3
15.	HSS	16G7H15	Applied Psychology for Engineers	3
16.	HSS	16G7H16	Foundational Course on Entrepreneurship	3
17.	AS	16G7H17	Unmanned Aerial Vehicles	3

Semester: VII					
MICROWAVE AND RADIATING SYSTEMS **(Theory and Practice)**					
Course Code	**:**	16EC71		**CIE**	**:**	100+ 50 Marks
Credits: L:T:P:S	**:**	4:0:1:0		**SEE**	**:**	100+50 Marks
Total Hours	**:**	46L		**SEE Duration**	**:**	3.00 Hours

Course Learning Objectives: The students will be able to	
1	Apply the knowledge of fields and waves to develop concepts of transmission line theory.
2	Describe the basic operation of microwave devices.
3	Describe the radiation from isolated, linear wire antennas and from linear elements near or on a conducting surface.
4	Calculate the fundamental parameters for antennas and the radiation field from an antenna using potential functions.

Unit-I	**09 Hrs**
Transmission Lines : Introduction, transmission lines equations and solutions, termination of line by infinite line, by characteristic impedance, short circuit line, open circuit line and any load resistive impedance ,input impedance reflection and transmission coefficients, standing waves and SWR(at both load end and generator end).	
Unit – II	**09 Hrs**
Impedance Transforms and Matching: Quarter wave transforms, Smith chart construction and properties, Single stub matching. **Microwave Waveguides:** Introduction, TE, TM waves Rectangular waveguides (quantitative analysis TE, TM modes), circular waveguides (quantitative analysis), dominant modes, group velocity phase velocity, and wave impedance, Microwave cavities (quantitative analysis), resonant frequency. **S-parameters:** Introduction, properties of S matrix (qualitative analysis)	
Unit –III	**09 Hrs**
Microwave Passive Devices: Waveguide Tee's, Directional couplers, circulators, power divider, Isolators (Faraday isolator), phase shifters (Rotary type), Attenuators (Rotary type), (s-parameters of all devices) **Microwave Sources:** Multicavity Klystron amplifier, Reflex klystron oscillator **RF Amplifiers and Front End Modules for Communications** – Gain and Output Power, Return Loss and Reverse Isolation, Noise Figure, Harmonics, Theory of Inter-modulation Distortion and measurement, Efficiency.	
Unit –IV	**09 Hrs**
Antenna Basics: Introduction, antenna radiation mechanism, basic Antenna parameters, patterns, beam area, radiation intensity, beam efficiency, diversity and gain, antenna apertures, effective height, bandwidth, radiation, efficiency, antenna temperature and antenna field zones. **Wire Antennas:** Electric dipoles: Introduction, short electric dipole (fields, power density, power radiated, directivity, radiation resistance), Half wave dipoles(field: qualitative analysis power density, power radiated, directivity, radiation resistance).	
Unit –V	**10 Hrs**
Antenna Arrays: Introduction, pattern multiplication, Array of two isotropic point sources, N element linear array with uniform spacing and phase(Array factor), Broadside and end fire array(Directivity, location of beam with, Beam width, etc).**Antenna Types:** Folded dipole, Yagi-Uda array, parabolic reflectors, log periodic antenna, Rectangular patch antenna, horn antenna (Qualitative analysis only: Construction, working).	

Practical's: Microwaves and Radiating systems lab
1. Study of mode curves of Reflex klystron source 2. Design and Simulation of Patch Antenna (coaxial feed), Dipole and Horn antenna using HFSS 3. Radiation Characteristics of Pyramidal Horn Antenna (X-band)

4. Characterization of Ring resonator, Power divider, Microwave Directional Coupler and Hybrid coupler (Strip line type, C-band)
5. Design and Simulation of Waveguide Magic-Tee using HFSS
6. Characterization of Microwave Magic Tee, Directional Coupler, Circulator, Tunable Attenuator and Isolator (Waveguide type, X-band)
7. Radiation characteristics of Log-periodic and Yagi antenna (C-band)
8. Radiation characteristics of Microstrip Patch and Printed Dipole Antenna(X-band)
9. Design and Simulation of a Printed Hybrid Ring using HFSS
10. Characterization of Lowpass, bandpass and band stop filters (C-Band)

Course Outcomes: After completing the course, the students will be able to	
CO1:	Explain and summarize the working of transmission line, Waveguides , Microwave Passive Devices and Antennas
CO2:	Analyze wave propagation in transmission line, Waveguides and characterize the passive microwave components and Antennas.
CO3:	Design the transmission lines, passive microwave components and Antennas for given specification and also match the impedance.
CO4:	Evaluate S-Parameter, VSWR for transmission lines, Microwave components and radiation pattern for Antennas.

Reference Books	
1	Microwave Engineering, David M Pozar, John Wiley, 3rd Edition, 2004,ISBN-13: 978-0471644514
2	Antenna Theory and Design, C A Balanis, John Wiley & sons, Inc. publication, 3rd Edition,2005,ISBN-13: 978-0471667827
3	National Instruments, 'Basics of Power Amplifier and Front End Module Measurements' White paper, http://www.ni.com/rf/
4	Foundations of Microwave Engineering, R E Collin, IEEE Press on Electromagnetic and Wave Theory, 2nd Edition, ISBN-13: 978-0-7803-6031-0/ 0-7803-6031-1
5	Antennas, John D.Krauss, McGraw-Hill International Edition, 3rd Edition, 2006.ISBN-13: 978-0071232012

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

Scheme of Continuous Internal Evaluation (CIE); Practical Test for 50 Marks
The Laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average marks (AM) over number of weeks is considered for 30 marks. At the end of the semester a test (T) is conducted for 10 marks. The students are encouraged to implement additional innovative experiments (IE) in the lab and are rewarded for 10 marks. Total marks for the laboratory is 50.
Total CIE is 30(AM) +10 (T) +10 (IE) =50 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering

the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Scheme of Semester End Examination (SEE); Practical Exam for 50 Marks
SEE for the practical courses will be based on experiment conduction with proper results, is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

Semester End Evaluation (SEE): Theory (100 Marks) + Practical (50 Marks) = Total 150 Marks

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	2	-	-	2	-	1
CO2	3	2	2	1	-	-	2	-	-	2	-	1
CO3	3	3	2	2	-	-	2	-	-	2	-	1
CO4	3	3	3	3	-	-	2	-	-	2	-	1

High-3: Medium-2: Low-1

Semester: VII					
BROADBAND WIRELESS -LTE 4G **(Theory)**					
Course Code	:	16EC72		**CIE**	:	100 Marks
Credits: L:T:P:S	:	4:0:0:0		**SEE**	:	100 Marks
Total Hours	:	46L		**SEE Duration**	:	03 Hours

Course Learning Objectives: The students will be able to

1	Identify real life channels and statistical characterization for them.
2	Identify GSM, its physical layer and call processing as well as scenarios and services.
3	Analyze the concept and applications of spread spectrum techniques including Synchronization.
4	Identify physical layer and call processing protocols for cellular CDMA.

Unit-I	09 Hrs
Review of Legacy Systems **Key Enablers for LTE features:** OFDM, Single carrier FDMA, Single carrier FDE, Channel Dependant Multiuser Resource Scheduling, Multiantenna Techniques, IP based Flat network Archite09ure, LTE Network Architecture. **Wireless Fundamentals:** Cellular concept, Broadband wireless channel (BWC), Fading in BWC, Modeling BWC – Empirical and Statistical models, Mitigation of Narrow band and Broadband Fading	

Unit – II	09 Hrs
Multicarrier Modulation: OFDM basics, OFDM in LTE, Timing and Frequency Synchronization, PAR, SC-FDE. **OFDMA and SC-FDMA:** OFDM with FDMA, TDMA, CDMA, OFDMA, SC-FDMA, OFDMA and SC-FDMA in LTE **Multiple Antenna Transmission and Reception:** Spatial Diversity overview, Receive Diversity, Transmit Diversity, Interference cancellation and signal enhancement, Spatial Multiplexing, Choice between Diversity, Interference suppression and Spatial Multiplexing	

Unit –III	09 Hrs
Overview and Channel Structure of LTE: Introduction to LTE, Channel Structure of LTE, Downlink OFDMA Radio Resource, Uplink SC-FDMA Radio Resource . **Downlink Transport Channel Processing:** Overview, Downlink shared channels, Downlink Control Channels, Broadcast channels, Multicast channels, Downlink physical channels, H-ARQ on Downlink	

Unit –IV	10 Hrs
Uplink Channel Transport Processing: Overview, Uplink shared channels, Uplink Control Information, Uplink Reference signals, Random Access Channels, H-ARQ on uplink **Physical Layer Procedures:** Hybrid – ARQ procedures, Channel Quality Indicator CQI feedback, Precoder for closed loop MIMO Operations, Uplink channel sounding, Buffer status Reporting in uplink, Scheduling and Resource Allocation, Cell Search, Random Access Procedures, Power Control in uplink.	

Unit –V	09 Hrs
Radio Resource Management and Mobility Management: PDCP overview, MAC/RLC overview, RRC overview, Mobility Management, Inter-cell Interference Coordination	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Associate terms in the system architecture to the functional standard specified in LTE 4G.
CO2:	Analyze the role of LTE radio interface protocols and EPS Data convergence protocols to set up, reconfigure and release data and voice from users.
CO3:	Demonstrate the UTRAN and EPS handling processes from set up to release including

		mobility management for a variety of data call scenarios.
CO4:		Test and Evaluate the Performance of resource management and packet data processing and transport algorithms.

Reference Books	
1	Fundamentals of LTE, Arunabha Ghosh, Jan Zhang, Jefferey Andrews, Riaz Mohammed, Prentice Hall, Communications Engg and Emerging Technologies.
2	LTE for UMTS Evolution to LTE-Advanced', Harri Holma and Antti Toskala,, 2nd Edition - 2011, John Wiley & Sons, Ltd. Print ISBN: 9780470660003.

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping											
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	-	2	-	-	2	-	3
CO2	3	2	2	1	-	-	2	-	-	2	-	3
CO3	3	3	2	2	-	-	2	-	-	2	-	3
CO4	3	3	3	3	-	-	2	-	-	2	-	3

High-3: Medium-2: Low-1

VII Semester						
MINOR PROJECT						
Course Code	:	16EC73P		**CIE**	:	100 Marks
Credits: L: T: P: S	:	0:0:3:0		**SEE**	:	100 Marks
Hrs/week	:	06		**SEE Duration**	:	3 Hours
Course Learning Objectives: The students will be able to						
1	Create interest in innovative developments and preferably interdisciplinary field.					
2	Work independently, analyze, evaluate and solve the given problem.					
3	Inculcate the skills for good presentation and improve the technical report writing skills.					
4	Recognize the need for planning, preparation, management and financial budgeting.					
5	Acquire collaborative skills through working in a team to achieve common goals.					

Mini Project Guidelines:

1. Each project group will have two to four students, they can form their groups amongst their class.
2. Each group has to select a current topic that will use the technical knowledge of their program of study after intensive literature survey.
3. Guides will be allotted by the department based on the topic chosen.
4. The project should result in system/module which can be demonstrated, using the available resources in the college.
5. The CIE evaluation will be done by the committee constituted by the department. The committee shall consist of respective guide & two senior faculty members as examiners. The evaluation will be done for each student separately.
6. The final copy of the report should be submitted after incorporation of any modifications suggested by the evaluation committee

Guidelines for Evaluation:

CIE Assessment:

The following are the weightages given for the various stages of the project:

1. Selection of the topic and formulation of objectives: 10%
2. Design and Development of Project methodology: 30%
3. Execution of Project: 30%
4. Presentation, Demonstration and Discussion: 20%
5. Report Writing:10%

Evaluation will be carried out in three phases:

Phase	Activity	Weightage
I	Synopsis submission, approval of the selected topic, formulation of objectives	20%
II	Mid-term evaluation to review the progress of work and documentation	30%
III	Submission of report, Final presentation and demonstration	50%

SEE Assessment:

The following are the weightages given during SEE Examination:

1. Written presentation of synopsis:10%
2. Presentation/Demonstration of the project: 30%
3. Methodology and Discussion: 30%
4. Technical Report: 10%
5. Viva Voce: 20%

Course Outcomes of Mini Project:	
1	Define Specifications, Conceptualize, Design and implement a project
2	Communicate the work carried out as a technical report and orally
3	Work in a team and contribute to team work
4	Indulge in self-learning and be motivated for life-long learning

Semester: VII					
SATELLITE COMMUNICATIONS & GPS **(Group F: Professional Core Elective)**					
Course Code	:	16EC7F1		**CIE**	:	100 Marks
Credits: L:T:P:S	:	4:0:0:0		**SEE**	:	100 Marks
Total Hours	:	50L		**SEE Duration**	:	03 Hours
Course Learning Objectives: The students will be able to					
1	Understand the Satellite orbits and orbital perturbations.				
2	Analyze link power budget calculations and losses in the atmosphere.				
3	Understand the components of the satellite in space and Earth stations				
4	Analyze Fixed Coordinate System and GPS C/A Code Signal Structure				

Unit-I	**10 Hrs**
Over View of Satellite Systems: Introduction, frequency allocation, Kepler laws, definitions, orbital element, apogee and perigee heights, orbit perturbations, inclined orbits, calendars, universal time, sidereal time, orbital plane, local mean time and sun synchronous orbits, Geostationary orbit: Introduction, antenna, look angles, polar mix antenna, limits of visibility, earth eclipse of satellite, sun transit outage.	

Unit – II	**10 Hrs**
Propagation Impairments and Space Link: Introduction, atmospheric loss, ionospheric effects, rain attenuation, other impairments. Space Link: Introduction, EIRP, transmission losses, link power budget, system noise, CNR, uplink, down link, effects of rain, combined CNR.	

Unit –III	**10 Hrs**
Space Segment: Introduction, power supply units, altitude control, station keeping, thermal control, TT&C, transponders, antenna subsystem. Earth Segment: Introduction, receive only home TV system, outdoor unit, indoor unit, MATV, CATV, Tx – Rx earth station	

Unit –IV	**10 Hrs**
GPS: Introduction, History of GPS Development, A Basic GPS Receiver, Approaches of Presentation, Software Approach, Potential Advantages of the Software Approach. **Basic GPS Concept:** Introduction, GPS Performance Requirements, Basic GPS Concept, Basic Equations for Finding User Position, Measurement of Pseudo-range, Solution of User Position from Pseudo-ranges, Position Solution with more than Four Satellites, User Position in Spherical Coordinate System, Earth Geometry, Basic Relationships in an Ellipse, Calculation of Altitude, Calculation of Geodetic Latitude, Calculation of a Point on the Surface of the Earth, Satellite Selection, Dilution of Precision. **Satellite Constellation:** Introduction, Control Segment of the GPS System, Satellite Constellation, Maximum Differential Power Level from Different Satellites, Sidereal Day, Doppler Frequency Shift, Average Rate of Change of the Doppler Frequency, Maximum Rate of Change of the Doppler Frequency, Rate of Change of the Doppler Frequency Due to User Acceleration, Kepler's Equation, True and Mean Anomaly, Signal Strength at User Location.	

Unit –V	**10 Hrs**
Earth-Centered, Earth-Fixed Coordinate System : Introduction, Direction Cosine Matrix, Satellite Orbit Frame to Equator Frame Transform, Vernal Equinox, Earth Rotation, Overall Transform from Orbit Frame to Earth-Centered, Earth-Fixed Frame, Perturbations, Correction of GPS System Time of Transmission, Calculation of Satellite Position, Coordinate Adjustment for Satellites, Ephemeris Data.: **GPS C/A Code Signal Structure:** Introduction, Transmitting Frequency, Code Division-Multiple Access (CDMA) Signals, P Code, C/A Code and Data Format, Generation of C/A Code, Correlation Properties of C/A Code, Navigation Data Bits, Telemetry (TLM) and Hand Over Word (HOW), GPS Time and the Satellite Z Count, Parity Check Algorithm, Navigation Data from sub frame 1, Navigation Data from subframes 2 and 3, Navigation Data from subframes 4 and 5–Support Data, Ionospheric Model, Tropospheric Model, Selectivity Availability (SA) and Typical Position Errors.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Analyse the basic concepts of orbital mechanics of satellites and GPS
CO2:	Apply the basic concepts to solve problems in satellites and GPS
CO3:	Analyze various transmission losses and components of space & Earth Segment
CO4:	Evaluate noise effect and Signal Structure of Satellite and GPS.

Reference Books	
1	Satellite Communications, Dennis Roddy, McGraw-Hill, 4th Edition, 2006, ISBN 0-07-146298-8
2	Satellite Communications, Timothy Pratt, Charles Bostian and Jeremy Allnutt, John Wiley & Sons, 2nd Edition, 2003, ISBN: 978-0-471-37007-9
3	Fundamentals of Global Positioning System Receivers: A Software Approach James Bao-Yen, Tsui, John Wiley,2nd Edition , 2005, ISBN: 978-0-471-70647-2
4	Fundamentals of Satellite Communication, K. N. Raja Rao, PHI Learning Pvt. Ltd, 2nd Edition, ISBN, 8120324013

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	-	-	-	-	-	1	-	1
CO2	3	3	2	1	-	-	-	-	-	1	-	1
CO3	3	1	2	1	-	-	-	-	-	1	-	1
CO4	3	2	2	1	-	-	-	-	-	1	-	1

Low-1 Medium-2 High-3

Semester: VII					
ARM PROGRAMMING & OPTIMIZATION					
(Group F: Professional Core Elective)					
Course Code	:	16EC7F2		**CIE**	:	100 Marks
Credits: L:T:P:S	:	4:0:0:0		**SEE**	:	100 Marks
Total Hours	:	50L		**SEE Duration**	:	03 Hours
Course Learning Objectives: The students will be able to					
1	Discuss the basic principles of ARM system design.				
2	Identify the major hardware components ARM data path architecture.				
3	Identify the design issues ARM based embedded system with the basic knowledge of firmware, embedded OS & ARM architectures.				
4	Analyze the execution of instructions/program knowing the basic principles of ARM architecture and assembly language.				
5	Compare programs written in C & assembly to execute on ARM platform.				

