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 for VII & VIII Semesters

2016 SCHEME

INDUSTRIAL ENGINEERING AND MANAGEMENT

VISION

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

MISSION

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

QUALITY POLICY

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

CORE VALUES

Professionalism, Commitment, Integrity, Team Work, Innovation

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2016 SCHEME

DEPARTMENT OF

INDUSTRIAL ENGINEERING AND MANAGEMENT

DEPARTMENT VISION

Imparting innovation and value based education in Industrial Engineering and Management for steering organizations to global standards with an emphasis on sustainable and inclusive development.

DEPARTMENT MISSION

- To impart scientific knowledge, engineering and managerial skills for driving organizations to global excellence.
- To promote a culture of training, consultancy, research and entrepreneurship interventions among the students.
- To institute collaborative academic and research exchange programs with national and globally renowned academia, industries and other organizations.
- To establish and nurture centers of excellence in the niche areas of Industrial and Systems Engineering.

PROGRAM EDUCATIONAL OBJECTIVES (PEOS)

PEO1. Conceive, design, implement and operate integrated systems, focus on appropriate measures of performance at strategic, tactical and operational levels.
PEO2. Develop competency to adapt to changing roles for achieving organizational excellence.
PEO3. Design and develop sustainable technologies and solutions for betterment of society.
PEO4. Pursue entrepreneurial venture with a focus on creativity and innovation for developing newer products, processes and systems.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO	Description
PSO1	Design, develop, implement and improve integrated systems that include people, materials, information, equipment and energy.
PSO2	Apply statistical and simulation tools, optimization and meta heuristics techniques for analysis of various systems leading to better decision making.
PSO3	Demonstrate the engineering relationships between the management tasks of planning, organization, leadership, control, and the human element in various sectors of economy.

Lead Society: Institute of Industrial Engineers (IIE)

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 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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INDUSTRIAL ENGINEERING AND MANAGEMENT

SEVENTH SEMESTER CREDIT SCHEME								
Sl. No.	**Course Code**	**Course Title**	**BoS**	**CREDIT ALLOCATION**				**Total Credits**
				Lecture	**Tutorial**	**Practical**	**SS**	
1.	16IM71	Principles of Soft Computing	IM	3	0	0	0	3
2.	16IM72	Financial Accounting and Costing	IM	3	0	0	1	4
3.	16IM73	Product Design and Development	IM	3	0	1	0	4
4.	16IM74	Foundations of Business Analytics	IM	3	1	0	0	4
5.	16IM7FX	Elective F (PE)	IM	4	0	0	0	4
6.	16IM7GX	Elective G(PE)	IM	4	0	0	0	4
7.	16G7HXX	Elective H(GE)*	Respective BoS	3	0	0	0	3
Total number of Credits				**23**	**01**	**01**	**01**	**26**
Number of Hours / Week				**23**	**02**	**2.5**	**04**	

*Students should take other department Open Elective courses;

EIGTH SEMESTER CREDIT SCHEME								
Sl. No.	**Course Code**	**Course Title**	**BoS**	**CREDIT ALLOCATION**				**Total Credits**
				Lecture	**Tutorial**	**Practical**	**SS**	
1.	16IM81	Major Project	IM	0	0	16	0	16
2.	16IM82	Technical Seminar	IM	0	0	2	0	2
3.	16HS83	Innovation and Social Skills	HSS	0	0	2	0	2
Total number of Credits				**00**	**00**	**20**	**00**	**20**
Total Number of Hours / Week				**00**	**00**	**50**	**00**	

**Non contact hours

VII Semester		
GROUP F: PROFESSIONAL ELECTIVES		
Sl. No.	**Course Code**	**Course Title**
1.	16IM7F1	Industry 4.0 – A Growth in Manufacturing
2.	16IM7F2	Retail Supply Chain Management
3.	16IM7F3	Big Data Analytics
4.	16IM7F4	Technology Management
5.	16IM7F5	Supply Chain Technologies
VII Semester		
GROUP G: PROFESSIONAL ELECTIVES		
Sl. No.	**Course Code**	**Course Title**
1.	16IM7G1	Additive Manufacturing Methods
2.	16IM7G2	Lean Manufacturing Systems
3.	16IM7G3	Engineering Optimization
4.	16IM7G4	Energy Management
5.	16IM7G5	Predictive Analytics

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.	TC	16G7H11	Space Technology and Applications
12.	MA	16G7H12	Advanced linear Algebra
13.	PY	16G7H13	Thin Film Nanotechnology
14.	CY	16G7H14	Engineering Materials 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 **PRINCIPLES OF SOFT COMPUTING** **(Theory)**						
Course Code:	**:**	**16IM71**		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S:	**:**	**3:0:0:0**		**SEE**	**:**	**100 Marks**
Hours:	**:**	**33L**		**SEE Duration**	**:**	**02Hrs**

Course Learning Objectives: The students will be able to	
1	To gain insight into the principles and components of soft computing.
2	To learn the unified and exact mathematical basis as well as the general principles of various soft computing techniques.
3	To gain knowledge on fundamentals of non-traditional technologies and approaches to solving hard real-world problems, namely of fundamentals of artificial neural networks, fuzzy sets and fuzzy logic and genetic algorithms.

UNIT-I	**06 Hrs**
Introduction: Intelligent systems, Knowledge based systems, Knowledge representation and processing, Soft computing, problems.	
UNIT-II	**07 Hrs**
Fundamentals of Fuzzy Logic Systems: Introduction, background, fuzzy sets, fuzzy logic operations, generalized fuzzy operations, implication, definitions, fuzziness and fuzzy resolution, fuzzy relations, composition and interference. **Fuzzy logic control:** Introduction, background, basics of fuzzy control, defuzzification, fuzzification, fuzzy control architectures, properties of fuzzy control, robustness and stability.	
UNIT-III	**07 Hrs**
Fundamentals of Artificial Neural Networks: Introduction, learning & acquisition of knowledge, features of artificial neural networks (ANN), fundamentals of connectionist modeling. **Major classes of Neural Networks:** Introduction, the multilayer perceptron, radial basis function network, Kohonen's self organizing network, the Hopfield network., industrial and commercial applications of ANN.	
UNIT-IV	**07 Hrs**
Evolutionary computing: Introduction, overview of evolutionary computing, genetic algorithms (GA) and optimization, the schema theorem, GA operators, integration of GA with neural networks, integration of GA with fuzzy logic, known issues in GA, Population based incremental learning, evolutionary strategies, ES applications.	
UNIT-V	**06 Hrs**
Tools of soft computing in real world applications: Soft computing tools for solving a class of facilities layout planning problem, mobile position estimation using an RBF network in CDMA cellular systems, learning-based resource optimization in ATM networks.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Apply the principles and components of soft computing in solving problems.
CO2:	Develop intelligent systems through case studies, simulation examples and experimental results
CO3:	Develop program systems using approaches of these theories for solving various real-world problems.
CO4:	Evaluate and compare solutions by various soft computing approaches for a given problem.

<table>
<tr><td colspan="2">Reference Books</td></tr>
<tr><td>1.</td><td>Soft Computing and Intelligent Systems Design – Theory Tools and Applications, Fakhreddine O Karray & Clarence De Silva, 2009, PEARSON Education, ISBN: 978-81-317-2324-1.
It is first level course introduced and the units are from the following chapters:
<table>
<tr><td>Unit No</td><td>I</td><td>II</td><td>III</td><td>IV</td><td>V</td></tr>
<tr><td>Chapter No</td><td>1</td><td>2,3</td><td>4,5</td><td>8</td><td>10</td></tr>
</table></td></tr>
<tr><td>2.</td><td>Principles of Soft Computing, S.N. Sivanandam and S.N. Deepa, 1st Edition, 2007, Wiley India (P) Ltd., ISBN: 10:81-265-1075-7.</td></tr>
<tr><td>3.</td><td>Fuzzy and Soft Computing; A Computational Approach to Learning and Machine Intelligence, J S R Jang, C-T Sun, E Mizatani, Neurp, 1997, Prentice Hall, ISBN: 10:0132610663.</td></tr>
<tr><td>4.</td><td>Soft Computing and its Applications, K A Thev & RR Aliev, 2001, World Scientific Publishing Co., Inc. River Edge, NJ, USA, ISBN: 98102 47001.</td></tr>
</table>

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	2											1
CO2		2	2		1			1				
CO3			2						1			
CO4		2		1	1							

Low-1 Medium-2 High-3

Semester: VII						
FINANCIAL ACCOUNTING AND COSTING (Theory)						
Course Code	**:**	**16IM72**		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S	**:**	**3:0:0:1**		**SEE**	**:**	**100 Marks**
Hours	**:**	**33**		**SEE Duration**	**:**	**3Hrs**

Course Learning Objectives: The students will be able to	
1	To introduce the basic tools and techniques required in financial accounting
2	To provide an over view of nature of costing and cost accounting.
3	To give an understanding on activity based costing.

UNIT-I	**07 Hrs**
Financial Accounting: Generally Accepted Accounting Practices (GAAP), difference between financial and cost accounting, Book keeping: double-entry accounting, journal & ledger posting.	
UNIT-II	**07 Hrs**
Financial Statements: Trial balance, preparation of Trading and Profit & Loss account, Balance sheet. (problems with simple adjustments)	
UNIT-III	**07Hrs**
Costing: Objectives of costing, Elements of costing, preparation of cost sheet. **Job Costing:** Introduction, Batch Costing, **Process Costing:** introduction to Process Costing, Cost accumulation in process costing.	
UNIT-IV	**06 Hrs**
Standard Costing: Components of standard cost, Material cost variance, labour cost variance, overhead cost variance.	
UNIT-V	**06 Hrs**
Budgeting: sales budget, production budget, cash budget, flexible budget, master budget, zero based budgeting. Overview on activity based costing, lean accounting and accounting packages.	

