RV Educational Institutions ®
RV College of Engineering ®

Autonomous Institution Affiliated to Visvesvaraya Technological University, Belagavi

Approved by AICTE, New Delhi

Go, change the world

SCHEME & SYLLABUS
THIRD YEAR B.E. PROGRAMS

MECHANICAL ENGINEERING

BACHELOR OF ENGINEERING (B.E.)
2021 SCHEME

ACADEMIC YEAR 2023-24

MECHANICAL ENGINEERING

DEPARTMENT VISION

Quality Education in Design, Materials, Thermal and Manufacturing with emphasis on Research, Sustainable technologies, and Entrepreneurship for Societal Symbiosis

DEPARTMENT MISSION

- Imparting knowledge in basic and applied areas of Mechanical Engineering
- Providing state-of-art laboratories and infrastructure for academics and research
- Facilitating faculty development through continuous improvement programs
- Promoting research, education and training in frontier areas of nanotechnology, advanced composites, surface technologies, MEMS and sustainable technology
- Strengthening collaboration with industries, research organizations and institutes for internship, joint research and consultancy
- Imbibing social and ethical values in students, staff and faculty through personality development programs

PROGRAM EDUCATIONAL OBJECTIVES

PEO1 Successful professional careers with sound fundamental knowledge in Mathematics, Physical Sciences and Mechanical Engineering leading to leadership, entrepreneurship or pursuing higher education.

PEO2 Expertise in specialized areas of Mechanical Engineering such as Materials, Design, Manufacturing and Thermal Engineering with a focus on research and innovation.

PEO3 Ability of problem solving by adopting analytical, numerical and experimental skills with awareness of societal impact.

PEO4 Sound communication skills, team working ability, professional ethics and zeal for life-long learning.

PROGRAM SPECIFIC OUTCOMES

PSO1 Project Innovation: Competency, creativity and innovativeness in Mechanical Engineering with Multidisciplinary approach.

PSO2 Research Innovation: Analytical, research and communication skills for placement in industries, research organizations and for pursuing higher education.

PSO3 Special Labs: Knowledge in cutting edge technologies and skills in modern simulation tools.

LEAD SOCIETY

American Society of Mechanical Engineers – ASME

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

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Bachelor of Engineering in
MECHANICAL ENGINEERING

V SEMESTER

Sl. No.	Course Code	Course Title	Credit Allocation				BoS	Category	CIE Duration (H)	Max Marks CIE		SEE Duration (H)	Max Marks SEE	
			L	T	P	Total				Theory	Lab		Theory	Lab
1	21HS51B	Principles of Management & Economics	3	0	0	3	HSS	Theory	1.5	100	****	3	100	****
2	21ME52	Design of Machine Elements – I	3	1	0	4	ME	Theory	1.5	100	****	4	100	****
3	21ME53	Flexible Manufacturing Systems	3	0	1	4	ME	Theory & Lab	1.5	100	50	3	100	50
4	21ME54	Heat Transfer	3	0	1	4	ME	Theory & Lab	1.5	100	50	3	100	50
5	21ME55BX	Professional Core Elective-II (Group-B)	3	0	0	3	ME	Theory	1.5	100	****	2	100	****
6	21ME56CX	Professional Core Elective-III (Group C)	2	0	0	2	ME	NPTEL	1.5	50	****	3	50	****
7	21MEI57	Summer Internship- II	0	0	2	2	ME	Internship	1	****	50	2	****	50
						22								

VI SEMESTER

Sl. No.	Course Code	Course Title	Credit Allocation				BoS	Category	CIE Duration (H)	Max Marks CIE		SEE Duration (H)	Max Marks SEE	
			L	T	P	Total				Theory	Lab		Theory	Lab
1	21HS61A	Intellectual Property Rights & Entrepreneurship	3	0	0	3	HSS	Theory	1.5	**100**	****	**3**	**100**	****
2	21ME62	Design of Machine Elements - II	3	0	1	4	ME	Theory & Lab	1.5	**100**	**50**	**3**	**100**	**50**
3	21ME63	Finite Element Analysis	3	0	1	4	ME	Theory & Lab	1.5	**100**	**50**	**3**	**100**	**50**
4	21ME64CX	Professional Core Elective-III (Group – D)	3	0	0	3	ME	Theory	1.5	**100**	****	**3**	**100**	****
5	21ME65DX	Professional Core Elective (Cluster Elective) (Group- E) (TWO Courses under Each Program)	3	0	0	3	Respective BoS	Theory	1.5	**100**	****	**3**	**100**	****
6	21IE6FX	Institutional Electives – I (Group F)	3	0	0	3	Respective BoS	Theory	1.5	**100**	****	**3**	**100**	****
						20								

Elective D			
Sl. No.	**Course Code**	**Course Title**	**Credits**
1	21ME64D1	Mechanical Vibrations	03
2	21ME64D2	Cryogenic Engineering	03
3	21ME64D3	Modelling and Simulation of Manufacturing Processes	03
4	21ME64D4	Product Life Cycle Management	03
5	21ME64D5	Electric Vehicle Technology	03

Elective E – Cluster Elective (Common to ME, AS, IEM)			
Sl. No.	**Course Code**	**Course Title**	**Credits**
1	21ME65E1	Hydraulics and Pneumatics	03
2	21ME65E2	Turbomachinery	03
3	21AS65E1	Airport engineering	03
4	21AS65E2	Space vehicle design	03
5	21IM65E1	Lean manufacturing systems	03
6	21IM65E2	Total quality management	03

Institutional Electives I – Group F			
Sl. No.	**Course Code**	**BoS**	**Course Title**
1	21IE6F1	CH	Industrial Safety and Risk Management
2	21IE6F2	EE	Renewable Energy Systems
3	21IE6F3	IM	Systems Engineering
4	21IE6F4	ME	Mechatronics
5	21IE6F5	MA	Mathematical Modelling
6	21IE6F6	ME	Industry 4.0 – Smart Manufacturing for The Future
7	21IE6F7	HSS	Industrial Psychology for Engineers
8	21IE6F8	IM	Elements of Financial Management
9	21IE6F9	HSS	Universal Human Values-II
10	21IE6F10	EC	Human Machine Interface (Industry Offered Elective)

Semester: V/VI						
PRINCIPLES OF MANAGEMENT & ECONOMICS **Category: Professional Core** (Common to all Programs) **(Theory)**						
Course Code	**:**	21HS51B / 61B		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**06 Hrs**
Introduction to Management: Management Functions – POSDCORB – an overview, Management levels & Skills, Management History - **Classical Approach:** Scientific Management, Administrative Theory, **Quantitative Approach:** Operations Research, **Behavioral Approach:** Hawthorne Studies, **Contemporary Approach:** Systems Theory, Contingency Theory. **Caselets / Case studies**	
Unit – II	**10 Hrs**
Foundations of Planning: Types of Goals & Plans, Approaches to Setting Goals & Plans, Strategic Management Process, Corporate strategies – types of corporate strategies, BCG matrix, Competitive Strategies – Porters Five force Model, types of Competitive Strategies. **Caselets / Case studies Organizational Structure & Design:** Overview of Designing Organizational Structure - Work Specialization, Departmentalization, Chain of Command, Span of Control, Centralization & Decentralization, Formalization, Mechanistic & Organic Structures. **Caselets / Case studies**	
Unit –III	**10 Hrs**
Motivation: Early Theories of Motivation - Maslow's Hierarchy of Needs Theory, McGregor's Theory X & Theory Y, Herzberg's Two Factor Theory. Contemporary Theories of Motivation: Adam's Equity theory, Vroom's Expectancy Theory. **Caselets / Case studies** **Leadership:** Behavioral Theories: Blake & Mouton's Managerial Grid, Contingency Theories of Leadership: Hersey & Blanchard's Situational Leadership, Contemporary Views of Leadership: Transactional & Transformational Leadership. **Caselets / Case studies**	
Unit –IV	**10 Hrs**
Introduction to Economics: Microeconomics and Macroeconomics, Circular flow model of economics, An Overview of Economic Systems. **Macroeconomic models**- The classical growth theory, Keynesian cross model, IS-LM-model, The AS-AD model, The complete Keynesian model, The neo-classical synthesis. National Budgeting process in India. **Macroeconomic Indicators:** Prices and inflation, Consumer Price Index, Exchange rate, Labor Market, Money and banks, Interest rate. Gross Domestic product (GDP) - components of GDP, Measures of GDP: Outcome Method, Income method and Expenditure method, Numericals on GDP Calculations.	
Unit –V	**09 Hrs**
Essentials of Microeconomics: Demand, Supply, and Equilibrium in Markets for Goods and Services, Price Elasticity of Demand and Price Elasticity of Supply, Elasticity and Pricing, Numericals on determining price elasticity of demand and supply. Changes in Income and Prices Affecting Consumption Choices, Monopolistic Competition, Oligopoly.	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Elucidate the principles of management theory & recognize the characteristics of an organization.
CO2	Demonstrate the importance of key performance areas in strategic management and design appropriate organizational structures and possess an ability to conceive various organizational dynamics.
CO3	Compare and contrast early and contemporary theories of motivation and select and implement the right leadership practices in organizations that would enable systems orientation.
CO4	Demonstrate an understanding on the usage and application of basic economic principles.
CO5	Appreciate the various measures of macro-economic performance and interpret the prevailing economic health of the nation.

Reference Books:	
1.	Management, Stephen Robbins, Mary Coulter & NeharikaVohra, 15th Edition, 2021, Pearson Education Publications, ISBN: 13: 978-0-13-558185-8
2.	Management, James Stoner, Edward Freeman & Daniel Gilbert Jr, 6th Edition, 2009, PHI, ISBN: 81-203-0981-2.
3.	Principles of Microeconomics, Steven A. Greenlaw, David Shapiro, 2nd Edition, 2017, ISBN:978-1-947172-34-0
4.	Macroeconomics: Theory and Policy, Dwivedi D.N, 5th Edition, 2021, McGraw Hill Education; ISBN : 9789353163334

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	COMPONENTS	MARKS
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20) **Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only; wherein one sub division will be a caselet in the related topics)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: V						
DESIGN OF MACHINE ELEMENTS - I **Category: Professional Core** **(Theory)**						
Course Code	**:**	21ME52		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:1:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L + 30T		**SEE Duration**	**:**	**3 Hours**

Unit-I	**09 Hrs**
Fundamentals of Machine Design: Machine Design, Basic Procedure of Machine Design, Basic requirements of machine elements, Use of standards in design, Types of design, Standards and Codes, Factor of safety, Material selection – weighted point method, manufacturing considerations in design of castings, forging & machined parts. **Static Stresses**: Static loads. Normal, Bending, Shear and Combined stresses. Stress concentration and determination of stress concentration factor.	
Unit – II	**10 Hrs**
Design for Impact and Fatigue Loads: **Impact Loading:** Impact stress due to Axial, Bending and Torsional loads. Impact Factor, Numerical **Fatigue failure**: Endurance limit, S-N Diagram, Low cycle fatigue, High cycle fatigue, modifying factors: size effect, surface effect. Stress concentration effects, Notch sensitivity, fluctuating stresses, Goodman and Soderberg relationship, stresses due to combined loading, cumulative fatigue damage.	
Unit –III	**10 Hrs**
Design of Shafts, Joints, and Couplings and Keys: **Shafts**, design for strength and rigidity with steady loading, ASME codes for power transmission shafting, shafts under combined loads. **Design of Cotter and Knuckle joints**, Rigid and flexible couplings, Flange coupling, Bush and Pin type coupling and Oldham's coupling. Design of keys - rectangular/square sections	
Unit –IV	**08 Hrs**
Riveted Joints and Welded Joints: **Riveted Joints:** Rivet types, rivet materials, failures of riveted joints, Joint Efficiency, Boiler Joints **Welded Joints:** Types of welded joints, Strength of butt and fillet welds, welded brackets with transverse and parallel fillet weld.	
Unit –V	**08 Hrs**
Threaded Fasteners and Power Screws: **Threaded Fasteners**: Stresses in threaded fasteners, Effect of initial tension, Design of threaded fasteners under static loads. **Power Screws:** Types of power screws, Torque required to raise/lower the loads, efficiency and self-locking, Design of power screws for C-clamps, Machine vice, sluice gates, etc.	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Demonstrate the ability to apply the fundamentals of stress analysis, theories of failure and material science in the design of machine component (L1, L2)
CO2	Design specific mechanical elements based on required specifications (L3)
CO3	Analyse different types of forces and its influence on the component design (L4, L5)
CO4	Examine and relate importance of component design to complete system. (L6)

