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 and VIII Semesters

2016 Scheme

ELECTRICAL & ELECTRONICS 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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2018 SCHEME

DEPARTMENT OF
ELECTRICAL AND ELECTRONICS ENGINEERING

Department Vision

Attain technical excellence in Electrical and Electronics Engineering through graduate programs and interdisciplinary research related to sustainability in power, energy and allied fields.

Department Mission

- To provide technical education that combines rigorous academic study and the excitement of innovation enabling the students to engage in lifelong learning
- To establish Centre of Excellence in sustainable electrical energy, smart grids and systems
- To establish tie-ups with industries and institutions of repute and to foster building up of a wide knowledge base to keep in tune with upcoming technologies.
- To motivate commitment of faculty and students to collate, generate, disseminate, persevere, knowledge and to work for the benefit of society.
- To develop simple, appropriate and cost effective inclusive technologies which are instrumental in the up-liftment of the rural society.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: To provide a strong foundation in Mathematics, Science and Electrical & Electronics Engineering to comprehend, analyze, design, innovate and develop products for real world applications.

PEO2: To inculcate ethical attitude, effective communication skills, leadership qualities and team spirit for a successful professional career with concern for society.

PEO3: To provide a holistic academic environment to foster excellence, entrepreneurship and multidisciplinary approach to inculcate an aptitude for research and lifelong learning.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO	Description
PSO1	The B.E. EEE Program must demonstrate knowledge and competence in the application of circuit analysis, control systems, field theory, analog and digital electronics, Power Electronics, microcontrollers , microprocessors, Signal processing and conditioning, computer hardware and software to the design, building , testing, protection and operation of electrical machines, power systems, electrical and electronic systems.
PSO2	The B.E. EEE Program must demonstrate knowledge and competence in the application of basic sciences, rigorous mathematics and project management techniques in the design of complex electrical and electronic systems.
PSO3	The B.E. EEE Program must demonstrate the ability to effectively work in a team, communicate correctly and develop an ethical attitude and concern for society and environment.

Lead Society: Institute of Electrical & 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.	PE	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 ENGINEERNG®, BENGALURU-560 059

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ELECTRICAL & ELECTRONICS ENGINEERING

SEVENTH SEMESTER CREDIT SCHEME								
Sl. No.	**Course Code**	**Course Title**	**BOS**	**Credit Allocation**				**Total Credits**
				L	**T**	**P**	**SS**	
1	16EE71	Power Systems Analysis –II	EEE	4	0	1	0	5
2	16EE72	Switch Gear and Protection	EEE	4	0	1	0	5
3	16EE73P	Mini Project **	EEE	0	0	3	0	3
4	16EE7FX	Elective F (PE)	EEE	4	0	0	0	4
5	16EE7GX	Elective G(PE)	EEE	4	0	0	0	4
6	16GH7XX	Elective H (GE)*	Respective BOS	3	0	0	0	3
Total number of Credits				**19**	**0**	**5**	**0**	**24**
Total Number of Hours / Week				**19**	**0**	**10**	**0**	

*Students should take other department Global Elective courses;
** Minor Project-6 hours per week;

EIGHTH SEMESTER CREDIT SCHEME								
Sl. No.	**Course Code**	**Course Title**	**BOS**	**Credit Allocation**				**Total Credits**
				L	**T**	**P**	**SS**	
1	16EE81	Major Project	EEE	0	0	16	0	16
2	16EE82	Technical Seminar	EEE	0	0	2	0	2
3	16HS83	Innovation and Social Skills	HSS	0	0	2	0	2
4	16EE84	Industrial Tour		**0**	**0**	**1**	**0**	1
Total number of Credits				**0**	**0**	**21**	**0**	**21**
Total Number of Hours / Week				**0**	**0**	**42**	**0**	

VII Semester		
GROUP F: PROFESSIONAL ELECTIVES		
Sl. No.	**Course Code**	**Course Title**
18.	16EE7F1	Communication Systems and networking
19.	16EE7F2	Object oriented Modelling and Design
20.	16EE7F3	Program Logic Controller and Supervisory Control & Data Acquisition (PLC And SCADA)
21.	16EE7F4	Flexible AC Transmission Systems (FACTS)
VII Semester		
GROUP G: PROFESSIONAL ELECTIVES		
Sl. No.	**Course Code**	**Course Title**
1.	16EE7G1	Industrial Drives and Applications
2.	16EE7G2	Electrical Installation Estimation and Costing
3.	16EE7G3	Digital protection of power systems
4.	16EE7G4	Power system operation and control

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

Semester: VII		
POWER SYSTEM ANALYSIS II (Theory and Practice)		
Course Code: 16EE71		**CIE Marks: 100+50**
Credits: L:T:P:S 4:0:1:0		**SEE Marks: 100+50**
Hours: 48L+24P		**SEE Duration: 03+03Hrs**

Course Learning Objectives: The students will be able to

1	Learn about different techniques of formation of Ybus, Zbus and their applications,
2	Analyse different techniques of load flows and apply the suitable technique for a given system.
3	Solve for the stability of the system using different numerical techniques.
4	Model various power system components for frequency control.
5	Apply load frequency control for single area and two area systems.

UNIT-I	**09 Hrs**

Formation of Network Admittance Matrix :
Introduction, Elementary graph theory- oriented graph, tree, co-tree, basic cut-sets, basic loops; Element-node and bus incidence matrices; Primitive network- impedance form and admittance form ; Formation of Y_{BUS}- by method of inspection (including transformer off-nominal tap setting), by method of singular transformation with and without mutual coupling.

UNIT II	**10 Hrs**

Formation of Network Impedance Matrix:
Formation of Bus impedance matrix (Z_{BUS}) by step by step building algorithm, Modification of Z_{BUS}...Fault current calculation using Z_{BUS}

UNIT III	**09 Hrs**

Load Flow Studies:
Newton Raphson Method – Algorithm & flow chart for NR method in polar coordinates (numerical problem for one iteration only); Algorithm for Fast Decoupled load flow method; Comparison of load flow methods. Bus currents, Line flows, Bus injections.

UNIT IV	**10 Hrs**

Transient Stability Studies :
Steady state and transient stability, Power angle equation for non-salient pole machines, Rotor dynamics and the swing equation Equal-area criterion for transient stability evaluation and its applications. Numerical solution of Swing equation – Point-by-Point method, Modified Euler's method, Runge-Kutta method.

UNIT V	**10 Hrs**

Load Frequency Control:
Modelling of power system components like governor, generator, load etc. Complete ALFC block diagram, load frequency analysis, AGC in single area system and two area system, Tie line bias control.

LABORATORY EXPERIMENTS

1. Formation of Y Bus for power systems by inspection method and by singular transformation method with & without mutual coupling,
2. Formation of Z-bus by using Z-bus building algorithm. Determination of bus currents, bus power and line flows for a specified system voltage (bus) profile.
3. Program to perform load flow analysis using different methods through MATLAB and software packages.
4. To determine fault currents and fault MVA for various faults
5. Economical generator scheduling for thermal power plants with and without losses.
6. Solution of swing curve with Modified Euler's method and Runge - Kutta method.

7. Study of Load frequency analysis of single area system and two area system.

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the fundamental concepts of power system networks and models of various components.
CO2	Apply numerical techniques to evaluate the power flows and stability of power systems.
CO3	Derive the load frequency control model and determine the control settings.
CO4	Use MATLAB and commercial power system software packages for system studies

Reference Books	
1.	Computer Methods in Power System Analysis, Stag, G.W and EI-Abiad A H, McGraw Hill International Student Edition, 2006,ISBN: 978-0070606586
2.	Computer Techniques and Models in Power Systems, K. Uma Rao, I.K.International publishing House Pvt.Ltd, 2nd Edition, 2014, ISBN : 9789382332312
3.	Computer Techniques in Power System Analysis, Pai,M.A, TMH, 2nd Edition, 2006, ISBN : 007096551X, 9780070965515.
4.	Modern Power System Analysis, Nagrath, I.J and Kothari D.P.,TMH, 3rd Edition, 2003, ISBN : 978-0-07-107775-0.

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 50. The marks component for Assignment/Presentation/Project 10.

Total CIE is 30(Q) +50(T) +10(A) =100 Marks.