Unit-I	10 Hrs
Introduction, Data Path Architecture, Registers, Modes, Exceptions **ARM Instructions:** Data processing instructions, Branch instructions, Load store instructions, software interrupt instructions, program status register instructions, loading constants, ARMv5E extension, and conditional execution.**Thumb Instructions:** Thumb register usage, ARM Thumb inter working, Other branch instructions, data processing instructions, single register load store instructions, multiple register load store instructions, stack instructions, software interrupt instruction.	
Unit – II	10 Hrs
Programming in C for ARM: Overview of C Compilers and optimization, basic C data types, C looping structures, register allocation, function calls, pointer aliasing, structure arrangement, bit fields, unaligned Data and Endianess, division, floating point, inline functions and inline assembly, portability issues.	
Unit –III	10 Hrs
Writing and Optimizing ARM Assembly Code: Writing assembly code, profiling and cycle counting, instruction scheduling, register allocation, conditional execution, looping constructs, Bit manipulation, efficient switches. Handling unaligned data	
Unit –IV	10 Hrs
Digital Signal Processing on ARM: Representing a digital signal, Introduction to DSP on the ARM, FIR filters, Realization of filters on ARM7 and Cortex M3, IIR Filters, Realization of filters on ARM7 and Cortex M3, CMSIS DSP Library	
Unit –V	10 Hrs
Exception and Interrupt Handling Exception Handling, Interrupts, Non-nested Interrupt handler, Re-entrant Interrupt handler Firmware & Boot loader Embedded **Operating Systems** Fundamental Components, Simple Operating System	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Describe the programmer's model of ARM processor and analyse the instruction set architecture to realize complex operations.
CO2:	Apply the optimization methods available for ARM architectures to design embedded software to meet given constraints with the help of modern engineering tools.
CO3:	Realize real time signal processing applications & primitive OS operations on different ARM architectures by making use of software libraries.
CO4:	Engage in self-study to formulate, design, implement, analyze and demonstrate an application realized on ARM development boards through assignments.

	Reference Books
1	ARM System Developers Guide, Andrew N Sloss, Dominic Symes, Chris Wright, Elsevier, Morgan Kaufman publishers, 2008, ISBN-13:9788181476463
2	ARM Architecture Reference Manual, David seal, Addison-Wesley, 2nd Edition, 2009, ISBN-13:9780201737196
3	ARM System on Chip Architecture, Steve Furber, Pearson Education Limited,2nd Edition, ISBN-13:9780201675191
4	Technical reference manual for ARM processor cores, including Cortex, ARM 11, ARM 9 & ARM 7 processor families.
5	User guides and reference manuals for ARM software development and modeling tools.

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	-	-	-	-	-	-		-	-
CO2	3	2	2	3	-	-	-	2	2		-	-
CO3	2	2	3	3	-	-	-	2	2		-	-
CO4	3	3	3	3	2	3	2	3	3	3	2	3

High-3: Medium-2: Low-1

Semester: VII					
SPEECH PROCESSING **(Group F: Professional Core Elective)**					
Course Code	:	16EC7F3		**CIE**	:	100 Marks
Credits: L:T:P:S	:	4:0:0:0		**SEE**	:	100 Marks
Total Hours	:	50L		**SEE Duration**	:	03 Hours
Course Learning Objectives: The students will be able to					
1	Develop the students mathematical, scientific, and computational skills relevant to the field of biomedical signal processing.				
2	Enhance the student's ability in formulating problems and designing analysis tools for biological signals.				
3	Increase the students awareness of the complexity of various biological phenomena and cultivate an understanding of the same				
4	Foster effective interaction skills and teamwork communication				

Unit-I	**10 Hrs**
Introduction to digital speech signal processing: Digitization and recording, Human speech production and source filter model, Place and manner at articulation, Articulatory and acoustic phonetics, Uniform tube modeling of speech processing, Human auditory system, Speech perception.	
Unit – II	**10 Hrs**
Time Domain Models for Speech Processing: Time dependent representation of speech, Short time average zero crossing rate, Speech vs. silence discrimination using energy and zero crossing, pitch period estimation using parallel processing approach, short time autocorrelation function, Short time average magnitude difference function, Pitch period estimation using autocorrelation function.	
Unit –III	**10 Hrs**
Short Time Fourier Analysis: introduction, Definitions and properties, Fourier transform interpretation, linear filtering interpretation, Sampling rates of X(ejw) in time and frequency, Filter bank summation method of short time synthesis, Spectrographic displays.	
Unit –IV	**10 Hrs**
Feature extraction: Extraction of Fundamental frequency, Frequency domain fundamental frequency detection algorithm, Segmental and supra segmental features of speech signal, Cepstral transform coefficients parameters extraction, Mel-frequency Cepstral coefficients, MFCC features vector.	
Unit –V	**10 Hrs**
Speech based Applications: Text to speech synthesis, Automatic speech recognition, Statistical modelling of automatic speech recognition, and Speech based technology development for e learning.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Analyze the basic signal processing techniques in biological signals
CO2:	Apply basic mathematical, scientific and computational skills necessary to analyze biomedical signals.
CO3:	Formulate and solve basic problems in biomedical signal analysis.
CO4:	Design of Signal processing algorithm to be used in DSP Processor

Reference Books	
1	Digital Processing of Speech Signals, L R Rabiner and R W Schafer, Pearson Education 2004. ISBN: 0-13-213603-1
2	Digital Speech Processing, Synthesis and Recognition, Sadoaki Furui, Second Edition,Mercel Dekk er 2002. ISBN-13: 978-0824704520
3	Fundamentals of Speech Recognition, Rabiner and B.Juang ,Pearson Education, 2004, ISBN-13: 978-0130151575

4	Discrete-Time Speech Signal Processing: Principles and Practice , Thomas F. Quatieri, Prentice Hall; 1 edition (10 November 2008),ISBN:0-13-242942-X
5	Theory and Applications of Digital Speech Processing, L. R. Rabiner and R. W. Schafer, Pearson; 1 edition (3 March 2010),ISBN: 978-0136034285

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping											
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	3	2	1	2	2	3	3	3
CO2	3	3	3	2	3	1	1	1	3	1	3	3
CO3	3	3	3	2	3	1	1	1	2	1	3	3
CO4	3	3	3	3	2	1	1	1	2	1	3	3

High-3: Medium-2: Low-1

Semester: VII						
RADIO FREQUENCY INTEGRATED CIRCUITS DESIGN **(Group F: Professional Core Elective)**						
Course Code	:	16EC7F4		**CIE**	:	100 Marks
Credits: L:T:P:S	:	4:0:0:0		**SEE**	:	100 Marks
Total Hours	:	50L		**SEE Duration**	:	03 Hours
Course Learning Objectives: The students will be able to						
1	Define and demonstrate the importance of radio frequency design.					
2	Analyze the functionality and design issues of RF circuits and systems.					
3	Design and implement RF transceiver.					
4	Evaluate the different performance parameters used in RF design.					

Unit-I	**10 Hrs**
Introduction to RF Design and Wireless Technology - various disciplines in RF design, RF design hexagon. **Basic concepts in RF design -** Units in RF design, Nonlinearity and Time Variance, Effects of nonlinearity – harmonic distortion, gain compression – 1 dB compression point, desensitization, blocking, cross modulation, intermodulation – third intercept point, cascaded nonlinear stages – IM spectra in a cascade.	
Unit – II	**10 Hrs**
Noise in RF circuits - Representation of noise in circuits – input referred noise, Noise figure, Noise figure of cascaded stages, Noise figure of lossy circuits, Sensitivity, dynamic range – spurious free dynamic range (SFDR). **Transceiver architectures** – channel selection and band selection, Heterodyne – constant LO and constant IF downconversion, problem of image, image rejection vs channel selection, dual IF topology, Homodyne – simple homodyne and homodyne with quadrature down conversion, issues in homodyne receivers, Image Reject – Hartley & Weaver architecture. Transmitter architectures - Direct conversion and two-step transmitters.	
Unit –III	**10 Hrs**
Passive impedance transformation – Quality factor, series to parallel conversion, basic matching networks- L, T, Pi-match networks, tapped inductor and capacitor networks **Low noise Amplifier -** Performance parameters, Problem of Input matching, CS stage with inductive load, Cascode CS stage with inductive degeneration (MOSFET circuits only), Noise figure calculation.	
Unit –IV	**10 Hrs**
Mixer - Performance parameters, Mixer noise figures, single balanced and double balanced (active and passive) – working (MOSFET circuits only) **Oscillators** - Performance parameters, Feedback view and one port view of oscillators, Cross coupled oscillator, three point oscillators, (MOSFET circuits only), Ring oscillators.	
Unit –V	**10 Hrs**
Phase Locked Loops - Basic concepts - Phase detector, Type I PLL, Dynamics of simple PLL, Drawbacks of simple PLL, Type II PLLs - PFD, charge pump, charge pump PLL, PFD/CP Nonidealities (concepts only) – Up and Down Skew and Width Mismatch, Charge Injection and clock feedthrough.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Investigate the functionality of a typical RF system.
CO2:	Analyze CMOS circuits and its impact on Radio frequency IC design.
CO3:	Design and implement RF transceiver chain with specification.
CO4:	Evaluate the different performance parameters used in RF design using CAD tools.

	Reference Books
1	RF Microelectronics, Behzad Razavi, 2nd Edition Pearson Education, 2012
2	The Design of CMOS Radio Frequency Integrated Circuits, Thomas H Lee, 2nd Edition, Cambridge University Press, 2004
3	Radio Frequency Integrated Circuits Design, John Rogers ,Calvin Plett, Artech House, 2003
4	VLSI for Wireless Communications, Bosco Leung, Pearson Education, 2004

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping											
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	2
CO2	3	2	-	-	-	-	-	-	-	-	-	2
CO3	3	3	2	-	2	-	-	3	2	-	-	2
CO4	3	3	-	-	2	-	-	-	-	-	-	2

High-3: Medium-2: Low-1

Semester: VII					
HIGH PERFORMANCE COMPUTING					
(Group F: Professional Core Elective)					
Course Code	:	16EC7F5	**CIE**	:	100 Marks
Credits: L:T:P:S	:	4:0:0:0	**SEE**	:	100 Marks
Total Hours	:	50L	**SEE Duration**	:	03 Hours
Course Learning Objectives: The students will be able to					
1	To review the trends in parallel programming.				
2	To demonstrate the basic ideas of multiprocessing and parallel operations with case studies.				
3	To expose to basics of parallel programming.				
4	To demonstrate parallel programming using MPI, OpenAcc and OpenMP.				

Unit-I	**10 Hrs**
Multiprocessors and Thread level parallelism: Introduction, Symmetric shared memory architectures; Performance of symmetric shared-memory multiprocessors, Distributed shared memory and directory-based coherence, Basics of synchronization, Models of memory consistency.	
Unit – II	**10 Hrs**
Data-Level Parallelism in Vector, SIMD, and GPU Architectures: Introduction, Vector Architecture, SIMD Instruction Set Extensions for Multimedia, Graphics Processing Units, Detecting and Enhancing Loop-Level Parallelism, Mobile versus Server GPUs and Tesla versus Core i7.	
Unit –III	**10 Hrs**
Introduction to Parallel Programming: Motivation, Scope of Parallel Computing, Principles of Parallel Algorithm design: Preliminaries, Decomposition Techniques, Characteristics of Tasks and Interactions, Mapping Techniques for Load Balancing, Methods for containing Interaction Overheads, Parallel Algorithms Models.	
Unit –IV	**10 Hrs**
Programming Using the Using Message Passing Paradigm: Principles of Message Passing Programming, Building Blocks, MPI, Topologies and Embedding, Overlapping Communication with computation, Collective Communication and computation operations, Groups and Communicators.	
Unit –V	**10 Hrs**
GPU Programming using Open ACC: Serial to parallel programming using OpenACC: A Simple Data-Parallel Loop, Task-Parallel Example, Amdahl's Law and Scaling, Parallel Execution and Race Conditions, Lock-Free Programming, Controlling Parallel Resources. **Pipelining data transfers with OpenACC:** Introduction to Pipelining, Mandelbrot Generator, Pipelining Across Multiple Devices.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Explore the fundamentals of high-performance computing concepts.
CO2:	Analyze the performance of parallel programming.
CO3:	Design parallel computing constructs for different applications.
CO4:	Demonstrate Parallel computing concepts for suitable applications.

Reference Books	
1	Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar, Introduction to Parallel Computing, 2nd Edition, 2013, Pearson Education, ISBN 13: 9788131708071.
2	CUDA Programming: A Developers Guide to Parallel Computing with GPUs, Shane Cook, 1st Edition, 2013, Morgan Kaufmann, ISBN:9780124159334.
3	Parallel Programming with Open ACC, Rob Farber, 1st Edition, 2016, Morgan Kaufmann (MK) Publication, ISBN :9780124103979.

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping											
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	1	-	1
CO2	3	2	2	1	-	-	-	-	-	1	-	1
CO3	3	3	2	2	2	-	-	-	-	1	-	1
CO4	3	3	3	3	2	-	-	-	-	1	-	1

High-3: Medium-2: Low-1

Semester: VII					
INTEGRATED PHOTONICS					
(Group F: Professional Core Elective)					
Course Code	:	16EC7F6		**CIE**	:	100 Marks
Credits: L:T:P:S	:	4:0:0:0		**SEE**	:	100 Marks
Total Hours	:	52L		**SEE Duration**	:	03 Hours

Course Learning Objectives: The students will be able to	
1	Learn the fundamental principles of photonics and light-matter interactions
2	Explain and illustrate light guiding, calculate wave propagation in waveguide systems
3	Calculate characteristics of optical resonators
4	Develop the ability to formulate problems related to photonic structures/processes and analyze them

Unit-I	**10 Hrs**
Introduction to EM theory: EM wave in dielectric media, Monochromatic EM waves, Absorption and Dispersion, Pulse propagation in Dispersive media, Polarization of light, Reflection and Refraction, Optics in Anisotropic media**.**	
Unit – II	**11 Hrs**
Interaction of optical waves: with dielectric and metal interfaces, matrix optics. Computational methods for integrated photonics. Propagation-matrix approach, multilayered and periodic media.	
Unit –III	**11 Hrs**
Waveguide optics: Symmetric dielectric waveguides. Asymmetric dielectric waveguides. Rectangular waveguides. Optical fibers. Attenuation and dispersion in optical waveguides. Signal distortion in optical waveguides, group delay. **Silicon waveguides:** fabrication, waveguide loss, scattering, absorption, radiation. Dispersion engineering. Optical nonlinearities in silicon waveguides. Coupling to waveguide: edge, grating, evanescent coupling, spot-size converters.	
Unit –IV	**10 Hrs**
Coupled optical waveguides: Mach-Zehnder interferometer, cascaded MZI optical filters, star couplers. Filters figures of merit. Optical ring resonators. Add-drop multiplexers. Waveguide Bragg gratings. Polarization dependence and management. Waveguide polarization splitters and rotators. Optical isolation**.**	
Unit –V	**10 Hrs**
Photonic modulators: electro-optical and thermo-optical effects. Phase and amplitude modulators. Thermal phase shifter, thermo-optic switch. **Non-linear optics:** Non-linear media, Second-order Non-linear optics, Third-order Non-linear optics.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Define and explain the propagation of light in conducting and non-conducting media.
CO2:	Define and explain the physics governing laser behaviour and light matter interaction
CO3:	Apply wave optics and diffraction theory to a range of problems
CO4:	Calculate properties of and design modern optical fibres and photonic crystals.

Reference Books	
1	Fundamentals of Photonics, B.E.A. Saleh, M.C. Teich, Wiley India Pvt Ltd; 2nd edition, 2012, ISBN: 9788126537747
2	Photonics - Optical Electronics in Modern Communications, A. Yariv and P. Yeh, Oxford University Press, 6th Edition, ISBN: 0195179463

3	Photonic Crystals – Molding the Flow of Light, John D. Joannopoulos, Steven G. Johnson, Joshua N. Winn, and Robert D. Meade, Princeton University Press; 2nd Revised edition, 2013, ISBN-10: 0691124566
4	Silicon Photonics - Fundamentals and Devices, M. Jamal Deen and P.K. Basu, John Wiley & Sons Ltd.,3rd Edition 2010,ISBN: 0-321-26977-2

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping											
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	1	-	1
CO2	3	2	2	1	-	-	-	-	-	1	-	1
CO3	3	3	2	2	-	-	-	-	-	1	-	1
CO4	3	3	3	3	-	-	-	-	-	1	-	1

High-3: Medium-2: Low-1

Semester: VII					
NANOELECTRONICS **(Group F: Professional Core Elective)**					
Course Code	:	16EC7F7	**CIE**	:	100 Marks
Credits: L:T:P:S	:	4:0:0:0	**SEE**	:	100 Marks
Total Hours	:	50L	**SEE Duration**	:	03 Hours
Course Learning Objectives: The students will be able to					
1	Develop substantial understanding of contemporary relevance and potential of nanoelectronics;				
2	Develop appreciation of how factors like scaling and dimension lead to novel behaviour of nanoelectronic components;				
3	Develop understanding of the importance of quantum ideas and their place in modelling of nanoelectronic phenomena and devices;				
4	Expose to a variety of nanoelectronic phenomena, nanoelectronic components and their possible applications.				

Unit-I	**10 Hrs**
Review of Electrons Quantum mechanics: Electrons wave particle duality**,** Wave equation, Wave packets and uncertainty, Schrodinger's Equation, The Time Independent Schrödinger Equation, Stationary States, The Infinite Square Well, Harmonic Oscillator-Algebraic method	
Unit – II	**10 Hrs**
Free and confined electrons: Free electrons, Periodic boundary conditions, Electrons Confined to a Bounded Region of Space, and Quantum Numbers, Fermi level and Chemical potential, Partially Confined Electrons**-** Finite Potential Wells, Quantum Dots, Wires, and Wells	
Unit –III	**10 Hrs**
Electrons subject to a periodic potential: Electrons in periodic potential, Kronig-Penney of Band structure- Effective Mass, **Band theory of Solids:** Interacting system model, Band structure, electronic band transition, graphene and carbon nanotube	
Unit –IV	**10 Hrs**
Tunnel junctions and applications of tunneling: Tunneling Through a Potential Barrier, Potential Energy Profiles for Material Interfaces, Applications of Tunneling, Field Emission, Gate—Oxide Tunneling and Hot Electron Effects in MOSFETs, Scanning Tunneling Microscope, Double Barrier Tunneling and the Resonant Tunneling Diode	
Unit –V	**10 Hrs**
Coulomb blockade and the single-electron transistor: Tunnel Junction Excited by a Current Source, Coulomb Blockade in a Quantum Dot Circuit, The Single-Electron Transistor, Single-Electron Transistor Logic, Other SET and FET Structures, Carbon Nanotube Transistors (FETs and SETs), Semiconductor Nanowire FETs and SETs, Molecular SETs and Molecular Electronics	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Define novel behaviour of nanoelectronics devices and quantum behaviour of matter at the nano scale & modelling of nanoelectronics devices.
CO2:	Comprehend principles of devices such as tunneling diodes, single electron transistor, spintronic devices.
CO3:	Analysis fundamental concepts and methods of Analysis quantum tunneling, resonant tunneling, Coulomb blockade, density of quantum states, quantum statistics and quantum modelling.
CO4:	Evaluate nano scale effects in futuristic electron devices & quantum level computing

	Reference Books
1	Fundamentals of Nanoelectronics, George W. Hanson, Pearson, 1st edition, (2009), ISBN: 978-8131726792
2	Introduction to Quantum Mechanics, J. Griffiths David, Pearson Education, 2nd edition (2015), ISBN-13: 978-9332542891
3	Introduction to Nanotechnology, Charles P. Poole, Jr., Frank J. Owens, Wiley (15 January 2007), ISBN:978-8126510993
4	Nanoelectronics and Information Technology, Rainer Waser, Wiley VCH; 3rd Revised edition edition(2012), ISBN: 978-3527409273

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project is 10.

Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	1	2	-	-	-	-	2
CO2	3	2	1	-	-	1	2	-	-	-	-	2
CO3	3	3	2	-	2	1	2	-	-	-	-	2
CO4	3	3	3	2	2	1	2	-	-	-	-	2

High-3: Medium-2: Low-1

	Semester: VII			
	RADAR & NAVIGATION			
	(Group G: Professional Core Elective)			
Course Code	:	16EC7G1	**CIE**	:	100 Marks
Credits: L:T:P:S	:	4:0:0:0	**SEE**	:	100 Marks
Total Hours	:	48L	**SEE Duration**	:	03 Hours

Course Learning Objectives: The students will be able to	
1	Understand the basic operation of pulse and CW radar systems.
2	Evaluate the radar performance based on pulse width, peak power and beam width.
3	Choose suitable tracking radar for a given problem.
4	Understand the working of phased array radars and navigational aids

Unit-I	**10 Hrs**
Radar and Radar Equation: Introduction, Radar block diagram and operation, frequencies, applications, types of displays, derivation of radar equation, minimum detectable signal, probability of false alarm and threshold detection, radar cross-section, system losses.	
Unit – II	**10 Hrs**
CW Radar: Doppler Effect, CW Radar, applications, FM – CW radar, altimeter, Multiple Frequency Radar. Pulse Radar – MTI, Delay Line Canceller, Multiple Frequencies, Range-gated Doppler Filters, Non-coherent MTI, Pulse Doppler Radar	
Unit –III	**10 Hrs**
Tracking Radar: Sequential lobing, conical scanning, monopulse, phase comparison monopulse, tracking in range, comparison of trackers.	
Unit –IV	**09 Hrs**
Detection: Introduction, Matched Filter, Detection Criteria, Detector characteristics.	
Unit –V	**09 Hrs**
Phased Arrays: Basic concepts, feeds, phase shifters, frequency scan arrays, multiple beams, applications, advantages and limitations. Navigational Aids: Direction Finder, VOR, ILS and Loran	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the basic operation of pulse and CW radar systems.
CO2:	Evaluate the radar performance based on pulse width, peak power and beam width.
CO3:	Choose suitable tracking radar for a given problem.
CO4:	Select appropriate criterion for detecting a target.

Reference Books	
1	Understanding Automotive Electronics, Williams. B. Ribbens, Elsevier science, 6th Edition, Newness publication,2003, ISBN-9780080481494.
2	Automotive Electronics Handbook, Robert Bosch, John Wiley and Sons, 2004
3	Automotive Embedded Systems Handbook, Nicolas Navet, F Simonot-Lion, Industrial Information Technology Series, CRC press.
4	Automotive Control Systems Engine, Uwekiencke and lars Nielsen, Driveline and vehicle", Springer, 2nd Edition, 2005, ISBN 0-387-95368X

Continuous Internal Evaluation (CIE); Theory (100 Marks)
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Semester End Evaluation (SEE); Theory (100 Marks)
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CO-PO Mapping											
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	1	-	-	-	-	-	-	-	1
CO2	3	2	2	1	-	1	-	-	-	-	-	1
CO3	3	2	2	1	-	1	-	-	-	-	-	1
CO4	3	1	2	1	-	1	-	-	-	-	-	

Low-1   Medium-2   High-3

Semester: VII					
AUTOMOTIVE ELECTRONICS					
(Group G: Professional Core Elective)					
Course Code	:	**16EC7G2**		**CIE**	:	100 Marks
Credits: L:T:P:S	:	4:0:0:0		**SEE**	:	100 Marks
Total Hours	:	48L		**SEE Duration**	:	03 Hours

Course Learning Objectives: The students will be able to	
1	Acquire the knowledge of automotive domain fundamentals, need of Electronics and communication interfaces in Automotive systems.
2	Apply various types of sensors, actuators and Motion Control techniques in Automotive systems
3	Understand digital engine control systems and Embedded Software's and ECU's used in automotive systems.
4	Analyse the concepts of Diagnostics, safety and advances in Automotive electronic Systems.

Unit-I	**10 Hrs**
Fundamentals of Automotive: Use of Electronics in Automotive, Evolution of Electronics in Automotive, Automotive Systems, The Engine, Engine Control, Internal Combustion Engines, Spark Ignition Engines and Alternative Engines. Ignition System, Ignition Timing, Drivetrain, Suspensions, Brakes and Steering Systems, Demonstration of Four Cylinder manual transmission Engine. **Basics of electronic engine control:** Motivation for Electronic Engine Control – Exhaust Emissions, Fuel Economy, Concept of an Electronic Engine control system, Definition of General terms, Definition of Engine performance terms, Engine mapping, Effect of Air/Fuel ratio, spark timing and EGR on performance, Control Strategy, Electronic Fuel control system, Analysis of intake manifold pressure, Electronic Ignition.	

Unit – II	**10 Hrs**
Automotive Sensors and Actuators: System Approach to Control and Instrumentation: Concept of A System, Analog and Digital Systems, Basic Measurement Systems, Analog and Digital Signal Processing, Automotive Control System Applications of Sensors and Actuators, **Sensors:** Air Flow Sensor, Engine Crankshaft Angular Position Sensor, Throttle Angle Sensor, Temperature Sensor, Sensors for Feedback Control, Sensors for Driver Assistance System: Radar, Lidar, Video Technology. **Actuators:** Solenoids, Piezo Electric Force Generators, Electric Motors and Switches.	

Unit –III	**10 Hrs**
Digital Engine Control Systems: Digital Engine control features, Control modes for fuel Control (Seven Modes), EGR Control, Electronic Ignition Control - Closed Loop Ignition timing, Spark Advance Correction Scheme, Integrated Engine Control System - Secondary Air Management, Evaporative Emissions Canister Purge, Automatic System Adjustment, System Diagnostics. **Vehicle Motion Control:** Typical Cruise Control System, Digital Cruise Control System, Digital Speed Sensor, Throttle Actuator, Digital Cruise Control configuration, Cruise Control Electronics (Digital only), Antilock Brake System (ABS)	

Unit –IV	**09 Hrs**
Automotive Communication Systems: Automotive networking: Bus systems, Technical principles, network topology. Buses in motor vehicles: CAN, Flex Ray, LIN, Ethernet, IP, PSI5, MOST, D2B and DSI. **Automotive Embedded Software Development** Fundamentals of Software and software development lifecycles. Overview of AUTOSAR methodology and principles of AUTOSAR Architecture. Use of MoTeC M800 ECU in engine management and data Acquisition Solutions.	

Unit –V	**09 Hrs**
Diagnostics and Safety in Automotive: Timing Light, Engine Analyzer, Electronic Control System Diagnostics: Onboard diagnostics, Off-board diagnostics, Expert Systems, Occupant Protection Systems – Accelerometer based Air Bag systems, Case study on ON-BOARD, OFF-BOARD diagnostics.	

Advances in Automotive Electronic Systems: Alternative Fuel Engines, Electric and Hybrid vehicles, Fuel cell powered cars, Collision Avoidance Radar warning Systems, Navigation: Navigation Sensors, Radio Navigation, dead reckoning navigation, Video based driver assistance systems, Night vision Systems

Course Outcomes: After completing the course, the students will be able to	
CO1:	Acquire the knowledge of automotive domain fundamentals, need of Electronics and communication interfaces in Automotive systems.
CO2:	Apply various types of sensors, actuators and Motion Control techniques in Automotive systems
CO3:	Analyze digital engine control systems and Embedded Software's and ECU's used in automotive systems.
CO4:	Illustrate the concepts of Diagnostics, safety and advances in Automotive electronic Systems.

Reference Books	
1.	Understanding Automotive Electronics, Williams. B. Ribbens, 6th Edition, 2003, Elsevier science, Newness publication, ISBN-9780080481494.
2.	Automotive Electronics Handbook, Robert Bosch, 2004, John Wiley and Sons,

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping											
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	1	-	-	-	-	-	-	-	1
CO2	3	2	2	1	-	1	-	-	-	-	-	1
CO3	3	2	2	1	-	1	-	-	-	-	-	1
CO4	3	1	2	1	-	1	-	-	-	-	-	

Low-1   Medium-2   High-3

Semester: VII					
MULTIMEDIA COMMUNICATION					
(Group G: Professional Core Elective)					
Course Code	:	16EC7G3	**CIE**	:	100 Marks
Credits: L:T:P:S	:	4:0:0:0	**SEE**	:	100 Marks
Total Hours	:	48L	**SEE Duration**	:	03 Hours
Course Learning Objectives: The students will be able to					
1	Understand the basics of analog and digital video: video representation and transmission				
2	Analyze analog and digital video signals and systems				
3	Analyze the fundamental video processing techniques & acquire the basic skill of designing video compression				
4	Design video transmission systems: error control and rate control				

Unit-I	10 Hrs
Multimedia Communications: multimedia information representation, multimedia networks, multimedia applications, network QoS and application QoS	
Unit – II	**10 Hrs**
Text and image compression,, compression principles, text compression- Runlength,Huffman, LZW, Image compression- GIF, TIFF and JPEG.	
Unit –III	**10 Hrs**
Audio and video compression: Introduction, audio compression, DPCM, ADPCM, APC, LPC, video compression, video compression principles,	
Unit –IV	**09 Hrs**
Video compression standards: H.261, H.263, MPEG, MPEG 1, MPEG 2, MPEG-4 and Reversible VLCs,	
Unit –V	**09 Hrs**
The Internet: Introduction, IP datagrams, fragmentation, Ip address, ARP and RARP, QoS. Transport Protocol: Introduction, TCP/IP, TCP, UDP, RTP and RTCP.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Describe and describe various multimedia data.
CO2:	Analyze the representation of multimedia data.
CO3:	Describe the concept involved in MPEG4 standards.
CO4:	Develop algorithms for protocols like RTP,RTCP for multimedia communication .over mobile networks.

Reference Books	
1	Multimedia Communications, Fred Halsall, Pearson education, 2001. ISBN: 8131709949, 978-8131709948
2	Multimedia Communication Systems, K. R. Rao, Zoran S. Bojkovic, Dragorad A. Milovanovic, Pearson education, 2004.ISBN: 013031398X978-0130313980
3	Multimedia: Computing, Communications and Applications, Raif steinmetz, Klara Nahrstedt, Pearson education, 2002,ISBN: 3540408673, 978-3540408673
4	Multimedia : An Introduction, John Billamil, Louis Molina, PHI, 2002, ISBN: 1575765578, 978-1575765570

Continuous Internal Evaluation (CIE); Theory (100 Marks)
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Semester End Evaluation (SEE); Theory (100 Marks)
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CO-PO Mapping											
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	1	-	-	-	-	-	-	-	1
CO2	3	2	2	1	-	1	-	-	-	-	-	1
CO3	3	2	2	1	-	1	-	-	-	-	-	1
CO4	3	1	2	1	-	1	-	-	-	-	-	

Low-1   Medium-2   High-3

Semester: VII					
VLSI TESTING FOR ICs					
(Group G: Professional Core Elective)					
Course Code	:	16EC7G4	**CIE**	:	100 Marks
Credits: L:T:P:S	:	4:0:0:0	**SEE**	:	100 Marks
Total Hours	:	48L	**SEE Duration**	:	03 Hours
Course Learning Objectives: The students will be able to					
1	Understand different types of faults associated with logic circuits and types of testing by employing fault models to the logic circuits.				
2	Understand advanced methods of simulation and digital testing algorithms and use the appropriate methods for achieving fault coverage specifications in design.				
3	Explain the concepts Design for Testability				
4	Recognize different techniques in Built In Self-Test (BIST) such as MBIST and LBIST**.**				

Unit-I	**10 Hrs**
Introduction to Testing- Introduction to Testing, Role of testing VLSI circuits, VLSI trends affecting testing, Faults in digital circuits. **Fault Modeling**- Functional Testing, Structural Testing, Types of Fault Models, Stuck-at Faults, Bridging Faults, cross point faults, Fault Equivalence, Fault Dominance	
Unit – II	**10 Hrs**
Fault Simulation- Fault Simulation algorithm- Serial, Parallel, Deductive and Concurrent Fault Simulation. **Testability Measure** - Controllability, Observability, SCOAP measures for combinational and sequential circuits.	
Unit –III	**10 Hrs**
ATPG for Combinational Circuits- Path Sensitization Methods, Roth's D- Algorithm, Boolean Difference, Complexity of Sequential ATPG, Time Frame Expansion. **Design for Testability**- Ad-hoc, Structured DFT- Scan method, Scan Design Rules, Overheads of Scan Design, partial scan methods, multiple chain scan methods.	
Unit –IV	**09 Hrs**
Self-test And Test Algorithms-Built-In self-Test, test pattern generation for BIST, response compaction - Parity checking, Ones counting, Transition Count, Signature analyser (SISR and MISR). Circular BIST, BIST Architectures.	
Unit –V	**09 Hrs**
Memory Testing-Testable Memory Design Test Algorithms, Reduced Functional Faults-MARCH and MAT+ algorithm. Test generation for Embedded RAMs. MBIST..	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Attain knowledge about testing, fault modeling & collapsing.
CO2:	Explore various fault simulation methods.
CO3:	Evaluate the significance of combinational ATPG and sequential test pattern generation.
CO4:	Get complete knowledge about different methods of LBIST and MBIST associated with testing.

Reference Books	
1	VLSI Test Principles and Architectures, L. T. Wang, C. W. Wu, and X. Wen, Morgan Kaufmann, 2006, ISBN-13: 978-0-12-370597-6, ISBN-10: 0-12-370597-5.
2	Digital Circuit Testing and Testability, Parag.K.Lala, Academic Press.
3	Essentials of Electronic Testing for Digital, Memory, and Mixed-Signal VLSI Circuits M. L. Bushnell and V. D. Agrawal, Kluwer Academic Publishers, 2000, ISBN: 0-7923-7991-8.

4	Digital Systems Testing and Testable Design M. Abramovici, M. A. Breuer, and A. D. Friedman, Computer Science Press, 1990, ISBN: 0-7167-8179-4.

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Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

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CO1	2	2	2	-	2	-	-	-	-	1	-	1
CO2	2	2	2	1	2	-	-	-	-	1	-	1
CO3	2	3	2	2	2	-	-	-	-	1	-	1
CO4	2	3	2	3	2	-	-	-	-	1	-	1

Low-1 Medium-2 High-3

		Semester: VII				
		HIGH SPEED DIGITAL DESIGN				
		(Group G: Professional Core Elective)				
Course Code	:	16EC7G5		**CIE**	:	100 Marks
Credits: L:T:P:S	:	4:0:0:0		**SEE**	:	100 Marks
Total Hours	:	48L		**SEE Duration**	:	03 Hours
Course Learning Objectives: The students will be able to						
1	Understand analog circuit principles relevant to high speed digital design.					
2	Analyze power distribution and noise in Power supply network and signaling over transmission lines.					
3	Demonstrate the functionality of different clocked and non-clocked digital circuits and memory elements.					
4	Analyze the performance of clocked, non-clocked and latching circuits.					

Unit-I	**10 Hrs**
The Interconnect: Introduction, Interconnect Modelling, Resistance, Capacitance, Inductance, Skin Effect, Temperature Dependence, Interconnect Impact: Delay, Energy, Crosstalk, Inductive Effects, An Aside on Effective Resistance and Elmore Delay, Interconnect Engineering, Width, Spacing, and Layer, Repeaters, Crosstalk Control, Low-Swing Signalling, Regenerators, Logical Effort with Wires.	
Unit – II	**10 Hrs**
Introduction to high speed digital design: Frequency, time and distance issues in digital VLSI design. Capacitance and inductance effects, high speed properties of logic gates, speed and power. Modeling of wires, geometry and electrical properties of wires, Electrical models of wires, transmission lines, lossless LC transmission lines, lossy RLC transmission lines and special transmission lines.	
Unit –III	**10 Hrs**
Power distribution and Noise: Power supply network, local power regulation, IR drops, area bonding. On-chip bypass capacitors and symbiotic bypass capacitors. Power supply isolation. Noise sources in digital systems, power supply noise, crosstalk and inter symbol interference. Power distribution on chips.	
Unit –IV	**09 Hrs**
Clocked & non clocked Logics:Non clocked Logic Styles: Static CMOS, DCVS Logic, Non-Clocked Pass Gate Families**Clocked Logic Styles**: Single-Rail Domino Logic, Dual-Rail Domino Structures	
Unit –V	**09 Hrs**
Latching Strategies: Basic Latch Design, and Latching single-ended logic and Differential Logic, Race Free Latches for Pre-charged Logic Asynchronous Latch Techniques, DDR memories.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Investigate the special requirements that are imposed on high speed digital design.
CO2:	Analyze the characteristics of transmission lines and high speed latches and circuits.
CO3:	Analyze the Signaling convention in transmission media and high speed digital logics.
CO4:	Evaluate the performance of various transmission lines and high speed digital circuits.