Reference Books	
1.	Bhandari.V.B. 'Design of Machine Elements', Tata McGraw Hill Publishing Company Ltd., 2nd Edition; ISBN: 9780070611412.
2.	K Raghavendra, 'Design of Machine Elements – I, CBS Publishers, 1st Edition, ISBN:978-93-890-1718-2
3.	Shigley J.E, Mischke.C.R., 'Mechanical Engineering Design', McGraw Hill International, 6th Edition, ISBN: 0070494620
4.	Spotts. M F, Shoup T E, Hornberger L E, Jayram S R, Venkatesh C V, 'Design of Machine Elements', Pearson Education, 8th Edition; ISBN – 10: 9788177584219
5	K L Narayana, P Kannaiah, K Venkata Reddy, "Machine Drawing" New Age International, 3rd Edition. ISBN-13: 978-81-224-2518-5

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	COMPONENTS	MARKS
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

Semester: V						
FLEXIBLE MANUFACTURING SYSTEMS **Category: Professional Core** **(Theory & Practice)**						
Course Code	**:**	21ME53		**CIE**	**:**	**100 + 50 Marks**
Credits: L:T:P	**:**	3:0:1		**SEE**	**:**	**100 + 50 Marks**
Total Hours	**:**	45 L + 30 P		**SEE Duration**	**:**	**3 Hours + 3 Hrs**

Unit-I	**09 Hrs**
Automated Manufacturing systems Plant configurations, product/production relationships, categories of automation, Manufacturing flexibility defined, CAD/CAM database, components of flexible manufacturing systems, typical layouts, flexible machining cell, types of automated guided vehicle systems and conveyors, components and working of Automated storage/Retrieval and carousal systems, automated inspection systems.	
Unit – II	**09 Hrs**
Analysis of Material handling and storage systems Analysis of vehicle-based systems, AGVS routing, Conveyor analysis – Single direction, continuous loop, recirculating, Sizing the rack structure, throughput, storage capacity and through put analysis for AS/RS and carousal storage systems **(Numerical problems)** **Manufacturing Metrics** Cycle time and production rate for jobshop, batch and mass production, workload and production capacity, manufacturing lead time and work in process, bottleneck model in FMS. **(Numerical Problems)**	
Unit –III	**09 Hrs**
Automated production lines General configuration, Work Part Transport, Storage Buffers, cycle time analysis and performance measures, analysis of production lines without storage buffer and with storage buffer. **(Numerical Problems)** **Coordinate transformation and Kinematic analysis of Robots** Homogeneous 2D and 3D Translation, Rotation, scaling, composite transformation matrices, reflection about arbitrary line, rotation/scaling about arbitrary point. Three dimensional transformations – robotic frame examples Links and joints, degrees of freedom of robots, Implementing the DH convention, Obtaining the DH displacement matrices, simple applications of DH method for forward and inverse kinematics. **(Numerical problems).**	
Unit –IV	**09 Hrs**
Computer numerical control and Direct numerical control Fundamentals of NC, classification of NC controls, NC coordinate systems, Structure of CNC machine tools, DNC – types and operation, Types of CNC turning centers and machining centers with axis designations., tool presetting, ISO coding of CNC tool, Automatic Pallet Changer (APC) and Automatic Tool Changer (ATC). **CNC programming for turning centers** G and M codes, Single pass canned cycles (G90, G92, G94), Multipass canned cycles (G70, G71, G72, G73, G74, G75, G76), M codes for turning centers, tool turret, Programming exercises.	

Unit –V	09 Hrs

CNC programming for machining centers

Multipass canned cycles for drilling (G80, G81, G82, G83, G84, G85, G86), tool length compensation G43, end milling with cutter radius compensation G41 and G42, Sub programming, MACRO variables, functions and branching. Programming exercises.

Robot Programming

VAL/VAL II Programming instructions – Monitor commands, Motion control commands, Interlock commands, program control and Subroutine commands, End effector and sensor commands. Simple exercises on palletising, depalletizing, weld curve.

Laboratory component – Section II

Part A

Exercises on step turning, taper turning, grooving, peck drilling and thread cutting.

Part B

Exercises on end milling, profile milling, circular and rectangular pocket milling, slab milling, drilling and drilling on PCD, scaling and mirroring.

Demonstration

CNC programming in flexible manufacturing cell.

Course Outcomes: After completing the course, the students will be able to:	
CO1	Illustrate the basic elements in an automated manufacturing work cell layout, production line system and robots.
CO2	Analyse the transformation and kinematics of robot structure for a flexible manufacturing cell.
CO3	Apply the concepts of process planning for the purpose of selection of appropriate machining parameters and cutting tools for CNC milling and turning.
CO4	Develop Manual part programs and Robot VAL II programs and validate manual NC part program data using standard commercial CAM package/Robo simulator.

Reference Books	
1.	Automation, production systems and computer integrated manufacturing, Mikell P Groover, 4th Edition, 2016. Pearson education –ISBN: 978-9332572492
2.	Chennakesava R. Alavala, CAD/CAM: Concepts and Applications, Published by PHI, 2008, ISBN 10: 8120333403 / ISBN 13: 9788120333406
3.	Computer-integrated Manufacturing: Automation in Manufacturing, R. Panneerselvam,P. Senthilkumar, P. Sivasankaran, 1st Edition, 2020 Cengage Learning India Pvt. Ltd. ISBN: 978-9353503208
4.	Performance modelling of automated manufacturing systems, N Vishwanadham, Y Narahari, 2015. PHI learning pvt ltd, ISBN: 978-81-203-0870-1.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	COMPONENTS	MARKS
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. Each quiz is evaluated for 10 marks adding up to 20 MARKS	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for	**40**

	50Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (10) Designing & Modeling (10) **Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (20 Marks), and Innovative Experiment/ Concept Design and Implementation (20 Marks) and lab test (10 Marks) adding up to 50 Marks. THE FINAL MARKS WILL BE 50 MARKS	**50**
	MAXIMUM MARKS FOR THE CIE (THEORY & PRACTICE)	**150**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

RUBRIC FOR SEMESTER END EXAMINATION (LAB)		
Q. NO.	**CONTENTS**	**MARKS**
1	Write Up	**10**
2	Conduction of the Experiments	**20**
3	Viva	**20**
	TOTAL	**50**

Semester: V						
HEAT TRANSFER **Category: Professional Core** **(Theory & Practice)**						
Course Code	**:**	21ME54		**CIE**	**:**	**100 Marks + 50 Marks**
Credits: L:T:P	**:**	3:0:1		**SEE**	**:**	**100 Marks + 50 Marks**
Total Hours	**:**	45 L + 30 P		**SEE Duration**	**:**	**3 Hours + 3 Hours**

Unit-I	**08 Hrs**
Steady state heat conduction Modes of heat transfer: Basic laws governing conduction, convection and radiation heat transfer, Thermal conductivity; Convective heat transfer co-efficient; Boundary conditions - I, II and III kind, General 3 – dimensional heat conduction equation in Cartesian co-ordinates Steady state heat conduction in plane wall and multilayer walls, Thermal contact resistance, discussion on 3-D conduction in cylindrical and spherical coordinate systems (No derivation), plane and multilayer Cylinders, plane and multilayer Spheres, Overall heat transfer coefficient, Critical radius of insulation	
Unit – II	**10 Hrs**
Heat transfer from finned surfaces: Governing equations, solutions for different boundary conditions, fin efficiency and effectiveness, Selection of fins. problems **Transient Heat Conduction:** Lumped system analysis, transient heat conduction in large plane walls, long cylinders, use of charts for Transient heat conduction in semi-infinite and infinite solids. Numerical problems	
Unit –III	**12 Hrs**
Forced Convection: Dimensional analysis, Physical significance of Reynolds, Prandtl, Nusselt and Stanton numbers. External forced convection: Dimensional analysis, flow over flat plates, and flow across cylinders, Spheres; Internal forced convection: Laminar and turbulent flow in tubes with entry length concepts. Problems **Natural Convection:** Physical mechanism of convection, classification of fluid flow, concepts of velocity boundary layer; General expressions for drag coefficient and drag force; thermal boundary layer, general expression for local heat transfer coefficient, Average heat transfer coefficient Physical mechanism of natural convection, dimensional analysis, natural convection over surfaces - Vertical plates, cylinders, horizontal and inclined plates. Numerical problems	
Unit –IV	**07 Hrs**
Boiling and Condensation: Film and Drop wise Condensation, Boiling regimes, Heat pipe, Problems. **Radiation Heat Transfer:** Thermal radiation, Laws of radiation, Black body radiation, Radiation intensity, View factor and its relations, Black Surfaces and grey surfaces, Radiation shields and the radiation effect, Problems	
Unit-V	**08 Hrs**
Heat Exchangers: Types of heat exchangers, overall heat transfer co-efficient, Log Mean Temperature Difference; Analysis of heat exchangers (parallel, counter, cross and shell and tube), fouling and fouling factor, effectiveness, NTU method, Problems	

PART – B – HEAT TRANSFER LABORATORY	30 Hrs

Section – I

1. Determination of thermal conductivity of metal rod
2. Determination of thermal conductivity of insulating powder
3. Determination of Stefan Boltzmann constant
4. Determination of Emissivity of a surface

Section – II

1. Determination of heat transfer co-efficient in free convection for Vertical cylinder and Horizontal cyclinder
2. Determination of heat transfer co-efficient in forced convection flow through a circular pipe
3. Determination of heat transfer co-efficient in forced and free convection for pin –fin equipment.
4. Determination of overall heat transfer co-efficient and effectiveness in parallel flow, counter flow, and Cross flow heat exchanger.

Course Outcomes: After completing the course, the students will be able to:	
CO1	Explain the process of conductive, convective and radiation heat transfer. (L1 & L2)
CO2	Formulate and solve conduction problems. (L3 & L4)
CO3	Identify and analyse flow regime and use correlation for solving heat transfer. (L5)
CO4	Design and analyse performance of heat exchangers. (L5)

Reference Books	
1	Heat and Mass Transfer, Yunus A Cengel, 4th Edition, 2011, Tata McGraw Hill, ISBN: 978007107786
2.	Heat Transfer, J P Holman, 10th Edition, 2011, Tata McGraw Hill, ISBN: 9780071069670
3.	Heat Transfer, P K Nag, 2002, 2nd Edition, Tata McGraw Hill, ISBN: 0070473374
4.	Fundamentals of Heat and Mass Transfer, M Thirumaleshwar, 2nd Edition, 2009, ISBN: 9788177585193

RUBRICFOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. Each quiz is evaluated for 10 marks adding up to 20 MARKS	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50Marks**, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (10) Designing & Modeling (10) **Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (20 Marks), and Innovative Experiment/ Concept Design and Implementation (20 Marks) and lab test (10 Marks) adding up to 50 Marks. THE FINAL MARKS WILL BE 50 MARKS	**50**
	MAXIMUM MARKS FOR THE CIE (THEORY & PRACTICE)	**150**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

RUBRIC FOR SEMESTER END EXAMINATION (LAB)		
Q. NO.	**CONTENTS**	**MARKS**
1	Write Up	**10**
2	Conduction of the Experiments	**20**
3	Viva	**20**
	TOTAL	**50**

Semester: V						
ADVANCED MECHANISM DESIGN **Category: Professional Elective** **(Theory)**						
Course Code	**:**	21ME55B1		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**
Introduction: Introduction to kinematics and mechanisms, motion, The Four-Bar Linkages, The Science of Relative Motion, Kinematics diagram, Degrees of freedom, Degree of Freedom, planar, Spherical and Spatial Mechanism, Kinetic inversion, Grashof's Law, Mechanical Advantage. Equivalent mechanism, Analysis Versus Syntheses, Problems	
Unit – II	**10 Hrs**
Synthesis of Mechanisms- Analytical Method: Type, Number and Dimensional Synthesis, Function Generation, path Generation and Body Guidance, Design of a slider-crank mechanism, Four-bar crack rocker mechanism, Crank-Rocker mechanism with optimum Transmission Angle, **Precision points** for Function Generation, Structural Error, Chebychev Spacing, Frudenstein's Equation for both four bar and slider-crank mechanism, Bloch's Method of Synthesis Analytic Complex Number Modeling in Kinematic Synthesis, Problems	
Unit –III	**12 Hrs**
Synthesis of Mechanisms: Graphical Method: Dead Centre problems (Slider-crank and Crack-Rocker mechanisms), Synthesis of a Quick-Return Mechanisms, Crank-Rocker Mechanisms with optimum Transmission Angle, Three-position Synthesis, Four-Position Synthesis (Point-Position Reduction) The Overlay Method, Motion Generation Mechanism coupler as the output (two positions, three position), Coupler-Curve Synthesis (two position, Four positions, Five position), Rober-Chevschev synthesis, Pole, Relative pole, Synthesis of Four bar and slider crank mechanism (Two position and Three position), Problems	
Unit –IV	**08 Hrs**
Synthesis of Spatial Mechanism: Introduction, Exceptions in the Mobility of Mechanisms, The Position-Analysis Problem, The Eulerian Angles, introduction to Robotics, Topology arrangements of robotic arms, Forward Kinematics, Invrse Position Analysis, Inverse Velocity and Acceleration Analyses.	
Unit-V	**07 Hrs**
Curvature Theory: Introduction, Fixed and Moving Centrodes, Velocities, Accelerations, Inflection Points and the Inflection Circle, The Euler-Savary Equation	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Explain forces and links in mechanisms using design criteria
CO2	Analyse mechanisms graphically and analytically
CO3	Synthesize and design links and mechanisms
CO4	Analyse kinematics of spatial mechanisms in Robotics