Laboratory- 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 of marks over number of weeks is considered for 40 marks. At the end of the semester a test is conducted for 10 marks. Total marks for the laboratory is 50.

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.

Laboratory- 50 Marks
Experiment Conduction with proper results is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

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

High-3 : Medium-2 : Low-1

Semester: VII		
SWITCH GEAR AND PROTECTION (Theory and practice)		
Course Code: 16EE72		**CIE Marks:** 100+50
Credits: L:T:P: S:4:0:2:0		**SEE Marks:** 100+50
Hours: 46L+40P		**SEE Duration:** 03Hrs+03Hrs

Course Learning Objectives: The students will be able to	
1	Understand the operation of Fuse ,Circuit breaker and Relays
2	Calculate the re-striking and recovery voltages during Circuit breaking
3	Analyze the arc characteristics and Circuit Breaker ratings
4	Explain and Analyze the principle and operation of Different types of circuit breakers relays and test the characteristics in ,Laboratory

UNIT-I	**10 Hrs**
Fuses: Introduction, Definition, Classification, HRC fuse, Selection of Fuses, characteristics **Circuit Breakers theory:** Arc characteristics, Theories of current interruption, Recovery, Restriking Voltage and Recovery voltages.- Re-striking Phenomenon, Average and Max. RRRV, Numerical Problems - Current Chopping and Resistance Switching,, Interruption of Capacitive Current Examples	
UNIT-II	**10 Hrs**
Circuit Breakers: Air break CB, Air Blast CB, SF_6CB : construction, operation, application and merits, Vacuum CB construction, operation, application and merits, CB ratings and Specifications: Types and Numerical Problems. – Auto reclosures. **DC Circuit Breaker:** Introduction, DC Breaking, General design and construction	
UNIT-III	**10 Hrs**
Introduction to Relays: Principles and need for protective schemes –Relay terminology, definitions, Zones of protection and essential qualities of protection, relay classification, Relay design considerations **Relay Operating Principles, construction and Characteristics:** **Electromechanical relays**: over current: directional and non-directional, differential relays. Universal torque equation Illustrative examples **Static relays:** Introduction, Advantages and Disadvantages –IDMT static relays(Block diagram) **Numerical relays:** Introduction ,Block diagram of a numerical relay, Advantages and Disadvantages – Block diagram for over current relay and Flow Chart.	
UNIT-IV	**08 Hrs**
Transformer Protection: Differential protection of power transformer, Biased differential Protection Buchhloz relay for incipient faults , Hormonic restraint relay - Illustrative examples **Generator protection:** Introduction to stator and rotor side protection, differential protection Illustrative examples **Bus bar protection**: Differential protection of bus bars, Illustrative examples	
UNIT-V	**08 Hrs**
Distance Protection of Transmission lines: Impedance, reactance and admittance characteristics with torque equations, relay settings for 3-zone protection, numerical relays for transmission line protection, microprocessor based impedance relay (block diagram) and Flow chart **Pilot Protection of Transmission Lines:** Introduction, communication channels, tripping v/s blocking, Directional comparison blocking, Directional comparison unblocking, under reaching transfer trip.	

LABORATORY EXPERIMENTS	
1.	IDMT characteristics of o/v & u/v relay (solid stare or electromechanical type).
2.	Generation of standard lightning impulse & to determine η & energy of impulse generator.
3.	Determination of 50% flashover voltage of air for point-plane & plane-plane gaps.
4.	Current-time characteristics of fuse.
5.	Operating characteristics of microprocessor based (numeric) over-current relay.
6.	Operating characteristics of microprocessor based (numeric) over/under voltage relay.
7.	Generator protection -Merz-Price- protection scheme.
8.	Spark-over characteristics of plane-plane and point-plane electrodes under HVAC and HVDC in air.
9.	Measurement of HVAC and HVDC using standard spheres.
10.	Breakdown strength of transformer oil using oil-testing unit.
11.	Field mapping using electrolytic tank for co-axial cable.
12.	Differential protection of transformer
13.	Design and simulation experiments in PSCAD

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain and understand the operation of different types of relays, circuit Breakers and fuses in power systems
CO2	Analyze and compare the performance of different protection relays, circuit breakers and fuses
CO3	Evaluate the settings of various types of relays for equipment protection and ratings of circuit breakers
CO4	Apply the advanced relaying techniques with pilot communication and modern circuit breakers in harmony with the present and future power system and practice to realise the numerical relaying schemes

Reference Books	
1.	Power System Protection and Switchgear ,BadriRam, 3rd Edition TataMc-Graw Hill Pub , 2011.
2.	Fundamentals of Power System Protection, Y.G. Paithankar and S.R. Bhide, 2 ndedition,Prentice Hall of India Pvt. Ltd., New Delhi–110001, 2003.
3.	Power system relaying, Staley H.Horowitz&ArunG.Padke, 3rd Edition, John Wiley & Sons Inc., 1995.
4.	A Text Book on PowerSystem Engineering, M.L. Soni, P.V. Gupta, V.S. Bhatnagar, A. Chakrabarti ,2nd Edition, DhanpatRai& Co. 1998.

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 50. The marks component for Assignment/Presentation/Project 10.

Total CIE is 30(Q) +50(T) +10(A) =100 Marks.

Laboratory- 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 of marks over number of weeks is considered for 40 marks. At the end of the semester a test is conducted for 10 marks. Total marks for the laboratory is 50.

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.

Laboratory- 50 Marks

Experiment Conduction with proper results is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

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

High-3: Medium-2: Low-1

Semester: VII		
MINI PROJECT		
Course Code: 16EE73P		**CIE Marks: 100**
Credits: L: T: P: S:: 0:0:3:0		**SEE Marks: 100**
Hrs/week: 06		**SEE Duration: 3 Hrs**

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:

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%

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%

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		
COMMUNICATION SYSTEMS AND NETWORKING **(Group F: Professional Elective)**		
Course Code:16EE7F1		**CIE Marks:** 100
Credits: L:T:P:S 4:0:0:0		**SEE Marks:** 100
Hours: 48L		**SEE Duration:** 03Hrs
Course Learning Objectives: The students will be able to		
1	Optimize logic expressions using Karnaugh map, Tabular method and VEM method.	
2	Simplify Boolean equations and design combinational circuits with optimal gates.	
3	Analyze the working principles of Flip-Flops and design asynchronous sequential circuits.	
4	Design simple synchronous digital circuits based on finite state machine algorithm.	
5	Design, simulate and implement digital systems using HDL.	

UNIT-I	**10 Hrs**
Introduction to electronic communication : The Significance of Human Communication, Communication Systems, Types of Electronic Communication, Modulation and Multiplexing, The Electromagnetic Spectrum, Bandwidth. **Amplitude Modulation Fundamentals:** AM Concepts, Modulation Index and Percentage of Modulation, Sidebands and the frequency Domain, AM Power, Single sideband Modulation. **Fundamentals of Frequency Modulation:** Basic Principles of FM, Principles of Phase Modulation, Modulation Index and Sidebands, Noise Suppression Effects of FM, FM Versus AM.	
UNIT-II	**09 Hrs**
Digital Communication Techniques: Digital Transmission of Data, Parallel and serial Transmission, Data Conversion, Pulse Modulation **Multiplexing and DE multiplexing:** Multiplexing Principles, Frequency Division Multiplexing, Time Division Multiplexing, Pulse Code Modulation, Duplexing	
UNIT-III	**09 Hrs**
The Transmission of Binary data in Communication Systems: Digital Codes, Principles of Digital Transmission, Transmission Efficiency, Modem Concepts and Methods, Wideband Modulation, Broadband Modem Techniques, Error Detection and Correction, Protocols. **Optical Communication**: Optical principles, Optical Communication Systems, Fibber Optic Cables, Optical Transmitters and Receivers, Wavelength Division Multiplexing, Passive Optical Networks	
UNIT-IV	**10 Hrs**
Cell Phone Technologies: Cellular Telephone Systems, The Advanced Mobile Phone Systems (AMPS) Digital cell phone Systems. **Computer Networks: Introduction :**LAN, MAN, WAN, wireless networks, home networks, Internetwork	
UNIT-V	**10 Hrs**
Network software, OSI reference model and TCP/IP Reference model and comparison, Physical layer: communication satellites**, Data link layer:** Error Detection and correction **The network layer:** Network layer in the internet ,**Transport layer**: Internet transport protocol **Application layer** :Electronic mail	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand different analog modulation techniques and applications of AM & FM. Optical communication, computer networks , digital cell phone systems, Layers of OSI model
CO2	Differentiate and evaluate parallel and serial transmission. Analyse different methods analog to digital data conversion.
CO3	Analysis of digital communication techniques and multiplexing.
CO4	Development and design of communication circuits and networking topologies and protocols

Reference Books	
1.	Principles of Electronic communication systems, Louis E. Frenzel, McGraw-Hill 3rd Edition, 2008, ISBN: 0070667551.
2.	Simon Haykin, John Wiley, "An Introduction to Analog and Digital communication ",2nd Edition, 2006,ISBN: 0-07-010829-3 6.
3.	George Kennedy ,"Electronic Communication System"- The McGraw-Hill Companies.4th Edition, 2006,ISBN-13: 978-0-07- 463682-4.
4.	Computer Networks by Andrew S Tanenbaumb, PHI Ltd. 4th Edition.ISBN -978-81-203-2175-5

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

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Total CIE is 30(Q) +50(T) +10(A) =100 Marks.