Reference Books	
1	Digital Systems Engineering, William S. Dally & John W. Poulton, Cambridge University Press, 1998. ISBN 0-521-59292-5
2	CMOS VLSI Design: A Circuit and Systems Perspective, Neil H. E. Weste David Money Harris Pearson Publication, 4th Edition,2011, ISBN 13: 978-0-321-54774-3
3	High Speed CMOS Design Styles, Kerry Bernstein, Keith M. Carrig, Christopher M. Durham, Patrick R. Hansen, David Hogenmiller, Edward J. Nowak, Norman J. Rohrer, Kluwer Academic Publishers in 1999, ISBN 978-1-4613-7549-4.

4	High Speed Digital Circuits, Masakazu Shoji, Addison Wesley Publishing Company, 1996. ISBN 978-0201634839.
5	High Speed Digital Design, Howard Johnson & Martin Graham, A Handbook of Black Magic, Prentice Hall PTR, 1993.
6	Digital Integrated Circuits: A Design Perspective, Jan M.Rabaey, Anantha Chadrakasan, Borivoje Nikolic, (2/e), Pearson 2016, ISBN-13: 978-0130909961.

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CO3	3	2	1	1	2	-	-	-	-	1	-	1
CO4	3	3	3	3	3	-	-	-	-	1	-	1

Low-1   Medium-2   High-3

Semester: VII					
MEMS AND SMART SYSTEMS					
(Group G: Professional Core Elective)					
Course Code	:	16EC7G6	**CIE**	:	100 Marks
Credits: L:T:P:S	:	4:0:0:0	**SEE**	:	100 Marks
Total Hours	:	48L	**SEE Duration**	:	03 Hours
Course Learning Objectives: The students will be able to					
1	Explain the operation principles of advanced micro- and smart systems.				
2	Describe the technology to fabricate advanced micro- and smart systems.				
3	Understand different methods to fabricate MEMS devices.				
4	Present the basics of implementation of MEMS into products				

Unit-I	**10 Hrs**
Introduction to Micro and Smart Systems: Introduction, Microsystem vs MEMS, Smart Materials, structures and system, Integrated Microsystems, Application of Smart Materials and Microsystems. Feynman's vision, Evolution of micro-manufacturing. Multi-disciplinary aspects. Applications areas. Commercial products. **Modelling:** Scaling issues, Scaling in geometry, Scaling in rigid body dynamics, scaling in electrostatic forces, scaling in electromagnetic forces, scaling in electricity, scaling in fluid dynamics. scaling effects in the optical domain, scaling in biochemical phenomena.	
Unit – II	**10 Hrs**
Micro and Smart Devices and Systems: Principles Definitions and salient features of sensors, actuators, and systems. Sensors: silicon capacitive accelerometer, piezo-resistive pressure sensor, Actuators: silicon micro-mirror arrays, magnetic micro relay, piezo-electric based inkjet printhead, electro-thermal actuator. portable blood analyzer, fiber optic sensors, Electrostatic Comb drive, Microsystems at Radio frequency.	
Unit –III	**10 Hrs**
Materials: Introduction, Substrates and Wafers, Active substrate materials, Si as a substrate material, Si compounds, Si Piezoresistors, Gallium Arsenide, Quartz, Piezoelectric Crystals and Polymers. **Micro Manufacturing and Material Processing:** Silicon wafer processing, Oxidation , CVD, PVD , lithography, thin-film deposition, etching (wet and dry), wafer-bonding, and metallization, Silicon micromachining: surface, bulk , bonding based process flows.	
Unit –IV	**09 Hrs**
Electronics Circuits for Micro and Smart Systems: Electronic Amplifiers, Signal Conditioning Circuits: Differential Amplifier, Instrumentation Amplifier, Wheatstone Bridge, Phase Locked Loop, Analog to Digital Conversion, Practical Signal Conditioning Circuits: Differential Charge Measurement, Switched Capacitor circuits, Circuits for frequency measurement shifts.	
Unit –V	**09 Hrs**
Electronics, Circuits and Packaging: Micro Systems Packaging, objectives and special issues in micro system packaging, Types of Microsystem Packages ,Packaging Technologies **Case study of devices** Cantilevers, Pressure sensors, accelerometers, micro heater.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Describe main principles of MEMS and smart systems.
CO2:	Demonstrate confidence in MEMS and smart systems through practical experience using typical modern Computer Aided Design software for this task.
CO3:	Apply a concept of a micro- and smart systems into a real device considering the scaling laws and boundary conditions involved.
CO4:	Evaluate the principles and processes involved in the implementation of MEMS devices

Reference Books	
1	MEMS & Microsystems: Design and Manufacture, Tai-Ran Tsu, Tata Mc-Graw-Hill.ISBN-13:9780070487093
2	Micro and Smart Systems, K.J.Vinoy, G.K.Ananthasuresh, S.Gopalakrishnan, K.N.Bhat, Wiley India, ISBN: 9788126527151
3	Microsystems Design, S. D. Senturia, Kluwer Academic Publishers, Boston, USA, 2001, ISBN 0-7923-7246-8.
4	Analysis and Design Principles of MEMS Devices, Minhang Bao, Elsevier, Amsterdam, Netherlands, ISBN 0-444-51616-6.

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Semester End Evaluation (SEE); Theory (100 Marks)
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CO3	3	1	2	3	2	1	1	1	1	1	-	1
CO4	1	3	3	3	2	1	1	1	1	1	-	1

Low-1 Medium-2 High-3

Semester: IV					
NANOTECHNOLOGY **(Group H: Global Elective)**					
Course Code	:	16G7H01	**CIE**	:	100 Marks
Credits: L:T:P:S	:	3:0:0:0	**SEE**	:	100 Marks
Total Hours	:	36L	**SEE Duration**	:	3.00 Hours
Course Learning Objectives: The students will be able to					
1	To have the basic knowledge of nanomaterials and the process.				
2	Describe methods of nanoscale manufacturing and characterization can be enabled.				
3	To learn about Nano sensors and their applications in mechanical, electrical, electronic, Magnetic, Chemical field.				
4	To understand the concept for a nanoscale product based on sensing, transducing, and actuating mechanism.				
5	To have awareness about the nanoscale products used in multidisciplinary fields.				

Unit-I	**06 Hrs**
Introduction to Nanomaterials: History of Nanotechnology, structures and properties of carbon based: Fullerenes (Bucky Ball, Nanotubes), metal based: Nano Shells, Quantum Dots, Dendrimers, Diamond like carbon (DLC) Nanocarriers, bionanomaterails: protein & DNA based nanostructures, Hybrids: hybrid biological/inorganic, Nanosafety Issues: Toxicology health effects caused by nanoparticles.	

Unit – II	**08 Hrs**
Characterization of Nanostructures: Spectroscopy: UV-Visible spectroscopy, Fourier Transform infrared spectroscopy (FTIR), Raman Spectroscopy, X-ray spectroscopy. **Electron microscopy**: Scanning electron microscopy (SEM), Transmission electron microscopy (TEM).**Scanning probe microscopy**: Atomic Force microscopy (AFM), Scanning tunnel microscopy (STM). **Nano Synthesis and Fabrication**: Introduction & overview of Nanofabrication: Bottom up and Top down approaches using processes like Ball milling, Sol-gel Process, Chemical Vapour deposition (CVD), plsma arching and various lithography techniques (Hard & Soft lithography).	

Unit –III	**09 Hrs**
Nanosensors: Overview of nanosensors, prospects and market. Types of Nanosensors and their applications. Electromagnetic nanosensors: Electronic nose and electronic tongue, Magnetic nanosensors. Mechanical nanosensors: Cantilever Nanosensors, Mechanics of CNTs, Biosensors: Biosensors in modern medicine.	

Unit –IV	**06 Hrs**
. **Micro & Nano-Electromechanical system**s **and Microfluidics**: MEMS/NEMS: Magnetic, Chemical and Mechanical Transducers –Sensing and Actuators. Microfludics: Laminar flow, Hagen-Peouiselle equation, basic fluid ideas, Special considerations of flow in small channels, mixing, microvalves & micropumps.	

Unit –V	**07 Hrs**
Applications of Nanotechnology: Molecular electronics, molecular switches, mechanical cutting tools, machine components, DLC coated grinding wheels. solar cells, Batteries, fuel cells, Nanofilters. Medical nanotechnology: in Diagnostics, Therapeutics, Drug delivery and Nanosurgery.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Remember, understand, and apply knowledge about of nanomaterials and their uses.
CO2:	Interpret and apply the techniques of manufacturing and characterization processes
CO3:	Apply the knowledge of Nanosensors, related to nanosensors in electronics, mechanical, chemical, and biological systems.
CO4:	Create and evaluate nano Design, Devices and Systems in various disciplines

Reference Books	
1	Textbook of Nanosciences and Nanotechnology, B.S. Murty., P. Shankar., B.Raj, B..B. Rath, and J. Murday, Springer, Co-publication with University Press (India) Pvt. Ltd. VCH, XII.1st Edition, 2013, ISBN- 978-3-642-28030-6.
2	Physical, Chemical and Biological, V. K. Khanna, Nano sensors, CRC press, 1st edition, 2013, ISBN 9781439827123 (Unit III).
3	Nanostructured materials, Nanostructured materials, C. C. Kock, William Andrew Publishing, 2nd edition, 2007, ISBN 0-8155-1534-0.
4	Nanotechnology, M .Wilson., K. Kannangara., G.Smith., M.Simmons., B. Raguse, overseas Press (India) Private Ltd.,1st edition, 2005,ISBN 81-88689-20-3.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project 10. **Total CIE is 30(Q) +60(T) +10(A) =100 Marks.**

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Semester: VII					
INDUSTRIAL SAFETY AND RISK MANAGEMENT					
(Group H: Global Elective)					
Course Code	:	16G7H02	**CIE**	:	100 Marks
Credits: L:T:P:S	:	3:0:0:0	**SEE**	:	100 Marks
Total Hours	:	36L	**SEE Duration**	:	3.00 Hours
Course Learning Objectives: The students will be able to					
1	Understand the basics of risk assessment methodologies				
2	Select appropriate risk assessment techniques				
3	Analyze public and individual perception of risk				
4	Relate safety, ergonomics and human factors				
5	Carry out risk assessment in process industries				

Unit-I	**08 Hrs**
General Risk Identification Methods – I: Hazard identification methodologies, risk assessment methods-PHA, HAZOP, MCA, consequence analysis, hazards in workplaces-nature and type of work places, types of hazards, hazards due to improper housekeeping, hazards due to fire in multi floor industries and buildings.	
Unit – II	**07 Hrs**
Risk Assessment Methods – II: Risk adjusted discounted rate method, certainty equivalent coefficient method, quantitative analysis, probability distribution, coefficient of variation method, Simulation method, Shackle approach, Hiller‟s model, Hertz Model.	
Unit –III	**07 Hrs**
Risk Management – III: Emergency relief Systems, Diers program, bench scale experiments, design of emergency relief systems, risk management plan, mandatory technology option analysis, risk management alternatives, risk management tools, risk management plans, risk index method, Dowfire and explosion method, Mond index Method.	
Unit –IV	**07 Hrs**
Risk Assurance and Assessment – IV: Property insurance, transport insurance, liability insurance, risk Assessment, low Probability high consequence events. Fault tree analysis, Event tree analysis.	
Unit –V	**07Hrs**
Risk Analysis in Chemical Industries– V: Handling and storage of chemicals, process plants, personnel protection equipment's. International environmental management system.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Recall risk assessment techniques used in process industry
CO2:	Interpret the various risk assessment tools
CO3:	Use hazard identification tools for safety management
CO4:	Analyze tools and safety procedures for protection in process industries

Reference Books	
1	Functional Safety in the Process Industry : A Handbook of practical Guidance in the application of IEC61511 and ANSI/ISA-84, Kirkcaldy K.J.D Chauhan, North corolina, Lulu publication,2012,ISBN:1291187235
2	Safety Instrumented Systems Verification Practical probabilistic calculations, Goble and William M., Pensulvania ISA publication,2005,ISBN:155617909X
3	Industrial safety and risk Management, Laird Wilson and Doug Mc Cutcheon, The University of Alberta press,Canada, 1st Edition,2003,ISBN: 0888643942.
4	Environmental Engineering – A Design Approach, Sincero A P and Sincero G A, Prentice

5	Hall of India, New Delhi,1996, ISBN: 0024105643
	Risks in Chemical units, Pandya C G, Oxford and IBH publications, New Delhi,1992,ISBN: 8120406907

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Semester: VII					
INTELLIGENT TRANSPORT SYSTEM (Group H: Global Elective)					
Course Code	:	16G7H03	**CIE**	:	100 Marks
Credits: L:T:P:S	:	3:0:0:0	**SEE**	:	100 Marks
Total Hours	:	36L	**SEE Duration**	:	3.00 Hours
Course Learning Objectives: The students will be able to					
1	Understand basic traffic flow and control for ITS				
2	Understand user services for application in transportation system				
3	Understand ITS architecture and its planning at various levels				
4	Evaluate user services at various levels				

Unit – I	08 Hrs
Introduction: –Historical Background, Definition, Future prospectus, ITS training and educational needs. **Fundamentals of Traffic Flow and Control**- Traffic flow elements, Traffic flow models, Shock waves in Traffic streams, Traffic signalization and control principles, Ramp metering, Traffic simulation	

Unit – II	06 Hrs
ITS User services-User services bundles, Travel and Traffic management, Public Transportation Operations, Electronic Payment, Commercial Vehicles Operations, Emergency Management, Advanced Vehicle Control and safety systems, Information Management, Maintenance and construction Management	

Unit –III	07 Hrs
ITS Applications and their benefits-Freeway and incident management systems-objectives, functions, traffic Surveillance and incident detection, Ramp control, incident management, Advanced arterial traffic control systems- historical development, Adaptive traffic control algorithms, Advanced Public Transportation Systems-Automatic vehicle location systems, Transit Operations software and information systems, Electronic fare payment systems, Multimodal Traveler Information systems	

Unit –IV	07 Hrs
ITS Architecture-Regional and Project ITS Architecture, Need of ITS architecture, concept of Operations, National ITS Architecture, Architecture development tool. **ITS Planning**-Transportation planning and ITS, Planning and the National ITS Architecture, Planning for ITS, Integrating ITS into Transportation Planning, relevant case studies.	

Unit –V	08 Hrs
ITS Standards-Standard development process, National ITS architecture and standards, ITS standards application areas, National Transportation Communications for ITS Protocol, Standards testing. **ITS Evaluation** – Project selection at the planning level, Deployment Tracking, Impact Assessment, Benefits by ITS components, Evaluation Guidelines, Challenges and Opportunities.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Identify various applications of ITS
CO2:	Apply ITS applications at different levels.
CO3:	Examine ITS architecture for planning process.
CO4:	Define the significance of ITS for various levels

Reference Books	
1	Fundamentals of Intelligent Transportation Systems Planning, Choudury M A and Sadek A, Artech House publishers (31 March 2003); ISBN-10: 1580531601
2	Intelligent transportation systems standards, Bob Williams, Artech House, London, 2008. ISBN-13: 978-1-59693-291-3.
3	Intelligent Transport Systems: Technologies and Applications, Asier Perallos, Unai Hernandez-Jayo, Enrique Onieva, Ignacio Julio García Zuazola, Wiley Publishing ©2015, ISBN:1118894782 9781118894781
4	ITS Hand Book 2000 Recommendations for World Road Association (PIARC) by Kan Paul Chen, John Miles.
5	Intelligent Transport Systems, Dominique Luzeaux ,Jean-René Ruault, Michel Chavret, 7 MAR 2013 Copyright © 2010 by John Wiley & Sons, Inc DOI: 10.1002/9781118557495.ch6

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks are executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Semester: VII					
INTELLIGENT SYSTEMS					
(Group H: Global Elective)					
Course Code	:	16G7H04		**CIE**	:	100 Marks
Credits: L:T:P:S	:	3:0:0:0		**SEE**	:	100 Marks
Total Hours	:	35L		**SEE Duration**	:	3.00 Hours

Course Learning Objectives: The students will be able to

1	Understand fundamental AI concepts and current issues.
2	Understand and apply a range of AI techniques including search, logic-based reasoning, neural networks and reasoning with uncertain information.
3	Recognize computational problems suited to an intelligent system solution.
4	Identify and list the basic issues of knowledge representation, blind and heuristic search.

Unit-I	07 Hrs

Introduction: The Foundations of Artificial Intelligence, History of Artificial Intelligence, The State of the Art, **Intelligent Agent:** Introduction, How Agents Should Act, Structure of Intelligent Agents, **Problem-solving**: Solving Problems by Searching Search Strategies, Avoiding Repeated States ,Avoiding Repeated States

Unit – II	07 Hrs

Informed Search Methods: Best-First Search, Heuristic Functions, Memory Bounded Search, Iterative Improvement Algorithms
Game Playing: Introduction: Games as Search Problems, Perfect Decisions in Two-Person, Games Imperfect Decisions, Alpha-Beta Pruning, Games That Include an Element of Chance

Unit –III	07 Hrs

Knowledge Inference

Knowledge representation -Production based system, Frame based system. Inference - Backward chaining, Forward chaining, Rule value approach, Fuzzy reasoning - Certainty factors, Bayes Rule, Uncertainty Principles, Bayesian Theory-Bayesian Network-Dempster - Shafer theory.

Unit –IV	07 Hrs

Learning from Observations: A General Model of Learning Agents, Inductive Learning, Learning Decision Trees, Using Information Theory, Learning General Logical Descriptions, Why Learning Works: Computational Learning Theory
Reinforcement Learning: Passive Learning in a Known Environment, Passive Learning in an Unknown Environment, Active Learning in an Unknown Environment

Unit –V	07 Hrs

Expert Systems, Components, Production rules, Statistical reasoning, certainty factors,measure of belief and disbelief, Meta level knowledge, Introspection. Expert systems - Architecture of expert systems, Roles of expert systems - Knowledge Acquisition –Meta knowledge, Heuristics. Typical expert systems - MYCIN, DART, XOON, Expert systems shells.