Reference Books	
1	George N Sandoor / Arthur G. Erdman, Advanced Mechansim Design Analysis and Synthesis (Vol.2), (2010), ISBN 0-13-011437-5
2.	John J Uicker Jr. Gordon R. Pennock, Joseph E. Shigley, Theory of Machines and Mechanisms, 3rd Edition, Oxford University Press. (2003)
3.	Kinematics and Dynamics of Machines, R.L.Nortron, Mc Graw Hill, 2017, Edition, ISBN:9789351340201
4.	N.G.Sandorand, G.A.Erdman, Advanced Mechanism Design,Vol.2, Prentice Hall, 1984, 3rd Edition,ISBN-13: 978-0130408723ISBN-10: 0130408727
5.	A Ghoshand A K Mallik, Theory of Mechanism and Machines, EWLP, Delhi, 2008, Edition, ISBN:9788185938936
6.	C E Wilson, Kinematics and Dynamics of Machinery, Pearson Publications, Year, 3rd Edition, ISBN:0201350998

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

Semester: V						
FUNDAMENTALS OF COMBUSTION **Category: Professional Elective** **(Theory)**						
Course Code	**:**	21ME55B2		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**3 Hours**

Unit-I	**09 Hrs**
Introduction: Introduction to fuels, properties of gaseous and liquid fuels, liquid and solid fuels, Review of basic thermodynamics of ideal gas mixtures, First and Second Laws of Thermodynamics applied to combustion; Heat, temperature and composition of products in equilibrium.	
Unit – II	**09 Hrs**
Thermodynamics of Combustion: Stoichiometric air/fuel ratio for combustion of fuels-excess air, exhaust gas analysis, (conversion of mass analysis to volumetric analysis and vice versa). Calorific value, Combustion efficiency. Thermo-Chemistry, Basic reactor Kinetics, Elementary Reactions, Chain Reactions, Multi-Step Reaction Combustion Reactions, Enthalpy of formation, Entropy of formation, Internal energy of combustion. Adiabatic flame temperature, simple problems	
Unit –III	**09 Hrs**
Physics of Combustion: Laws of transport mechanism, premixed flames, ignition and flame stabilization and extinction, combustion control, co-ordinate master control, Combustion and Emission, Atmosphere, Chemical Emission from Combustion, Quantification of Combustion, Control of Emission & environment	
Unit –IV	**09 Hrs**
Chemistry of Combustion: Basics of reaction kinetics, fundamentals of elementary reactions, chain reactions, multi-step chain reactions, concept of pre-mixed and diffusion flame.	
Unit-V	**09 Hrs**
Combustion and Environment: Atmosphere, chemicals from combustion, quantification of emission, emission control methods.	

Course Outcomes: After completing the course, the students will be able to:	
CO1	Understand the basics of combustion.
CO2	Apply combustion concepts to solve engineering problems.
CO3	Analyse the thermodynamic properties of fuels for combustion applications.
CO4	Quantify the effects of combustion on environmental and society.

Reference Books	
1	D P Mishra, Fundamentals of Combustion, Revised Edition, PHI, 2013, ISBN: 9788120333482
2.	Holman B K, Heat Transfer, McGraw Hill, 9th Edition, 2022, ISBN: 978-0078447853
3.	Kuo K K, Principles of Combution, John Wiely and Sons, 2005, ISBN: 978-0471046899
4.	Strehlow R A, Fundamentals of Combustion, McGraw Hill, 1984, ISBN: 978-0882755397

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	COMPONENTS	MARKS
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

Semester: V						
ADVANCED MANUFACTURING PROCESSES **Category: Professional Elective** **(Theory)**						
Course Code	**:**	21ME55B3		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**3 Hours**

Unit - I	**09 Hrs**
Brief Introduction to Non-Traditional Machining Processes: Hybrid Non-Traditional Machining: Working Principle, Material Removal, Process Characteristics and Applications of Hybrid Chemical and Electrochemical Processes – Introduction, Electrochemical Grinding (ECG), Electrochemical Honing (ECH), Electrochemical Superfinishing (ECS), Electrochemical Buffing (ECB), Ultrasonic-Assisted ECM (USMEC), Laser-Assisted ECM (ECML), Electrochemical Discharge Machining or Electrochemical Spark machining (ECDM or ECSM).	
Unit – II	**09 Hrs**
Working Principle, Material Removal, Process Characteristics and Applications of Hybrid Thermal Processes – Introduction, Electro-erosion Dissolution Machining (EEDM), Electro-discharge Grinding (EDG), Abrasive Electro-discharge Grinding (AEDG), Abrasive Electrical Discharge Machining (AEDM), EDM with Ultrasonic Assistance (EDMUS), Electrochemical Discharge Grinding (ECDG), Brush Erosion-Dissolution Mechanical Machining (BEDMM). **Working Principles, Material Removal, Process Characteristics and Applications of:** Abrasive Flow Finishing (AFF), Magnetic Abrasive Finishing (MAF), Electro-stream Drilling (ESD), Electrochemical Deburring (ECDe), Shaped-Tube Electrolytic Machining (STEM), Magnetorheological Finishing (MRF) Process.	
Unit – III	**09 Hrs**
High Energy Rate Forming – Need, Electromagnetic Forming/Magnetic Pulse forming (EMF/MPF)-Process, Design Consideration for Coils, Design Consideration for Dies, Processes Parameters and Applications, Electrohydraulic Forming (EHF) – Process, Types of Discharges used in EHF, Equipment, Design Considerations for Dies, Processes Parameters and Applications. **Explosive Forming** – Process & Types, Types of Explosives, Characteristics of Gas Mixtures and reactions, Processes Parameters and Applications. Micro-bending with Laser - Mechanisms of Laser Forming, Machines for Laser Micro-bending Temperature gradient mechanism, Buckling mechanism, Upsetting mechanism.	
Unit – IV	**09 Hrs**
Manufacturing in the Twenty-First Century - I: Micromanufacturing – Overview, Classification, High Resolution Lithography - Types of Lithography Based Microfabrication Processes, Basic Scheme of Lithography Based Micromachining – Typical Steps and Basic Process, Silicon as a Material for Microelectromechanical Devices, Film and Film Deposition Techniques – Evaporation, Sputtering, Chemical Vapour Deposition (CVD)-Low Pressure and Plasma Enhanced CVD, Oxidation – Dry, Wet and Selective Oxidation, Lithography – Photoresist Spin Coating, Photoresist Patterning and Exposure Techniques, Difference between Positive and Negative Photo Resist, Etching – Wet Etching: Isotropic and Anisotropic Etching, Etching of {100} and {110} Si Wafers, Dry Etching: Plasma and Reactive Etching, Steps in Plasma Etching Process, Deep Reactive Ion Etching (DRIE), Difference Between Bulk and Surface Micromachining, Basic LIGA Process – Steps in LIGA Process, LIGA Masks – Steps in X – Ray Mask Fabrication.	
Unit – V	**09 Hrs**
Manufacturing in the Twenty-First Century – II: Generative Manufacturing and Self-Assembly – Rapid Prototyping (RP): Steps involved and process chain for RP development, Generative manufacturing processes	

(GMP) for RP – Basic Principles of GMP, General Features and Classification, Issues Related to CAD and GMP Software, Two-dimensional Layer-by-Layer Techniques – Stereolithography (STL) with Photopolymerization, STL with Liquid Thermal Polymerisation, Solid Foil Polymerization (SFP), Selective Laser Sintering (SLS), Selective Powder Binding, Ballistic Particle Manufacturing (BPM), Fused Deposition Modelling (FDM), Shape Melting, Laminated Object Manufacturing (LOM), Solid Ground Curing (SGC), Repetitive Masking and Depositing (MD*); Direct Three Dimensional Techniques for RP – Beam Interference Solidification (BIS), Ballistic Particle Manufacturing, Holographic Interference Solidification, Programmable Moulding; Laser based Fused Deposition Modelling using Metals, Advantages of GMP's, Considerations for Adopting RP Technology, Basic Principles of Self-Assembly Process.

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Understand the terminology related to Hybrid Non-Traditional Machining Processes.
CO2	Analyse and apply principles of Hybrid Non-Traditional Machining Processes, High Energy Rate Forming Methods, Lithography, and Rapid Prototyping to specific applications.
CO3	Assess, compare, and select appropriate Advanced Manufacturing Processes.
CO4	Apply the principles of Hybrid NTM, HER forming, Lithography and Rapid Prototyping to develop the mechanical components.

Reference Books	
1.	Advanced Machining Processes, Hassan El-Hofy, McGraw-Hill, ISBN 978-0-07145334-9.
2.	Manufacturing Science, 2nd Edition, Amitabha Ghosh and Asok Kumar Mallik, Affiliated East-West Press Pvt Ltd, New Delhi, ISBN 978-81-7671-063-3.
3.	Micromanufacturing Processes, V. K. Jain, CRC Press, ISBN 978-14-3985-290-3.
4.	Rapid Prototyping – A Brief Introduction, Amitabha Ghosh, Affiliated East-West Press Pvt Ltd, New Delhi, ISBN 81-85938-84-9.
5	Advanced Machining Processes, Vijay K. Jain, Allied Publishers Private Limited, India, ISBN 81-7764-294-4.
6	Manufacturing Processes for Engineering Materials, 5th edition, Serope Kalpakjian and Steven R. Schmid, Pearson Education India, ISBN 978-81-3170-566-7.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	COMPONENTS	MARKS
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

Semester: V						
OPERATIONS RESEARCH AND MANAGEMENT **Category: Professional Elective** **(Theory)**						
Course Code	**:**	21ME55B4		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**3 Hours**

Unit - I	**09 Hrs**
Linear programming and Assignment problem Operations research as a production improvement tool, Process planning and design, value analysis, Linear programming methods – Simplex method, Big M method, dual simplex method graphical method, Assignment problem – Hungarian method, Branch and bound method.	
Unit – II	**09 Hrs**
Forecasting Simple Moving Average Method, Weighted Moving Average Method, Double Moving Average Method, Simple (Single) Exponential Smoothing Method, Adjusted Exponential Smoothing Method Linear Regression, Semi-average Method, Delphi Method. **Queuing theory** Notation for queues, examples of queuing in manufacturing, performance measures, little's result, M/M/1 queue, M/M/1/N queue, M/M/m queue, M/G/1, M/D/1 queues (Numerical)	
Unit – III	**09 Hrs**
Facilities planning Factor Rating Analysis And Forced Decision Matrix, Break even analysis, single facility location problem. **Assembly line balancing** Objectives, concept of mass production, line balancing algorithms –largest candidate rule, Kilbridge and wester, ranked positional weights (Numericals).	
Unit – IV	**09 Hrs**
Material requirement planning MRP System Structure, Bill of Materials, MRP Procedure, MRP calculations, EOQ method, minimum cost per period method, period order quantity method, least unit cost method, part period balancing method, capacity requirement planning. **Aggregate planning and Master production scheduling** Strategies, graphical method, Heuristic method, Linear programming model for aggregate planning. Goal programming formulations of production scheduling, Linear decision rule.	
Unit – V	**09 Hrs**
Single Machine Scheduling Measures of performance, parallel processor machine scheduling, SPT, weighted Mean flow time EDD, FCFS, critical ratio, minimizing the number of tardy jobs, minimizing makes pan. **Flow shop and Job shop scheduling** Gantt chart, flow shop scheduling, Johnson's rule, branch and bound technique, CDS heuristic, palmers heuristic, job shop scheduling – heuristic procedures, graphical method, n jobs and m- machines scheduling, 2 jobs and M machines scheduling.	

Course Outcomes: After completing the course, the students will be able to:	
CO1	Illustrate the basic concepts of operations research and management in manufacturing systems.
CO2	Solve linear programming problems using appropriate techniques and optimization solvers, interpret the results obtained
CO3	Apply the concepts of purchase, stores and inventory management and analyse and evaluate material requirement decisions
CO4	Evaluate the concepts of analytical modeling paradigms for automation using queueing theory and scheduling algorithms.