SEE for 100 marksis 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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	-	1	-	2	-	1	-	-	2
CO2	2	2	2	1	-	1	1	-	2	1	-	1
CO3	2	2	2	2	2	2	2	1	2	2	-	1
CO4	3	2	2	3	1	2	2	1	2	2	2	2

High-3: Medium-2: Low-1

Semester: VII		
OBJECT ORIENTED MODELLING AND DESIGN **(Group F: Professional Elective)**		
Course Code: 16EE7F2		**CIE Marks:** 100
Credits: L:T:P:S: 4:0:0:0		**SEE Marks:** 100
Hours: 36L		**SEE Duration:** 3Hrs

Course Learning Objectives: The students will be able to	
1.	Understand the operation of an object in a software application.
2.	Design of an object by satisfying its requirements in the design stage.
3.	Interpreting various UML Diagrams for implementation of software application.
4.	Converting Legacy Systems to a programmable mode before Implementation.

UNIT-I	**07 Hrs**
INTRODUCTION, MODELING CONCEPTS, CLASS MODELING: What is Object Orientation? What is OO development? OO themes; Evidence for usefulness of OO development; OO modeling history. Modeling as Design Technique: Modeling; abstraction; the three models. Class Modeling: Object and class concepts; Link and associations concepts; Generalization and inheritance; A sample class model	
UNIT-II	**07 Hrs**
ADVANCED CLASS MODELING, STATE MODELING: Advanced object and class concepts; Association ends; N-ary associations; Aggregation; Abstract classes; Multiple inheritance; Metadata; Reification; Constraints; Derived data; Packages; State Modeling: Events, States, Transitions and Conditions; State diagrams; State diagram behavior;	
UNIT-III	**07 Hrs**
ADVANCED STATE MODELING, INTERACTION MODELING: Advanced State Modeling: Nested state diagrams; Nested states; Signal generalization; Concurrency; A sample state model; Relation of class and state models; Practical tips. Interaction Modeling: Use case models; Sequence models; Activity models. Use case relationships; P sequence models.	
UNIT-IV	**08 Hrs**
PROCESS OVERVIEW, SYSTEM CONCEPTION, and DOMAIN ANALYSIS: Process Overview: Development stages; Development life cycle. System Conception: Devising a system concept; elaborating a concept; preparing a problem statement. Domain Analysis: Overview of analysis; Domain class model; Domain state model; Domain interaction model; Iterating the analysis.	
UNIT-V	**07 Hrs**
CLASS DESIGN, IMPLEMENTATION MODELING, LEGACY SYSTEMS: Class Design: Overview of class design; Bridging the gap; Realizing use cases; Refactoring; Adjustment of inheritance; Organizing a class design; ATM example. Implementation Modeling: Overview of implementation; Fine-tuning classes; Fine-tuning generalizations; realizing associations. Legacy systems	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand existing models used in software application in terms of unified modelling language.
CO2:	Analyze the different working models to implement the software application.
CO3:	Evaluate the operation of legacy systems into implementable system.
CO4:	Design working software models.

Reference Books	
1.	Object-Oriented Analysis and Design with Applications, Grady Booch et al:, 3rd Edition, Pearson Education, 2007 ISBN 9780132797
2.	Object-Oriented Analysis, Design, and Implementation, Brahma Dathan, SarnathRamnath:, Universities Press, 2009.
3.	UML 2 Toolkit, Hans-Erik Eriksson, Magnus Penker, Brian Lyons, David Fado:, Wiley-Dreamtech India, 2004 ISBN 9781849965
4.	Object-Oriented Systems Analysis and Design Using UML,Simon Bennett, Steve McRobb and Ray Farmer:, 2nd Edition, Tata McGraw-Hill, 2002 ISBN 77094972

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

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Total CIE is 30(Q) +50(T) +10(A) =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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	-	1	-	2	-	-	-	-	1
CO2	2	2	2	1	-	1	1	-	-	1	-	1
CO3	2	2	2	2	2	2	2	1	1	1	-	1
CO4	2	2	2	2	1	2	2	1	1	1	-	2

High-3: Medium-2: Low-1

Semester: VII		
PROGRAM LOGIC CONTROLLER AND SUPERVISORY CONTROL & DATA ACQUISITION (PLC AND SCADA) **(Group F: Professional Elective)**		
Course Code: 16EE7F3		**CIE Marks:** 100
Credits: L:T:P:S 4:0:0:0		**SEE Marks:** 100
Hours: 48L		**SEE Duration:** 3Hrs

Course Learning Objectives: The students will be able to	
1	Recognize industrial control problems and access suitability of using PLC for control.
2	Understand PLC architecture and Programme PLC' using ladder logic.
3	Compare different SCADA Architecture and choose appropriate one and integrate SCADA with PLC.
4	Analyse different communication protocols used in automation
5	Design a control system and automate an industrial process using PLC.

UNIT-I	**09 Hrs**
Programmable Logic Controller (PLC) Basics: Introduction, Parts of PLC, Principles of operation, PLC size and applications, PLC Advantages and Disadvantages, PLC Manufacturers, PLC hardware components, I/O section, Analog I/O modules, Digital I/O modules, CPU- Processor memory module, Programming devices, Relay, Contactor, SPST, Push Buttons, NO/NC Concept.	
UNIT-II	**10 Hrs**
Programming of Programmable Logic Controller: General PLC Programming Procedures, Contacts and Coils, Program SCAN, Programming Languages, Ladder Programming, Relay Instructions, Instruction Addressing, Concept of Latching, Branch Instructions, Contact and Coil I/O Programming Examples, Relation of Digital Gate Logic to Contact/Coil Logic.	
UNIT-III	**10 Hrs**
Programmable Logic controller Functions: Timer Instructions: ON DELAY Timer and OFF DELAY timer. Counter Instructions: UP/DOWN Counters, Timer and Counter Applications, Program Control Instructions: Master Control Reset, Math Instructions- ADD, SUBS Data Handling: Data Move, Data Compare, Data Selection, Electro-pneumatic Sequential Circuits and Applications. Analog input output communication with PLC. Programming examples.	
UNIT-IV	**10 Hrs**
Communication with different sensors: Proximity sensors :Inductive, capacitive sensors, Photoelectric Sensors and Switches, Encoders, Temperature sensors, position and displacement sensors, pressure sensors **Industrial Communication Protocols:** RS232/RS485 Interface Standard, Modbus Protocol, Profit bus Protocol, Industrial Ethernet, ETHERCAT, Profinet Protocol.	
UNIT-V	**09 Hrs**
SCADA: Definition of SCADA, Elements of SCADA System, , SCADA architecture, Communication Access and Master-Slave architecture; determining scan interval; Introduction to Remote Control and RTU, Long Distance Communication, Communication System components in brief; - Protocols , Modems, Synchronous/Asynchronous telephone cable/radio, Half Duplex, Full Duplex System, Brief introduction to RTU and MTU, Applications-Automatic Control, Advisory Applications.	