Self Study:
Case study, Design and Emerging Technologies to be discussed pertaining to the course. **1 Credit: 4 Hrs / Week**

Course Outcomes: After completing the course, the students will be able to	
CO1.	Define the needs of the various users of accounting data and demonstrate the ability to communicate such data effectively, as well as the ability to provide knowledgeable recommendations.
CO2.	Apply appropriate judgment derived from knowledge of accounting theory, to financial analysis and decision making.
CO3.	Demonstrate an understanding of different accounting methods to evaluate business performance.
CO4.	Define and illustrate various cost terms and concepts and evaluate their relevancy for different decision-making purposes.

Reference Books	
1.	Cost Accounting, Khan M Y, 7th Reprint Edition, 2007, Tata McGraw-Hill, ISBN - 0070402248
2.	Financial Accounting, P.C. Tulsian, 4th Edition, 2009, Person Education, ISBN - 9788177582284.
3.	Handbook of Human Factors and Ergonomics, Gavriel. Salvendy, 3rd Edition, 2006, Wiley, Hoboken, New Jersey, USA, ISBN: 0471116904.
4.	Introduction to Human Factors Engineering, Christopher D. Wickens, John D. Lee, Yili Liu,

	Sallie Gordon-Becker, 2nd Edition, 2003, Pearson Publication, ISBN: 978-0131837362

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 Self Study/Presentation/Project 20. **Total CIE is 30(Q) +50(T) +20(SS) =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	1				1						
CO2	2	1				1						
CO3	1	2	1									
CO4		2		1								

Low-1 Medium-2 High-3

Semester: VII						
PRODUCT DESIGN & DEVELOPMENT (Theory & Practice)						
Course Code	**:**	**16IM73**		**CIE**	**:**	**100 + 50 Marks**
Credits: L:T:P:S	**:**	**3:0:1:0**		**SEE**	**:**	**100 + 50 Marks**
Hours	**:**	**33L**		**SEE Duration**	**:**	**3 + 3 Hrs**

Course Learning Objectives: The students will be able to	
1	To understand the structured product development processes
2	To understand the contributions and role of multiple organizational functions for creating a new product
3	To apply engineering knowledge for the development of innovative and market acceptable products.
4	To expose the tenets of design and development of a manufacturing process that builds the product at the scales and quality as demanded by the customer and the market
5	To develop an ability to coordinate multiple, interdisciplinary tasks in order to achieve the mission and goals of the product development organizations.

UNIT-I	**06 Hrs**
Introduction: Definition of product design, design by evolution, design by innovation, Essential factors of Product design, Characteristics of successful product development, The Morphology of Design (The seven phases), who Designs and develops products, duration and cost of product development, the challenges of product development. **Development Processes and Organizations:** A generic development process, concept development: the front-end process, adapting the generic product development process, the AMF development process, product development organizations, the AMF organization. **Product Planning:** The product planning process, identify opportunities. Product strategies, Analysis of a product, The three S's, Evaluate and prioritize projects, allocate resources and plan timing, complete pre project planning, reflect on the results and the process.	
UNIT-II	**06 Hrs**
Identifying Customer Needs: Gather raw data from customers; interpret raw data in terms of customer needs, organize the needs into a hierarchy, establish the relative importance of the needs and reflect on the results and the process. Quality Function Deployment. **Product Specifications:** What are specifications, Basic design considerations and constraints, Various types of specification, when are specifications established, establishing target Specifications, setting the final specifications. **Concept Generation:** The activity of concept generation, clarify the problem, search Externally, search internally, Benchmarking, explore systematically, reflect on the results and the process.	
UNIT-III	**07 Hrs**
Concept Selection: Overview of methodology, concept screening, concept scoring, caveats. Concept Testing: Define the purpose of concept test, choose a survey population, choose a survey format, communicate the concept, measure customer response, interpret the result, reflect on the results and the process. **Product Architecture:** What is product architecture, implications of the architecture, establishing the architecture, variety and supply chain considerations, platform planning, related system level design issues.	
UNIT-IV	**07 Hrs**
Industrial Design: Assessing the need for industrial design, the impact of industrial design, industrial design process, managing the industrial design process, assessing the quality of industrial design. Problems faced by Industrial design Engineer. **Design for Manufacturing:** Definition, Approach to design, Production Requirements, estimation of manufacturing cost, reducing the cost of components, assembly, supporting production, VCP, Overview of Design for production - Metal parts, Designing with plastics, Rubber,	

ceramics and wood, Impact of DFM & DFX on other factors. Concurrent engineering, reasons for adopting concurrent engineering, factors preventing the adoption of Concurrent engineering.
UNIT-V **07 Hrs**
Prototyping: Prototyping basics, principles of prototyping, technologies, planning for prototypes. **Product Development Economics:** Elements of economic analysis, base case financial mode. Sensitive analysis, project trade-offs, influence of qualitative factors on project success, Qualitative analysis. **Managing Projects:** Understanding and representing task, baseline project planning, Accelerating projects, project execution, post-mortem project evaluation.

Pedagogy or Method of conduction of exercises:
1. Explain the physical principle of working of the unit. 2. Prepare initial sketching of the Component and create a 3d model of the product. 3. Chart out design constraints and considerations. 4. Prepare component and sub-assembly drawings. 5. Identify the material for the component/ sub-assembly based on the requirement. (Reverse Engg)- Tool to be used- Pugh Matrix- Concept scoring and concept screening to be documented. 6. Identify quality parameters, critical to quality and critical to safety parameters and conduct FMEA. 7. List all the standards, codes referred. 8. Prepare Bill of materials for the identified parts. 9. Chart out the manufacturing process and sequence. 10. Prepare quality plan for production.
Exercises:
1. Assembly and Disassembly of a Machine Component. Eg: Engine or tail stock of Lathe etc
2. Assembly and Disassembly of an Electromechanical Component. Eg: Relays, Pumps, Motors, I/O modules, Knobs and Dials etc
3. Assembly and Disassembly of an Electronic component. Eg: Camera, Camcorder, VCR, PLC, Interface IC's, etc
4. Assembly and Disassembly of a Mechatronic component. Eg: Actuators, Sensors, Demo of hybrid car from "ASHWA". Study of electro-pneumatic circuit.
5. Assembly and Disassembly of a Opto-Electronics Eg: Displays, LED Lighting, LED Emitters, Lighting connectors.
6. Plumbing- Experiential learning. Eg: Cistern Pump, Coupling, Elbow, Bushing, Union.
7. Re-design using Rapid Prototyping machine Eg: Replace a worn out part with a newly developed prototype and check for form, fit and function.
8. Bring Your Own Device (BYOD)
9. Any other

Course Outcomes: After completing the course, the students will be able to	
CO1.	Explain the structured approaches to Product design and development projects.
CO2.	Understand the challenges facing product designers and appreciate the need for adapting a development mind set
CO3.	Develop the capability to work in teams and apply the structured product design and development methodologies for solving problems.
CO4.	Analyze the need for integrated product design and process development frameworks.
CO5.	Create product solutions and develop prototypes of concepts generated.
Reference Books	
1.	Product Design and Development, Karl.T.Ulrich, Steven D Eppinger, edition 2009, 2008, Tata McGrawHill, ISBN – 0-07058513-X.

2.	Product Design and Manufacturing, A C Chitale and R C Gupta, 4th Edition, 2007, PHI, ISBN: 9788120333178.
3.	New Product Development, Timjones, 1997, Butterworth Heinmann, Oxford. UCI, ISBN – 0750624273.
4.	Product Design for Manufacture and Assembly, Geoffery Boothroyd, Peter Dewhurst and Winston A Knight, 3rd Edition, 1994, Marcel Dekker Inc, ISBN 0824791762.
5.	Product Design, Kevin Otto and Kristen Wood, 1st Edition, 2001, Pearson Education-, ISBN-10: 0130212717.

Professional societies in Product design domain:

1. Industrial Designers Society of America - IDSA -(http://www.idsa.org/)
2. Product Development and Management Association (PDMA)- (http://www.pdma.org/)
3. Chartered Society of Designers-(https://www.csd.org.uk/)
4. Association of Designers of India (ADI)- (http://www.adi.org.in/)

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

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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 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.

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

Low-1 Medium-2 High-3

Semester: VII						
FOUNDATIONS OF BUSINESS ANALYTICS (Theory)						
Course Code	**:**	**16IM74**		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S	**:**	**3:1:0:0**		**SEE**	**:**	**100 Marks**
Hours	**:**	**36L+26T**		**SEE Duration**	**:**	**3Hrs**

Course Learning Objectives: The students will be able to	
1	Understand the need for using IT tools and the environment for a business to leverage IT
2	Differentiate between OLTP and OLAP systems
3	Specify requirements for data integration and reporting
4	Extract and analyze databases, and create reports
5	Understand the need for using IT tools and the environment for a business to leverage IT

UNIT-I	**08 Hrs**
Business view of IT applications: Core business processes, Purpose of using IT, Characteristics of Internet ready business applications **Types of digital data:** Structured, semi-structured and unstructured data	
UNIT-II	**07 Hrs**
Introduction to OLTP and OLAP: OLTP, OLAP, different architectures, models, OLAP operations, Leveraging ERP data using analytics **Business Intelligence :** Introduction, Definitions and Concepts, Framework, Users, Business intelligence applications	
UNIT-III	**07 Hrs**
Data Integration: ODS, Data warehouse, Mapping & staging, Approaches to integration, Integration Technologies, Data Quality, Data Profiling **Multidimensional data modelling:** Data modelling basics, Modelling Types and techniques, Dimension tables	
UNIT-IV	**08 Hrs**
KPI's and performance management: Terminology, Metrics supply chain, KPI usage in companies **Enterprise reporting:** Reporting perspectives, Presentation and practices, Balanced score card, Dashboards, Funnel analysis, Distribution Channel analysis, Performance analysis	
UNIT-V	**06 Hrs**
Business Intelligence trends: Business intelligence and mobility, Business intelligence and cloud computing, Business intelligence for ERP systems, Social CRM and Business Intelligence	

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain the need for data integration, extraction and reporting
CO2	Extract data from varied sources and integrate
CO3	Analyze data using data handling tools
CO4	Create enterprise reports for the purposes of monitoring.