Reference Books	
1	Panneerselvam, R. Production and Operations Management, 3rd Edition, 2012, ISBN: 978-812034-555-3
2.	R.B Khanna, Production and Operations Management, 2nd Edition, 2015, ISBN: 9788120351219
3.	Panneerselvam, R. Operations Research, 3rd Edition, PHI, 2015, ISBN: 978-93-5443-789-2

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

Semester: V						
AUTOMOTIVE MECHATRONICS **Category: Professional Elective** **(Theory)**						
Course Code	**:**	21ME55B5		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**03 Hours**

Unit-I	**09 Hrs**
Automobile Engines Classifications of Internal Combustion Engines**.** Engine nomenclature and mechanics. Mixture formation – External, internal, quality and quantity control – homogeneous and stratified injection. Thermodynamic principles of Otto and Diesel cycle. Characteristics – pressure curve and energy yield, engine speed, torque, and power	
Unit-II	**10 Hrs**
Engine Auxiliary Systems: Turbocharger, Intercooler, Exhaust manifold, 3-way catalytic convertor, Exhaust Gas Recirculation system. **Common Rail Fuel Injection system**- Low pressure and high pressure fuel systems, Return line, Quantity control valve and Injectors.	
Unit-III	**10 Hrs**
Vehicular Auxiliary Systems: Vehicle frame and body classification- Hatchback, Sedan, SUV, Coupe, Roadster. Adaptive Brakes - Disc and drum brakes, Antilock Braking Systems, ESP, TCS. Wheels and Tyres- Toe-In, Toe-Out, Caster and Camber angle. Classification of tyres, Radial, Tubeless. **Supplemental Restraint System**: Active and passive safety, Vehicle structure, Gas generator and air bags, Belt Tensioner, Acceleration sensor, Rollover sensor, Seat occupancy recognition.	
Unit-IV	**09 Hrs**
EV Technology: Types of EV's, ICE vs EV torque output, Architecture and Working of EV's. Battery Thermal Management System, Regenerative braking, Safety system and Impacts of EV on the environment.	
Unit-V	**07 Hrs**
Telematics in vehicles – Radio Transmission, Exchange of information, signal path & properties, Concept of radio waves. **Sensors:** Oxygen sensors, Crankshaft/Cam shaft Sensor, Boost Pressure Sensor, Coolant Temperature Sensor, Hot Film Air Mass flow Sensor, Throttle Position Sensor, Rain/Light sensor	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Describe the functions of Mechatronic systems in a modern automobile
CO2:	Evaluate the performance of an engine by its parameters
CO3:	Analyse the automotive exhaust pollutants as per emission norms
CO4:	Demonstrate communication of control modules using a On-Board Diagnostic kit

Reference Books	
1.	Automotive Technology – A systems approach, Jack Erjavec, 5th Edition, Delamr Cengage Learning, ISBN-13: 978-1428311497
2.	Automotive Engineering Fundamentals, Richard Stone and Jeffrey K. Ball, 2004, SAE International, ISBN: 0768009871
3.	Bosch Automotive Handbook, Robert Bosch, 9th Edition, 2004, ISBN: 9780768081527
4.	Understanding Automotive Electronics, William B Ribbens, 5th Edition, Butterworth–Heinemann, ISBN 0-7506-7008-8

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

Semester V						
WHEELED MOBILE ROBOTS **Category: Professional Elective** **(NPTEL Course)**						
Course Code	**:**	21ME56C1		**CIE Marks**	:	****
Credits: L:T:P	**:**	2:0:0		**SEE Marks**	:	100 Marks
Total Hours	**:**	30 L		**SEE Duration**	:	3 Hours

Unit – I	**10 Hrs**
Introduction to mobile robots and manipulators, locomotion and types of locomotion, Mobile robot kinematics, degree of manoeuvrability and types of wheels, kinematics of mobile robot, generalised wheel model examples, holonomic and non-holonomic mobile robots, kinematic of wheeled mobile robots.	
Unit – II	**10 Hrs**
Mobile robot dynamics, equation of motion and dynamic simulation of mobile robots, dynamic models with wheel configuration, dynamics of wheeled robots, kinematic and dynamic models of a mobile base, sensing and perception, commonly used sensors, sensor errors and error modelling, mobile robot localisation, Markov localisation, Kalman filter localisation, SLAM, mobile robot localisation.	
Unit – III	**10 Hrs**
Path planning graph construction, graph search methods, path planning and obstacle avoidance, motion control of mobile robots, kinematic control of land based mobile robots, dynamic control of mobile robots, cascaded or back stepping control of mobile robots, modern robotics and challenges, multiple mobile robotic systems, autonomous mobile robots and mobile manipulators, legged and mobile robots, underwater and aerial robots, healthcare robots.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand algorithmic approaches, mathematical models and computational and motion control methods applicable to mobile robotic systems
CO2:	Apply different motion planning and navigation schemes related to mobile robots
CO3:	Recognize and analyze the basic mechanical and electrical systems concerning robots' locomotion and manipulation
CO4:	Analyse and design the basic mobile robotic systems

References Books:	
1	Siegwart, Roland, et al. *Introduction to Autonomous Mobile Robots, Second Edition*. 2011. • ISBN-13 : 978-0262015356
2	https://www.youtube.com/playlist?list=PLyqSpQzTE6M9CXsZljkH_lCxRSiaXF566

Semester V						
DESIGN, TECHNOLOGY, AND INNOVATION **Category: Professional Elective** **(NPTEL Course)**						
Course Code	**:**	21ME56C2		**CIE Marks**	:	****
Credits: L:T:P	**:**	2:0:0		**SEE Marks**	:	100 Marks
Total Hours	**:**	30 L		**SEE Duration**	:	3 Hours

Unit – I	**10 Hrs**
Jaipur foot – vision, disability, manufacturing, customisation, advantages, High tech Jaipur foot, user centric helmet design- current scenario, typical construction, standard, three part folding, two part receding, self collapsing helmet, swivelling, ease of storage cluster, form refinement, product detailing, redesign, final mockup, challenges of reaching a million users.	
Unit – II	**10 Hrs**
Technology os solution, high fidelity model, restoration system, building of prototype, collaborative excellence, case studies, Ortho CAD TKP project, collaborative innovation methods, modular petrol pump, success ration for innovation, idea generation, crafting, concept innovation, idea generation, crafting, concept development, pitfall of innovation, failures and concerns, grassroot innovation – snapping and tapping empathetic innovations for capping inertia.	
Unit – III	**10 Hrs**
Biomed innovation process, medical device innovation, Indian industry landscape, funnel innovation, research to innovation – society business and technology, Business profit, technology feasibility, process knowledge, task, conceptual design, clarification, embodiment detailed design, case studies mobile arm support, smartcane for the blind.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	focus on establishing the methodology of innovation by showcasing the collaborative model of innovation and the Chakku's 7 Concerns which forms the backbone of the innovation process
CO2:	Apply the pitfalls of innovation and the stages of transformation of research into innovation
CO3:	Analyse learn the stages of the innovation, but also learn to collaborate with different people of different disciplines.
CO4:	Propose innovative ideas for different mechanisms.

References Books:	
1	https://www.youtube.com/playlist?list=PLOzRYVm0a65dRU1hBCsd3rqyhjpcGCioi

Semester V						
INTRODUCTION TO MACHINING AND MACHINING FLUIDS **Category: Professional Elective** **(NPTEL Course)**						
Course Code	**:**	21ME56C3		**CIE Marks**	:	****
Credits: L:T:P	**:**	2:0:0		**SEE Marks**	:	100 Marks
Total Hours	**:**	30 L		**SEE Duration**	:	3 Hours

Unit – I	**10 Hrs**
Introduction and Importance of Machining: Introduction to manufacturing, Top-down and bottom-up approaches, Machining and Various Machining Processes. Principles of Metal Cutting: Shear zone, Chip formation, chip thickness measurements, machining mechanics of ductile and brittle materials, Cutting tool: Tool Geometry, Tool signature. Cutting forces and Cutting velocities: Cutting forces, Merchant Circle, Empirical Models, Chip thickness ratio, Cutting velocities, Strain rates, Mathematical formulations. Tribology, Surface roughness in Machining: Chip-tool tribology, tool-workpiece tribology, Sticking and sliding zone, types of lubrication, Surface roughness, Materials removal rate, Machinability. Thermal Aspects of Machining: Cutting temperature, Measurement of temperature, heat generation, heat distribution, metallurgical and microstructural study.	
Unit – II	**10 Hrs**
Tool Wear and Tool life: Carter wear, flank wear, nose wear, other tool wears, tool life criteria. Tool Materials and Coatings: Coating materials, PVD, CVD, RF, Laser coatings, Tool texturing., Cutting Fluids: Classification, Functions, Types of lubrication, Cutting fluid additives, Emissions, Health Hazards, Rheology and Biodegradability, Cutting fluid application: Standoff distance, angle of impingement, contact angle, area of cooling, Solid lubricants., Eco-friendly cutting fluids: Development of eco-friendly cutting fluids, bio degradation of these fluids, COD, BOD, HRT, Advantages of sustainable cutting fluids over mineral oil based cutting fluids. Multipoint Machining Processes: Milling, Drilling, Broaching, Tapping, Sawing, Gear Cutting.	
Unit – III	**10 Hrs**
Abrasive machining processes: Grinding wheel specification, classification, Thermal aspects, Lapping, Honing, Super finishing, Drag finishing, vibratory finishing, Applications. Cutting fluids for abrasive machining processes: Cutting fluids in grinding, honing, super-finishing, Machining of Advanced Materials: Machining of Biomaterials, Aero Space materials, Smart Materials., Advances in Metal Cutting: Hard Machining, High Speed Machining, Diamond Turning, Double tool Machining, Machining with rotary tools, Thin wall machining, Laser Assisted Machining. Cutting fluids machining advanced materials: Cutting fluids for machining advanced materials, high speed machining, hard machining.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understanding the various machining processes and its physics.
CO2:	Apply the importance of machining, machining region mechanism, tool signatures, tool life, multipoint machining processes, cutting fluid, cutting fluid emissions and its effect on human kind.
CO3:	Analyse the emphasis on cutting fluid emissions and its effect on operators, environment and water pollution. How to develop the eco-friendly cutting fluids as an alternative to commercial miner oils
CO4:	Develop sustainable cutting fluids application techniques to improve the machining performance

References Books:	
1	M. C. Shaw, Metal Cutting, Tata McGraw Hill, New Delhi, 2004 ISBN-13 : 978-0198086116
2	G. Boothroyd and W. A. Knight, Fundamentals of Machining and Machine Tools, CRC-Taylor and Francis, 3rd edition 2006. ISBN-13 : 978-1574446593
3	https://www.youtube.com/playlist?list=PLSGws_74K0182SyuprWUsFkKHfiTvwPlG

Semester V						
STEAM AND GAS POWER SYSTEMS **Category: Professional Elective** **(NPTEL Course)**						
Course Code	**:**	21ME56C4		**CIE Marks**	:	****
Credits: L:T:P	**:**	2:0:0		**SEE Marks**	:	100 Marks
Total Hours	**:**	30 L		**SEE Duration**	:	3 Hours

Unit – I	**10 Hrs**
Review of thermodynamics, Rankine cycle, performance, binary vapour cycle and co generation, numerical. Steam generators, fire tube and water tube boilers, boiler mountings and accessories, high pressure boilers, drought, performance of boiler.	
Unit – II	**10 Hrs**
combustion of fuel, boiler trial, nozzle and diffusers, momentum and continuity equations, efficiency and critical pressure, general relationships and supersaturated flow, numericals, steam turbine, compounding, impulse steam turbine, performance, reaction steam turbine, performance, energy loss.	
Unit – III	**10 Hrs**
Condensors, gas turbine cycle, performance evaluations, modifications, problem solving, centrifugal compressors, characteristics, axial flow compressors, characteristics, jet propulsion, numericals.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the working of steam and gas power systems
CO2:	Perform analysis of vapour power cycle, steam generators and their accessories
CO3:	Evaluate the performance of Boilers and combustion of fuel, high pressure boilers and flow through steam and gas nozzles
CO4:	Illustrate The gas turbine cycle, working of gas turbines, centrifugal compressors, axial compressors and combustion chamber of gas turbines.