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

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Total CIE is 30(Q) +50(T) +10(A) =100 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marksis 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	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	1	3	-	2	-	-	-	1	2	1	1
CO2	3	2	2	2	2	-	-	-	2	2	-	1
CO3	2	2	3	2	2	-	-	-	2	2	1	1
CO4	3	2	3	2	1	-	-	-	2	2	1	1

High-3: Medium-2: Low-1

Semester: VII		
FLEXIBLE AC TRANSMISSION SYSTEMS (FACTS) **(Group F: Professional Elective)**		
Course Code:16EE7F4		**CIE Marks: 100**
Credits: L: T:P:S 4:0:0:0		**SEE Marks: 100**
Hours: 48L		**SEE : 03 Hrs**

Course Learning Objectives: The students will be able to	
1	Understand the need for power electronic device application in power systems.
2	Learn the fundamental concepts involved in design of various FACTS controllers.
3	Analyze and design control strategies for different applications.
4	Select, model, design and analyze the FACTS controllers to be deployed for a given system.
5	Power Quality problems and custom power devices to mitigate them.

UNIT-I	**10 Hrs**
Reactive Power Compensation and Introduction To FACTS: Basics of AC power transmission control of power flow, fundamentals of reactive power compensation, dynamic reactive power compensation, FACTS controllers and their application to transmission and distribution systems. Comparison between series and shunt compensation.	
UNIT-II	**10 Hrs**
SVC and TCSC: Configuration of different types of SVC, analysis of FC-TCR, harmonics and filtering, modelling and applications of SVC. Conventional series compensation, SSR, Extension of FC-TCR to series compensation-TCSC, Analysis, modelling and control of TCSC. Concept of GCSC; mitigation of SSR.	
UNIT-III	**10 Hrs**
STATCOM & SSSC: Analysis of six-pulse VSC using switching functions, application of VSC as a STATCOM, operation and control of STATCOM, application of VSC as a series compensator, SSSC	
UNIT-IV	**09 Hrs**
UPFC: Introduction to multi converter devices, concept of UPFC, control of UPFC. Multilevel converters and their applications in FACTS	
UNIT – V	**09 Hrs**
Power quality and Custom power devices: Introduction to power quality, power quality definitions, power quality standards, custom power devices, concepts of DVR, DSTATCOM, UPQC.	

Course Outcomes: After completing the course, the students will be able to	
CO1.	Understand the importance of FACTS and custom power devices in improving the power system performance from different perspectives.
CO2.	Analyze the need for standards and their role in design
CO3.	Choose and design a FACTS /custom power device for a given network and system requirement such as voltage control, power control etc.
CO4.	Design control strategies for the FACTS/ custom power devices

Reference Books:	
1.	FACTS controllers in power transmission and distribution, Padiyar, New Age International, 2007, ISBN: 8122421423, 9788122421422.
2.	Understanding FACTS: Concepts and technology of Flexible AC transmission systems , Naren G. Hingorani and Laszlo Gyugui, Standard publishers, New Delhi, 2000, ISBN: 0780334558, 978078033455.
3.	Flexible AC Transmission System, Y.H. Song and A.T.Hohns,Institution of Engineering and Technology, 2009, ISBN : 0-852967713.
4.	HVDC and FACTS controllers, Vijay K. Sood, Springer, 2004, ISBN : 1-4020-7891-9,.

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 50. The marks component for Assignment/Presentation/Project 10.
Total CIE is 30(Q) +50(T) +10(A) =100 Marks.

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

SEE for 100 marksis 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	2	2	2	1	1	1	1	1	1	2	-	1
CO2	2	2	2	2	1	1	1	1	1	2	-	1
CO3	3	3	2	2	1	1	2	1	1	2	-	1
CO4	3	3	2	2	1	1	2	1	1	2	-	1

Low-1 Medium-2 High-3

Semester: VII		
INDUSTRIAL DRIVES AND APPLICATIONS **(Group G: Professional Elective)**		
Course Code: 16EE7G1		**CIE Marks:** 100
Credits: L:T:P:S 4:0:0:0		**SEE Marks:** 100
Hours: 48L		**SEE Duration:** 3Hrs

Course Learning Objectives: The students will be able to	
1	Understand the concepts , principle of operation and performance of AC and DC Electric Drives
2	Analyze the power electronics controlling techniques of Induction motor
3	Analyze the concept and selection of Industrial drives
4	Analyze and testing the sequential circuit operations of machines.
5	To distinguish between various operating characteristics of AC and DC Drives

UNIT-I	**09 Hrs**
Fundamentals of Electric Drive: Electric Drives and its parts, advantages of electric drives. Classification of electric drives. Speed - torque conventions and multi-quadrant operations. Constant torque and constant power operation, Types of load, Load torque: components, nature and classification. **Selection of Motor Power rating:** Thermal model of motor for heating and cooling, classes of motor duty, determination of motor power rating for continuous duty, short time duty and intermittent duty, Load equalization	
UNIT-II	**09Hrs**
Dynamics of Electric Drive: Dynamics of motor-load combination, Steady state stability of Electric Drive. **Electric Braking:** Purpose and types of electric braking, braking of dc, three phases Induction and synchronous motors.	
UNIT-III	**10 Hrs**
Power Electronic Control of DC Drives: Single phase and three phase controlled converter fed separately excited dc motor drives (continuous conduction only), dual converter fed separately excited dc motor drive, rectifier control of dc series motor. Supply harmonics, power factor and ripples in motor current. Chopper control of separately excited dc motor and dc series motor.	
UNIT-IV	**10 Hrs**
Power Electronic Control of AC Drives: Three Phase induction Motor Drive: Static Voltage control scheme, static frequency control scheme (VSI, CSI, and cyclo - converter based) static rotor resistance and slip power recovery control schemes. **Three Phase Synchronous motor:** Self-controlled scheme. Merits and demerits of synchronous motor for drive applications. **Special Drives:** Switched Reluctance motor, Brushless dc motor. Selection of motor for particular applications	
UNIT-V	**10 Hrs**
Industrial Drives: Selection of drives for paper mill, Rolling mill, machine tool drives, textile mill drives and other industrial drives. **Energy conservation in Electric Drives:** Losses, measures for energy conservation, Power factor improvement, quality of supply	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand and describe the basic concept of different types of AC, DC and industrial Drives
CO2:	Evaluate the performance of AC and DC drives for speed control ,breaking and energy conservation
CO3:	Analyze the starting and braking ,speed control schemes of AC,DC and industrial drives
CO4:	Design and implement a suitable control strategy for optimum operation.

Reference Books	
1.	Fundamentals of Electrical Drives, G.K Dubey , 2nd Edition, 5th reprint Narosa Publishing House, Chennai, 2002.
2.	Electrical Drives, N.K De and P.K. Sen , PHI, 2007
3.	A First Course On Electric Drives, S.K Pillai,Wiley Eastern Ltd,1990.
4.	Electric Motor and Drives Modeling, Analysis and Control, Krishnan, R.,Prentice Hall of India, 2001.

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

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Total CIE is 30(Q) +50(T) +10(A) =100 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marksis 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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CO2	2	3	2	1	1	1	1	1	1	2	-	1
CO3	3	3	2	2	2	1	2	-	1	2	-	1
CO4	3	3	2	2	1	1	2	1	1	2	-	1

High-3: Medium-2: Low-1

Semester: VII		
ELECTRICAL INSTALLATION ESTIMATION AND COSTING (Group G: Professional Elective)		
Course Code: 16EE7G2		**CIE Marks: 100**
Credits: L:T:P:S: 4:0:0:0		**SEE Marks: 100**
Hours: 48L		**SEE Duration: 3 Hrs**

Course Learning Objectives: The students will be able to	
1.	To have knowledge in estimation and costing in residential, industrial wiring, substation, transmission and distribution system.
2.	To know the process involved in detailed estimation, tender process, issuing purchase order and testing of installations.
3.	To give an insight into issues involved during installation and the coordination from other engineering fields during execution of the project.
4.	To know the Indian Electrical Standards related to wiring and substation design.

UNIT-I	**09 Hrs**

General Principles of Estimation:

Purpose of Estimating and costing, electrical schedule, catalogues, market survey, recording of estimates, determination of required quantity of material, labour conditions. Determination of cost of material and labour, contingencies, overhead charges, profit, purchase system, purchase enquiry and selection of appropriate purchase mode. Comparative statements Purchase order, payment of bills. Tender form.