Reference Books	
1.	Fundamentals of Business Analytics, R N Prasad, Seema Acharya, 2nd edition, 2016, Wiley India Pvt Ltd, ISBN: 9788126563791, 8126563796
2.	Decision Support Systems and Intelligent Systems, Efraim Turban, Jay Aronson, 6th Edition, 2001, Pearson Education Asia, ISBN: 81 7808 367 1
3.	Business Analytics, James Evans, 2nd edition, Pearson, ISBN: 9789332582095, 9332582092
4.	Introduction to Business Analytics Using Simulation, Jonathan P. Pinder, Elsevier, 2016, ISBN: 0128104848, 9780128104842

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

Low-1 Medium-2 High-3

Semester: VII						
Industry 4.0 – A Growth in Manufacturing (Group F : Professional Elective)						
Course Code:	**:**	**16IM7F1**		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S:	**:**	**4:0:0:0**		**SEE**	**:**	**100 Marks**
Hours:	**:**	**44L**		**SEE Duration**	**:**	**3Hrs**

Course Learning Objectives: The students will be able to	
1	Realize about what is Industry 4.0 – A Growth in Manufacturing and its importance for today's Manufacturing industry
2	Learn the various components of Industry 4.0 in Manufacturing
3	Explore the future trends in Project Portfolio Selection for the Digital Transformation Era in manufacturing and service sectors.
4	Awareness of the latest manufacturing trends of Industry 4.0 in manufacturing.

Unit – I	**10 Hrs**
Understanding Industry 4.0: A Conceptual Framework for Industry 4.0, Introduction, Main Concepts and Components of Industry 4.0, State of Art, Supportive Technologies and Proposed Framework for Industry 4.0. **Key Business Model Components of Smart and Connected Products:** Proposed Framework, Value Proposition, IoT Value Creation Layers and Technologies.	
Unit – II	**09 Hrs**
Lean Production Systems for Industry 4.0: Introduction, Literature Review, The Proposed Methodology, Automation Based Lean Production Applications. **Maturity and Readiness Model for Industry 4.0 Strategy:** Existing Industry 4.0 Maturity and Readiness Models, IMPULS—Industry 4.0 Readiness, Industry 4.0/Digital Operations Self-Assessment, The Connected Enterprise Maturity Model, Comparison of Existing Industry 4.0 Maturity and Readiness Models, Proposed Industry 4.0 Maturity Model, An Application in Retail Sector.	
Unit – III	**09 Hrs**
Technology Roadmap for Industry 4.0: Proposed Framework for Technology Roadmap, Strategy Phase, New Product and Process Development Phase. **Project Portfolio Selection for the Digital Transformation Era:** Project Portfolio Optimization Model, Application. **Talent Development for Industry 4.0:** Skill Requirements in the Digital World, Talent Development Practices for Industry 4.0.	
Unit – IV	**08 Hrs**
Data Analytics in Manufacturing: Consumption in Manufacturing, Quality Prediction, Estimation of Manufacturing Cost of components, Internet of Things and New Value Proposition, 4 IoTs Value Creation Barriers: Standards, Security and Privacy Concerns, Privacy concerns, Standardization. **Advances in Robotics in the Era of Industry 4.0:** Recent Technological Components of Robots, Advanced Sensor Technologies, Cloud Robotics, Industrial Robotic Applications, Maintenance and Assembly.	
Unit-V	**08 Hrs**
Additive Manufacturing Technologies and Applications: Stereo lithography, Fused Deposition Modeling, Selective Laser Sintering, Laminated Object Manufacturing, Application Areas of Additive Manufacturing, Laser Engineered Net Shaping, Advantages of Additive Manufacturing, Disadvantages of Additive Manufacturing.	

Course Outcomes: After completing the course, the students will be able to	
CO1.	Understand the fundamental concepts of Industry 4.0 related to manufacturing
CO2.	Analyze Lean Production Systems for Industry 4.0 and Maturity and Readiness Model for Industry 4.0
CO3.	Evaluate the different components of Industry 4.0 Manufacturing systems.

CO4.	Elucidate different aspects of Data Analytics, Advances in Robotics in the Era of Additive Manufacturing Technologies and Applications used in Industry 4.0

Reference Books	
1.	Industry 4.0: Managing The Digital Transformation, Ustundag, Alp, Cevikcan, Emre, ISBN 978-3-319-57870-5, http://www.springer.com/978-3-319-57869-9
2.	Industry 4.0: The Industrial Internet of Things, Alasdair GILCHRIST, ISBN 978-1-4842-2047-4, http://www.springer.com/978-3-319-57869-9
3.	The Concept Industry 4.0-An Empirical Analysis of Technologies and Applications in Production Logistics, Bartodziej, Christoph Jan, 2017,Springer Gabler, ISBN 978-3-658-16502-4
4.	Industry 4.0: Entrepreneurship and Structural Change in the New Digital Landscape, Devezas, Tessaleno, Leitão, João, Sarygulov, Askar (Eds.), 2017, Springer, ISBN 978-3-319-49604-7

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

Low-1 Medium-2 High-3

Semester: VII						
RETAIL SUPPLY CHAIN MANAGEMENT **(Group F: Professional Elective)**						
Course Code	**:**	**16IM7F2**		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S	**:**	**4:0:0:0**		**SEE**	**:**	**100 Marks**
Hours	**:**	**44L**		**SEE Duration**	**:**	**3Hrs**
Course Learning Objectives: The students will be able to						
1	To explain the concepts and drivers of the retail supply chain.					
2	To identify the market need and market value to customers in retail supply chains.					
3	To apply tools and techniques for improving the retail supply chain processes.					
4	To evaluate and select among alternate retail formats for various applications.					

UNIT-I	**09 Hrs**
An Overview of Strategic Retail Management : Supply Chain: An Introduction to Retailing, Reasons for studying Retailing, Special characteristics of retailing, Importance of developing and applying a retail strategy, The Retail concept, **Case Studies** Building and Sustaining Relationships in Retailing Building and Sustaining Relationships in Retailing, Value and Value chain, Retailer relationships, Differences in relationship building between Goods and service retailers, Technology and relationships in retailing, Ethical performance and relationships in retailing	
UNIT-II	**09 Hrs**
Strategic Planning in Retailing, Situation Analysis, Ownership and management alternatives, Goods/service category, Personal abilities, Financial resources, Time demands, Objectives, Sales, Profit, Satisfaction of publics, Image, Selection of objectives Identification of consumer characteristics and need, Overall strategy, controllable variables, Integrating overall strategy specific activities, control, feedback, **Case Studies** Situation Analysis: Retail Institutions by Ownership , Independent, Chain, Franchising, Leased Department, Vertical Marketing System, Consumer Cooperative, Horizontal Marketing System, Retail Institutions by Store-Based Strategy Mix, Considerations in planning a retail strategy mix, the wheel of retailing, scrambled merchandising, retail life cycle, mergers, cost containment, rural retailing in India, Web, Nonstore-Based, and Other Forms of Nontraditional Retailing, Web Nonstore based, and other forms of non traditional retailing, Direct marketing, Domain of direct marketing, customer data base, key issues, steps in a direct marketing strategy, Vending Macines, Electronic retailing, emergence of world wide web, role of web, scope of web retailing, factors to consider, examples **Case Studies**	
UNIT-III	**08 Hrs**
Targeting Customers and Gathering Information: Identifying and Understanding Consumers, Consumer Demographics and lifestyles, Consumer needs and desires, Shopping attitudes and behavior, Retailer actions, Environmental factors, Information Gathering and Processing in Retailing, Information flows, Avoiding retail strategies based on inadequate information, Retail information system, Market research **Case Studies** Choosing a Store Location: Trading-Area Analysis, Use of geographic Information systems, Size and shape, Characteristics of Trading areas, Population, Economic base characteristics, nature of competition, Site location Managing a Retail Business: Retail Organization and Human Resource Management, Setting up a retail organization, Specifying tasks to be performed, dividing tasks among channel members and customers, grouping tasks into jobs, classifying jobs, developing an organization chart	
UNIT-IV	**09 Hrs**
Merchandising Management and pricing: Developing Merchandise plans, Merchandising philosophy, Busing Organization formats and processes, level of formality, Degree of centralization, Organizational breadth, Personnel Resources, Functions performed Devising Merchandising Plans, Category Management, Softwares Implementing Merchandise Plans: Gathering Information, Selection and interaction, Evaluation,	

Negotiation, Conclusion, Receipt and Stocking, Reordering, Re-evaluation, Logistics, Performance Goals, Supply Chain Management, Ordering Processing and Fulfillment, Transportation and Warehousing, Customer Transactions and customer service, Inventory management, Retailer tasks, Inventory levels, Security, Reverse logistics, Inventory analysis
UNIT-V **09Hrs**
Pricing in Retailing: External factors affecting a retail price strategy, consumer and retail pricing, government and retail pricing, Manufacturers, wholesalers, competition and retail pricing, Developing a retail price strategy, Retail Objectives and pricing, Broad price policy, Price strategy, Implementation, Price adjustments, **Case Studies** Putting it all together: Integrating and Controlling the Retail Strategy, Planning procedures and Opportunity Analysis, Defining Productivity in a manner consistent with the strategy, Performance measures, Scenario Analysis, **Case Studies**

Course Outcomes: After completing the course, the students will be able to	
CO1.	Explain the building blocks of a typical retail supply chain.
CO2.	Understand the functionalities of retail supply chain processes.
CO3.	Analyze various types and formats of retail supply chains.