References Books:	
1	Basic Engineering Thermodynamics, Rayner Joel, Longman; 5th edition, ISBN-13 : 978-0582256293
2	Gas Turbine Theory, HIH Saravanamuttoo, GFC Rogers, H Cohen, PV Straznicky, AC Nix, Pearson; 7th edition, ISBN-13 : 978-1292093093
3	https://www.youtube.com/playlist?list=PL6Qggk0O9yRItYPKm51jEnZoM-mSOM4XA

Semester V						
FUNDAMENTALS OF ELECTRONIC MATERIALS AND DEVICES **Category: Professional Elective** **(NPTEL Course)**						
Course Code	**:**	21ME56C5		**CIE Marks**	:	****
Credits: L:T:P	**:**	2:0:0		**SEE Marks**	:	100 Marks
Total Hours	**:**	30 L		**SEE Duration**	:	3 Hours

Unit – I	**10 Hrs**
Electronic materials, - metals, semiconductors, insulators, Energy bands in solids, Semiconductors band gap formation, energy vs bond length, electronic configuration, electron statistics in a solid, intrinsic semiconductors-conductivity, extrinsic semiconductors, fermi level, mobility – Numericals.	
Unit – II	**10 Hrs**
Metal semiconductor junctions, pn junctions in equilibrium, pn junction under bias, junction breakdown and heterojunction, transistors, junction field effect transistor, MOSFET, Numericals.	
Unit – III	**10 Hrs**
Optoelectronic devices, light emitting diodes, solid state semiconductor lasers, photodetectors, solar cells, solar spectrum, principle of a photo voltaic, Numericals.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Provide a fundamental understanding of the materials and devices used in the semiconductor industry.
CO2:	Analyse aircraft and vapour compression refrigeration systems.
CO3:	Understand Opto-electronic devices such as LEDs, lasers, solar cells, and their properties
CO4:	Analyse pn junctions under bias, Junction breakdown, and Heterojunctions

References Books:	
1	Semiconductor Physics And Devices, 3ed, An Indian Adaptation, S. M. Sze, M. K. Lee, ISBN: 9789354243226
2	https://www.youtube.com/playlist?list=PLyAZSyX8Qy5DzpVUmzfnR7Sgmh2ZpshR6

Semester: V						
SUMMER INTERNSHIP - II (Practical)						
Course Code	:	21XXI57		**CIE**	:	50 Marks
Credits: L: T: P	:	0:0:2		**SEE**	:	50 Marks
Total Hours	:	4 Weeks		**SEE Duration**	:	02 Hrs
Students can opt the internship with the below options						4 Weeks

A. Within the respective department at RVCE (Inhouse) Departments may offer internship opportunities to the students through the available tools so that the students come out with the solutions to the relevant societal problems that could be completed within THREE WEEKS.

B. At RVCE Center of Excellence/Competence

RVCE hosts around 16 CENTER OP EXCELLENCE in various domains and around 05 CENTER OP COMPETENCE. The details of these could be obtained by visiting the website https:/ /rvce.edu.in / rvce-center-excellence. Each centre would be providing the students relevant training/internship that could be completed in three weeks.

C. At InternShala

Intern Shala is India's no.1 internship and training platform with 40000+ paid internships in Engineering. Students can opt any internship for the duration of three weeks by enrolling on to the platform through https: / /internshala.com

D. At Engineering Colleges nearby their hometown

Students who are residing out of Bangalore, should take permission from the nearing Engineering College of their hometown to do the internship. The nearby college should agree to give the certificate and the letter/email stating the name of the student along with the title of the internship held with the duration of the internship in their official letter head.

E. At Industry or Research Organizations

Students can opt for interning at the industry or research organizations like BEL, DRDO, ISRO, BHEL, etc.. through personal contacts. However, the institute/industry should provide the letter of acceptance through hard copy/email with clear mention of the title of the work assigned along with the duration and the name of the student.

Procedures for the Internship:

1. Request letter/Email from the office of respective departments should go to Places where internships are intended to be carried out with a clear mention of the duration of Three Weeks. Colleges/Industry/ CoEs/CoCswill confirm the training slots and the number of seats allotted for the internship via confirmation letter/ Email.
2. Students should submit a synopsis of the proposed work to be done during internship program. Internship synopsis should be assessed or evaluated by the concerned Colleges/Industry/CoEs/CoC. Students on joining internship at the concerned Colleges/Industry/ CoEs/CoCs submit the Daily log of student's dairy from the joining date.
3. Students will submit the digital poster of the training module/project after completion of internship.
4. Training certificate to be obtained from industry.

Course Outcomes: After completing the course, the students will be able to: -	
CO1	Develop interpersonal, critical skills, work habits and attitudes necessary for employment.
CO2	Assess interests, abilities in their field of study, integrate theory and practice and explore career opportunities prior to graduation.
CO3	Explore and use state of art modern engineering tools to solve the societal problems with affinity towards environment and involve in ethical professional practice.
CO4	Compile, document and communicate effectively on the internship activities with the engineering community.

RUBRICS FOR THE CONTINUOUS INTERNAL EVALUATION		
#	**COMPONENTS**	**MARKS**
1.	**REVIEW I:** Explanation of the application of engineering knowledge in industries, ability to comprehend the functioning of the organization/ departments, exhibiting professional and ethical practice, communication skills (oral and body language).	**20**
2.	**REVIEW II**: Presentation in the form digital poster, report writing, exhibiting ethics in report writing, oral presentation.	**30**
MAXIMUM MARKS FOR THE CIE THEORY		**50**

RUBRICS FOR SEMESTER END EXAMINATION		
The SEE examination shall be conducted by an external examiner (domain expert) and an internal examiner.		
Q.NO.	**CONTENTS**	**MARKS**
1	Write Up	**10**
2	Conduction of the Experiments	**20**
3	Viva	**20**
	TOTAL	**50**

Semester: V / VI						
INTELLECTUAL PROPERTY RIGHTS AND ENTREPRENEURSHIP **Category: Professional Core** (Common to all Programs) **(Theory)**						
Course Code	**:**	21HS51B/61B		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE**	**:**	**3.00 Hours**

Unit-I	**09 Hrs**
Introduction: Types of Intellectual Property **Patents:** Introduction, Scope, and salient features of patent; patentable and non-patentable inventions, Patent Procedure – Overview, Transfer of Patent Rights; protection of traditional knowledge, Infringement of patents and remedy, Case studies Patent Search and Patent Drafting, Commercialization and Valuation of IP. Case examples.	
Unit – II	**08 Hrs**
Trade Secrets: Definition, Significance, Tools to protect Trade secrets in India. **Trademarks:** Concept, function and different kinds and forms of Trade marks, Registrable and non-registrable marks. Registration of Trade Mark; Deceptive similarity; Transfer of Trade Mark, ECO Label, Passing off, Infringement of Trade Mark with Case studies and Remedies. Case Examples.	
Unit –III	**08 Hrs**
Industrial Design: Introduction of Industrial Designs Features of Industrial, Design. Procedure for obtaining Design Protection, Revocation, Infringement and Remedies, Case studies. **Copy Right:** Introduction, Nature and scope, Rights conferred by copy right, Copy right protection, transfer of copy rights, right of broad casting organizations and performer's rights, Exceptions of Copy Right, Infringement of Copy Right with case studies. **Introduction to Cyber law**: Information Technology Act, cybercrime and e-commerce, data security, confidentiality, privacy, international aspects of computer and online crime.	
Unit –IV	**09 Hrs**
Entrepreneurship: Introduction, Evolution of the Entrepreneurship, Importance of Entrepreneurship, Concept of Entrepreneurship, Characteristics of a successful Entrepreneur, Classification of Entrepreneur, Myths of Entrepreneurship, Entrepreneurial Development Models, Problems Faced by Entrepreneurs and Capacity Building for Entrepreneurship .Women Entrepreneurship in Asia, Women Entrepreneurship in India, Challenges Faced by Women Entrepreneurs. Case studies. **Entrepreneurship in the New Age**: Getting to know your Business, it's Eco-system and Environment, Passion and Values driving, building and growing Family businesses, Challenges and suggested management approaches.	
Unit –V	**11 Hrs**
Business Plans: Introduction ,Purpose of a Business Plan ,Contents of a Business Plan, Business Concept, Business Strategy, Marketing Plan, Operations Plan, Financial Plan, Presenting a Business Plan, Oral and Visual Presentation, Why Do Some Business Plans Fail? Procedure for Setting Up an Enterprise, Business Models and Business Model Innovation Creating a Business Plan. Case lets/Case studies. **Preparation of project**: Meaning of Project; Project Identification; Project Selection; Project Report; Need and Significance of Report; Contents; formulation; Guidelines by Planning Commission for Project report; Network Analysis; Errors of Project Report; Project Appraisal. Identification of. Business Opportunities: Market Feasibility Study; Technical Feasibility Study; Financial Feasibility Study & Social Feasibility Study. Use of standard templates for preparation of project report.	

Reference Books	
1	Intellectual Property Rights: Unleashing Knowledge Economy, Prabuddha Ganguly, 1st Edition, 2001, Tata McGraw Hill Publishing Company Ltd., New Delhi, ISBN: 0074638602.
2.	Intellectual Property and the Internet, Rodney Ryder, 2002, Lexis Nexis U.K., ISBN: 8180380025, 9788180380020.
3.	Poornima M. Charantimath "Entrepreneurship Development and Small Business Enterprise", Pearson Education, 2005, ISBN: 9788177582604
4.	Dynamics of Entrepreneurial Development & Management-Vasant Desai, Himalaya Publishing House, 6th Edition, 2018, ISBN – 978-93-5299-133-4
5	Entrepreneurial development, Khanka, Shobhan Singh, S. Chand Publishing, 2006, ISBN – 8121918014, 9788121918015

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Comprehend the applicable source, scope and limitations of Intellectual Property within the purview of engineering domain.
CO2	Knowledge and competence related exposure to the various Legal issues pertaining to Intellectual Property Rights with the utility in engineering perspectives.
CO3	Enable the students to have a direct experience of venture creation through a facilitated learning environment.
CO4	It allows students to learn and apply the latest methodology, frameworks and tools that entrepreneurs use to succeed in real life.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)* (Small case lets and case example in one subdivision)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
DESIGN OF MACHINE ELEMENTS – II **Category: Professional Core** **(Theory & Practice)**						
Course Code	**:**	21ME62		**CIE**	**:**	**100 + 50 Marks**
Credits: L:T:P	**:**	3:0:1		**SEE**	**:**	**100 + 50 Marks**
Total Hours	**:**	40 L+ 30 P		**SEE Duration**	**:**	**3 Hours + 3 Hours**

Unit-I	**06 Hrs**
Design of Curved Beams: Difference between straight beam and curved beams, stresses in straight beam and curved beam, derivation of bending stress equation for curved beam, problems on crane hook, punching presses, clamps (symmetric and unsymmetrical sections), closed rings.	
Unit – II	**10 Hrs**
Design of Clutches and Brakes **Clutches:** Torque transmitting capacity, Types, uniform wear and pressure theory, friction, bearing pressure, single and multi-plate clutches. **Brakes:** Energy absorbed by brake, materials of brake, pivoted block or shoe brake, simple and differential band brake. **Design of Springs:** Introduction to springs; Types of Springs; Stresses in helical compression springs subjected to steady loads. Deflection in helical springs – Circular & Non-circular spring. Leaf springs – full length leaves, graduated leaves, stresses & deflection. Semi-elliptical springs; Equalization of springs (Nipping). Problems on semi-elliptical springs; automobile leaf springs	
Unit –III	**10 Hrs**
Design of Spur & Helical Gears: **Spur Gears**: Definition, Stresses in Gear Tooth, Lewis Equation, Form Factor, Design for Strength, Dynamic Load and wear load, material selection for different velocity ratios, types of tooth systems **Helical Gears:** Number of teeth, design based on strength, dynamics and wear loads, normal and transverse pitch, module, Herringbone gears, different forces on helical gear teeth	
Unit –IV	**06 Hrs**
Design of Bevel & Worm Gears: **Bevel Gear**: Definition, Formative Number of Teeth, Design based on Strength, Dynamics and Wear Loads, Cone Pitch Angle, Back Cone Radius, Acute, Obtuse and right-angle bevel gears **Worm Gears**: Definition, design based on strength, dynamic wear load and efficiency of gear drives, self-locking of worm gear drives.	

Unit –V	08 Hrs
Lubrication & Bearings: Basic modes of lubrication, viscosity, properties of lubricant, Petroff's equation, bearing materials, Sommerfeld number, bearing modulus, coefficient of friction, minimum oil film thickness, heat generated and dissipated. **Anti-friction Bearings:** Materials, types, ball and roller bearings, static and dynamic capacity, equivalent load, selection based on rated life and application.	