UNIT-II	**12 Hrs**

Wiring System:

Introduction, distribution board, methods of wiring,
Insulating materials, types of cables used in internal wiring, multistring cable.
Conduit accessories and fittings.

Residential building electrification:

Circuits and sub circuits, types of lighting circuits. General rules guidelines for wiring of residential installation and positioning of equipment's. Determination of total load, procedure of designing the circuits and deciding the sub circuits. Determination of size of conductor, single line diagram. Sequence to be followed to prepare estimate, preparation of detailed estimates and costing of residential instillation.

Inspection and testing of installations:

Inspection of internal wiring, of new installation. Testing of wiring installation. Reason for excess recording of energy consumption by energy meter

General idea about IE rules, major applicable IE rules.

UNIT-III	**09 Hrs**

Electrification of commercial installation:

Difference between electrification of residential and commercial installation. Fundamental considerations for planning o an electrical installation system for commercial building. Design considerations of electrical installation system for commercial building. Load calculation and selection of service connection and nature of supply. Deciding the size of the cables, bus bar and bus bar chambers, mounting arrangements and positioning of switch boards, distribution boards main switch etc. Earthing of the electrical installation, wiring system and layout. Sequence to be followed to prepare estimate. Preparation of detailed estimate and costing of commercial installation.

Electrical wiring and installation for power circuits:

Motor installation. Determination of input power, input current to motors. Determination of cables. Determination of rating of fuse. Determination of size of conduit, distribution board, main switch and starter. Estimation of power circuits.

UNIT-IV	09 Hrs
Design and Estimation of overhead transmission and distribution: Introduction, typical AC electrical power system main components of overhead lines, line supports. Factors governing height of pole, conductor material, determination of size of conductor, cross arms, ole brackets and clamps, guys and stays. Conductors configuration, spacing and clearances, span lengths, overhead line insulators, insulator materials, types of insulators. Lightning arresters, phase plates, danger plates, ant climbing devices bird guards etc. Erection of supports, fixing of cross arms, insulators, conductor erection. Dear end clamps. Earthing of transmission lines. Guarding of overhead lines	
UNIT-V	**09 Hrs**
Design and estimation of substations: Introduction, classification of substations, indoor substations, outdoor substations, selection and location of site for substation. Main electrical connections, graphical symbols for various types of apparatus and circuit elements, key diagrams of typical substations. Equipment for substations and switchgear installations, axillaries supply. Substation earthing.**Concept of Internal Rate of Return(IRR)**	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the procedure involved in estimating , costing and tender.
CO2:	Apply the technical knowledge in estimating the quantity of materials required for domesting and industrial electrification process.
CO3:	Design the circuits and sub circuits required for electrifying the commercial and power installation.
CO4:	Design and estimate the transmission lines and substation.

Reference Books	
1	Electrical installation estimating and costing, J.B.Gupta, 8th Edition, S.K Kataria and sons, New Delhi. *ISBN* 10: 8188458996;
2	Electrical Design Estimating and costing, K. Raina, S.K Bhattacharya, New age international, ISBN : 81-224-0363-8, 2005
3	Electrical Wiring Estimating and Costing, Uppal, Khanna Publishers, Delhi, I.E Rules and Act Manuals, ISBN : 8174092404, 9788174092403
4	Elements of Power Station design and practice, M.V. Deshpande, Wheeler Publishers.

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Total CIE is 30(Q) +50(T) +10(A) =100 Marks.

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

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

Low-1 Medium-2 High-3

Semester: VII		
DIGITAL PROTECTION OF POWER SYSTEMS **(Group G: Professional Elective)**		
Course Code:16EE7G3		**CIE Marks:** 100+50
Credits: L:T:P:S: 4:0:0:0		**SEE Marks:** 100+50
Hours: 48L		**SEE Duration:** 03Hrs+03Hrs

Course Learning Objectives: The students will be able to	
1	Describe the basic concept and principles of digital protection of power systems and understand the advance technology used in power system relaying.
2	Analyze the developments in the protection schemes with monitoring and control Understand the role of PMU and WAMS in modern grid systems
3	Evaluate the settings numerical relays for equipment protection in power systems
4	Design the protection of typical equipment in harmony with the smart grid Analyse the different modern protection their characteristics

UNIT-I	**10 Hrs**
Relay Operating Principles: Introduction, detection of faults, elements of protection systems, relay design considerations, International practices **Introduction To Digital Protection:** Development of Digital Protection, Historical background, Expected benefits of computer Relaying, Computer Relay Architecture, Advantages and disadvantages of digital protection, components, control circuits, applications, Logical Structures for digital Protection, Design of Digital protection and Control Devices. Digital filtering techniques.	
UNIT-II	**10 Hrs**
Digital Relaying Algorithms : Discrete Fourier Transform Technique, Removal DC offset, Microprocessor implementation of Digital Distance Relaying Algorithms. **Digital Relays for Synchronous Generators Protection**: Introduction, multifunction protection scheme, differential protection of stator windings, negative sequence protection, under impedance protection, out of set generator protection, over-fluxing detection algorithm.	
UNIT-III	**10 Hrs**
Microprocessor based Protective Relays: Over current Relays, Impedance Relay, Directional Relay, Reactance Relay, Generalised mathematical expression for Distance Relays. Measurement of R and X Mho and offset Mho Relays, Quadrilateral Relay, Generalised interface for distance relaying.	
UNIT-IV	**09 Hrs**
Adaptive Relaying: Introduction, Adaptive Relaying. The Main Approaches to Design and control, case studies. IEC 61850,104 **Introduction to** Phasor measurement units, Wide area monitoring and control, protection of Distribution systems and microgrids	
UNIT-V	**09Hrs**
Developments in new relaying principles: Introduction, travelling waves on single phase lines and three phase lines, differential Relaying with phasors, **Introduction** to substation automation and control, Literature Study, Case Studies.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain the fundamentals of Digital protection. ,microprocessor based and Adaptive relays
CO2	Analyze the operation of digital relays ,microprocessor based and Adaptive relays
CO3	Evaluate the performance of different types of digital protection
CO4	Apply and develop the advanced and new techniques for protection system

Reference Books	
1.	Fundamentals of power system protection, PaithenkarY.G.&BhideS.R, first Edition, Prentice Hall India,2004
2.	Digital Protection of Power Systems K.Parthasarathy, ISTE WPLP Learning Material Series, Indian Society for Technical Education, Bangalore, 2006**.**
3.	Computer Relaying for power system , Arun G Padke& James Thorp, John Wiley & Sons, 2nd Edition, 1995.
4.	Digital power system protection, S R Bhide, Pentice Hall India, Eastern Economical Edition,2014

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

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Total CIE is 30(Q) +50(T) +10(A) =100 Marks.

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

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

High-3: Medium-2: Low-1

Semester: VII		
POWER SYSTEM OPERATION AND CONTROL **(Group G: Professional Elective)**		
Course Code: 16EE7G4		**CIE Marks:** 100
Credits: L:T:P:S 4 :0:0:0		**SEE Marks:** 100
Hours: 48L		**SEE Duration:** 3Hrs

Course Learning Objectives: The students will be able to	
1.	Learn the fundamental principles of operation and control of the power system for reliable operation.
2.	Study the components of SCADA and challenges in applying it to power systems.
3.	Study , understand and compare the different algorithms for unit commitment and hydro-thermal scheduling
4.	Study the effect of tie-line control and frequency bias factors on AGC and develop the state space model for frequency analysis.
5.	Perform a complete contingency analysis and rank the contingencies

UNIT-I	**09 Hrs**
Introduction and SCADA in modern power systems : Operating states of the power system, objectives of control, key concepts of reliable operation, reliable operation, preventive and emergency controls, modern energy management centres, SCADA and its components, SCADA users in power systems, RTUs for power system SCADA, communication channels, challenges of application of SCADA	
UNIT-II	**09 Hrs**
Unit Commitment and hydro-thermal scheduling.: Problem of unit commitment, constraints, enumeration and priority list method, Dynamic programming, Scheduling of hydro-thermal systems ,discrete time interval method, scheduling from energy available, short-term scheduling using γ- λ method, scheduling using penalty factors	
UNIT-III	**10 Hrs**
Automatic Generation Control : Fundamentals of AGC, mathematical model of ALFC, AGC controller, AGC with integral controller, tie-line control, frequency bias-factors, state-space model, implementation of AGC	
UNIT-IV	**10 Hrs**
Voltage And Reactive Power Control: Reactive power, voltage control methods, cost saving, voltage control by reactive power injection, voltage control using transformers, voltage stability, voltage strength and voltage collapse.	
UNIT-V	**10 Hrs**
Power System Security And Contingency Analysis : Functions of security, contingency analysis and factors affecting it, Dc load flow, Generation shift sensitivity factors and line-outage sensitivity factors, contingency ranking, performance indices, 1P1Q method for selection,	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Have a thorough knowledge of the different operating states and the respective control actions available in each of them and the SCADA systems in use.
CO2:	Analyze the techniques used in the power industry for control of frequency and voltage.
CO3:	Provide solution for major operational and control issues during steady state and under contingencies.