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand and explore the basic concepts and challenges of Artificial Intelligence.
CO2:	Analyze and explain basic intelligent system algorithms to solve problems.
CO3:	Apply Artificial Intelligence and various logic-based techniques in real world problems.
CO4:	Assess their applicability by comparing different Intelligent System techniques

	Reference Books
1	AI – A Modern Approach ,Stuart Russel, Peter Norvig , 2nd Edition, Pearson Education, 2010, ISBN-13: 978-0137903955.
2	Artificial Intelligence (SIE) ,Kevin Night, Elaine Rich, Nair B., ,McGraw Hill, 1st Edition, 2008, ISBN: 9780070087705
3	Introduction to AI and ES ,Dan W. Patterson, Pearson Education, 1st Edition ,2007. ISBN: 0132097680
4	Introduction to Expert Systems ,Peter Jackson, 3rd Edition, Pearson Education, 2007, ISBN-978-0201876864

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 60 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project 10. **Total CIE is 30(Q) +60(T) +10(A) =100 Marks.**

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	3	2	2	1	2	-	2	2
CO2	3	3	3	3	3	2	2	1	2	-	2	2
CO3	3	3	3	3	3	2	1	1	2	-	2	2
CO4	3	3	3	3	3	1	2	1	1	1	2	2

High-3: Medium-2 : Low-1

Semester: VII					
IMAGE PROCESSING AND MACHINE LEARNING					
(Group H: Global Elective)					
Course Code	:	16G7H05		**CIE**	:	100 Marks
Credits: L:T:P:S	:	3:0:0:0		**SEE**	:	100 Marks
Total Hours	:	40L		**SEE Duration**	:	03 Hours
Course Learning Objectives: The students will be able to					
1	Understand the major concepts and techniques in image processing and Machine Learning				
2	To explore, manipulate and analyze image processing techniques				
3	To become familiar with regression methods, classification methods, clustering methods.				
4	Demonstrate image processing and Machine Learning knowledge by designing and implementing algorithms to solve practical problems				

Unit-I	**08 Hrs**
Introduction to image processing: Images, Pixels, Image resolution, PPI and DPI, Bitmap images, Lossless and lossy compression, Image file formats, Color spaces, Bezier curve, Ellipsoid, Gamma correction, Advanced image concepts	
Unit – II	**08 Hrs**
Basics of Python & Scikit image: Basics of python, variables & data types, data structures, control flow & conditional statements, uploading & viewing an image, Image resolution, gamma correction, determining structural similarities.	
Unit –III	**08 Hrs**
Advanced Image processing using Open CV Blending Two Images, Changing Contrast and Brightness Adding Text to Images Smoothing Images , Median Filter ,Gaussian Filter ,Bilateral Filter ,Changing the Shape of Images ,Effecting Image Thresholding ,Calculating Gradients , Performing Histogram Equalization	
Unit –IV	**08 Hrs**
Machine Learning Techniques in Image Processing Bayesian Classification, Maximum Likelihood Methods, Neural Networks; Non-parametric models; Manifold estimation, Support Vector Machines, Logistic Regression	
Unit –V	**08 Hrs**
Introduction to object Tracking , Modeling & Recognition Exhaustive vs. Stochastic Search, Shapes, Contours, and Appearance Models. Mean-shift tracking; Contour-based models, Adaboost approaches: Face Detection / Recognition, Tracking.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Gain knowledge about basic concepts of Image Processing
CO2:	Identify machine learning techniques suitable for a given problem
CO3:	Write programs for specific applications in image processing
CO4:	Apply different techniques for various applications using machine learning techniques.

Reference Books	
1	Practical Machine Learning and Image Processing: For Facial Recognition, Object Detection, and Pattern Recognition Using Python, by Himanshu Singh, Apress publisher.
2	Pattern Recognition and Machine Learning, by Christopher Bishop, Springer, 2008
3	Computer Vision: A modern Approach by David Forsyth and Jean Ponce, Prentice Hall India 2004.
4	Machine Vision : Theory Algorithms Practicalities ,by E.R. Davies Elsevier 2005.
5	Digital Image Processing, Rafael C. Gonzalez and Richard E. Woods Pearson Education, Ed, 2001.

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project 10. **Total CIE is 30(Q) +60(T) +10(A) =100 Marks.**

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

SEMESTER: VII						
DESIGN OF RENEWABLE ENERGY SYSTEMS **(Group H: Global Elective)**						
Course Code	:	16G7H06		**CIE Marks**	:	**100**
Credits: L:T:P:S	:	3:0:0:0		**SEE Marks**	:	**100**
Total Hours	:	**40L**		**SEE Duration**	:	**3.00 Hours**

Course Learning Objectives:

1	To provide opportunity for students to work on multidisciplinary projects.
2	To familiarize the students with the basic concepts of nonconventional energy sources and allied technological systems for energy conversion
3	To impart skill to formulate, solve and analyze basic Non – conventional energy problems and prepare them for graduate studies.
4	To enable the student to design primarily solar and wind power systems.
5	To expose the students to various applications of solar, wind and tidal systems.

UNIT – I	**07 Hrs**

An introduction to energy sources:
Industry overview, incentives for renewable, utility perspective, Relevant problems discussion, current positions of renewable energy conditions

UNIT – II	**09 Hrs**

PV Technology:
photovoltaic power, PV projects, Building-integrated PV system, PV cell technologies, solar energy maps, Technology trends, **Photovoltaic Power Systems**: PV cell, Module and Array, Equivalent electrical circuit, open-circuit voltage and short-circuit current, I-V and P-V curves, Array design (different methodologies), peak-power operation, system components.

UNIT – III	**09 Hrs**

Wind Speed and Energy:
Speed and power relations, power extracted from the wind, Air density, Global wind patterns, wind speed distribution (parameters calculations) , wind speed prediction, **Wind Power Systems :** system components , turbine rating , power vs. speed and TSR, maximum energy capture, maximum power operation, system-design trade-offs , system control requirements, environmental aspects.

UNIT – IV	**07 Hrs**

Geothermal and ocean energy:
Geothermal power, geo pressured sources, Geothermal well drilling, advantages and disadvantages, Comparison of flashed steam and total flow concept
Energy from ocean: OTEC power generation, OPEN and CLOSED cycle OTEC. Estimate of Energy and power in simple single basin tidal and double basin tidal system

UNIT – V	**08 Hrs**

Stand-alone system:
PV stand-alone, Electric vehicle, wind standalone, hybrid systems (case study), system sizing, wind farm sizing.
Grid-Connected Systems: introduction**,** interface requirements, synchronizing with the grid, operating limit, Energy storage and load scheduling**,** Grid stability issues**,** distributed power generation.

Course outcomes:
CO1: Demonstrate an understanding of the scientific principles of methodology of Non-conventional energy.
CO2: Acquire working knowledge of different Renewable energy science-related topics.
CO3: Ability to analyze the system related concepts effectively in the wind energy designing.
CO4: Students will be able to decide the appropriate procedures to ensure that the working model has developed properly.

Reference Books	
1.	Wind and Solar Power Systems Design, Analysis and operation, Mukund R Patel, 2nd Edition, 2006, Taylor and Francis publishers, ISBN 978-0-8493-1570-1.
2.	Non-Conventional sources of energy, G.D.Rai, 4th Edition, 2009, Khanna Publishers, ISBN 8174090738, 9788174090737,
3.	Solar Energy, Sukhatme, 4th Edition, 2017, McGraw Hill Education, **ISBN-13:** 978-9352607112
4.	Renewable energy sources, John Twidell, Tony Weir, 3rd Edition, 2015, Routledge Publisher, ISBN-13: 978-0415584388.

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project 10.

Total CIE is 30(Q) +60(T) +10(A) =100 Marks.
Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

VII Semester					
SYSTEMS ENGINEERING (Group H: Global Elective)					
Course Code	:	16G7H07	CIE Marks	:	100
Credits: L:T:P:S	:	3:0:0:0	SEE Marks	:	100
Total Hours	:	33L	SEE Duration	:	03 Hours
Course Learning Objectives:					
1	Develop an appreciation and understanding of the role of systems engineering processes and systems management in producing products and services.				
2	Document systematic measurement approaches for generally cross disciplinary development effort.				
3	Discuss capability assessment models to evaluate and improve orgnizational systems engineering capabilities.				

Unit-I	07 Hrs

System Engineering and the World of Modem System: What is System Engineering?, Origins of System Engineering, Examples of Systems Requiring Systems Engineering, System Engineering viewpoint, Systems Engineering as a Profession, The power of Systems Engineering, problems.
Structure of Complex Systems: System building blocks and interfaces, Hierarchy of Complex systems, System building blocks, The system environment, Interfaces and Interactions.
The System Development Process: Systems Engineering through the system Life Cycle, Evolutionary Characteristics of the development process, The system engineering method, Testing throughout system development, problems.

Unit – II	07 Hrs

Systems Engineering Management: Managing systems development and risks, Work breakdown structure (WBS), System Engineering Management Plan (SEMP), Risk Management, Organization of Systems Engineering, Systems Engineering Capability Maturity Assessment, Systems Engineering standards, Problem.
Needs Analysis: Originating a new system, Operations analysis, Functional analysis, Feasibility analysis, Feasibility definition, Needs validation, System operational requirements, problems.
Concept Exploration: Developing the system requirements, Operational requirements analysis, Performance requirements formulation, Implementation concept exploration, Performance requirements validation, problems.

Unit – III	07 Hrs

Concept Definition: Selecting the system concept, Performance requirements analysis, Functional analysis and formulation, Concept selection, Concept validation, System Development planning, System Functional Specifications, problems
Advanced Development: Reducing program risks, Requirements analysis, Functional Analysis and Design, Prototype development, Development testing, Risk reduction, problems.

Unit – IV	06 Hrs

Engineering Design: Implementing the System Building blocks, requirements analysis, Functional analysis and design, Component design, Design validation, Configuration Management, problems.
Integration and Evaluation: Integrating, Testing and evaluating the total system, Test planning and preparation, System integration, Developmental system testing, Operational test and evaluation, problems.

Unit – V	06 Hrs

Production: Systems Engineering in the factory, Engineering for production, Transition from development to production, Production operations, Acquiring a production knowledge base, problems.
Operations and support: Installing, maintenance and upgrading the system, Installation and test, In-service support, Major system upgrades: Modernization, Operational factors in system development, problems.

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the Life Cycle of Systems.
CO2	Explain the role of Stake holders and their needs in organizational systems.
CO3	Develop and Document the knowledge base for effective systems engineering processes.
CO4	Apply available tools, methods and technologies to support complex high technology systems.
CO5	Create the frameworks for quality processes to ensure high reliability of systems.

Reference Books	
1	Systems Engineering – Principles and Practice, Alexander Kossoakoff, William N Sweet, 2012, John Wiley & Sons, Inc, ISBN: 978-81-265-2453-2
2	Systems Engineering and Analysis, Blanchard, B., and Fabrycky W, 5th Edition, 2010, Saddle River, NJ, USA: Prentice Hall.
3	Handbook of Human Systems Integration, Booher, H. (ed.) 2003. Hoboken, NJ, USA: Wiley.
4	Systems Engineering: A 21st Century Methodology, Hitchins, D., 2007. Chichester, England: Wiley.

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Semester: VII						
MEMS AND APPLICATIONS						
(Group H: Global Elective)						
Course Code	:	16G7H08		**CIE**	:	100 Marks
Credits: L:T:P:S	:	3:0:0:0		**SEE**	:	100 Marks
Total Hours	:	35L		**SEE Duration**	:	3.00 Hours
Course Learning Objectives: The students will be able to						
1	Understand the rudiments of Micro fabrication techniques.					
2	Identify and associate the various sensors and actuators to applications.					
3	Analyze different materials used for MEMS.					
4	Design applications of MEMS to disciplines.					

Unit - I	**06 Hrs**
Overview of MEMS & Microsystems: MEMS and Microsystems, Typical MEMS and micro system products, Evolution of micro fabrication, Microsystems and microelectronics, Multidisciplinary nature of Microsystems, Design and manufacture, Applications of Microsystems in automotive, healthcare, aerospace and other industries. **Working Principle of Microsystems**: Biomedical and biosensors. Micro sensors: Acoustic, Chemical, Optical, Pressure, Thermal.	

Unit – II	**08 Hrs**
Micro actuation: Using thermal forces, shape memory alloys, Piezoelectric crystals and electrostatic forces. MEMS with micro actuators: Microgrippers, micromotors, microvalves and micropumps, micro accelerometers, microfluidics**.** **Introduction to Scaling:** Scaling in Geometry, Scaling in Rigid body dynamics, Scaling in Electrostatic forces, scaling in electromagnetic forces and scaling in fluid mechanics.	

Unit – III	**08 Hrs**
Materials for MEMS and Microsystems: Substrates and wafers, Active substrate materials, Silicon as substrate material, Silicon Compounds, Si-Piezo resistors, GaAs, Quartz, Piezoelectric Crystals, Polymers and packaging materials. Three level of Microsystem packaging, Die level packaging, Device level packaging, System level packaging. Interfaces in microsystem packaging. Essential packaging technologies: die preparation, Surface bonding, Wire bonding, Sealing, 3D packaging.	

Unit – IV	**06 Hrs**
Microsystem Fabrication Process: Introduction to microsystems, Photolithography, Ion Implantation, Diffusion, Oxidation, CVD,PVD-Sputtering, Deposition of Epiaxy, Etching, LIGA process: General description, Materials for substrates and photoresists, Electroplating and SLIGA process.	

Unit – V	**07 Hrs**
Tactile and Flow sensors – Piezoelectric sensors and actuators – piezoelectric effects – piezoelectric materials – Applications to Inertia, Acoustic, Tactile and Flow sensors. **Overview, Application, Fabrication Process in Applications:** Silicon Capacitive Accelerometer, Piezo resistive Pressure sensor, Electrostatic Comb drive, Portable blood analyzer, Piezo electric Inkjet Print head, Micromirror array for Video projection.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the operation of micro devices, micro systems and their applications.
CO2:	Apply the principle of material science to sensor design.
CO3:	Analyze the materials used for sensor designs.
CO4:	Conceptualize and design micro devices, micro systems.

	Reference Books
1	MEMS & Microsystems Design and Manufacture, Tai-Ran Hsu, 2nd Edition, 2002, Tata McGraw Hill Education, New Delhi, ISBN-13:978-0-07-048709-3.
2	Foundations of MEMS, Chang Liu, 2012, Pearson Education Inc., ISBN-13:978-0-13-249736-7.
3	Smart Material Systems and MEMS, Vijay K Varadan, K. J. Vinoy, S. Gopalakrishnan, 2006, Wiley-INDIA, ISBN-978-81-265-3170-7.
4	Micro and Smart Systems, G.K. Ananthasuresh, K.J .Vinoy, K.N. Bhat, V.K. Aatre, 2015, Wiley Publications, ISBN-:978-81-265-2715-1.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The marks component for Assignment is 10. **Total CIE is 30(Q) + 60(T) + 10(A) =100.**

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Semester: VII					
INTRODUCTION TO INTERNET OF THINGS					
(Group H: Global Elective)					
Course Code	:	16G7H09	**CIE**	:	100 Marks
Credits: L:T:P:S	:	3:0:0:0	**SEE**	:	100 Marks
Total Hours	:	39L	**SEE Duration**	:	3.00 Hours

Course Learning Objectives: The students will be able to	
1	Learn the fundamentals of IoT
2	Understands the hardware, networks & protocols used in IoT development
3	Illustrate smart applications using IoT devices and building applications
4	Know more advanced concepts like cloud connectivity in IoT
5	Learn the fundamentals of IoT

Unit-I	**06 Hrs**
Fundamentals Of IOT: Introduction, Physical design of IoT, Logical design of IoT, IoT Enabling technologies, IoT Levels and Deployment Templates, , IoTvs M2M	
Unit – II	**06 Hrs**
IOT Design Methodology: Need for IoT systems management, IoT Design Methodology **Internet of Things Strategic Research and Innovation Agenda:** Internet of Things Vision, IoT Strategic Research and Innovation Directions, IoT Smart-X Applications, Internet of Things and Related Future Internet Technologies.	
Unit –III	**11 Hrs**
IOT Systems - Logical Design using Python: Provides an introduction to Python, installing Python, Python data types & data structures, control flow, functions, modules, packages, file input/output, data/time operations and classes.	
Unit –IV	**09 Hrs**
IOT Physical Devices & Endpoints: What is an IoT device, Raspberry Pi device, About the board, Linux on Raspberry Pi, Raspberry Pi interfaces, Programming Raspberry Pi with Python.	
Unit –V	**07 Hrs**
IOT Physical Servers & Cloud Offerings: Provides an introduction to the use of cloud platforms and frameworks such as Xively and AWS for developing IoT applications.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the fundamentals of IoT.
CO2:	Analyse the IoT devices, programming, networking requirements and protocols for building IoT products.
CO3:	Apply the concepts to design and develop IoT applications
CO4:	Creating applications of IoT using physical devices and interfacing with cloud.

Reference Books	
1	Internet of Things (A Hands-on-Approach), Vijay Madisetti and ArshdeepBahga, 1st Edition, VPT, 2014, ISBN-13: 978-0996025515.
2	Internet of Things – From Research and Innovation to Market Deployment, OvidiuVermesan, Peter Friess, River Publishers Series in Communication, River Publishers, 2014, ISBN: ISBN: 978-87-93102-94-1 (Hard copy), 978-87-93102-95-8 (Ebook) (UnitsII 2nd part)
3	Rethinking the Internet of Things: A Scalable Approach to Connecting Everything, Francis daCosta, , 1st Edition, Apress Publications, 2013, ISBN-13: 978-1430257400.
4	Meta products - Building the Internet of Things, WimerHazenberg, Menno Huisman, BIS Publishers, 2012, ISBN: 9789863692515.

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project 10. **Total CIE is 30(Q) +60(T) +10(A) =100 Marks.**

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Semester: VII					
INDUSTRY 4.0– SMART MANUFACTURING FOR THE FUTURE **(Group H: Global Elective)**					
Course Code	:	16G7H10	**CIE**	:	**100 Marks**
Credits: L:T:P:S	:	3:0:0:0	**SEE**	:	**100 Marks**
Total Hours	:	39L	**SEE Duration**	:	**3.00 Hours**
Course Learning Objectives: The students will be able to					
1	Understand the importance and role of Smart Manufacturing Systems, IoT and IIoT				
2	Explain importance of automation technologies, sensors, Robotics and Machine vision.				
3	Understand application of artificial intelligence and the need for data transformation, handling, storing and security.				
4	Understand simulation, predictive and knowledge modeling along with analysis				
5	Learn networking, sustainable technology and factory networks.				