Section II – Design Laboratory
SECTION – I: Determination of Principal Stresses & Strains using strain rosette analysis Determination of Fringe Constant – Circular and Rectangular Specimens Determination of Stress Concentration Factor in a photo-elastic plate with hole Determination of pressure distribution in a Journal Bearing **SECTION – II:** Determination of Natural Frequency, Damping Ratio, Damping co-efficient for single degree freedom systems (Spring-Mass system) Balancing of rotating masses using force and coupling polygons Determination of critical speed of rotating shaft Determination of Equilibrium speed of governors Experiments with gyroscope

Reference Books	
1	Bhandari.V. B, 'Design of Machine Elements', Tata McGraw Hill Publishing Company Ltd., Ed.2nd; ISBN: 9780070611412
2.	K Raghavendra 'Design of Machine Elements II, CBS Publishers Pvt Ltd., 1st Edition, 2015, ISBN: 978-81-239-2633-9
3.	Shigley J.E, Mischke.C.R., 'Mechanical Engineering Design', McGraw Hill International, 6th Edition, ISBN: 0070494620
4.	Spotts. M F, Shoup T E, Hornberger L E, Jayram S R, Venkatesh C V, 'Design of Machine Elements', Pearson Education, 8th Edition; ISBN – 10: 9788177584219
Design Data Hand Book: Design Data Handbook for Mechanical Engineers by K.Mahadevan and K. Balaveera Reddy, CBS Publishers & Distributors Pvt Ltd., 4th Edition, ISBN: 978–81–239–2315–4	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Understand basic procedure to design a system component, or process to meet desired needs within realistic constraints. (L1 & L2)
CO2	Select suitable material and size for design of components in machines. (L3 & L4)
CO3	Identify, explain, formulate, and solve design engineering problems (L5)
CO4	Analyse and evaluate forces and stresses within a mechanical system (L6)

RUBRICFOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. Each quiz is evaluated for 10 marks adding up to 20 MARKS	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50Marks**, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (10) Designing & Modeling (10) **Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (20 Marks), and Innovative Experiment/ Concept Design and Implementation (20 Marks) and lab test (10 Marks) adding up to 50 Marks. THE FINAL MARKS WILL BE 50 MARKS	**50**
	MAXIMUM MARKS FOR THE CIE (THEORY & PRACTICE)	**150**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

RUBRIC FOR SEMESTER END EXAMINATION (LAB)		
Q. NO.	**CONTENTS**	**MARKS**
1	Write Up	**10**
2	Conduction of the Experiments	**20**
3	Viva	**20**
	TOTAL	**50**

Semester: VI						
FINITE ELEMENT ANALYSIS **Category: Professional Core** **(Theory & Practice)**						
Course Code	**:**	21ME63		**CIE**	**:**	**100 + 50 Marks**
Credits: L:T:P	**:**	3:0:1		**SEE**	**:**	**100 + 50 Marks**
Total Hours	**:**	40 L + 30 P		**SEE Duration**	**:**	**3 Hours + 3 Hours**

Unit-I	**06 Hrs**
Introduction to FEM, Basic steps in FEM, Advantages and limitations, Basic Equations of Elasticity: Stress-strain relationship, Differential equations of equilibrium, Strain displacement relations, Rayleigh Ritz Method, Galerkin's Method, Element types, Node numbering scheme (Numerical on Rayleigh Ritz and Galerkin's method only)	
Unit – II	**10 Hrs**
One Dimensional Finite Elements – Bar and Truss elements Linear element, Shape function, stiffness matrix, strain matrix, Gauss-Elimination method, Penalty method, boundary conditions and assemblage load vector, Convergence and Compatibility conditions, stiffness matrix for Truss elements, Numerical	
Unit –III	**10 Hrs**
Analysis of Beam Elements: Hermitian shape functions, formulations of element stiffness matrices, load vectors, Analysis of bending moment and shear force, Numerical **Two Dimensional CST Elements:** Iso, super and sub-parametric representation, Shape functions, Jacobian matrix, B-matrix, element stiffness and load vectors, Numerical	
Unit –IV	**06 Hrs**
Dynamic Analysis: Equations of motion, mass and stiffness matrices, distributed and consistent mass matrices, Eigen values and Eigen vectors. Numerical	
Unit-V	**08 Hrs**
Analysis of Heat Transfer 1-D element: Steady State Heat Transfer, Galerkin's Formulation of Element Equations for Heat Transfer, Heat flux boundary condition, Analysis of composite slabs **Analysis of thin fin:** Numerical for Heat transfer through fins, Heat flux boundary condition, Circular and rectangular fins.	

Part B	
Experiments executed using ANSYS-Work Bench software tool.	**36 Hrs**
1. Introduction to design modeler and problems related to 1D and 2D elements.	
2. Static structural analysis of plate with a hole.	
3. Static structural analysis of connecting rod (import from SolidWorks).	
4. Fatigue analysis of beam with rectangular cross section subjected to completely reversed cycles.	
5. Buckling analysis for a column with square cross section.	
6. Analyse contact stresses for a plate subjected to contact load by a sphere.	
7. Impact analysis of a plate subjected to speeding bullet.	
8. Analyse the mode shapes and modal frequencies for a free-free condition.	
9. Analysis of heat transfer through the composite wall and fins.	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Define the fundamentals of finite element methods.
CO2	Develop the knowledge to analyse structures in static, dynamic and thermal conditions
CO3	Assess numerical techniques for solving engineering problems.
CO4	Formulate finite element model to implement industrial projects.

Reference Books	
1	Introduction to Finite Elements in Engineering, T.R. Chandrapatla, A D Belegundu, Pearson Publications, 4th Edition, 2011, ISBN: 13-978-0132162746
2.	Fundamentals of Finite Element Analysis, David Hutton, Tata McGraw Hill Education, 4th Edition, 2017, ISBN: 13-978-0070601222
3.	The Finite Element Method in Engineering, Rao S S, Butterworth-Heinemann, 5th Edition, 2017, ISBN: 13- 978-1856176613
4.	A First Course in Finite Element Methods, Daryl L Logon, Thomson Brooks, 5th Edition, 2012, ISBN: 13-978-8131517307

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. Each quiz is evaluated for 10 marks adding up to 20 MARKS	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50Marks**, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (10) Designing & Modeling (10) **Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (20 Marks), and Innovative Experiment/ Concept Design and Implementation (20 Marks) and lab test (10 Marks) adding up to 50 Marks. THE FINAL MARKS WILL BE 50 MARKS	**50**
	MAXIMUM MARKS FOR THE CIE (THEORY & PRACTICE)	**150**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

RUBRIC FOR SEMESTER END EXAMINATION (LAB)		
Q. NO.	**CONTENTS**	**MARKS**
1	Write Up	**10**
2	Conduction of the Experiments	**20**
3	Viva	**20**
	TOTAL	**50**

Semester: VI						
MECHANICAL VIBRATIONS **Category: Professional Elective** **(Theory)**						
Course Code	**:**	21ME64D1		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	40 L		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**
Introduction to Undamped free vibration systems. Fundamentals of vibration – Basic concept of vibration, Importance of the study of vibration, Classification of vibration, Vibration analysis procedure, Simple Harmonic Motion, Addition of two harmonics (analytical and graphical method), Springs in series & parallel, Effect of mass of spring, Numerical	
Unit – II	**09 Hrs**
Forced Vibration with harmonic excitation: Single degree freedom systems, Steady state solution with viscous damping due toharmonic force, solution and response. Forced Vibration with rotating unbalance and base excitation: Single degree freedom systems, reciprocating and rotating imbalance, whirling of shafts without air damping, discussion on speeds above and below critical speeds. **Damped free vibrations**: Single degree freedom systems, different types of damping, concept of critical damping and its importance, study of response of viscous damped systems for cases of under damping, critical and over damping, logarithmic decrement.	
Unit –III	**10 Hrs**
Vibration Control – Introduction, Vibration severity, ISO recommendations, Reduction of vibration at the source, Whirling of rotating shafts, vibration isolation, vibration absorbers. Transmissibility ratio, base excitation **Vibration Measuring Instruments** – Introduction, Transducers, Vibration pickups, Frequency measuring instruments, Frahm's Reed Tachometer, Fullerton tachometers, Vibration exciters.	
Unit –IV	**06 Hrs**
Numerical methods for Multi degree Freedom systems: Introduction, influence coefficients, Maxwell reciprocal theorem, Dunkerley'sequation, method of matrix iteration, method of determination of all the natural frequencies using sweeping matrix and orthogonality principle. **Modal analysis** – Fundamentals of Modal Analysis, Structural Dynamics Background, Modal analysis for single degree freedom system, Frequency Response measurements. Impact testing of structures	
Unit-V	**07 Hrs**
Finite Element Dynamic Analysis – Introduction, Eigen value Analysis, Axial vibrations of bar element, Transverse vibrations of beams, Numerical examples **Human vibration** – Hand Arm Vibration, Whole Body Vibration – Basic concept & modelling.	

Course Outcomes: After completing the course, the students will be able to:	
CO1	Explain free and forced vibrations for single, two and multi degrees of freedom systems.
CO2	Apply the influence of damping in free and vibration isolation in forced vibration systems.

CO3	Evaluate natural frequencies in multi degrees of freedom system using numerical methods and to understand modal analysis for various applications
CO4	Apply finite element methods to dynamic analysis problems and to comprehend basic concepts of human vibration

Reference Books	
1.	Rao S.S., Mechanical Vibrations, 5th Edition, Prentice Hall, 2007. ISBN: 0201526867
2.	Thomson W.T., "Theory of Vibration with applications", Pearson Education Inc., 5th Edition, 2003. ISBN: 0044450699
3.	Graham Kelly S, Schaum's Outline of Mechanical Vibrations, 1st Edition, McGraw-Hill, 1996, ISBN 0070340412
4.	Lasithan L.G, Mechanical Vibrations and Industrial Noise control, PHI learning India Pvt. Ltd., 2nd Edition, India, 2014, ISBN-978-81-203-4779-3
5.	V P Singh, Mechanical Vibrations, Danpat Rai and Co., 2010, 7th Edition, ISBN:

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

Semester: VI						
CRYOGENIC ENGINEERING **Category: Professional Elective** **(Theory)**						
Course Code	**:**	21ME64D2		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**3 Hours**

Unit-I	**09 Hrs**
Introduction: Applications areas of Cryogenic Engineering, Low temperature properties of engineering materials – Mechanical properties, Thermal properties, Electrical properties. Introduction thermodynamically ideal system, Production of low temperatures – Joule Thompson Effect, Adiabatic expansion. Second law of Thermodynamics, Carnot refrigerator, Vapor Compression Refrigeration Cycle, components, Properties of Refrigerants	
Unit – II	**09 Hrs**
Gas Liquefaction and refrigeration systems: Liquification systems for Air Simple Linde –Hampson System, Claude System, Heylndt System, Dual pressure, Claude Liquefaction cycle Kapitza System. **Liquefaction:** Comparison of Liquefaction Cycles, liquefication cycle for hydrogen, helium and Neon, Critical components of liquefaction systems.	
Unit –III	**09 Hrs**
Gas Cycle Cryogenic Refrigeration Systems: Classification of Cryo coolers Stirling cycle Cryo – refrigerators, Ideal cycle – working principle. Schmidt's analysis of Stirling cycle Various configurations of Stirling cycle refrigerators Integral piston Stirling cryo-cooler, Free displacer split type Stirling Cryo coolers, Gifford Mcmahon Cryo- refrigerator, Pulse tube refrigerator, Solvay cycle refrigerator, Vuillimier refrigerator, Cryogenic regenerators. **Gas Separation and Gas Purification Systems:** Thermodynamic ideal separation system, Properties of mixtures, Principles of gas separation, Linde single column air separation. Linde double column air separation, Argon and Neon separation systems. Adsorption Process, PSA systems.	
Unit –IV	**09 Hrs**
Vacuum Technology: Fundamental principles. Production of high vacuum, Mechanical vacuum pumps, Diffusion pumps, Cryo-pumping, Measurement of high vacuum level. Cryogenic Insulation: Heat transfer due to conduction, Evacuated porous insulation Powder & Fibers Opacified powder insulation, Gas filled powders & Fibrous materials Multilayer super-insulation, Composite insulation. **Low Temperature Insulation:** Reflective insulation, Evacuated powders, Rigid foams, Super insulation. Cooling by adiabatic de-magnetization, Storage and handling of cryogenic liquids, Dewars and other types of containers.	
Unit-V	**09 Hrs**
Application Of Cryogenic Systems: Cryogenic application for food preservation – Instant Quick-Freezing techniques, Super conductive devices, Cryogenic applications for space technology, Expansion fitting, cryobiology, cryosurgery, computers, underground power lines. **Safety in Cryogenics:** Need for safety, basic hazards, protection from hazards	

Course Outcomes: After completing the course, the students will be able to:	
CO1	Understand the principles of cryogenics and its applications.
CO2	Apply the different techniques for producing cryogenic fluids.
CO3	Analyse different Cryogenic Refrigeration and purification systems.
CO4	Selection of materials and equipment for cryogenic systems adhering to safety norms.