Reference Books	
1.	Retail Management: A Strategic Approach, Barry Berman, Joel R. Evans and Mini Mathur, 11th Edn, 2011, Pearson Education, ISBN - 9788131733769,
2.	Supply Chain Management for Retailing, Rajesh Ray, 2009, Tata McGraw Hill, ISBN : 978-0-07-014504-7
3.	Retail Supply Chain Management, James B Ayers, Mary Ann Odegaard, 1st Edition, 2007, Auerbach publications, ISBN:978-0-8493-9052-4
4.	Retail Supply Chain Management, quantitative models and empirical studies, NarendraAgarwal, Stephen A.Smith, 2009, Springer publications, ISBN:978-0-387-78902-6

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

Low-1 Medium-2 High-3

Semester: VII						
BIG DATA ANALYTICS (Group F : Professional Elective)						
Course Code	**:**	**16IM7F3**		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S	**:**	**4: 0: 0: 0**		**SEE**	**:**	**100 Marks**
Hours	**:**	**44L**		**SEE Duration**	**:**	**3Hrs**

Course Learning Objectives: The students will be able to	
1	Define big data for business intelligence
2	Analyze business case studies for big data analytics
3	Explain managing of Big data Without SQL
4	Develop map-reduce analytics using Hadoop and related tools

UNIT-I	**10 Hrs**
UNDERSTANDING BIG DATA: What is big data, why big data, Data Storage and Analysis, Comparison with Other Systems, Rational Database Management System , Grid Computing, Volunteer Computing, convergence of key trends – unstructured data – industry examples of big data – web analytics – big data and marketing – fraud and big data – risk and big data – credit risk management – big data and algorithmic trading – big data and healthcare – big data in medicine – advertising and big data – big data technologies – introduction to Hadoop – open source technologies – cloud and big data – mobile business intelligence	
UNIT-II	**10 Hrs**
NOSQL DATA MANAGEMENT: Introduction to NoSQL – aggregate data models – aggregates – key-value and document data models – relationships – graph databases – schema less databases – materialized views – distribution models – shading — version – map reduce – partitioning and combining – composingmap-reduce calculation	
UNIT-III	**08 Hrs**
BASICS OF HADOOP: Data format – analyzing data with Hadoop – scaling out – Hadoop streaming – Hadoop pipes – design of Hadoop distributed file system (HDFS) – HDFS concepts – Java interface – data flow – Hadoop I/O – data integrity – compression – serialization	
UNIT-IV	**08 Hrs**
MAPREDUCE APPLICATIONS: MapReduce workflows – unit tests with MRUnit – test data and local tests – anatomy of MapReduce job run – classic Map-reduce – YARN – job scheduling – shuffle and sort – task execution – MapReduce types – input formats – output formats	
UNIT-V	**08 Hrs**
HADOOP RELATED TOOLS: Hbase – data model and implementations – Hbase clients – Hbase examples –praxis. Cassandra – Cassandra data model – Cassandra examples – Cassandra clients – Hadoop integration. Pig – Grunt – pig data model. Hive – data types and file formats – HiveQL data definition – HiveQL data manipulation – HiveQL queries.	

Course Outcomes: After completing the course, the students will be able to	
CO1.	Describe big data and use cases from selected business domains and explain NoSQL big data management
CO2.	Install, configure, and run Hadoop and HDFS
CO3.	Perform map reduce analytics using Hadoop
CO4.	Analyze big data using Hadoop related tools such as HBase, Cassandra, Pig, and Hive

Reference Books	
1.	Hadoop: The Definitive Guide, Tom White, 3rd Edition, 2012, O'Reilley, ISBN-13: 978-1449311520
2.	Hadoop Operations, Eric Sammer, 2nd Edition, 2015, O'Reilley, ISBN-13: 978-1491923832
3.	Big data analytics with R and Hadoop, Vignesh Prajapati, 2013, Packt Publishing Limited, **ISBN-13:** 978-1782163282
4.	HBase: The Definitive Guide, Lars George, 2nd Edition, 2017, O'Reilley, ISBN-13: 978-

	1491905852
5.	Programming Pig**:** Dataflow Scripting with Hadoop, Alan Gates and Daniel Dai, 2nd Edition, 2016, Shroff Publishers & Distributors Pvt. Ltd., **ISBN-13:** 978-9352134885

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

Low-1 Medium-2 High-3

Semester: VII						
TECHNOLOGY MANAGEMENT (Group F : Professional Elective)						
Course Code	**:**	**116IM7F4**		**CIE**	**:**	**100 Marks**
Credits:L:T:P:S	**:**	**4: 0: 0:0**		**SEE**	**:**	**100 Marks**
Hours	**:**	**44L**		**SEE Duration**	**:**	**3Hrs**

Course Learning Objectives: The students will be able to	
1	Explain the concepts and meaning of technology with an emphasis on Technology as a commodity.
2	Identify the challenges in adoption of new technology.

UNIT-I	**09 Hrs**
The Concept of Technology: Introduction, The nature of knowledge, Aspects of classification, Concept and Meaning of technology, the character of a specific technology, Scope of technology, Levels of technology, technology portfolios, technology as an environment.	
UNIT-II	**09 Hrs**
The Nature of Technological Change: Introduction, Meaning of technological change, Concept of invention, Nature of innovation, Emergence of new technologies, Life cycle of a technology, Motivation for technological change, Nature of technological progress, Nature of mature technology, Nature of diffusion, Technological convergence.	
UNIT-III	**08 Hrs**
The Economics of Technology: Introduction, Meaning of technological economics, Examples of technological economics, Scope of technological economics, Engineering economics, Production economics, Concept of economy of scale, Concept of optimum size, technology as a commodity, technology at the macro-economic level.	
UNIT-IV	**08 Hrs**
Corporate Technology Strategy: Introduction, The business mission, Where is the business? Concept of business strategy, Capability for strategic planning, Corporate technology strategy, Competitive technology, Focus of strategy, technological alliances, Realization of strategy, technology crisis.	
UNIT-V	**10 Hrs**
Technology an Instrument of Competition: Introduction, Securing competitive advantage, Technological competition analysis, Technological leadership, Adoption of new technology, marketing a new technology product, Retention of competitive advantages. **Concurrent Engineering** –Introduction, Basic principles, components of CE models, Benefits, co-operative concurrent teams, Types of CE organisations.	

Course Outcomes: After completing the course, the students will be able to	
CO1.	Explain the nature of technological change and its life cycle.
CO2.	Apply skills necessary to analyze challenges in adoption of new technology.
CO3.	Evaluate the importance of Economics in technology assessment and related strategies in various industries.
CO4.	Select relevant technologies and plan for execution.

Reference Books	
1.	The Management Of Technology – Perceptions & Opportunities, Paul Lowe, 1995, Chapman & Hall, London.
2.	Strategic Management of Technology, Frederick Betz, 1993, McGraw- Hill Inc.
3.	Management of Technology & Innovation**:** Competing Through Technological Excellence, 1995, Rastogi, P. N , Sage Publications.
4.	Concurrent Engineering – Shortening Lead Times, Raising Quality & Lowering Costs, Hartely R John, 1998, Productivity Press, Portland, Oregon ISBN – 1563271893.

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

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

Low-1 Medium-2 High-3

Semester: VII						
SUPPLY CHAIN TECHNOLOGIES **(Group F : Professional Elective)**						
Course Code	**:**	**16IM7F5**		**CIE**	**:**	**100 Marks**
Credits:L:T:P:S	**:**	**4:0:0:0**		**SEE**	**:**	**100 Marks**
Hours	**:**	**45L**		**SEE Duration**	**:**	**3Hrs**
Course Learning Objectives: The students will be able to						
1	Describe systems available to give support to Supply chain Information Systems support, demonstrating key tasks with Analytical techniques support.					
2	Understand the foundations of Supply Chain Technologies, and their contribution in institutionalizing Industry best practices.					
3	Explore the full array of technology tools to assist in the management of every business activity from Manufacturing to transaction control, to internet based trade and commerce.					

UNIT-I	**09 Hrs**
Lean Supply Chain and Technology: A Perfect Combination, How Big an Opportunity Is It, The Extended and Often Global Supply Chain and Technology, Information Systems (IS) Versus Information Technology (IT), Risks and Rewards, Linking Competitive Strategy to the Value Chain, Competitive Strategy, Business Processes, and IT Structure Aligned Software and Hardware Sourcing Process and Applications of Supply Chain and Logistics Management Technology, The Procurement Process, Identify and Review Requirements, Software and Hardware Selection, Implementation Partner/VAR Selection, Make or Buy, SCM System Costs and Options, "Best-in-Class" Versus Single Integrated Solution, Consultants, Project Management, Supply Chain Software Market, Supply Chain Planning (SCP), Supply Chain Execution (SCE), Other Supply Chain Technologies, Emerging Supply Chain Technology Trends	
UNIT-II	**09 Hrs**
PLAN: Supply Chain Network Optimization, Strategic Planning Level, Tactical Planning Level, Operational Planning, Demand Forecasting Systems, A Lean Approach to Forecasting, Typical Forecasting Process, Forecasting Technology Options and Requirements, Lean Forecasting Technology Case Studies, Sales and Operations Planning (S&OP), OP/Aggregate Planning Technology, Lean S&OP/Aggregate Planning and Technology Case Studies **SOURCE:** Material Requirements Planning (MRP), Procurement and Purchasing Defined, The Purchasing Process, Types of Business Purchasing, Material Requirements Planning Technology, Lean MRP and Technology Case Studies, Procurement (and e-Procurement) Systems, The Procurement Process, Automation of Procurement Documents and Processes Procurement Technology	
UNIT-III	**09 Hrs**
MAKE: Enterprise Resource Planning (ERP) Systems, Manufacturing Execution Systems (MES), The Role of MES in Today's Competitive Environment, Manufacturing Execution Systems and Lean, MES, Lean, and Visual Management Systems, Lean Supply Chain and Manufacturing Execution Systems Case Studies Advanced Planning and Scheduling (APS) Systems, Advanced Planning and Scheduling Systems Technology, Advanced Planning and Scheduling Systems Technology Case Studies **DELIVER:** Distribution Requirements Planning (DRP), DRP Software, DRP Case Studies, Transportation Management Systems (TMS), Transportation Management System Technology, TMS Case Studies, Order-Fulfillment Systems, Warehouse Management System (WMS), Order Management Systems (OMS), Customer Relationship Management (CRM) Systems, Lean and Order Fulfillment , Order Fulfillment Case Studies	
UNIT-IV	**09 Hrs**
RETURN: Reverse Logistics Systems, Lean Reverse Logistics, Elements Key to a Lean Reverse Logistics Process, Lean and Reverse Logistics Technology Cases **ENABLE:** Measurements, Metrics, and Analytics, Measurement and Analysis Process, What and Where to Measure, Using the SCOR Model to Measure and Control, Supply Chain Analytics, Supply	