Unit-I	**06 Hrs**
Smart Manufacturing and Industry 4.0 Need for Smart Manufacturing, Advantages, Emerging technologies in Smart manufacturing, CAD Architecture surrounding 3D Models (B-rep and CSG), MEMS, Industry 4.0–Interoperability, Information transparency, Technical assistance, Decentralized decision-making, Internet of Things(IoT), Industry Internet of Things (IIoT), Future of Manufacturing industries	
Unit – II	**09 Hrs**
Manufacturing Automation Technology intensive manufacturing and cyber-physical systems, Automation using Robotics, Data storage, retrieval, manipulation and presentation; Mechanisms for sensing state and modifying processes, Material handling systems, controlling material movement and machine flow, Mechatronics, Transducers and sensors, Proximity sensors, Biosensors, Acceleration Machine Vision–Flaw detection, Positioning, Identification, Verification and Measurement–Application of Machine Vision in industries	
Unit –III	**09 Hrs**
Data handling using Embedded Systems Data transformation–Mathematical functions, Regression, Need for different functions, Data merging–Discrete and Random variables, Transformation languages, Interfacing systems-Microprocessors, Direct memory access, Data transfer schemes and systems, Communication systems–Modulation, Time domain and frequency domain, Industrial Network Data Communications, Data Security Artificial Intelligence – Intelligent systems, Fuzzy logics, Neural networks –Supervised, Unsupervised and Reinforced learning	
Unit –IV	**06 Hrs**
Simulation, Modeling and Analysis Simulation - system entities, input variables, performance measures, and Functional relationships, types of simulation. Predictive modeling and simulation tools, Knowledge Modeling –types and technology options, Functional analysis of control systems – Linear and Non-linear, Functional decomposition, Functional sequencing, Information / dataflow, Interface	
Unit –V	**09 Hrs**
Performance Measures of Smart Manufacturing Systems- Smart manufacturing- Sensing and Perception, Manipulation, Mobility and Autonomy, Factory Networks, Information Modeling and Testing, Performance Measurement and Optimization, Engineering System integration, Production Network integration, Production network data quality, Sustainable Processes and Resources, Integration Infrastructure for Sustainable Manufacturing	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Explain role and importance of Smart Manufacturing Systems, IoT and IIoT
CO2:	Explain importance of automation technologies, sensors, robotics and machine vision
CO3:	Illustrate the application of artificial intelligence and need for data transformation, handling
CO4:	Explain analytical and simulation for performance study of smart technologies and networks

Reference Books	
1	Smart Manufacturing Innovation and Transformation: Interconnection And Intelligence Zongwei Luo, 1st Edition, IGI Global Publications, 2014,ISBN-13: 978-1466658363 ISBN-10: 1466658363
2	Simon Frechette, Yan Lu. KC Morris, Smart Manufacturing Standards, NIST, 1st Edition, 2016, Project report.

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project 10. **Total CIE is 30(Q) +60(T) +10(A) =100 Marks.**

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Semester: VII					
SPACE TECHNOLOGY AND APPLICATIONS **(Group H: Global Elective)**					
Course Code	:	16G7H11	**CIE**	:	100 Marks
Credits: L:T:P:S	:	3:0:0:0	**SEE**	:	100 Marks
Hrs/Week	:	35L	**SEE Duration**	:	3.00 Hours
Course Learning Objectives: The students will be able to					
1	Define the earth environment and its behavior, launching vehicles for satellites and its associated concepts.				
2	Analyze satellites in terms of technology, structure and communications.				
3	Use satellites for space applications, remote sensing and metrology.				
4	Apply the space technology, technology mission and advanced space systems to nation's growth.				

UNIT-I	07 Hrs
Earth's environment: Atmosphere, ionosphere, Magnetosphere, Van Allen Radiation belts, Interplanetary medium, Solar wind, Solar- Earth Weather Relations. **Launch Vehicles:** Rocketry, Propellants, Propulsion, Combustion, Solid, Liquid and Cryogenic engines, Control and Guidance system, Ion propulsion and Nuclear Propulsion.	

UNIT-II	07 Hrs
Satellite Technology: Structural, Mechanical, Thermal, Power control, Telemetry, Telecomm and Quality and Reliability, Payloads, Space simulation. **Satellite structure:** Satellite Communications, Transponders, Satellite antennas.	

UNIT-III	07 Hrs
Satellite Communications: LEO, MEO and GEO orbits, Altitude and orbit controls, Multiple Access Techniques. **Space applications:** Telephony, V-SAT, DBS system, Satellite Radio and TV, Tele-Education, Tele-medicine, Satellite navigation, GPS.	

UNIT-IV	07 Hrs
Remote Sensing: Visual bands, Agricultural, Crop vegetation, Forestry, water Resources, Land use, Land mapping, geology, Urban development resource Management, and image processing techniques. **Metrology:** Weather forecast (Long term and Short term), weather modelling, Cyclone predictions, Disaster and flood warning, rainfall predictions using satellites.	

UNIT-V	07Hrs
Satellite payloads: Technology missions, deep space planetary missions, Lunar missions, zero gravity experiments, space biology and International space Missions. **Advanced space systems:** Remote sensing cameras, planetary payloads, space shuttle, space station, Inter-space communication systems.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain different types of satellites, orbit and associated subsystems.
CO2	Apply the basics of launching vehicles, satellites and sub systems for space applications.
CO3	Analyze the applications of satellite in the area of communication, remote sensing, metrology etc.,
CO4	Study technology trends, satellite missions and advanced space systems.

	Reference Books
1	Atmosphere, weather and climate, R G Barry, Routledge publications, 2009, ISBN- 10 :0415465702.
2	Fundamentals of Satellite Communication, K N Raja Rao, PHI, 2012, ISBN:9788120324015.
3	Satellite Communication, Timothy pratt, John Wiley, 1986 ISBN: 978-0- 471- 37007 -9, ISBN 10: 047137007X.
4	Remote sensing and applications, B C Panda, VIVA books Pvt. Ltd., 2009, ISBN: 108176496308.

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Semester: VII					
ADVANCED LINEAR ALGEBRA					
(Group H: Global Elective)					
Course Code	:	16G7H12		**CIE**	:	100 Marks
Credits: L:T:P:S	:	3:0:0:0		**SEE**	:	100 Marks
Total Hours	:	39L		**SEE Duration**	:	3.00 Hours

Course Learning Objectives: The students will be able to

1	Adequate exposure to learn the fundamental concepts to model a system of linear equations and to obtain the solution of system of linear equations.
2	Analyze and extend the structure of vector spaces, linear transformations, Symmetric matrices, quadratic forms required in applications of Business, Science and Engineering.
3	Apply the concept of Eigenvalues to study differential equations and dynamical systems. Apply the concept of Orthogonality to examine some of the least-squares problems.
4	Apply Linear Programming to Network problems and Game theory.

Unit-I	07 Hrs
System of linear equations	
Matrices and system of linear equations, Geometry of linear equations, Linear models in Business, Science and Engineering-Input-Output model in Economics, Balancing chemical equations and Electrical networks.	
Unit – II	**09 Hrs**
Vector spaces and linear transformations	
Revision of Vector Spaces, Subspaces, Linear independence, Basis, Dimension and Change of basis. Applications to Difference equations, Markov chains. Intersection, Sum, Product of spaces and Tensor product of two vector spaces. Introduction to Linear transformations, Geometrical interpretations in 2-dimensions and 3-dimensions.	
Unit –III	**09 Hrs**
Orthogonality, Eigen values and Eigen vectors	
Orthogonality, Inner product spaces, Applications to Weighted least-squares and Fourier series, Fast Fourier transform. Eigen values and Eigen vectors, Applications to Differential equations, Discrete dynamical systems.	
Unit –IV	**07 Hrs**
Symmetric matrices and quadratic forms	
Introduction to symmetric matrices, Quadratic forms, Test for Positive definiteness, Constrained Optimization, Singular Value Decomposition. Applications to image processing.	
Unit –V	**07 Hrs**
Linear programming and game theory	
A Geometrical introduction to Linear programming, Simplex method and its geometrical meaning, Network models-Max flow-min cut theorem, Payoff matrix and Matrix games.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Identify and interpret the fundamental concepts of linear equations, vector spaces, linear transformations, Orthogonality, Eigen values, symmetric matrices, quadratic forms, linear programming and game theory.
CO2:	Apply the knowledge and skills of Linear algebra to solve linear equations, difference and differential equations, constrained optimization problems, linear programming problems and related problems.
CO3:	Analyze the input-output models, Markov chains, discrete dynamical systems, singular value decomposition, network models and related problems.
CO4:	Using the overall mathematical knowledge of Linear Algebra to solve problems arising in practical situations.

	Reference Books
1	Linear Algebra and Its Applications, David C Lay, Pearson Education; III Edition; 2003; ISBN: 978-81-775-8333-5.
2	Linear Algebra with Applications, Gareth Williams; 6th edition; 2008; Narosa publications; ISBN: 978-81-7319-981-3.
3	Linear Algebra and Its Applications; Gilbert Strang; IV Edition; Cengage Learning India Edition; 2006; ISBN: 81-315-0172-8.
4	Elementary Linear Algebra Applications, Version Howard Anton and Chris Rorres; Wiley Global Education; 11th Edition; 2013; ISBN: 9781118879160.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 60 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	1	-	-	-	-	-	-	-	2
CO2	3	2	1	-	-	-	-	-	-	-	-	2
CO3	2	3	2	2	-	-	-	-	-	-	-	1
CO4	3	3	1	2	1	-	-	-	-	-	-	3

High-3: Medium-2 : Low-1

Semester: VII					
THIN FILM NANOTECHNOLOGY					
(Group H: Global Elective)					
Course Code	:	16G7H13	**CIE**	:	100 Marks
Credits: L:T:P:S	:	3:0:0:0	**SEE**	:	100 Marks
Total Hours	:	39L	**SEE Duration**	:	3.00 Hours
Course Learning Objectives: The students will be able to					
1	Understand the importance of vacuum in thin film fabrication				
2	Acquire the knowledge of thin film preparation by various techniques				
3	Analyze the properties of thin films using different characterization methods				
4	Optimize the process parameter and property dependence				
5	Apply the knowledge for developing thin film devices.				

Unit-I	**08 Hrs**

Vacuum Technology: Basics of Vacuum - Principles of different vacuum pumps: Rotary, Roots, Diffusion, Turbo molecular and Cryogenic pumps; Measurement of vacuum - Concept of Capacitance Manometer, Pirani and Penning gauges - Vacuum Systems & Applications.

Unit – II	**08 Hrs**

Methods of thin film preparation
Physical Vapor Deposition (PVD) Techniques**:**
Evaporation: Thermal evaporation, Electron beam evaporation, Laser ablation, and Cathode arc deposition. *Sputtering*: DC sputtering, RF Sputtering, Magnetron sputtering, Reactive Sputtering, and Ion beam sputtering.
Chemical Vapor Deposition (CVD) Techniques**:** Conventional CVD, Plasma Enhance CVD (PECVD) and Atomic layer deposition (ALD).
Other Methods: Spin coating and Spray Pyrolysis.

Unit –III	**07 Hrs**

Surface Modification and Growth of Thin Films:
Surface preparation & Engineering for Thin film growth: Cleaning, Modification, Masking & Patterning, Base Coats and Top Coats.
Thin Film growth: Sequence of thin film growth, Defects and impurities, Effect of Deposition Parameters on film growth.

Unit –IV	**08 Hrs**

Properties and Characterization of Thin Films
Film thickness (Quartz crystal thickness monitor and Stylus Profiler);
Film Adhesion (Tape, Cross-hatch test, and Humidity methods);
Surface morphology and topography (SEM and AFM);
Film composition (X-ray Photoelectron Spectroscopy);
Film structure (X-ray diffraction and Raman studies);
Electrical characterization (Four Probe and Semiconductor Analyzer); and
Optical characterization (Spectrophotometer).

Unit –V	**08 Hrs**

Thin Film Applications:
  - Electrodes: Deposition of a Metal film, Ex: Aluminum.
  - Transparent conducting oxides (TCO) – Preparation and Optimization of a semiconducting film, Ex: ZnO.
  - Optimization of a dielectric film, Ex: Al_2O_3 or Si_3N_4.
  Thin Film Devices:
    - Thin Film Transistors (TFT),
    - Thin Film Sensors
    - Thin Film Capacitors
    - Thin film Solar Cells,

	• Thin film Solar Absorbers
▪	Diamond-like carbon (DLC) coating
▪	EMI Shielding coatings
▪	Hard coatings
▪	Coatings on Plastics/Polymers.

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the importance of vacuum technology for thin film growth
CO2	Prepare various kinds of thin films using different deposition techniques
CO3	Characterize the deposited films for various properties
CO4	Fabricate thin film based devices.

Reference Books	
1.	Vacuum Technology by A. Roth, Elsevier, 3rd Edition, 1976, ISBN: 9780444880109, 9780444598745,
2.	Thin Film Phenomenon by K.L. Chopra, McGraw-Hill, 1st Edition, 1969, ISBN: 0070107998, 978-0070107991
3.	Materials Science of Thin Films by Milton Ohring, Elsevier, 2rdEdition, 2001, **ISBN:** 9780125249751
4.	Thin-Film Deposition: Principles and Practice by Donald Smith, McGraw-Hill, 1st Edition, 1995, ISBN: 0070585024, 9780070585027

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 60 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project 10. **Total CIE is 30(Q) +60(T) +10(A) =100 Marks.**

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping											
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1			1									2
CO2			2									2
CO3					2							2
CO4			2	2	2		2		2	2		2

High-3; Medium-2; Low-1

Semester: VII				
ENGINEERING MATERIALS FOR ADVANCED TECHNOLOGY **(Group H: Global Elective)**				
Course Code:	:	16G7H14	**CIE**	:	100 **Marks**
Credits: L:T:P:S	:	3:0:0:0	**SEE**	:	100 **Marks**
Total Hours	:	39L	**SEE Duration**	:	3.00 **Hours**

Course Learning Objectives: The students will be able to	
1	Aapply the basic concepts of Chemistry to develop futuristic materials for high-tech applications in the area of Engineering.
2	Impart sound knowledge in the different fields of material chemistry so as to apply it to the problems in engineering field.
3	Develop analytical capabilities of students so that they can characterize, transform and use materials in engineering and apply knowledge gained in solving related engineering problems.

UNIT-I	**08 Hrs**

Coating and packaging materials
Surface Coating materials:
Synthesis and applications of Polymer coating materials: Teflon, Silicone films Polyvinyl chloride & its copolymers, Poly vinyl acetate, Poly ethylene-HDPE, LDPE, Polyurethane.
Properties required in a pigment and extenders.
Inorganic pigments-titanium dioxide, zinc oxide, carbon black, chromate pigments, chrome green, ultramarine blue, iron blue, cadmium red.
Corrosion inhibiting pigments- zinc phosphate, zinc and barium chromate pigments, ceramic pigments, metal flake pigments, extenders.
Developments in new polymers such as dendrimers, biopoplymers & biodegradable polymers.
Packaging materials:
Food products: Cellulosic and Polymeric packaging materials and their properties – including barrier properties, strength properties, optical properties. Glass, aluminium, tin, paper, plastics, composites.
Pharmaceutical products: Injectibles and tablet packaging materials.

UNIT-II	**07 Hrs**

Adhesives
Introduction-Classification of Adhesives-Natural adhesives, synthetic adhesives-drying adhesives, pressure sensitive adhesives, contact adhesives, hot adhesives. One part adhesives, multi part adhesives. Adhesive Action. Development of Adhesive strength- Physical factors influencing Adhesive Action-surface tension, surface smoothness, thickness of adhesive film, elasticity and tensile strength. Chemical Factors Influencing Adhesive action - presence of polar groups, degree of polymerization, complexity of the adhesive molecules, effect of pH. Adhesive action- specific adhesive action, mechanical adhesive action, fusion adhesion. Development of adhesive strength- adsorption theory and diffusion theory. Preparation, curing and bonding Processes by adhesives-with reference to Epoxy, phenolics, Silicone, Polyurethane, Acrylic adhesives, Poly vinyl alcohol, Polyvinyl acetate.

UNIT-III	**08 Hrs**

Optical fibre materials
Fiber Optics, Advantages of optical fiber communication over analog communication, Classification based on refractive index of the core- step index and graded index optical fibres, Classification based on core radius-single mode and multimode optical fibres, Fibre fabrication.-Methods to manufacture optical glass fibres. Double crucible method and preform methods. Manufacture of perform- Chemical Vapour Deposition (CVD), Modified vapour deposition (MCVD) Plasma activated vapour deposition (PCVD), Outside vapour deposition (OVD)-Vapour-phase axial deposition (VAD). Drawing the fibres from perform, coating and jacketing process.
Ion exchange resins and membranes
Ion exchange resins-Introduction, Types, physical properties, chemical properties-capacity, swelling, kinetics, stability, ion exchange equilibrium, regeneration. Applications of ion exchange resins-softening of water, demineralization of water, advantages and disadvantages of ion exchange resins-calcium sulphate fouling, iron fouling, adsorption of organic matter, bacterial contamination. Ion

exchange membranes, Types, Classification, Fabrication of ion exchange cottons- anion exchange cotton and cation exchange cotton. Application of ion exchange membranes in purification of water by electro dialysis method.

UNIT-IV	08 Hrs

Spectroscopic Characterization of materials:
Electromagnetic radiation, interaction of materials with electromagnetic radiation.

UV- visible spectrophotometry :Introduction-Electronic transitions- factors influencing position and intensity of absorption bands-absorption spectra of dienes, polyene and α,β-unsaturated carbonyl compounds, Working of UV-Vis spectrophotometer, Theoretical calculation of λ_{max} by using Woodward-Fieser rules- for cyclic and α,β-unsaturated carbonyl compounds.

IR Spectroscopy: Introduction, principle, molecular vibrations, vibrational frequency, number of fundamental vibrations, factors influencing fundamental vibrations, instrumentation of IR spectrophotometer, sampling techniques and application of IR spectroscopy in characterization of functional groups.

UNIT-V	08 Hrs

NMR spectroscopy:
H^1 NMR Spectroscopy: Basic concepts- relaxation process. NMR spectrometer-FT NMR-Solvents used in NMR, internal standards-Chemical equivalence -Integrals and Integrations- chemical shift-Factors affecting chemical shifts- shielding and deshielding effects – chemical and magnetic equivalent – magnetic anisotropy-spin-spin splitting rules- Application of NMR on various compounds such as alkanes, alkenes, alkynes, alkyl halides, alcohols, ethers, amines, aldehydes, ketones, carboxylic acids, esters, amides & mono substituted aromatic compounds. Problems on prediction of structure of compounds.