CO4:	Design control strategies under different operating conditions
Reference Books	
1.	Power System Operation and Control", K. Uma Rao, Wiley India , 2012, *ISBN* 13, : 9788126534418
2.	Electric power systems, B.M.Weedy, B.J.Cory, John Wiley , 2010, *ISBN*: 9780470682685 ..... *2010*
3.	Power Generation, operation and control, Allen J Wood, B.F. Wollenberg, John Wiley, *ISBN*: 978-0-471-79055-6
4.	Modern Power System Analysis Nagrath, I.J and Kothari D.P., TMH, 3rd Edition, 2003, ISBN : 978-0-07-107775-0.
5.	Advanced power system Analysis and Dynamics, Singh, L.P., New age International (p) Ltd, New Delhi, 4th Edition, 2006, ISBN: 81-224-1732-9

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 50. The marks component for Assignment/Presentation/Project 10.

Total CIE is 30(Q) +50(T) +10(A) =100 Marks.

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

SEE for 100 marksis 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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	1	1	-	1	-	-	2	-	1
CO2	2	2	2	2	2	-	1	-	-	2	-	1
CO3	3	3	2	2	2	-	2	-	-	2	-	1
CO4	3	3	2	2	2	-	2	-	-	2	-	1

High-3: Medium-2: Low-1

Semester: VII						
NANOTECHNOLOGY (Group H: Global Elective)						
Course Code	**:**	16G7H01		**CIE**	**:**	100 Marks
Credits: L:T:P	**:**	3:0:0		**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 systems 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	B.S. Murty., P. Shankar., B.Raj, B..B. Rath, and J. Murday, Textbook of Nanosciences and Nanotechnology, Springer, Co-publication with University Press (India) Pvt. Ltd. VCH, XII.1st Edition, 2013, ISBN- 978-3-642-28030-6.
2	V. K. Khanna, Nanosensors:, Physical, Chemical and Biological, CRC press, 1st Edition, 2013, ISBN 9781439827123 (Unit III).
3	C. C. Kock., Nanostructured materials, Nanostructured materials, William Andrew Publishing, 2nd Edition, 2007, ISBN 0-8155-1534-0.
4	M .Wilson., K. Kannangara., G.Smith., M.Simmons., B. Raguse., Nanotechnology, , 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	**:**	3:0:0		**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	Kirkcaldy K.J.D Chauhan, Functional Safety in the Process Industry : A Handbook of practical Guidance in the application of IEC61511 and ANSI/ISA-84,North corolina, Lulu publication,2012,ISBN:1291187235
2	Goble and William M. Safety Instrumented Systems Verification Practical probabilistic calculations, Pensulvania ISA publication,2005,ISBN:155617909X
3	Laird Wilson and Doug Mc Cutcheon. Industrial safety and risk Management,The University of Alberta press,Canada, 1st Edition,2003,ISBN: 0888643942.
4	Sincero A P and Sincero G A Environmental Engineering – A Design Approach,Prentice

	Hall of India, New Delhi,1996, ISBN: 0024105643
5	Pandya C G, Risks in Chemical units, 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	**:**	**3:0:0**		**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	**8 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	**6 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	**7 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	**7 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	**8 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	Choudury M A and Sadek A, "Fundamentals of Intelligent Transportation Systems Planning" Artech House publishers (31 March 2003); ISBN-10: 1580531601
2	Bob Williams, "Intelligent transportation systems standards" ,Artech House, London, 2008. ISBN-13: 978-1-59693-291-3.
3	Asier Perallos, Unai Hernandez-Jayo, Enrique Onieva, Ignacio Julio García Zuazola "Intelligent Transport Systems: Technologies and Applications" Wiley Publishing ©2015, ISBN:1118894782 9781118894781
4	ITS Hand Book 2000 Recommendations for World Road Association (PIARC) by Kan Paul Chen, John Miles.
5	Dominique Luzeaux ,Jean-René Ruault, Michel Chavret "Intelligent Transport Systems" 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/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 50. The marks component for Assignment/Presentation/Project 10.

Total CIE is 30(Q) +50(T) +10(A) =100 Marks.

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	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	36L		**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**		**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.

Semester: VII						
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	**:**	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, microaccelerometers, 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-Piezoresistors, 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 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 50. The marks component for Assignment/Presentation/Project 10.

Total CIE is 30(Q) +50(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 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	**:**	3:0:0		**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	**:**	3:0:0		**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	Zongwei Luo, Smart Manufacturing Innovation and Transformation: Interconnection And Intelligence, 1st Edition, IGI Global Publications, 2014,ISBN-13: 978-1466658363 ISBN-10: 1466658363
2	Yan Lu. KC Morris, Simon Frechette, 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 G: Global Elective)						
Course Code	**:**	16G7H12		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**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	David C Lay; Linear Algebra and Its Applications; Pearson Education; III Edition; 2003; ISBN: 978-81-775-8333-5.
2	Gareth Williams; Linear Algebra with Applications; 6th edition; 2008; Narosa publications; ISBN: 978-81-7319-981-3.
3	Gilbert Strang; Linear Algebra and Its Applications; IV Edition; Cengage Learning India Edition; 2006; ISBN: 81-315-0172-8.
4	Howard Anton and Chris Rorres; Elementary Linear Algebra Applications Version; 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 G: Global Elective)						
Course Code	**:**	**16G7H13**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**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	

Semester: VII
▪ 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

ENGINEERING MATERIALS FOR ADVANCED TECHNOLOGY (Group H: Global Elective)						
Course Code:	**:**	16G7H14		**CIE**	**:**	100 **Marks**
Credits: L:T:P	**:**	3**: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						
APPLIED PSYCHOLOGY FOR ENGINEERS (Group H: Global Elective)						
Course Code	**:**	**16G7H15**		**CIE**	**:**	**100**
Credits: L:T:P	**:**	3:0:0		**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	**7 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	**7 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	**7 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	**7 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	**7 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.
CO5	Understand the application of psychology in engineering and technology and develop a route to accomplish goals in their work environment.
Reference Books:	
1. . Understanding Psychology Feldman R. S, 4th Edition, (1996) McGraw Hill India	
2. Psychology Robert A. Baron, 3rd 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	
5. Psychology-themes and variations , Wayne Weiten, 4th Edition, Brooks / Cole Publishing Co.	

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.

Scheme of Semester End Examination (SEE): 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						
FOUNDATIONAL COURSE ON ENTREPRENEURSHIP (Group : 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/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 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						
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/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.