Reference Books	
1.	Cryogenic Systems by R.F Barron, Oxford University Press, 1985
2.	Randall F. Barron, "Cryogenics Systems", 2nd Edition, Oxford University Press New York, Clarendon Press, Oxford, 1985.
3.	Timmerhaus, Flynn, "Cryogenics Process Engineering", Plenum Press, New York.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

Semester: VI						
MODELLING AND SIMULATION OF MANUFACTURING PROCESSES **Category: Professional Elective** **(Theory)**						
Course Code	**:**	21ME64D3		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**3 Hours**

Unit-I	**09 Hrs**
Mathematical Modeling and Engineering Problem Solving – A Simple Mathematical Model and the engineering problem solving process, mathematical modelling process, Hierarchical vs. Concurrent approach, multi-scale models. **Modelling of Sand-Casting and Fusion Welding: Casting:** Mechanism of solidification – Rate of solidification, Solidification of large casting in an insulating mould; **Fusion Welding:** Heat Source – Emission and ionization of electric arc, arc structure and characteristics, modes of metal transfer in arc welding, Arc efficiency; Heat input to the weld, Relation between weld cross-section and energy input, Heat input rate, Width of the heat affected zone, Cooling rates, Numerical problems.	
Unit – II	**09 Hrs**
Modelling of Forming Processes: Engineering and true stress-strain, Flow stress, Yield criteria; **Slab method: Forging –** Analysis of forging pressure for rectangular and circular disc. Numerical problems. **Wire Drawing –** Analysis of Drawing stress, Maximum reduction; **Extrusion (Round bar/wire) –** Extrusion workload & Stress analysis; **Deep Drawing:** Blank holding and drawing force analysis. Numerical problems.	
Unit –III	**10 Hrs**
Modelling of Machining Processes: Review on Orthogonal cutting; **Oblique Cutting:** Direction of chip flow, Rake angles, cutting ratios, Velocity relationship, Shear angle; **Mechanics of Turning Process:** Analysis of chip flow direction, Effective rake angle, Power and forces, Specific cutting resistance. Numerical problems. **Ultrasonic Machining:** Grain throwing and grain hammering models, parametric analysis, and process Parameters; **Electric Discharge Machining:** Analysis of R-C circuits, Condition for maximum power generation, Material removal rate, Surface finish, Process parameters. Numerical problems.	
Unit –IV	**08 Hrs**
Introduction to Fuzzy Logic: Crisp and Fuzzy sets operations and properties, Representation of a fuzzy set, Membership functions, Definitions in fuzzy sets, Standard operations in fuzzy sets and relations. Numerical problems. Measures of fuzziness and inaccuracy of fuzzy sets, **Fuzzy Logic Controller:** Mamdani approach, Takagi and Sugeno's approach. Numerical problems.	
Unit-V	**09**
Fundamentals of Neural Networks: Artificial neuron, Transfer functions; **Multi-Layer Feed-Forward Neural Network**: Training of network using back-propagation algorithm, Types of training methods. (No problems) **Neuro-Fuzzy System:** Mamdani Approach – Tuning of the Neuro-Fuzzy System using a Back-Propagation algorithm; **Adaptive Neuro-Fuzzy Inference System:** Takagi and Sugeno's approach. (No problems)	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Analyse models for metal casting and fusion welding processes.
CO2	Apply models to analyse forces in forming processes.

CO3	Analyse models for traditional and non-traditional machining processes.
CO4	Apply the principles of soft computing tools to create models for the manufacturing process inputs and outputs.

Reference Books	
1	"Manufacturing Science", Amitabha Ghosh, East-West Press Pvt Ltd, 2nd ed., 2010, ISBN-13: 978-81-767-1063-3.
2.	"Welding Science and Technology", Md. Ibrahim Khan, New Age International (P) Limited, 2017, ISBN-13: 978-81-224-2621-5.
3.	"Welding Processes and Technology", R.S. Parmar, Khanna Publishers, 3rd Edition, 2020, ISBN-13: 978-81-7409-126-2.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

Semester: VI						
PRODUCT LIFE CYCLE MANAGEMENT **Category: Professional Elective** **(Theory)**						
Course Code	**:**	21ME64D4		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**3 Hours**

Unit-I	**09 Hrs**
Introduction – Definition, PLM model, Threads of PLM, Need for PLM, Benefits of PLM, Drivers for Change. PLM feasibility study, PLM visioning. Development, Validation, Production, Support of PLM.	
Unit – II	**09 Hrs**
Product life cycle management – Generic PLC, Components of PLM, Software and Hardware life cycle development processes. **PLM Strategy** – Principles, developing a PLM Strategy, A Five-step Process, Communicating the Strategy, Strategy identification and selection, PLM business goals.	
Unit –III	**10 Hrs**
Product data Management – PDM supporting the whole PLC. Basic functionality, Trends in PDM. **Implementing PDM system –** Categories, Information management, Workflow management, Engineering Change management.	
Unit –IV	**08 Hrs**
Document management systems – Document management and PDM, Document life cycle and document management**,** Document management resources on the Internet. **Innovation** – Components of Successful Innovation, Cycle of Innovation, Global Innovation Opportunities, People Drive Innovation, Innovation Method**.**	
Unit-V	**09 Hrs**
Design for Environment – Environmental Impacts, Design for Environment Process – DFE Agenda, Internal and External Drivers of DFE, DFE Guidelines. **Standards** – Requirements, PDM, Life cycle process, CMM	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Explain the structured approaches to Product life cycle management and development of projects.
CO2	Understand the challenges faced by 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	Analyse the need for integrated product life cycle design and process development frameworks.

Reference Books	
1	Product Lifecycle Management Paradigm for century Product Realization – John Stark, Springer Verlag, 21st Edition, London, 3rd printing -2011, ISBN 978-0-85729-545-3

2.	Crnkovic, Ivica; Asklund, Ulf; & Dahlqvist, Annita Persson. Implementing and Integrating Product Data Management and Software Configuration Management, Artech House Publishers, 2003. ISBN 1580534988.
3.	Karl T. Ulrich, Steven D. Eppinger, Product Design and Development, 6th Edition, McGraw-Hill Education. A, ISBN 978-0-07-802906-6

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

Semester: VI						
ELECTRIC VEHICLE TECHNOLOGY **Category: Professional Elective** **(Theory)**						
Course Code	**:**	21ME64D5		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**3 Hours**

Unit-I	**06 Hrs**
Introduction: Overview of Evs: Components – architecture – Comparison in reference of: Energy source, Pollution, Energy diversification, Efficiency, Capital & operating cost, Performance. Classifications: Classification of Evs in reference to: Propulsion devices, Energy sources, Energy carriers, Configurations of Pure Electric Vehicles (PEV) – Hybrid Electric Vehicles (HEV) and Plug-in Hybrid Electric Vehicles (PHEV).	
Unit – II	**09 Hrs**
Design Considerations: Aerodynamics, Rolling Resistance, Transmission Efficiency, Consideration of Vehicle Mass, Electric Vehicle Chassis and Body Design, Electric Vehicle Recharging and Refuelling Systems. Tractive Effort, Vehicle Acceleration, Electric Vehicle Range. **Ancillary Systems**: Heating and Cooling Systems, Power Steering, Choice of Tyres, Wing Mirrors, Aerials and Luggage Racks	
Unit –III	**09 Hrs**
Batteries, Flywheels and Super capacitors: Battery Parameters, Lead Acid Batteries, Nickel-Based Batteries, Sodium-Based Batteries, Lithium Batteries, Metal–Air Batteries, Super capacitors and Flywheels, Battery Charging, Batteries in Hybrid Vehicles, Battery Management Systems. **Fuel Cells**: Hydrogen Fuel Cells, Connecting Cells in Series, Water Management in the PEMFC, Thermal Management of the PEMFC, Fuel Cell System, Practical Efficiency of Fuel Cells, Hydrogen as a Fuel-Reforming, Efficiency, Storage.	
Unit –IV	**08 Hrs**
EV Drives: BEV, HEV, FCEV, EV motor drive technologies – IC engine vehicle force – speed characteristics (5-gears), BEV characteristics (fixed gears) – Comparison between ICE vehicles & BEV force – speed characteristics. **Requirement of EV motor** compared to industrial motors – classification of EV motors (DC, Induction, BLDC, PMSM) – Types, Principle, Construction, Control – Electric Drive Train and its types and Power Converters.	
Unit-V	**08 Hrs**
Types of Chargers: AC charging and DC charging – On board and off board charger specification – Type of Mode of charger Mode 2, Mode 3 and Mode 4 – EVSE associated charging time calculation, selection and sizing of fast and slow charger (AC & DC) – AC Pile Charger, DC Pile Charger. **ICE Performance Characteristics –** Electric Motor Performance Characteristics – Battery Performance Characteristics -Transmission and Drivetrain Characteristics – Regenerative Braking Characteristics.	
Course Outcomes: After completing the course, the students will be able to:	
CO1	Understand the basics of electric and hybrid electric vehicles, their architecture and technologies.
CO2	Explain energy storage technologies of electric vehicles and energy management system
CO3	Apply the concepts of electric drive systems suitable for electric vehicles.

CO4	Analyse the different charging methods for Performance Characteristics.

Reference Books	
1	James Larminie, John Lowry, "Electric Vehicle Technology Explained", Wiley Publisher, 2nd Edition, 2012, ISBN: 9781119942733
2.	Iqbal Hussain, "Electric & Hybrid Vehicles – Design Fundamentals", Second Edition, CRC Press, 2011, ISBN: 0-8493-1466-5
3.	Davide Andrea," Battery Management system for large Lithium Battery Packs", ARTECH HOUSE 4th Edition, 2010, ISBN-13 978-1-60807-104-3
4.	F. BADIN, Hybrid Vehicles from Components to System", Editions Technip, Paris, 2013, 3rd Edition, ISBN: 978-2-7108-0994-4

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

Semester: VI						
HYDRAULICS AND PNEUMATICS **Category: Professional Cluster Elective** **Stream: Common to ME, AS and IEM** **(Theory)**						
Course Code	**:**	21ME65E1		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**
Introduction to hydraulic power Pascal's law and its application, components and applications of a fluid power system, construction and working of gear, vane and piston pumps(all types) Classification, parts and working of hydraulic cylinders – single acting, double acting, tandem, telescopic, cushioned. Basic motor principle. Numerical Problems on Pump and Motor volumetric displacement, theoretical and actual flow rate, power and efficiency, Hydrostatic Transmission, Cylinder Thrust, Power, capacity, speed, Mechanics of hydraulic Cylinder loading.	
Unit – II	**10 Hrs**
Introduction to Pneumatic power Production of compressed air – compressors- vane, piston, diaphragm type, preparation of compressed air- driers, filters, regulators, FRL unit, lubricators, distribution of compressed air, pneumatic double pilot valve, cushioned cylinder, shuttle valve, dual pressure valve, pressure sequence valve and time delay valve. **Control components and accessories** Symbolic representation and constructional features of Directional control valve (spool type) valves, method of actuation – manual, solenoid, pilot. Pressure relief valve(direct and pilot), pressure reducing valve, unloading valve, counterbalance valve, pressure sequence valves, Flow control valves- one way and pressure compensated. Hydraulic fluids, reservoir, sealing devices, filters and strainers, accumulators.	
Unit –III	**10 Hrs**
Hydraulic Circuit Design Control of single acting and double acting cylinder and motors, Pump unloading, Counterbalance application, Sequencing circuit, locked cylinder with pilot check, pressure reducing valve circuit, accumulator circuits. **Analysis of Hydraulic circuits** Regenerative Circuit**,** Cylinder Synchronizing circuits, Double Pump Hydraulic System, Meter in and meter out flow control, (numerical), Analysis of open-ended hydraulic circuits of industrial machine tools using various hydraulic valves and accessories.	
Unit –IV	**09 Hrs**
Design of pneumatic circuits ISO 5599 symbolic representations, structure of pneumatic circuits, Circuit diagrams on Direct and Indirect control of pneumatic cylinders, control of pneumatic motor, use of memory valve, supply air throttling and exhaust air throttling, auto return motion, quick exhaust valve. **Logic control and Multicylinder applications** Moving Part Logic Control of Circuits, Practical examples involving the use of AND and OR gates. Applications of pressure dependent control and time delay valve, cascading principle, displacement step and timing diagram, coordinated motion control, Signal elimination using reversing valves (two cylinders).	
Unit-V	**07 Hrs**
Electro Pneumatics Electrical switching devices, symbolic representation, direct and indirect control of single acting and double acting cylinders, relay control circuit, latching circuit, auto return using proximity sensors, control of double acting cylinder using electrical timer. **Applications of Fluid power systems**	

Cyclic operation of double acting cylinder, automatic gate, dual cylinder sequence, box sorting system, electrical control of regenerative circuit, circuit for stamping device.