Course Outcomes: After completing the course, the students will be able to	
CO1	Identify sustainable engineering materials and understand their properties.
CO2	Apply the basic concepts of chemistry to develop futuristic materials for high-tech applications in different areas of engineering.
CO3	Analyze and evaluate the specific application of materials.
CO4	Design the route for synthesis of material and its characterization.

Reference Books	
1.	Materials Science, G.K.Narula, K.S.Narula & V.K.Gupta. 38th Edtion, 2015, Tata McGraw-Hill Publishing Company Limited ISBN: 978-0-07-451796-3.
2.	Solar Lighting, Ramachandra Pode and Boucar Diouf, Springer e-book, 2011, ISBN: 978-1-44-712133-6 (Print) 978-1-44-712134-3 (Online),
3.	Spectroscopy of organic compounds, P.S.Kalsi, 6th Edition, 2013, New Age International(P) ltd,publisher, ISBN: 978-1-22-415438-6.
4.	Food Packaging Materials, Mahadeviah M & Gowramma RV, 6th Edition, 1996, Tata McGraw Hill Publishing Company Ltd, ISBN :746-2-23-82 9780-0.

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for Assignment/Presentation/Project 10.

Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Semester: VII (Global elective)					
APPLIED PSYCHOLOGY FOR ENGINEERS **(Group H: Global Elective)**					
Course Code	:	16G7H15	**CIE**	:	100
Credits: L:T:P:S	:	3:0:0:0	**SEE**	:	100
Total Hours	:	35	**SEE Duration**	:	3 Hours

Course Learning Objectives: The students will be able to

1	To appreciate human behavior and human mind in the context of learner's immediate society and environment.
2	To understand the importance of lifelong learning and personal flexibility to sustain personal and Professional development as the nature of work evolves.
3	To provide students with knowledge and skills for building firm foundation for the suitable engineering professions.
4	To prepare students to function as effective Engineering Psychologists in an Industrial, Governmental or consulting organization.
5	To enable students to use psychological knowledge, skills, and values in occupational pursuits in a variety of settings that meet personal goals and societal needs.

Unit – I	07 Hrs
Introduction to Psychology: Definition and goals of Psychology: Role of a Psychologist in the Society: Today's Perspectives (Branches of psychology). Psychodynamic, Behavioristic, Cognitive, Humanistic, Psychological Research and Methods to study Human Behavior: Experimental, Observation, Questionnaire and Clinical Method.	

Unit - II	07 Hrs
Intelligence and Aptitude: Concept and definition of Intelligence and Aptitude, Nature of Intelligence. Theories of Intelligence – Spearman, Thurston, Guilford Vernon. Characteristics of Intelligence tests, Types of tests. Measurement of Intelligence and Aptitude, Concept of IQ, Measurement of Multiple Intelligence – Fluid and Crystallized Intelligence.	

Unit – III	07 Hrs
Personality: Concept and definition of personality, Approaches of personality- psychoanalytical, Socio-Cultural, Interpersonal and developmental, Humanistic, Behaviorist, Trait and type approaches. Assessment of Personality: Self- report measures of Personality, Questionnaires, Rating Scales and Projective techniques, its Characteristics, advantages & limitations, examples. Behavioral Assessment. Psychological Stress: a. Stress- Definition, Symptoms of Stress, Extreme products of stress v s Burnout, Work Place Trauma. Causes of Stress – Job related causes of stress. Sources of Frustration, Stress and Job Performance, Stress Vulnerability-Stress threshold, perceived control.	

Unit – IV	07 Hrs
Application of Psychology in Working Environment: The present scenario of information technology, the role of psychologist in the organization, Selection and Training of Psychology Professionals to work in the field of Information Technology. Distance learning, Psychological consequences of recent developments in Information Technology. Type A and Type B Psychological Counseling - Need for Counseling, Types – Directed, Non- Directed, Participative Counseling.	

Unit – V	07 Hrs
Learning: Definition, Conditioning – Classical Conditioning, Basics of Classical Conditioning (Pavlov), the process of Extinction, Discrimination and Generalization. Operant Conditioning (Skinner expt). The basics of operant conditioning, Schedules of reinforcement. Cognitive – Social approaches to learning – Latent Learning, Observational Learning, Trial and Error Method, Insightful Learning.	

Experimental Psychology (Practicals)- Self Study 2 Hrs /Week	
1.Bhatia's Battery of Performance and intelligence test	
2.Multidimensional Assessment of Personality	
3.David's Battery of Differential Abilities (Aptitude test)	

4.Bilateral Transfer of Training Mirror drawing apparatus with Electronic Digital Reset Error Counter (Performance)
5. Student Stress Scale.

Course Outcomes: After completing the course, the students will be able to	
CO1	Describe the basic theories, principles, and concepts of applied psychology as they relate to behaviors and mental processes.
CO2	Define learning and compare and contrast the factors that cognitive, behavioral, and Humanistic theorists believe influence the learning process.
CO3	Develop understanding of psychological attributes such as intelligence, aptitude, creativity, resulting in their enhancement and apply effective strategies for self-management and self-improvement.
CO4	Apply the theories into their own and others' lives in order to better understand their personalities and experiences.

Reference Books	
1.	Understanding Psychology Feldman R. S, IV edition, (1996) McGraw Hill India
2.	Psychology Robert A. Baron, III edition (1995) Prentice Hall India
3.	Organizational Behaviour , Stephen P Robbins Pearson Education Publications, 13th Edition, ISBN – 81-317 – 1132 – 3
4.	Organisational Behaviour : Human Behaviour at Work ,John W.Newstrem and Keith Davis. Tata McGraw Hill India, 10th Edition, ISBN 0-07-046504-5

Continuous Internal Evaluation (CIE); Theory (100 Marks)
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Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

VII Semester					
FOUNDATIONAL COURSE ON ENTREPRENEURSHIP					
(Group H: Global Elective)					
Course Code	:	16G7H16		**CIE Marks**	:	100
Credits: L:T:P:S	:	3:0:0:0		**SEE Marks**	:	100
Total Hours	:	36L		**SEE Duration**	:	03 Hours

Course Learning Objectives:

1	To make participants self-discover their innate flow, entrepreneurial style, and identify problems worth solving thereby becoming entrepreneurs
2	To handhold participants on lean methodology to craft value proposition and get ready with lean canvas
3	To create solution demo by conducting customer interviews and finding problem-solution fit for building Minimum Viable Product (MVP)
4	To make participants understand cost structure, pricing, revenue types and importance of adopting shared leadership to build good team
5	To help participants build a strong brand and identify various sales channels for their products and services
6	To take participants through basics of business regulations and other legal terms along-with understanding of Intellectual Property Rights

Unit-I	**07 Hrs**
Self-Discovery and Opportunity Discovery	
Finding the Flow; Effectuation; Identifying the Effectuation principles used in activities; Identifying Problem Worth Solving; Design Thinking; Brainstorming; Presenting the Identified problems; Identifying the Entrepreneurial Style.	

Unit – II	**07 Hrs**
Customer, Solution and Lean Methodology	
Customers and Markets; Segmentation and Targeting; Identifying Jobs, Pains, and Gains and Early Adopters; Crafting Value Proposition Canvas (VPC); Presenting VPC; Basics of Business Model and Lean Approach; Sketching the Lean Canvas; Risks and Assumptions; Presenting Lean Canvas.	

Unit – III	**07 Hrs**
Problem-Solution Fit and Building MVP	
Blue Ocean Strategy - Plotting the Strategy Canvas; Four Action Framework: Eliminate-Reduce-Raise-Create Grid of Blue Ocean Strategy; Building Solution Demo and Conducting Solution Interviews; Problem-Solution Fit; Building MVP; Product-Market Fit; Presenting MVP.	

Unit – IV	**06 Hrs**
Financial Planning & Team Building	
Cost Structure - Estimating Costs; Revenues and Pricing: Revenue Streams, Revenue Types, Identifying Secondary Revenue Streams, Estimating Revenue and Price; Profitability Checks; Bootstrapping and Initial Financing; Practising Pitch; Shared Leadership; Hiring and Fitment, Team Role and Responsibilities.	

Unit – V	**09 Hrs**
Marketing, Sales, Regulations and Intellectual Property	
Positioning and Branding; Channels; Sales Planning; Project Management; Basics of Business Regulations; How to Get Help to Get Started; Patents, Trademark, Licensing, Contracts; Common Legal mistakes, Types of Permits, Tax Registration Documents, Compliance; Infringement and Remedies, Ownership and Transfer.	

Course Outcomes: After completing the course, the students will be able to	
CO1	showcase the ability to discern distinct entrepreneurial traits
CO2	Know the parameters to assess opportunities and constraints for new business ideas
CO3	Understand the systematic process to select and screen a business idea
CO4	design strategies for successful implementation of ideas
CO5	Create Business Model and develop Minimum Viable Product

Reference Books	
1	Running Lean: Iterate from Plan A to a Plan That Works. O'Reilly Media, Maurya, A., 2012.
2	Entrepreneurship. Roy, R., 2012. Oxford University Press
3	Intellectual Property Law in India. Gupta, T. S., 2011. Kluwer Law International
4	Flow: The Psychology of Optimal Experience. Czikszentmihalyi, M., 2008. Harper Perennial Modern Classics
5	Effectuation: Elements of Entrepreneurial Expertise. Sarasvathy, S. D., 2009. Edward Elgar Publishing Ltd.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)- (Needs to be discussed)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Semester: IIV				
UNMANNED AERIAL VEHICLES				
(Group H: Global Elective)				
Course Code	:	16G7H17		**CIE**	:	**100 Marks**
Credits: L:T:P:S	:	3:0:0:0		**SEE**	:	**100 Marks**
Hours	:	36L		**SEE Duration:**	:	**3Hrs**

Course Learning Objectives: The students will be able to

1	Get an overview of the history of UAV systems
2	Understand the importance of aerodynamics, propulsion, structures and avionics in the design of UAV
3	Demonstrate ability to address the various mission payloads - on-board & off-board, propulsion systems, integration with manned systems
4	Assess the performance and airworthiness of the designed UAV

Unit-I	**06 Hrs**

Introduction to Flight Vehicles:
History of Flight Vehicles and UAVs, Classifications, Woking principles of flight vehicle.
Introduction to Unmanned Aircraft Systems
Types of UAVs, configurations and their advantages disadvantages, System Composition, Applications of UAVs, Characteristics of Aircraft

Unit – II	**07 Hrs**

Design of UAV Systems: Governing aspects:
    a.   Aerodynamics, b. Propulsion, C. structure, d. Controls
Aerodynamics:
Introduction basic Aerodynamics, lift, drag, Aerofoils, wing area optimization.
Propulsion:
Introduction to propulsion system in UAV, Propulsion system for fixed wing UAV and VTOL (Vertical take-off and landing) UAV, Advanced propulsion systems, fuel cells, generators based systems.

Unit -III	**07Hrs**

Structures of UAV:
Mechanic loading, basics of types of load calculation and structural engineering, Material used for UAV (general introduction), FRP and methods of usage in UAV, Testing of FRP specimens for UAV, selection criteria for structure, Types of structural elements used in UAV their significance and characteristics, Methods of manufacturing UAV structure.

Unit -IV	**07 Hrs**

Controls, Avionics, Hardware, Communication, Payloads:
Basics of control system and Systems for control system in UAV, PID control, simulation introduction to Hardware in loop system (HILS), Avionics: Autopilot (AP) – architecture of AP, sensors, actuators, power supply, integration, installation, configuration, and testing.

Hardware, Communication
Electronics Hardware in UAV, Communication methods, communication antenna and their significance.

Payloads:
Payload types and their applications

Unit -V	**09 Hrs**

Design of UAV Systems: Fixed wing UAV and Rotary wing UAV (VTOL) Task specific, activity based exercise

Course Outcomes: At the end of this course the student will be able to :	
CO1	Appraise the evolution of UAVs and understand the current potential benefits of UAVs
CO2	Apply the principles of Aerospace Engineering in design and development of UAVs
CO3	Determine and evaluate the performance of UAV designed for various Missions and applications
CO4	Assess the performance and airworthiness of the designed UAV

Reference Books	
1	Unmanned Aircraft Systems UAV design, development and deployment, Reg Austin, 1st Edition, 2010, Wiley, ISBN 9780470058190.
2	Flight Stability and Automatic Control, Robert C. Nelson, 2nd Edition, October 1, 1997, McGraw-Hill, Inc, ISBN 978-0070462731.
3	Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy, Kimon P. Valavanis, 1st Edition,2007, Springer ISBN 9781402061141
4	Introduction to UAV Systems, Paul G Fahlstrom, Thomas J Gleason, 4th Edition, 2012, Wiley, ISBN: 978-1-119-97866-4
5	Design of Unmanned Air Vehicle Systems, Dr. Armand J. Chaput, 3rd Edition, 2001, Lockheed Martin Aeronautics Company, ISBN: 978-1-60086-843-6

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)- (Needs to be discussed)
SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1	1	3	2	2				1
CO2	2	3	3	3	1	1	1	1				2
CO3	1		3	3								2
CO4	3	3	3	3		2	1	2				2

High-3 : Medium-2 : Low-1

Semester: VIII					
MAJOR PROJECT					
(Common to all Programs)					
Course Code	:	16EC81		CIE	:	100 Marks
Credits: L:T:P:S	:	0:0:16:0		SEE	:	100 Marks
Hours / Week	:	32		SEE Duration	:	3.00 Hours
Course Learning Objectives: The students will be able to					
1	Acquire the ability to make links across different areas of knowledge and to generate, develop and evaluate ideas and information so as to apply these skills to the project task.				
2	Acquire the skills to communicate effectively and to present ideas clearly and coherently to a specific audience in both written and oral forms.				
3	Acquire collaborative skills through working in a team to achieve common goals.				
4	Self-learn, reflect on their learning and take appropriate action to improve it.				
5	Prepare schedules and budgets and keep track of the progress and expenditure.				

Major Project Guidelines:
1. The project topic, title and synopsis have to be finalized and submitted to their respective internal guide(s) before the beginning of the 8th semester.
2. The detailed Synopsis *(approved by the department Project Review Committee)* has to be submitted during the 1st week after the commencement of 8th semester.

Batch Formation:
➢ Students are free to choose their project partners from within the program or any other program;
➢ Each student in the team must contribute towards the successful completion of the project. The project may be carried out In-house / Industry / R & D Institution;
➢ *The project work is to be carried out by a team of two to four students , in exceptional cases where a student is placed in a company and offered an internship through the competitive process or student is selected for internship at national or international level through competitive process*, the student can work independently.
➢ *The students are allowed to do either a project for full 5 days in the industry or full 5 days in the college.*
➢ *In case the project work is carried out outside Bengaluru, such students must be available during Project Evaluation process scheduled by the respective departments and they must also interact with their guide regularly through Email / Webinar / Skype etc.*

Project Topic Selection:
The topics of the project work must be in the *field of respective program areas or in line with CoE's (Centre of Excellence) identified by the college* or List of project areas as given by industry/Faculty. The projects as far as possible should have societal relevance with focus on sustainability.

Project Evaluation:
➢ Continuous monitoring of project work will be carried out and cumulative evaluation will be done.
➢ The students are required to meet their internal guides once in a week to report their progress in project work.
➢ **Weekly Activity Report** (WAR) has to be maintained in the form of a diary by the project batch and the same has to be discussed with the Internal Guide regularly.
➢ In case of *Industry project*, during the course of project work, the internal guides will have continuous interaction with external guides and will visit the industry at least twice during the project period.

- For CIE assessment the project groups must give a final seminar with the draft copy of the project report.
- The presentation by each group will be for 20-30 minutes and every member of the team needs to justify the contributions to the project.
- The project team is required to submit Hard copies of the detailed Project Report in the prescribed format to the department.
  - For CIE 50% weightage should be given to the project guide and 50% weightage to the project evaluation committee.
  - Before the final evaluations the project group is required to produce a No dues certificate from Industry, Central Library and Department.

Course Outcomes of Major Project:	
1	Apply knowledge of mathematics, science and engineering to solve respective engineering domain problems.
2	Design, develop, present and document innovative/multidisciplinary modules for a complete engineering system.
3	Use modern engineering tools, software and equipment to solve problem and engage in life-long learning to follow technological developments.
4	Function effectively as an individual, or leader in diverse teams, with the understanding of professional ethics and responsibilities.

CIE Assessment:

The following are the weightings given for the various stages of the project.

1.	Selection of the topic and formulation of objectives	10%
2.	Design and Development of Project methodology	25%
3.	Execution of Project	25%
4.	Presentation, Demonstration and Results Discussion	30%
5.	Report Writing & Publication	10%

SEE Assessment:

The following are the weightages given during Viva Examination.

1.	Written presentation of synopsis	10%
2.	Presentation/Demonstration of the project	30%
3.	Methodology and Experimental Results & Discussion	30%
4.	Report	10%
5.	Viva Voce	20%

Calendar of Events for the Project Work:

Week	Event
Beginning of 7th Semester	Formation of group and approval by the department committee.
7th Semester	Problem selection and literature survey
Last two weeks of 7th Semester	Finalization of project and guide allotment
II Week of 8th Semester	Synopsis submission and preliminary seminar
III Week	First visit of the internal guides to industry (In case of project being carried out in industry)
III to VI Week	Design and development of project methodology
VII to IX Week	Implementation of the project
X Week	Submission of draft copy of the project report

XI and XII Week	Second visit by guide to industry for demonstration. Final seminar by Department project Committee and guide for internal assessment. Finalization of CIE.

Evaluation Scheme for CIE and SEE

Scheme of Evaluation for CIE		Scheme of Evaluation for SEE	
Particulars	**%Marks**	**Particulars**	**%Marks**
Project Evaluation I	10%	Project Synopsis (Initial Write up)	10%
Project Evaluation II	25%	Project Demo / Presentation	30%
Project Evaluation III	25%	Methodology and Results Discussion	30%
Project Evaluation Phase-IV (Submission of Draft Project Report for Verification)	30%	Project Work Report	10%
Project Evaluation Phase-V (Project Final Internal Evaluation)	10%	Viva-voce	20%
Total	100	Total	100

Semester: VIII					
TECHNICAL SEMINAR (Common to all Programs)					
Course Code	:	16EC82		**CIE**	:	**100 Marks**
Credits: L:T:P:S	:	0:0:2:0		**SEE**	:	**100 Marks**
Hours / Week	:	04		**SEE Duration**	:	**3.00 Hours**

Course Learning Objectives: The students will be able to	
1	Recognize recent developments in specific program and in multidisciplinary fields.
2	Summarize the recent technologies and inculcate the skills for literature survey.
3	Demonstrate good presentation skills.
4	Plan and improve the Technical Report writing skills.
5	Support Group discussion and Team work.