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

VIII Semester		
MAJOR PROJECT		
Course Code: 16EE81		**CIE Marks: 100**
Credits: L: T: P: S:: 0:0:16:0		**SEE Marks: 100**
Hrs/week: 32		**SEE Duration: 3 Hrs**
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 programme or any other programme.
- 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%

VIII Semester		
TECHNICAL SEMINAR		
Course Code: 16EE82		**CIE Marks: 50**
Credits: L: T: P: S:: 0:0:2:0		**SEE Marks: 00**
Hrs/week: 4		**SEE Duration: NA**

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%

VIII Semester		
INNOVATION & SOCIAL SKILLS		
Course Code: 16HS83		**CIE Marks: NA**
Credits: L: T: P: S:: 0:0:1:0		**SEE Marks: NA**
Hrs/week: 2		**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

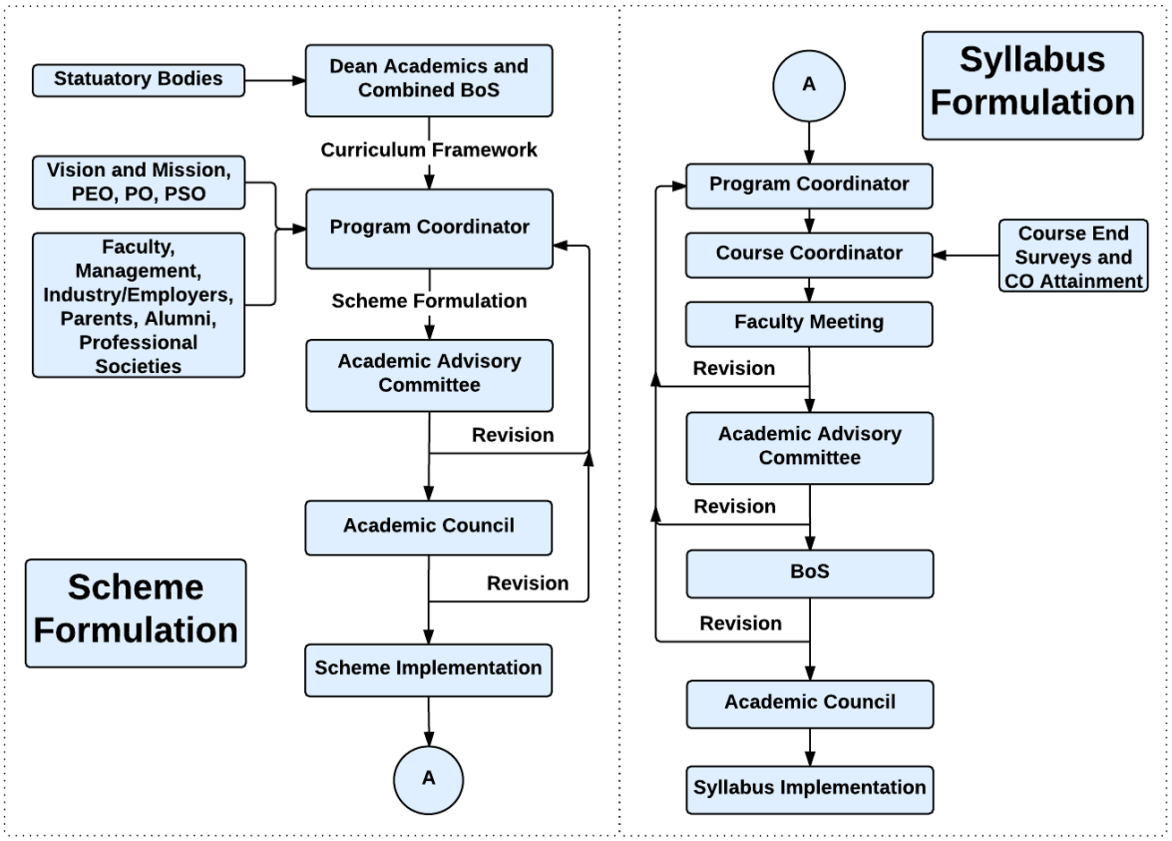
VIII Semester		
INDUSTRIAL TOUR		
Course Code: 16EE84		**CIE Marks: NA**
Credits: L: T: P: S:: 0:0:1:0		**SEE Marks: NA**
Hrs/week: 2		**SEE Duration: NA**

Course Learning Objectives: The students will be able to	
1	To provide a platform for the students to understand different generating, and distribution power stations.
2	To identify the different functional parts of power stations.
3	To understand and analyse the working concept of power generators.
4	To understand the interconnection different power generating stations.

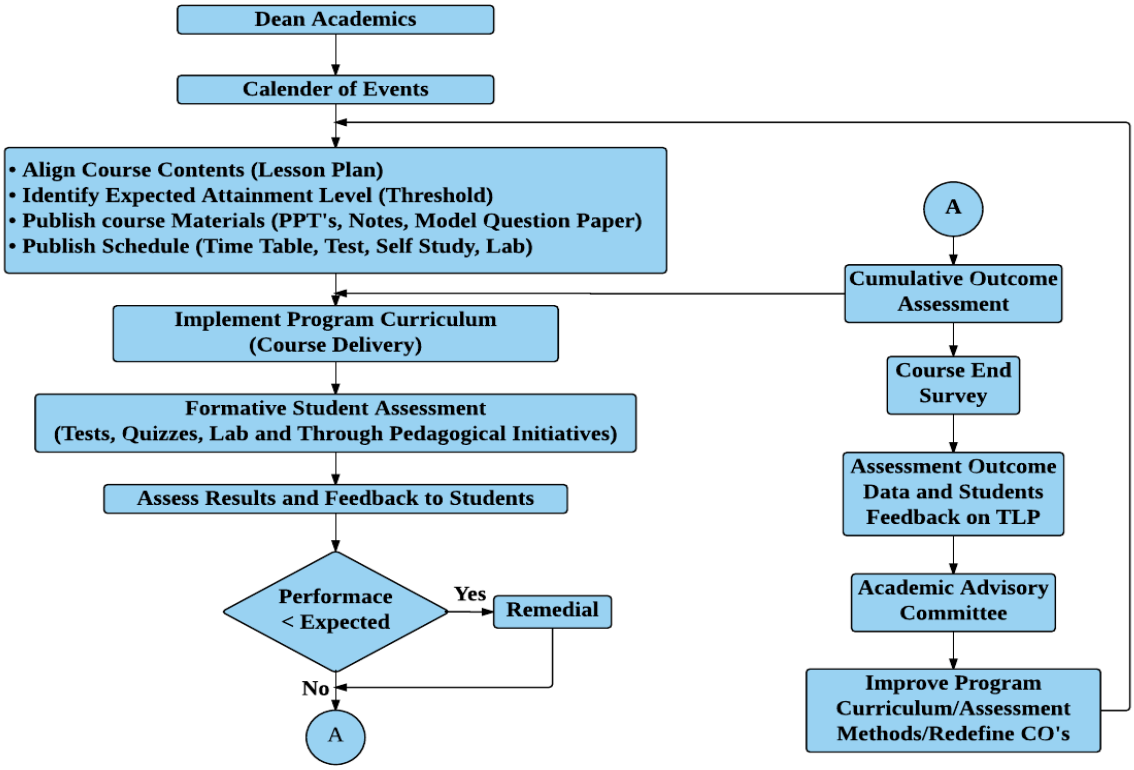
After the completion of 7th semester exam and before commencement of 8th semester, the students of the class have to visit nuclear, hydel, thermal, Solar, wind and diesel power plants. This tour is of 4-5 days duration. Students have to submit report.

Course Outcomes of Industrial Tour:	
1	Analyse economics of power plants and list factors affecting the power plants and interpret the performance of various power plants based on load variations
2	Identify elements and their functions and operations of various power plants.
3	Acquire knowledge and analyse the working concept of various power generators /power plants.
4	Analyse interconnection different power generating stations