Chain Decision Support and Analytics Technology, Lean and Supply Chain Analytics Technology Case Studies	
UNIT-V	**09 Hrs**
FUTURE TRENDS: Collaborative Supply Chain Systems, The 80/20 Rule, Collaboration for a Lean Supply Chain, Integrated and Collaborative Technology for a Leaner Supply Chain, Lean and Collaboration Technology Case Studies, Emerging Technologies and Their Potential Impacts on the Lean Supply Chain, General Supply Chain Trends, Supply Chain Software and Connectivity Technology Trends, Supply Chain Software Best Practices Supply Chain Hardware Technology Trends, Hardware Technologies for a Competitive Advantage in the Next Decade, Future Supply Chain Technology Spending, Looking Ahead	

Course Outcomes: After completing the course, the students will be able to	
CO1.	Explain in detail how Supply chain processes are combined with technologies to provides complete end to end solutions in line with Industry best practices
CO2.	Understand and assess the fusion of best practices with development in technologies to solve problems for Industry on a mass scale.
CO3.	Analyze the future course of development of Supply Chain Technologies in line with the latest solutions to business problems and assess their impact.

Reference Books	
1.	Lean and Technology: Working Hand in Hand to Enable and Energize Your Global Supply Chain Paul A. Myerson, Published Oct 27, 2016 by Pearson FT Press. Part of the FT Press Operations Management series.
2.	Introduction to Supply Chain Management Technologies, David Frederick Ross, 2nd Edition CRC Press Taylor & Francis Croup Boca Raton London New York.
3.	Supply Chain Information Technology, David Olson, 2012, Business Expert Express
4.	The Global Supply Chain: How Technology and Circular Thinking Transform Our Future, Wolfgang Lehmacher, 2017, Springer, ISBN 9783319511146

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

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

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

Low-1 Medium-2 High-3

Semester: VII						
ADDITIVE MANUFACTURING METHODS (Group G: Professional Elective)						
Course Code	**:**	**16IM7G1**		**CIE**	**:**	**100 Marks**
Credits :L:T:P:S	**:**	**4:0:0:0**		**SEE**	**:**	**100 Marks**
Hours	**:**	**44L**		**SEE Duration**	**:**	**3Hrs**
Course Learning Objectives:						
1	Explain different prototyping techniques and solutions.					
2	Contrast and enumerate advantages from different prototyping solutions					

Unit-I	**09 Hrs**
Introduction: Definition of Prototype, Types of prototype, Need for the compression in product development, History of RP systems, classification of RP systems, Process Chain of RP.	
UNIT-II	**09 Hrs**
Liquid Based Rapid Prototyping System: Stereo lithography Systems - Principle, process specification & materials, advantages and disadvantages. **Rapid Freeze Prototyping:** Principle, process specification & materials, advantages and disadvantages.	
UNIT-III	**09 Hrs**
Solid Based Rapid Prototyping System: Fused Deposition Modeling (FDM): Principle, Process specification & materials, advantages and disadvantages. **Laminated Object Manufacturing (LOM):** Principle, LOM specification & materials, advantages and disadvantages. **3D System's Multi-Jet Modelling System (MJM):** Principle, process specification & advantages and disadvantages.	
UNIT-IV	**09 Hrs**
Powder Based Rapid Prototyping System: Selective Laser Sintering (SLS): Principle of operation, process parameters, advantages and disadvantages. **Laser Engineering Net Shaping (LENS):** Principle of operation, process parameters, advantages and disadvantages. **3-D Printer:** Principle of operation, process parameters, advantages and disadvantages.	
UNIT-V	**08 Hrs**
Rapid Prototyping Data Formats & Applications: Data Formats, STL Format, STL file problems, consequences of building valid and invalid tessellated models, STL file repair. Applications: Material Relationship, finishing processes, Design, Manufacturing and Tooling, automotive Industry, Jeweler Industry, Coin Industry, Tableware Industry, Arts and architecture.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Explain the basic principles and methodology of various additive manufacturing processes that are used for the production of mechanical parts and products.
CO2:	Compare and contrast the advantages and limitations of different additive manufacturing processes
CO3:	Solve the problems on processing time and economics of processing of material with respect to an additive manufacturing process.
CO4:	Apply the design concept of various additive manufacturing processes when a specific product has to be manufactured.

Reference Books	
1	Rapid Prototyping Principles and Applications, C.K.Chua,K.F.Leong C.S Lim, 3rd Edition, 2010, Cambridge University Press India Pvt. Ltd., ISBN:13:978-81-7596-778-6
2	Rapid Manufacturing, Pham D.T & Dinjoy S.S, 2001, Verlog London.
3	Wohler's Report 2000, Terry Wohler's, 2000, Wohler's Association.
4	Additive Manufacturing Technologies - 3D Printing, Rapid Prototyping & Direct Digital

	Manufacturing, Ian Gibson, David Rosen, Brent Stucker, 2nd Edition 2014, Springer, ISBN: 978-1-4939-2112-6

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	1											
CO2	2								2			
CO3		2		2								
CO4		1			1	1		1			1	

High-3 : Medium-2 : Low-1

Semester: VII						
LEAN MANUFACTURING SYSTEMS (Group G: Professional Elective)						
Course Code	**:**	**16IM7G2**		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S	**:**	**4:0:0:0**		**SEE**	**:**	**100 Marks**
Hours	**:**	**44L**		**SEE Duration**	**:**	**3Hrs**

Course Learning Objectives: The students will be able to	
1	Explain the practices of lean manufacturing in Toyota production system
2	Implement lean in different projects.

UNIT-I	**09 Hrs**
Lean Manufacturing and the Toyota Production System: Definition of Lean, Ohno's thought about the Toyota Production System, The TPS and Lean Manufacturing Defined, The Two Pillars of the TPS, Several Revolutionary Concepts in the TPS, The TPS Is Not a Complete Manufacturing System, Where Lean Will Not Work… or Not Work Quite so Well.	
UNIT – II	**09 Hrs**
Inventory and Variation: Background, Need of the Inventory, disadvantages of Inventory, About Variation, Buffers, Kanban, Kanban Calculations, Finished Goods Inventory Calculations, Kanban Calculations, Make-to-Stock versus Make-to-Order Production Systems **Lean Manufacturing:** The Philosophy and Objectives, the Foundation of Quality Control, Quantity Control	
UNIT – III	**09 Hrs**
The Significance of Lead Time: History of Lead Time, Benefits of Lead-Time Reductions, Lead-Time Reductions, Techniques to Reduce Lead Times **How to Do Lean—Cultural Change Fundamentals:** Three Fundamental Issues of Cultural Change, Some Cultural Aspects of a Lean Implementation **How to Do Lean—the Four Strategies to Becoming Lean:** Overview of the Lean Implementation Strategies, Implementing Lean Strategies on the Production Line	
UNIT – IV	**09 Hrs**
How to Implement Lean—The Prescription for the Lean Project: An Overview on How to Implement Lean and steps: Assess the Three Fundamental Issues to Cultural Change, Complete a System wide Evaluation of the Present State, Perform an Educational Evaluation, Document the Current Condition, Redesign to Reduce Wastes, Evaluate and Determine the Goals for the Line, Implement the Kaizen Activities, Evaluate the Newly Formed Present State, Stress the System.	
UNIT – V	**08 Hrs**
Planning and Goals: Hoshin–Kanri Planning, importance of Goals and Goal Deployment, Policy Deployment, Leadership in Goal Development and Deployment. **Sustaining the Gains:** Importance of Sustaining the Gains, existence of Process gain and loss.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain the principles of Lean and Toyota Manufacturing systems.
CO2	Appreciate the utility and capability of Lean thinking.
CO3	Apply the tools in lean manufacturing to analyse a manufacturing system and plan for its improvements.
CO4	Develop the skills to implement lean manufacturing in industry and manage the change process to achieve continuous improvement of efficiency and productivity.

Reference Books	
1.	How to Implement Lean Manufacturing, Lonnie Wilson, The McGraw-Hill Companies, ISBN: 978-0-07-162508-1.

2.	REENGINEERING THE CORPORATION, A Manifesto for Business Revolution, Michael Hammer & James Champy, Harper Business Essentials
3.	The Toyota Way, Jeffrey K. Liker, The McGraw-Hill Companies, ISBN-10:0-07-058747-7.
4.	Just In Time Manufacturing, M.G. Korgaonker, 2006, Macmillan India Ltd., ISBN: 0333 926633.

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

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

High-3 : Medium-2 : Low-1

Semester: VII						
ENGINEERING OPTIMIZATION (Group G: Professional Elective)						
Course Code	**:**	**16IM7G3**		**CIE**	**:**	**100 Marks**
Hrs/Week: L:T:P:S	**:**	**4:0:0:0**		**SEE**	**:**	**100 Marks**
Credits	**:**	**44L**		**SEE Duration**	**:**	**3Hrs**

Course Learning Objectives: The students will be able to	
1	Develop the skills in the application of advanced constructs of operations research models for complex decision making situations.
2	Implement the advanced methodology and tools of operations research to assist decision-making
3	Analyze, reason and interpret information in a manner that can be communicated effectively to non-specialists.