General Guidelines for the Seminar
1. The seminar has to be presented by individual student.
2. The topic of the seminar should be from current thrust area along with consultation with the guide.
3. The topic can be based on standard papers (like IEEE/ACM/CSI etc.) in the thrust area for the selected topic.
4. Presenting/publishing this paper in conference/ Journal will be given weightage in CIE.
5. The student needs to submit both hard & soft copy of the seminar report.
6. **As Outcome of Technical Seminar, each student has to prepare a technical paper out of seminar topic.**

Course Outcomes of Technical Seminar:	
1	Communicate effectively on complex engineering problems and demonstrate contextual knowledge to assess societal and environmental contexts.
2	Identify, formulate, review research literature, analyze and Design solutions for complex engineering problems using appropriate techniques with effective documentation.
3	Analyze, interpret and synthesize the information to provide valid conclusions with innovative ideas and ethical principles.
4	Apply the knowledge of engineering specialization to suggest solutions to complex engineering problems and recognize the need for technological changes.

Evaluation of CIE Marks:

1.	Relevance of the topic	10%
2.	Literature Survey	10%
3.	Presentation	40%
4.	Report	20%
5.	Paper Publication	20%

Semester: VIII					
INNOVATION & SOCIAL SKILLS					
(Common to all Programs)					
Course Code	**:**	16HSS83		**CIE**	**:**	NA
Credits: L:T:P:S	**:**	0:0:1:0		**SEE**	**:**	NA
Hours / Week	**:**	02		**SEE Duration**	**:**	NA

Course Learning Objectives: The students will be able to	
1	To provide a platform for the students to exhibit their organizational capabilities, team building, ethical values and extra mural abilities.
2	To encourage to carryout innovative ideas and projects.
3	Take part in societal and community building activities.
4	Make self-learning, ethics and lifelong learning a motto.

Guidelines

1. The HSS will be evaluated individually based on the broad parameters which include the progress made by student during 3rd & 4th year in innovative projects, Seminar, Paper Presentation, Field activity & other Co-curricular activities.
2. Students shall submit a report and documents as a proof his/her achievements.

Course Outcomes of Innovation & Social Skills:	
1	Apply the knowledge and skills for solving societal issues
2	Plan to work in team in various areas with inclusive effort and sustainability
3	Organize various events and use managerial and budgeting abilities
4	Demonstrate leadership qualities and ethics

Curriculum Design Process
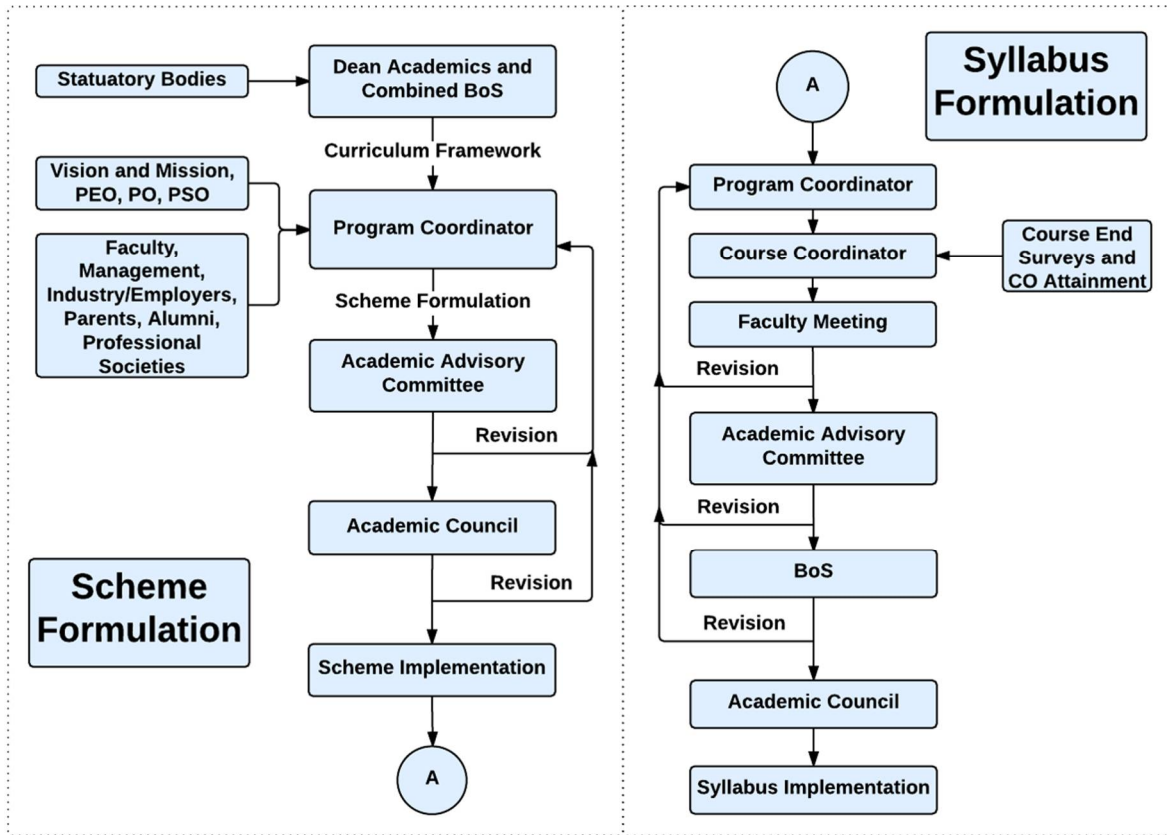
Academic Planning and Implementation

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┌──────────────────────┐
│    Dean Academics    │
└──────────────────────┘
            │
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│  Calender of Events  │
└──────────────────────┘
            │
┌──────────────────────────────────────────────────────┐
│ • Align Course Contents (Lesson Plan)                 │
│ • Identify Expected Attainment Level (Threshold)      │
│ • Publish course Materials (PPT's, Notes, Model       │
│   Question Paper)                                      │
│ • Publish Schedule (Time Table, Test, Self Study, Lab)│
└──────────────────────────────────────────────────────┘
            │
┌──────────────────────────────┐
│  Implement Program Curriculum │
│      (Course Delivery)        │
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┌──────────────────────────────────────────────────────┐
│         Formative Student Assessment                  │
│ (Tests, Quizzes, Lab and Through Pedagogical          │
│  Initiatives)                                         │
└──────────────────────────────────────────────────────┘
            │
┌──────────────────────────────────────────┐
│  Assess Results and Feedback to Students  │
└──────────────────────────────────────────┘
            │
        ◇───────── Yes ──────► ┌──────────┐
     Performace                │ Remedial │
     < Expected                └──────────┘
        ◇
        │ No
       (A)
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A

Cumulative Outcome Assessment

Course End Survey

Assessment Outcome Data and Students Feedback on TLP

Academic Advisory Committee

Improve Program Curriculum/Assessment Methods/Redefine CO's

PROCESS FOR COURSE OUTCOME ATTAINMENT

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┌─────────────────────────────┐
│      Course Curriculum       │
└─────────────────────────────┘
              │
              ▼
┌─────────────────────────────┐
│        CO-PO Mapping         │
└─────────────────────────────┘
              │
              ▼
┌─────────────────────────────┐
│     Mapping of COs to CIE QP │
└─────────────────────────────┘
              │
              ▼
┌──────────────────────────────────┐
│ Weightage of COs from tests and quizzes │
└──────────────────────────────────┘
              │
              ▼
┌──────────────────────────────────┐
│ Students marks from tests and quizzes │
└──────────────────────────────────┘
              │
              ▼
┌──────────────────────┐        ⊕        ┌──────────────────────┐
│ Lab experiment       │───────►   ◄─────│ Self Study assessment │
│ assessment, Score    │                 │ score and weightage   │
│ and weightage        │                 │                       │
└──────────────────────┘                 └──────────────────────┘
              │
              ▼
┌──────────────────────────────────┐
│   Attainment of CO for each student │
└──────────────────────────────────┘
              │
              ▼
┌──────────────────────────────────┐
│ Number of students getting more than the │
│         target attainment         │
└──────────────────────────────────┘
```
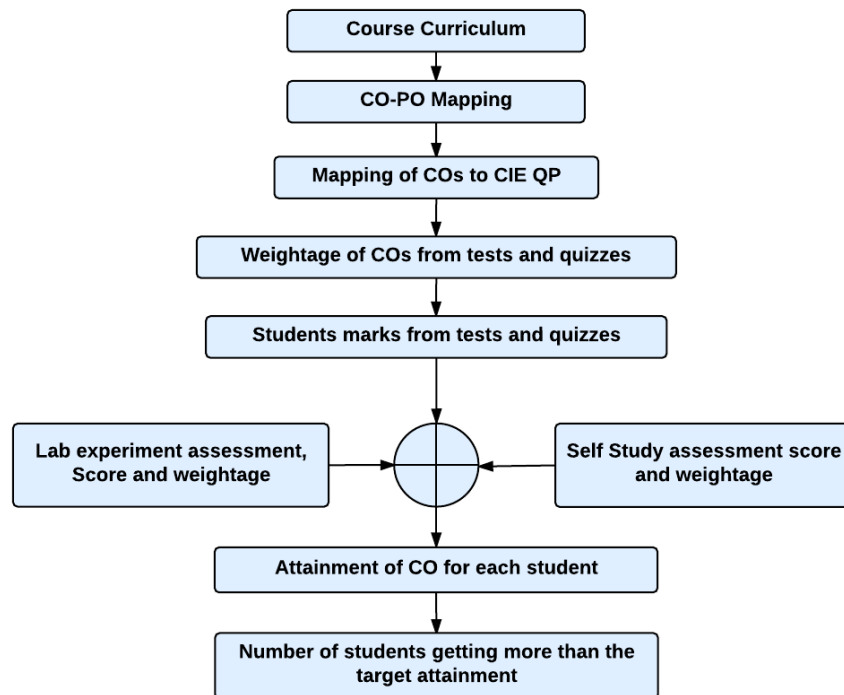
Final CO Attainment Process
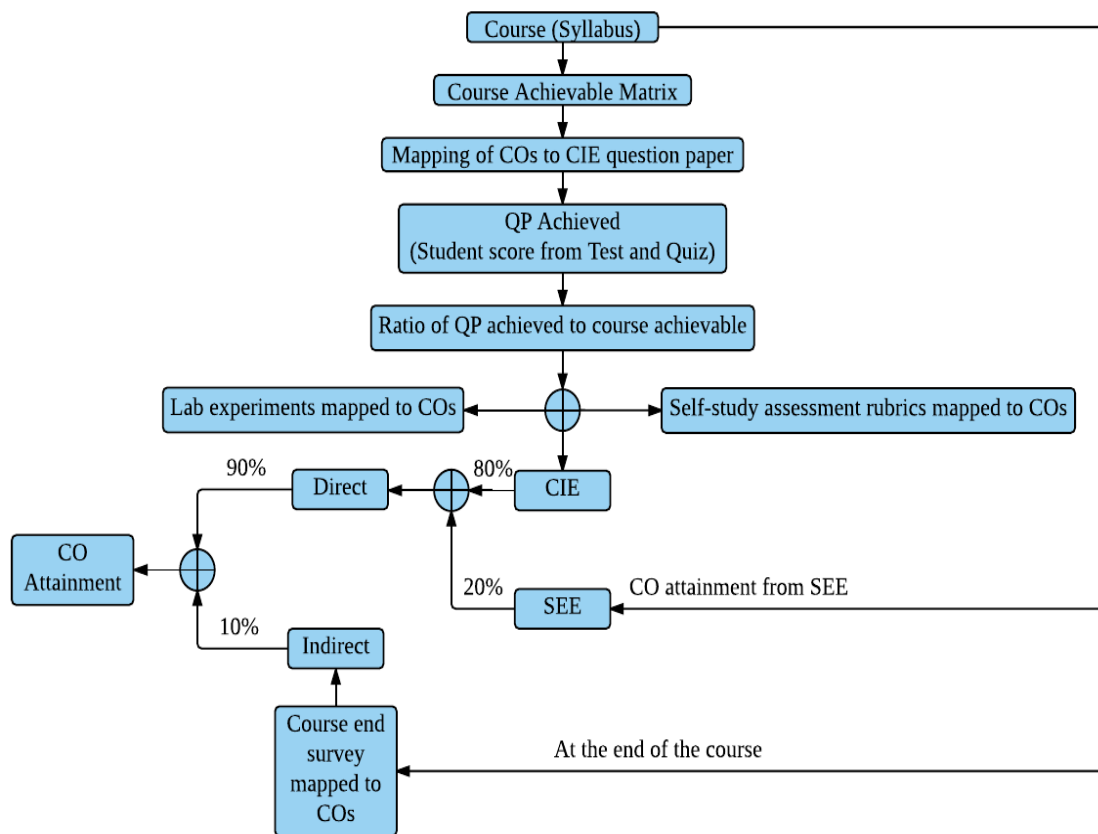
Program Outcome Attainment Process

```
          ┌─────────────────────────┐
          │     Course (Syllabus)   │
          └─────────────────────────┘
                       │
                       ▼
          ┌─────────────────────────┐
          │       CO Attainment     │
          └─────────────────────────┘
                       │
                       ▼
          ┌─────────────────────────┐
          │      CO –PO Mapping      │
          └─────────────────────────┘
                       │
                       ▼
          ┌─────────────────────────┐
          │      PO Attainment      │
          │         DIRECT          │
          └─────────────────────────┘
                       │  80%
                       ▼
                      ( )  ──────────►  ┌──────────────────┐
                       ▲                │  PO Attainment   │
                       │  20%           └──────────────────┘
          ┌─────────────────────────┐
┌──────────────┐│    PO Attainment    │┌──────────────────┐
│ Alumni Survey│►│      INDIRECT       │◄│ Employer Survey  │
└──────────────┘└─────────────────────┘└──────────────────┘
                       ▲
                       │
          ┌─────────────────────────┐
          │    Senior Exit Survey   │
          └─────────────────────────┘
```
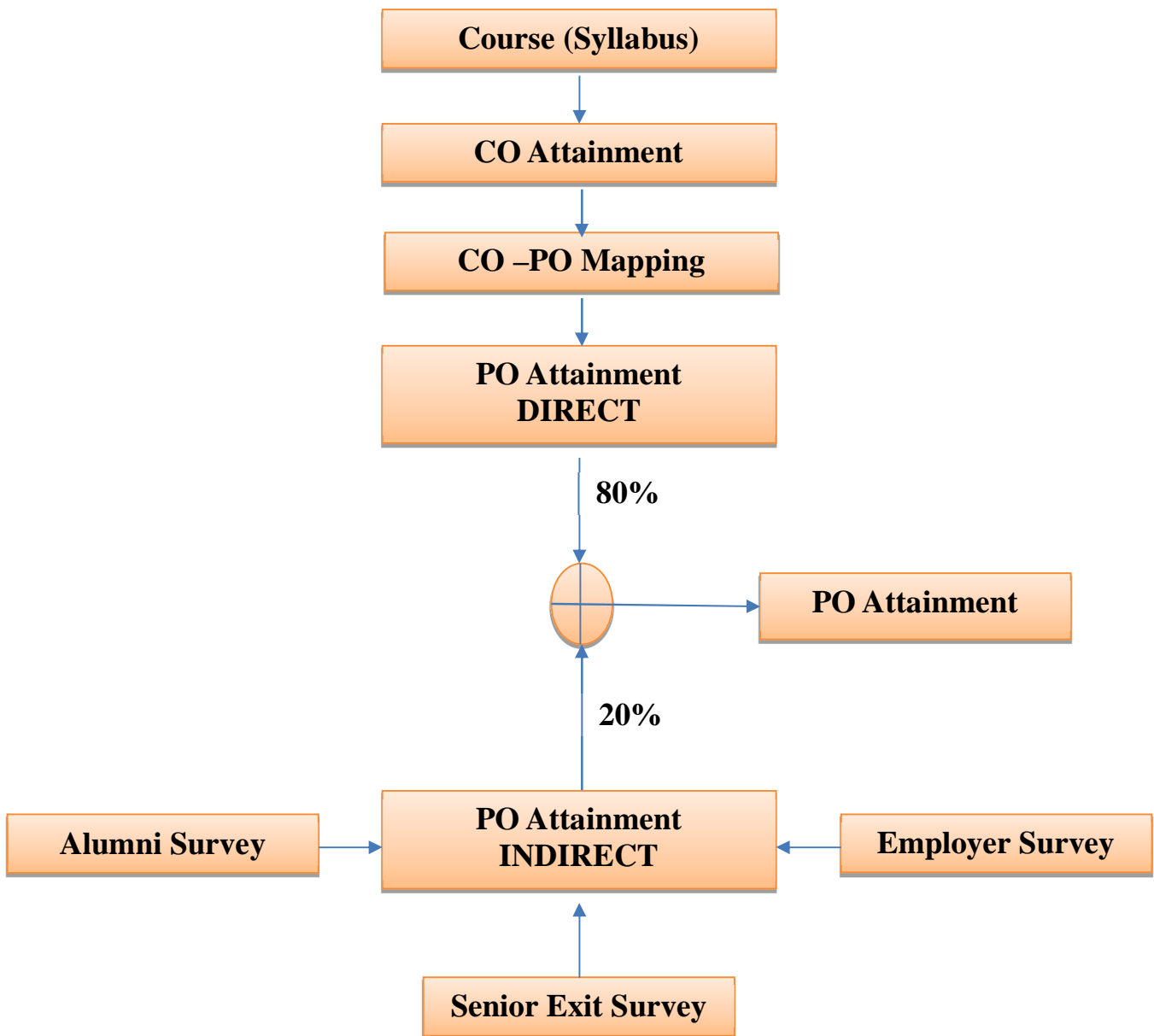
Guidelines for Fixing Targets
- The target may be fixed based on last 3 years' average attainment

PROGRAM OUTCOMES (POs)

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation for the solution of complex engineering problems.

2. **Problem analysis:** Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet t h e specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling to complex engineering activities, with an understanding of the limitations.

6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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

9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with t h e society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning:** Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.