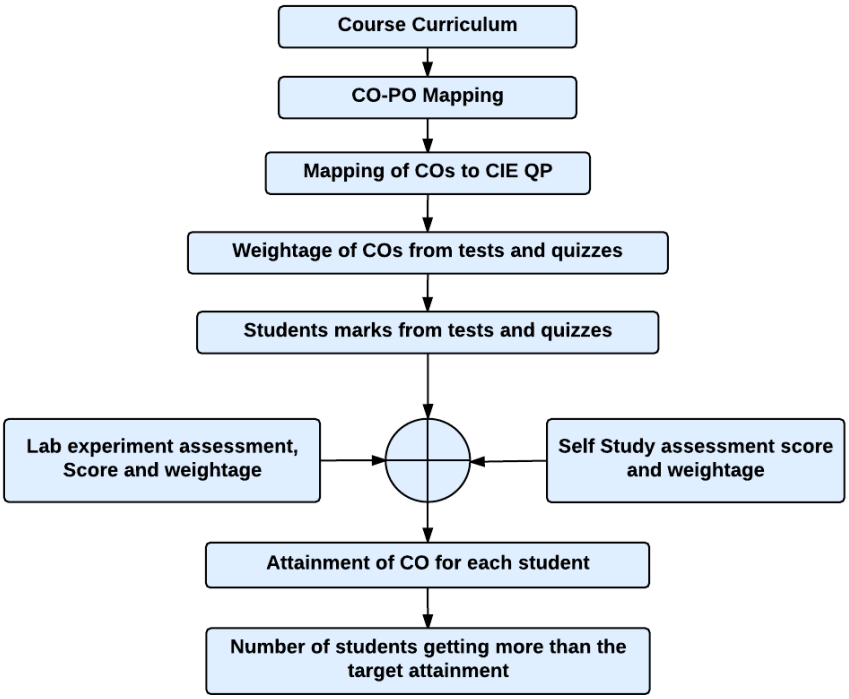
Curriculum Design Process



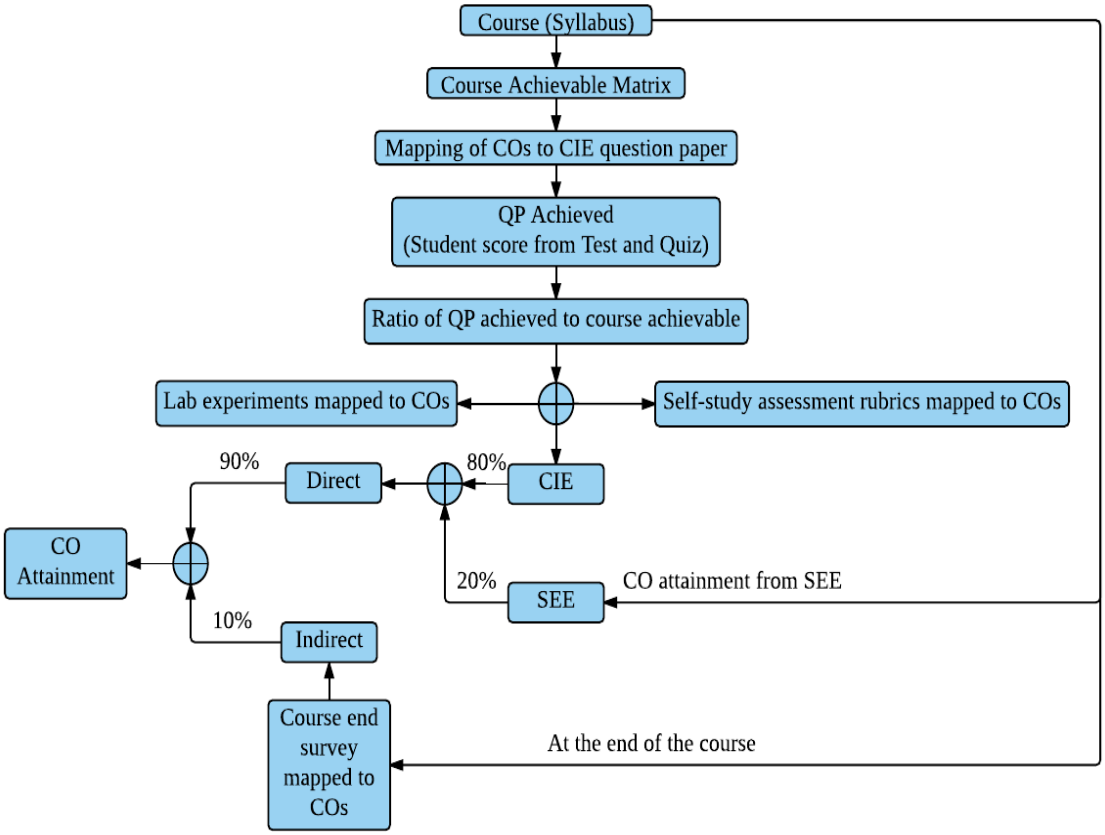
Academic Planning and Implementation



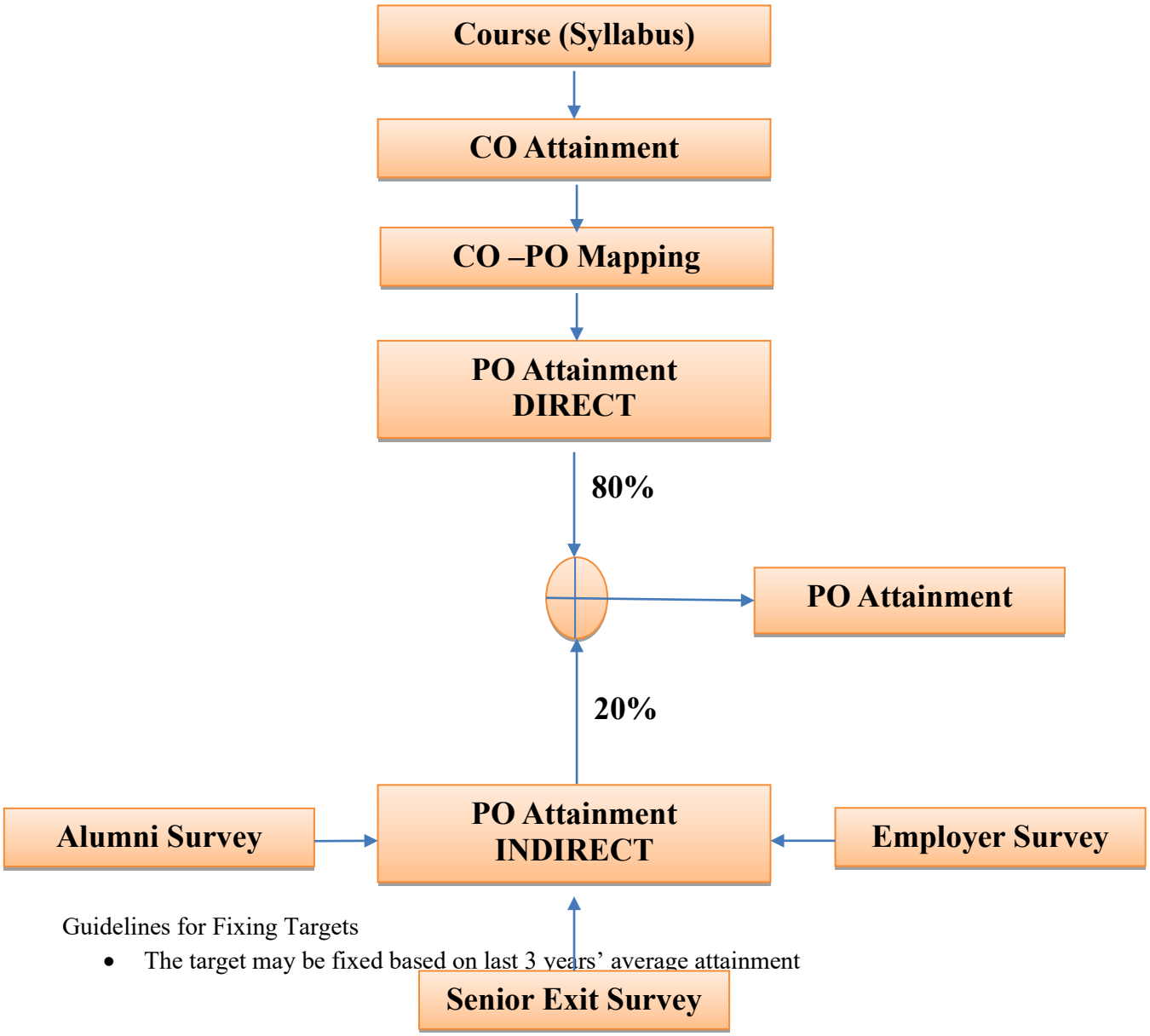
PROCESS FOR COURSE OUTCOME ATTAINMENT



Final CO Attainment Process



Program Outcome Attainment Process



Guidelines for Fixing Targets

- The target may be fixed based on last 3 years' average attainment

PROGRAM OUTCOMES (PO)

PO1: **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: **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.

PO5:**Modern tool usage** : Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6:**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.

PO7**: 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.

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

PO9: **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10:**Communication:** Communicate effectively on complex engineering activities with the engineering community and with 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.

PO11**: 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.

PO12: **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.