UNIT-I	**09 Hrs**
Introduction: Engineering Applications of Optimization, Statement and Classification of Optimization Problems **Linear Programming Topics:** Duality in Linear Programming, Decomposition Principle, Sensitivity or Post optimality Analysis, Karmarkar's Interior Method, Quadratic Programming	
UNIT – II	**09 Hrs**
Nonlinear Programming - Unconstrained Optimization Techniques: Classification of Unconstrained Minimization Methods, General Approach, Rate of Convergence, Scaling of Design Variables, Direct Search Methods - Random Search Methods, Grid Search Method, Indirect Search (Descent) Methods - Gradient of a Function, Steepest Descent (Cauchy) Method, Newton's Method	
UNIT – III	**09 Hrs**
Nonlinear Programming - Constrained Optimization Techniques: Characteristics of a Constrained Problem, DIRECT METHODS - Random Search Methods, Sequential Linear Programming, Sequential Quadratic Programming	
UNIT – IV	**08 Hrs**
Modern Methods of Optimization: Genetic Algorithms, Simulated Annealing, Particle Swarm Optimization, Ant Colony Optimization, Optimization of Fuzzy Systems	
UNIT – V	**09 Hrs**
Practical Aspects of Optimization: Reduction of Size of an Optimization Problem, Fast Reanalysis Techniques, Sensitivity of Optimum Solution to Problem Parameters, Multilevel Optimization, Multiobjective Optimization - Utility Function Method, Inverted Utility Function Method, Global Criterion Method, Bounded Objective Function Method, Goal Programming Method, Goal Attainment Method	

Course Outcomes: After completing the course, the students will be able to	
1	Identify areas of applications for linear & non linear programming, and the practical aspects of optimization with usage of tools.
2	Apply various operations research techniques to solve problems related to optimization of processes.
3	Analyze the results of optimization techniques usage for multi variable and multi objective optimization problems.
4	Incorporate practical aspects of optimization in the analyses of systems.

Reference Books	
1.	Engineering Optimization Theory and Practice, Singiresu S. Rao, 4th Edition, 2009,John Wiley & Sons, Inc., ISBN: 978-0-470-18352-6
2.	Operation Research An Introduction, Taha H A, 8th Edition, 2009,PHI, ISBN: 0130488089.
3.	Principles of Operations Research – Theory and Practice, Philips, Ravindran and Solberg - John 2nd Edition, 2000, Wiley & Sons (Asia) Pte Ltd, ISBN 13: 978-81-265-1256-0

4.	Introduction to Operation Research, Hillier, Liberman, Nag, Basu, 9th Edition, 2012,Tata McGraw Hill ISBN 13: 978-0-07-133346-7

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		1			1					1		
CO2	2											1
CO3		2		2						1		1
CO4	1		1		1							

Low-1 Medium-2 High-3

Semester: VII						
ENERGY MANAGEMENT (Group G: Professional Elective)						
Course Code		**16IM7G4**		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S		**4:0:0:0**		**SEE**	**:**	**100 Marks**
Hours:		**44L**		**SEE Duration**	**:**	**3 Hrs**

Course Learning Objectives: The students will be able to	
1	To identify opportunities for energy reduction in production and usage of goods and services
2	To describe the effects of usage of energy inefficient goods and services on our environment
3	To analyze the cost and performance comparatively for different processes and systems in order to design and build better products and services
4	To produce goods and provide services within acceptable levels of environmental degradation.

UNIT-I	**09 Hrs**
Introduction: Energy sources, energy demand and supply, Energy crisis, future scenario; Energy system efficiency; energy conservation aspects; Instrumentation and measurements. **Principles of Energy Management and Energy Audit:** General principles, planning and program; Introduction to energy audit; General methodology; Site surveys; Energy systems survey, energy audit; Instrumentation; Analysis of data and results.	
UNIT-II	**09 Hrs**
Heating and Cooling Management: General principles of energy managements in HVAC systems; Human comforts and health requirements; HVAC systems; Chillers, fans, pumps, cooling towers, Energy management opportunities; Modeling of heating and cooling loads in buildings. **Electrical Load and Lighting Management:** General principles; Illumination and human comfort; Lighting systems; Equipments; Energy management opportunities; Electrical systems; Electrical load analysis; Peak load controls.	
UNIT-III	**09 Hrs**
Process Energy Management: Principles; Process heat, Combustion, Automatic fuel controls; Steam generation and distribution, Hot water and pumping, Furnaces and ovens; Process electricity; Compressed air; Manufacturing process; Energy storage for process industries; Process control.	
UNIT-IV	**08 Hrs**
Integrated Building systems: General principles; Environment conformation; Passive design considerations; Building envelope design consideration, Integration of building system, Energy storage-cold storage techniques, Economic analysis. Green buildings.	
UNIT-V	**09 Hrs**
Economic Aspects of Energy Management: General considerations; Economic analysis methods; Life-cycle costing, Break even analysis, benefit cost analysis, payback period analysis, present worth analysis, equivalent annual cost analysis; Management of energy with environment aspects.	

Course Outcomes: After completing the course, the students will be able to	
CO1.	Identify and report opportunities for energy efficient practices in the construction of building sand HVAC systems
CO2.	Describe the different sources of energy and their current usage, along with their effects on the environment
CO3.	Analyze the utilization of energy to maximize profits (minimize costs) and enhance competitive positions.
CO4.	Perform economic analysis on the proposals to help in the choice of a cost effective and energy efficient product or service
CO5.	Construct strategies for adjusting and optimizing usage of energy, through systems and procedures so as to reduce energy requirements per unit of output.

Reference Books	
1.	Energy Management, W R Murphy and G Mckay; B.S. Publications.
2.	Renewable Energy and Energy Management, S C Patra, B C Kurse and R Kataki; International Book Co.
3.	Rural Energy Management, S Kaushik and T Verma Deep; Deep Publications.

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			1					2		2		1
CO2	1		1					1		1		
CO3	1	2			2							
CO4		2			2	2						

Low-1 Medium-2 High-3

Semester: VII						
PREDICTIVE ANALYTICS (Group G: Professional Elective)						
Course Code	**:**	**16IM7G5**		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S	**:**	**4:0:0:0**		**SEE**	**:**	**100 Marks**
Hours	**:**	**44L**		**SEE Duration**	**:**	**3Hrs**

Course Learning Objectives: The students will be able to	
1	Understand various multivariate techniques for analysis of real life processes
2	Use techniques such as regression, factor analysis, clustering to describe and infer about processes through analysis of data
3	Compare processes by analyzing them by using specific multivariate techniques.

UNIT-I	**09 Hrs**
Aspects of Multivariate Analysis – Introduction, Applications, Data organization, Descriptive Statistics, Data Displays and Pictorial Representations, Distance. **Matrix algebra and Random vectors -** Basics of Matrix and Vector Algebra. Positive Definite Matrices. A Square-Root Matrix. Random Vectors and Matrices. Mean Vectors and Covariance Matrices.	
UNIT-II	**09 Hrs**
Multiple Regression Multivariate Multiple Regression. The Concept of Linear Regression. Comparing the Two Formulations of the Regression Model. Multiple Regression Models with Time Dependent Errors. **Principal component analysis:** Population Principal Components. Summarizing Sample Variation by Principal Components. Graphing the Principal Components.	
UNIT-III	**09 Hrs**
Factor Analysis and Inference for Structured Covariance Matrices. The Orthogonal Factor Model. Methods of Estimation. Factor Rotation. Factor Scores. Perspectives and a Strategy for Factor Analysis. Structural Equation Models.	
UNIT-IV	**08 Hrs**
Discrimination and Classification Separation and Classification for Two Populations. Classifications with Two Multivariate Normal Populations. Evaluating Classification Functions. Fisher's Discriminant Function	
UNIT-V	**09 Hrs**
Clustering, distance methods and ordination: Similarity Measures. Hierarchical Clustering Methods. Nonhierarchical Clustering Methods. Multidimensional Scaling. Correspondence Analysis. Biplots for Viewing Sample Units and Variables. Procustes Analysis: A Method for Comparing Configurations.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Explain the applicability of various multivariate techniques to analyse different sample data sets
CO2:	Apply multivariate techniques to draw inferences about various processes by analysing the data from the processes.
CO3:	Analyse and interpret data so as to describe the process and to aid in decision making.
CO4:	Evaluate processes by analysing their data using multivariate techniques to help in predicting performance measures.

Reference Books	
1.	Applied Multivariate Statistical Analysis, Johnson & Wichern, 6th Edition, 2008, Pearson Education, ISBN-13: 9780131877153
2.	An Introduction to Multivariate Statistical Analysis, T.W. Anderson, 3rd Edition, 2003, Wiley, ISBN: 978-0-471-36091-9
3.	Applied Predictive Analytics: Principles and Techniques for The Professional Data Analyst, Dean Abbott, 2014, John Wiley and Sons, ISBN: 978-1-118-72796-6
4.	Fundamentals of Machine Learning for Predictive Data Analytics,John D. Kelleher, Brian Mac Namee and Aoife D'Arcy, 2015, MIT Press, ISBN: 97802620 29445

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

Low-1 Medium-2 High-3

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

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

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

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CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**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)
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Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

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: i**ntroduction**,** 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.

I Semester VI						
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.
5	Systems Thinking, Systems Practice, Checkland, P. 1981. 2nd Edition, 1999,Hoboken, NJ, USA: Wiley
6	Systems Architecting, Rechtin, E. 1991, Upper Saddle River, NJ,USA: Prentice Hall.
7	Handbook of Human Systems Integration, Booher, H. (ed.) 2003. Hoboken, NJ, USA: Wiley.
8	Systems Engineering: A 21st Century Methodology, Hitchins, D., 2007. Chichester, England: Wiley.

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

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

High-3: Medium-2: Low-1

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.

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Semester End Evaluation (SEE); Theory (100 Marks)
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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:	**:**	**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 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	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
- 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 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			**1**									**2**
CO2				**2**								**2**
CO3					**2**							**2**
CO4			**2**	**2**	**2**		**2**		**2**	**2**		**2**

High-3; Medium-2; Low-1

Semester: VII						
ENGINEERING MATERIALS FOR ADVANCED TECHNOLOGY (Group H: Global Elective)						
Course Code:	**:**	**16G7H14**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**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 L**		**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, IV edition, (1996) McGraw Hill India
2. Psychology Robert A. Baron, III edition (1995) Prentice Hall India.
3. Organizational Behaviour , Stephen P Robbins Pearson Education Publications, 13th Edition, ISBN – 81-317 – 1132 – 3
4. Organisational Behaviour : Human Behaviour at Work ,John W.Newstrem and Keith Davis. Tata McGraw Hill India, 10th Edition, ISBN 0-07-046504-5
5. Psychology-themes and variations , Wayne Weiten, IV 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.**

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

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

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

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

Unit-I	**07 Hrs**
Self Discovery and Opportunity Discovery Finding the Flow; Effectuation; Identifying the Effectuation principles used in activities; Identifying Problem Worth Solving; Design Thinking; Brainstorming; Presenting the Identified problems; Identifying the Entrepreneurial Style.	
Unit – II	**07 Hrs**
Customer, Solution and Lean Methodology Customers and Markets; Segmentation and Targeting; Identifying Jobs, Pains, and Gains and Early Adopters; Crafting Value Proposition Canvas (VPC); Presenting VPC; Basics of Business Model and Lean Approach; Sketching the Lean Canvas; Risks and Assumptions; Presenting Lean Canvas.	
Unit – III	**07 Hrs**
Problem-Solution Fit and Building MVP Blue Ocean Strategy - Plotting the Strategy Canvas; Four Action Framework: Eliminate-Reduce-Raise-Create Grid of Blue Ocean Strategy; Building Solution Demo and Conducting Solution Interviews; Problem-Solution Fit; Building MVP; Product-Market Fit; Presenting MVP.	
Unit – IV	**06 Hrs**
Financial Planning & Team Building Cost Structure - Estimating Costs; Revenues and Pricing: Revenue Streams, Revenue Types, Identifying Secondary Revenue Streams, Estimating Revenue and Price; Profitability Checks; Bootstrapping and Initial Financing; Practising Pitch; Shared Leadership; Hiring and Fitment, Team Role and Responsibilities.	
Unit – V	**09 Hrs**
Marketing, Sales, Regulations and Intellectual Property Positioning and Branding; Channels; Sales Planning; Project Management; Basics of Business Regulations; How to Get Help to Get Started; Patents, Trademark, Licensing, Contracts; Common Legal mistakes, Types of Permits, Tax Registration Documents, Compliance; Infringement and Remedies, Ownership and Transfer.	

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

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

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and Assignment/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						
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:**	**:**	**3 Hrs**

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

Semester: VIII						
MAJOR PROJECT (Common to all Programs)						
Course Code	**:**	**16IM81**		**CIE**	**:**	**100 Marks**
Credits: L: T: P: S	**:**	**0:0:16:0**		**SEE**	**:**	**100 Marks**
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 program or any other program;
- Each student in the team must contribute towards the successful completion of the project. The project may be carried out In-house / Industry / R & D Institution;
- ***The project work is to be carried out by a team of two to four students , in exceptional cases where a student is placed in a company and offered an internship through the competitive process or student is selected for internship at national or international level through competitive process*****,** the student can work independently.
- ***The students are allowed to do either a project for full 5 days in the industry or full 5 days in the college.***
- ***In case the project work is carried out outside Bengaluru, such students must be available during Project Evaluation process scheduled by the respective departments and they must also interact with their guide regularly through Email / Webinar / Skype etc.***

Project Topic Selection:

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

Project Evaluation:

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

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

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

CIE Assessment:

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

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

SEE Assessment:

The following are the weightages given during Viva Examination.

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

Calendar of Events for the Project Work:

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

Evaluation Scheme for CIE and SEE

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

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

High-3 : Medium-2 : Low-1

Semester: VIII						
TECHNICAL SEMINAR (Common to all Programs)						
Course Code	**:**	**16IM82**		**CIE**	**:**	**100 Marks**
Credits: L: T: P: S	**:**	**0:0:2:0**		**SEE**	**:**	**100 Marks**
Hrs/week	**:**	**4**		**SEE Duration**	**:**	**3Hrs**

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.**

General Guidelines for the Internship

1. Students have to start the Industrial Training / Internship for a minimum duration of two weeks during 6th & 7th semester break.
2. Students have to complete the Internship reporting and presentation within the first two weeks of the 7th Semester. A report has to be submitted at the end of Internship.
3. Credits will be awarded in 8th Semester.

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 / work 10%
2. Literature Survey / Background 10%
3. Presentation 40%
4. Report 20%
5. Paper Publication 20%

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

Low-1 Medium-2 High-3

Semester: VIII						
INNOVATION & SOCIAL SKILLS (Common to all Programs)						
Course Code	**:**	**16HS83**		**CIE**	**:**	**100 Marks**
Credits: L: T: P: S	**:**	**0:0:2:0**		**SEE**	**:**	**100 Marks**
Hrs/week	**:**	**2**		**SEE Duration**	**:**	**3Hrs**

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

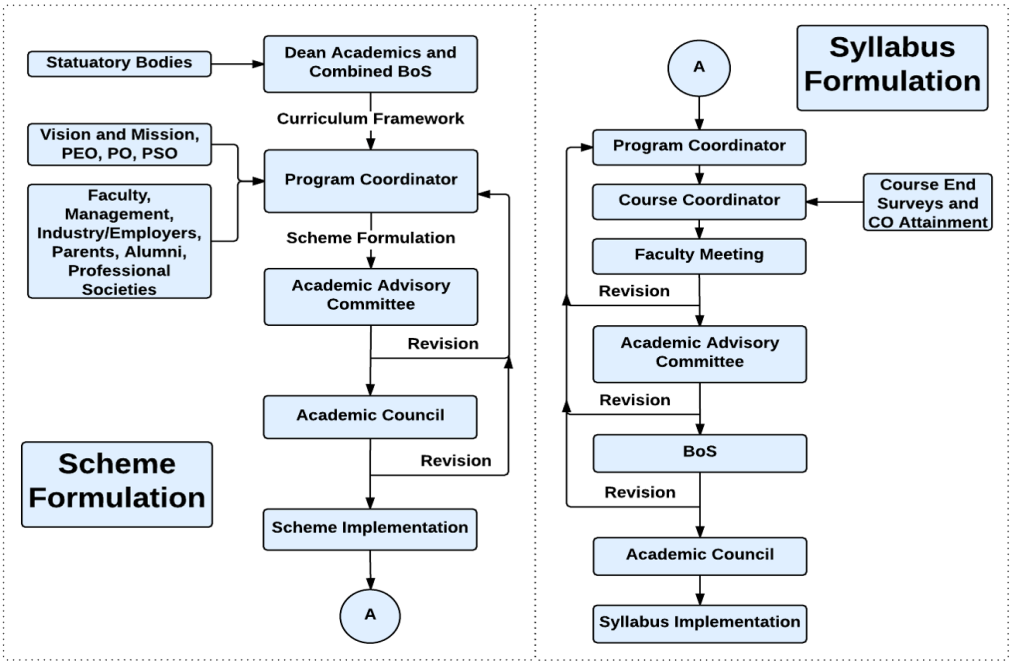
1. The HSS will be evaluated individually based on the broad parameters which include the progress made by student during 3rd& 4th year in innovative projects, Seminar, Paper Presentation, Field activity & other Co-curricular activities.
2. Students shall submit a report and documents as a proof his/her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

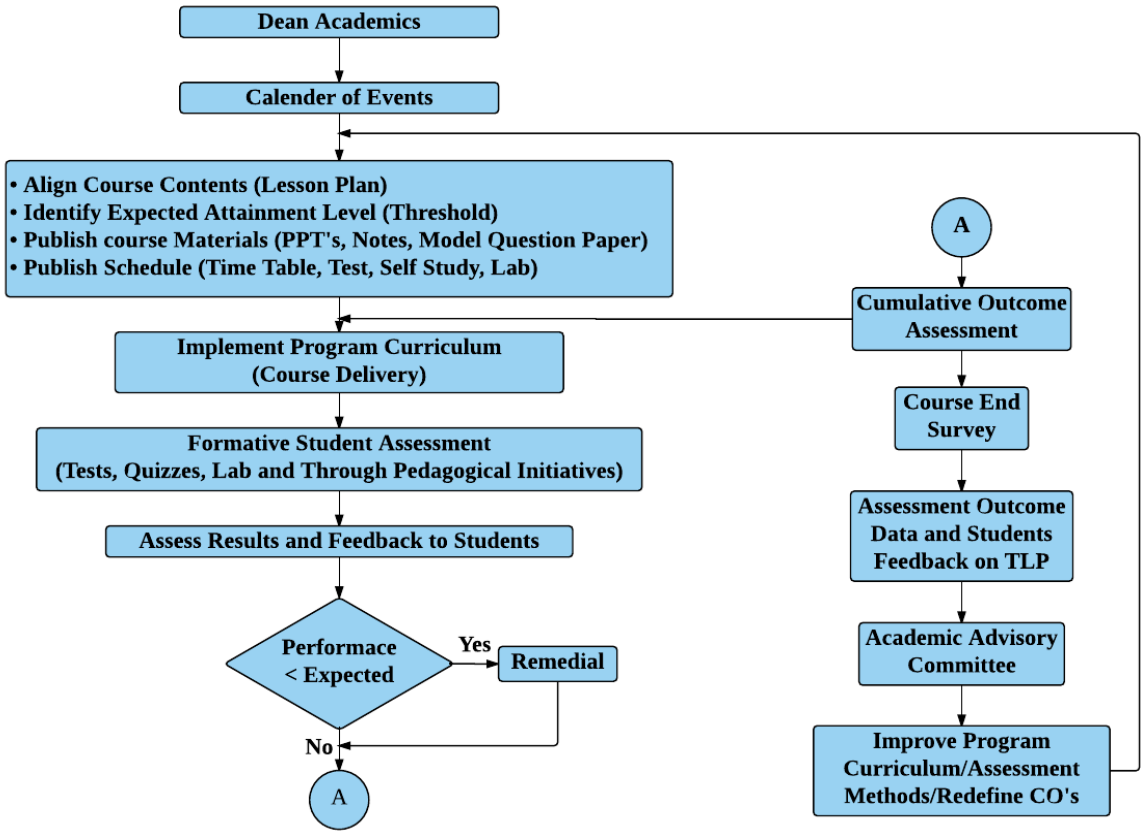
CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1			1		2	1	1				1
CO2					3	2	2	1	3			
CO3							1	1	3	3	3	2
CO4								3	3	2		1

Low-1 Medium-2 High-3

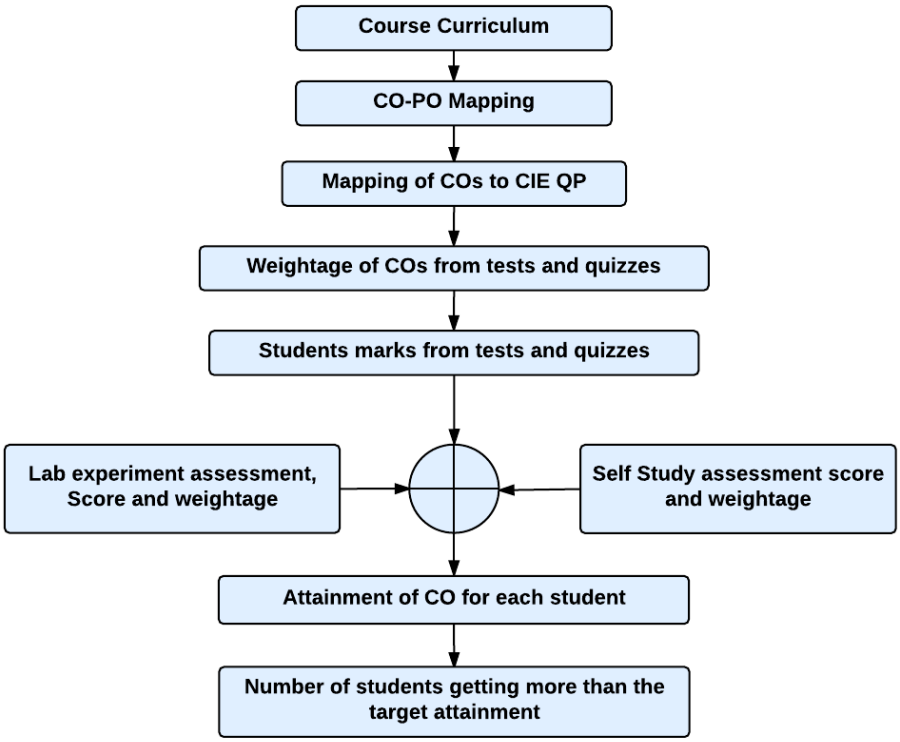
Curriculum Design Process



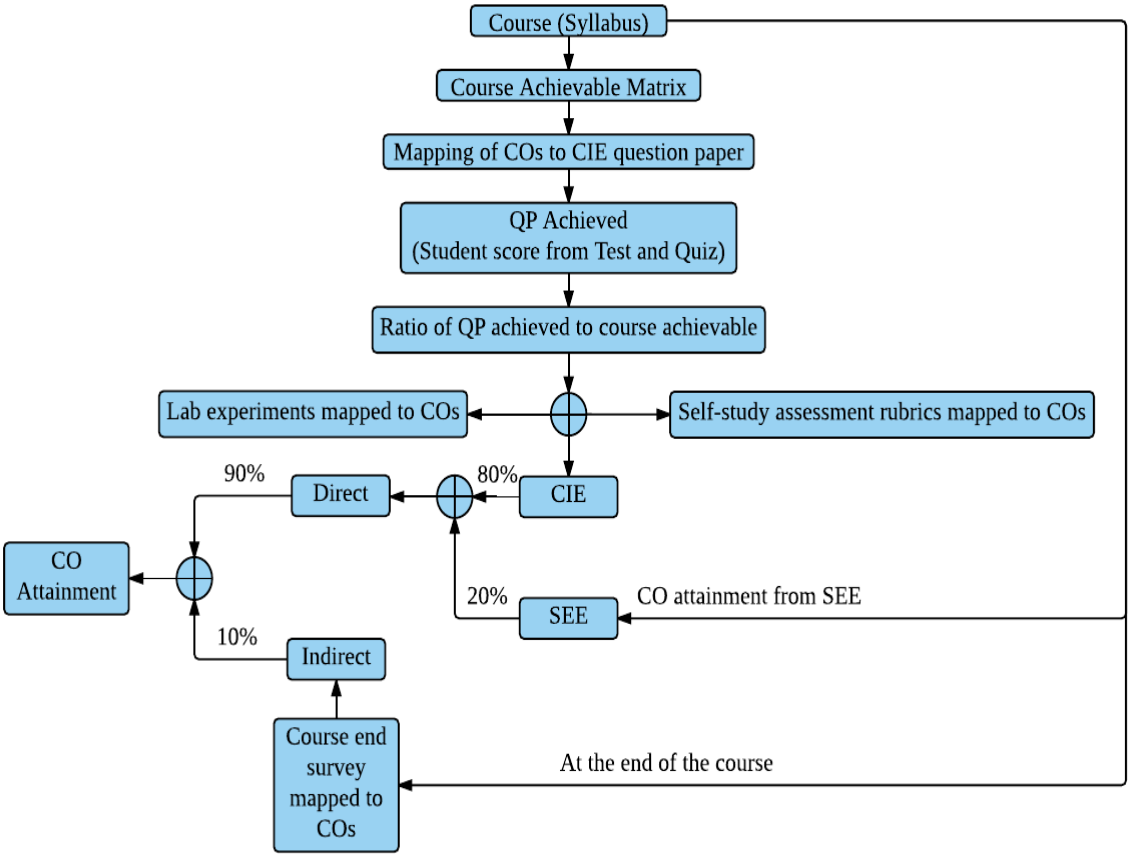
Academic Planning and Implementation



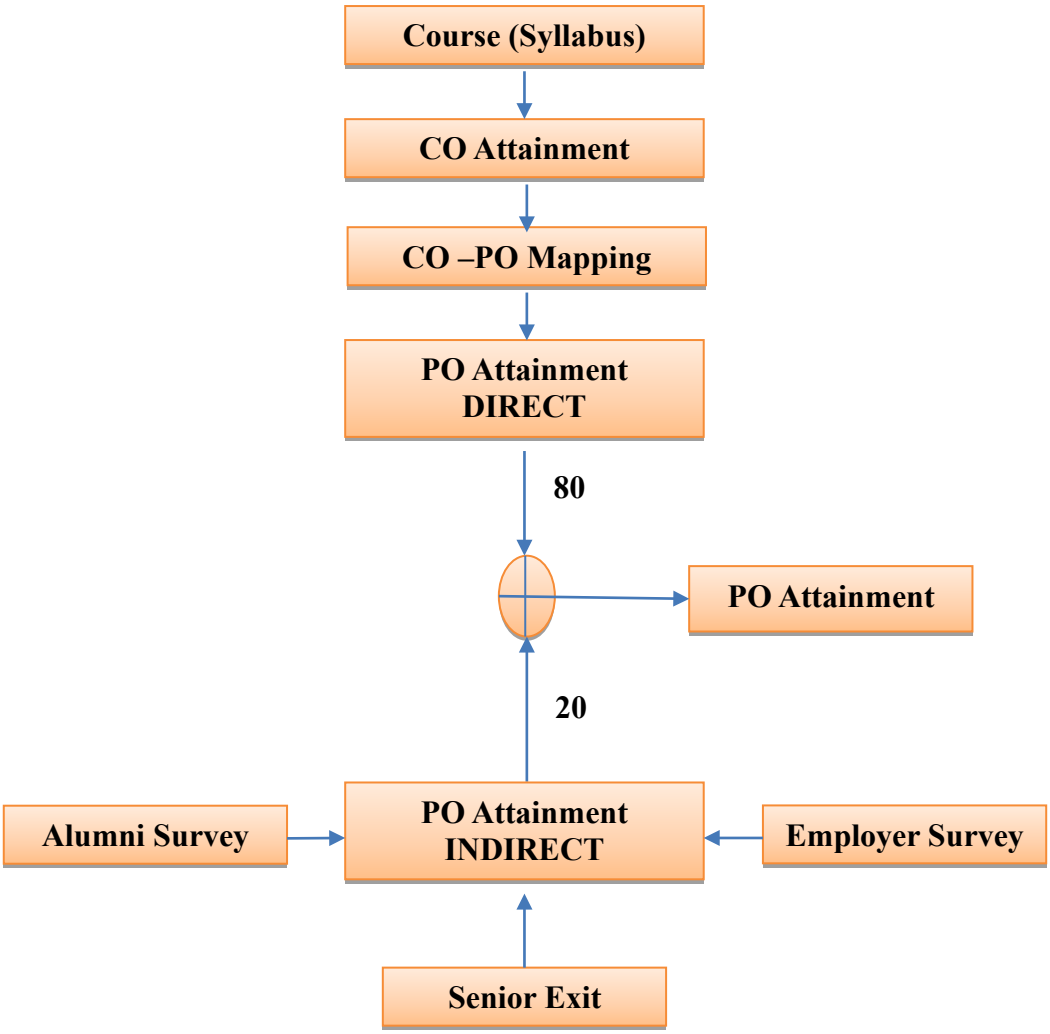
Process for Course Outcome Attainment



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.