Course Outcomes: After completing the course, the students will be able to:	
CO1	Explain the basic components of hydraulic and pneumatic power pack and structure of circuits.
CO2	Identify the hydraulic and pneumatic power symbolic representations and troubleshoot the problems.
CO3	Determine the performance parameters of hydraulic pumps, actuators, filters and valves.
CO4	Design an efficient hydraulic and pneumatic circuit diagrams for industrial applications

Reference Books	
1.	S. Ilango, V. Soundararajan, 'Introduction to Hydraulics and Pneumatics', PHI learning, 2nd Edition, 2011, ISBN: 978812034406–8.
2.	Andrew Parr, 'Hydraulics and Pneumatics', Elsevier, 3rd Edition, 2011, ISBN: 978008096674–8.
3.	Anthony Esposito, 'Fluid Power with Applications', 7th Edition, 2013, ISBN – 13; 978–9332518544.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

Semester: VI						
TURBOMACHINERY **Category: Professional Cluster Elective** **Stream: Common to ME, AS, IEM** **(Theory)**						
Course Code	**:**	21ME65E2		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**3 Hours**

Unit-I	**09 Hrs**
Introduction: Fluid machines, Classification, Comparison with positive displacement machines, Dimensional analysis, Dimensionless parameters and their physical significance; Specific speed; dimensional analysis and model studies. Basic Euler turbine equation and its alternate forms, Components of energy transfer, General expression of degree of reaction, Relation between degree of reaction and utilization factor, concept of velocity triangles.	
Unit – II	**10 Hrs**
Compression Process: Overall isentropic efficiency of compression, Stage efficiency, Comparison and relation between overall efficiency and stage efficiency; Polytropic efficiency and pre-heat factor **Expansion Process:** Overall isentropic efficiency for a turbine, Stage efficiency for a turbine, Comparison and relation between stage efficiency and overall efficiency for expansion process; Polytropic efficiency for expansion process and reheat factor for expansion process.	
Unit –III	**10 Hrs**
Centrifugal Pumps: Definition of terms used in the design of centrifugal pumps like manometric head, suction head, delivery head, Efficiencies of pump, multi-stage centrifugal pumps. **Centrifugal Compressors** Expression for overall pressure ratio, Slip factor and power input factor, Surging and its control.	
Unit –IV	**08 Hrs**
Axial Flow Compressors: Classification, expression for stage pressure ratio, work done factor, analysis of air compressors. **Steam Turbines:** Impulse and reaction turbines, velocity and pressure compounding; condition for maximum utilization factor for multistage turbine with equiangular blades, effect of blade and nozzle losses	
Unit –V	**08 Hrs**
Hydraulic Turbines: Pelton wheel, Bucket dimensions, turbine efficiency; Francis and Kaplan Turbines, Velocity triangles, Draft tubes and their function, Types of draft tube.	

Course Outcomes: After completing the course, the students will be able to:	
CO1	Explain working principles of turbines and compressors.

CO2	Analyse the characteristics of power absorbing and power generating turbo machines.
CO3	Evaluate performance of turbo machines.
CO4	Discuss selection of turbo machine for industrial application.

Reference Books	
1	Principles of Turbo Machinery, Shephered.D.G, 10th Edition,McMillan Company, ISBN: 078623241-2
2.	Turbine Compressors and Fans, Yahya. S.M., 2nd Edition,Tata McGraw Hill, ISBN: 99862228-0
3.	Introduction to Energy Conversion, Kadambi and Manohar Prasad, 7th Edition, 2003, Wiley Eastern, ISBN: 765329176-x
4.	A Treatise on Turbo Machines, Gopalakrishna G and Prithviraj D, 3rd Edition, 2002, SciTech Publications, ISBN: 8793452172-1

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

Semester: VI						
AIRPORT ENGINEERING **Category: Professional Cluster Elective** **Stream: Common to ME, AS, IEM** **(Theory)**						
Course Code	**:**	21AS65E1		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 T		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**09 Hrs**
Aviation logistics solutions: Introduction: Environment, transport and mobility. Systematic description and current challenges. Development of aircraft design driver-speed and range. Development of Airport, Airlines, ICAO, Regulatory Framework and Market Aspects.	
Unit – II	**09 Hrs**
Aircraft traits and manufacturing sources: Classification of flight vehicles, cabin design, basics of flight physics- structures, mass and balance. Flight performance and mission. Aircraft manufacturers, development process, production process, supply chain.	
Unit –III	**09 Hrs**
Airline operations, airports, and associated infrastructure: Airline types, Network management. Flight strategy and aircraft selection, flight operations, MRO. Role of Airport, Regulatory Issues, Airport operation and services. Airport planning – Infrastructure.	
Unit –IV	**09 Hrs**
Aerial Navigation Networks and Environmental Monitoring: Principle of operation- Role of Air Navigation services. Air space structures, Airspace and Airport capacity, Aircraft separation. Flight guidance system. Communication system. Integrated air traffic management and working system. Environmental aspects-emission, noise, and sound.	
Unit –V	**09 Hrs**
Managerial Practices and Strategies in Aviation: Airline passenger marketing, forecasting methods, pricing and demand. Air cargo-market for air freight. Principles of airline scheduling. Fleet planning.	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Develop a holistic understanding of the air transportation system, encompassing its various components and functions.
CO2	Illustrate the intricate structure of the aviation industry, covering airlines, airports, and their associated infrastructure, while also addressing key managerial aspects
CO3	Explore the various air navigation and environmental systems utilized to enhance the efficiency and sustainability of the air transportation system.
CO4	Summarize essential information about aircraft, including their basic characteristics and major manufacturers

Reference Books	
1	Dieter Shmitt, and Valker Gollnick, Air Transport System, Springer, 2016.
2	John G Wensveen, Air Transportation-A Management Prospective, Ashgate Publishing Ltd 2011
3	Mike Hirst, The Air Transportation System, Wood head publishing Ltd, England, 2008

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

Semester: VI						
SPACE VEHICLE DESIGN **Category: Professional Cluster Elective** **Stream: Common to ME, AS, IEM** **(Theory)**						
Course Code	**:**	21AS65E2		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**10 Hrs**
History of rocketry & launch vehicles , Ascent Mission Basics, Force and Geometry Models 1 & 2, Idealized Performance, Current & future launch vehicles. Orbit/trajectory requirements and missions.	
Unit – II	**10 Hrs**
Idealized Performance, Trajectory Under Gravity, Impact of Gravity, Impact of Drag, Δv & initial sizing, inboard profile & layout. Engine selection. Preliminary mass estimation	
Unit –III	**10 Hrs**
Ascent Mission Design, Multi-stage Rocket Concept, Multi-stage Design Basics, Multi-stage Formulation, Optimal Staging Concept, Lagrange's Solution, Approximate Staging Solution	
Unit –IV	**08 Hrs**
Concept of Rocket Variant , Variant Design Solution, Parallel Staging Concept, Relativistic and SSTO Rocket Concepts, Air-breathing Rockets and Ballistic Missiles	
Unit –V	**07 Hrs**
Jet Damping and Spin in Rockets and Missiles, Basics of Rocket Launching, Fundamentals of Re-entry, Typical Re-entry Techniques	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Understand the fundamental concepts of development of various launch vehicle
CO2	Demonstrate the working principles of different types of space vehicle
CO3	Identify and Classify the required systems, trajectory and orbit employed based on the mission requirements
CO4	Compute and Evaluate the fundamental parameters involved in the stage design and vehicle sizing for specific missions

Reference Books	
1	Space Vehicle Design, Griffin and French, AIAA, 2004, ISBN 1563475391
2	Spacecraft Systems Engineering P. Fortescue, J. stark, and G. Swinerd Wiley-Blackwell, 4th revised edition,2011
3	Manned Spacecraft Design Principles, Sforza, Elsevier, 2016, ISBN 9780128044254.
4	Elements of Space Technology, R. Meyer, Academic Press, 1999, ISBN 0124929400
5	Astronautics, U. Walter, WILEY-VCH, 2008, ISBN 9783527406852

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

VI Semester						
LEAN MANUFACTURING SYSTEMS **Category: Professional Cluster Elective** **Stream: Common to ME, AS, IEM** **(Theory)**						
Course Code	**:**	21IM65E1		**CIE**	**:**	**100 Marks**
Credits: L: T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**3.0 Hours**

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 **The Significance of Lead Time:** History of Lead Time, Benefits of Lead-Time Reductions, Lead-Time Reductions, Techniques to Reduce Lead Times	
UNIT – III	**09 Hrs**
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 **Process Improvement and Lean Six Sigma:** Introduction, An LSS quality focus on the Business process, objectives of process improvement, cross functional focus, critical success factors, Nature and advantage of LSS process Improvement, Process owner, Process ownership. **Integrating LSS and DMAIC with DMADV:** Overview, Goals of lean DMADV, Lean Design, Goals of DMAIC/DMADV, comparing DMAIC and DMADV, Integrating lean with DMAIC/DMADV	
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. **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.	
UNIT – V	**09 Hrs**
Lean 4.0: Dimensions of lean manufacturing, Industry 4.0, Integration of Lean Manufacturing and Industry 4.0, Summary of lean dimensions, challenges and solutions.	

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.	Lonnie Wilson, How to Implement Lean Manufacturing, ISBN: 978-0-07-162508-1, The McGraw-Hill Companies,
2.	Frank Voehl, H James Harrington, Chuck Mignosa, Rich Charron, The Lean Six Sigma Black Belt Hand Book-Tools and methods for process acceleration, CRC Press Taylor & Francis group,2014,ISBN-13:978-1-4665-5468-9
3.	Michael Hammer & James Champy, REENGINEERING THE CORPORATION, A Manifesto for Business Revolution,Harper Business Essentials
4.	Jeffrey K. Liker, The Toyota Way, ISBN-10:0-07-058747-7, The McGraw-Hill Companies
5.	M.G. Korgaonker, "Just In Time Manufacturing", Macmillan India Ltd., 2006, ISBN: 0333 926633.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

VI Semester						
TOTAL QUALITY MANAGEMENT **Category: Professional Cluster Elective** **Stream: Common to ME, AS, IEM** **(Theory)**						
Course Code	**:**	21IM65E2		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**3.00 Hours**

UNIT-I	**09 Hrs**
Quality Pioneers: Deming's approach, Juran's quality trilogy, Crosby and quality treatment, Imai's Kaizen, Ishikawa's company-wide quality control, and Feigenbaum's theory of TQC. **Evolution of Quality Concepts and Methods:** Quality concepts, Development of four fitness's, evolution of methodology, evolution of company integration.	
UNIT-II	**09 Hrs**
Four Revolutions in Management thinking, Focus on customers: Change in work concept, market-in, and customers. **Continuous Improvement:** Improvement as problem solving process: Management by process, WV model of continuous improvement. **Reactive Improvement**: Identifying the problem, standard steps, seven steps case study, General guidelines for managers diagnosing a QI story. **Proactive Improvement:** Introduction to proactive improvement, standard steps for proactive improvement, semantics, Seven Management and Planning Tools.	
UNIT-III	**09 Hrs**
Total Participation; Teamwork skill, Dual function of work, teams and teamwork, principles for activating teamwork, creativity in team processes, Initiation strategies, **Hoshin Management**: Definition, Concepts, Phases in Hoshin Management – overview. **Societal Networking:** Networking and societal diffusion, infrastructure for networking. TQM as learning system, a TQM model for skill development.	
UNIT-IV	**09 Hrs**
Introduction to Six Sigma: Benefits, fundamentals, myths, essentials and costs of Six Sigma. Assessing readiness for Six Sigma, five key players, Planning for the Six Sigma initiative. Case discussions. **Statistical Foundation:** Variation & causes, normal distribution, process capability, rolled throughput yield, Cost of poor quality. **Metrics for Six Sigma:** The critical-to-quality concept, criteria to metrics, universal standard, baselines, benchmarking, guidelines for metrics.	
UNIT-V	**09 Hrs**
Project Selection: Project selection process, evaluating projects. Project selection matrix, project review. DMAIC phases. **Design for Six Sigma:** Overview of DFSS, DMADV Method. **Beyond Six sigma:** Supply chain management using Lean and Six Sigma, Knowledge management and Six Sigma, Growth Management System – building blocks and architecture.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Explain the TQM & Six Sigma principles and concepts for organizations
CO2:	Compare TQM and Six Sigma methodologies.
CO3:	Evaluate and select the appropriate framework for continuous improvement.
CO4:	Design & implement TQM & Six Sigma projects in organizational situations.

Reference Books	
1	Shoji Shiba, Alan Graham and David Walden, A New American TQM – Four Practical Revolutions in Management, Productivity Press, Portland (USA), 2nd Edition, 1993, ISBN: 9781563270321
2	Greg Brue and Rod Howes, Six Sigma, TATA McGraw-Hill 3rd Edition 2006, ISBN: 0-07-063468-8
3	N Logothetis , Managing for total quality: from Deming to Taguchi and SPC, Prentice Hall of India, 1993, ISBN: 978-0133535127
4	Dale H. Besterfield, Carol Besterfield-Michna, Glen Besterfield, Mary Besterfield – Sacre, Total Quality Management, Pearson Education, 2002, 3rd Edition, ISBN-81-297-0260-6.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

Semester: VI						
INDUSTRIAL SAFETY AND RISK MANAGEMENT **Category: Institutional elective - I** **(Theory)**						
Course Code	**:**	21IE6F1		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	40 L		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**
Introduction Safety: Introduction to industrial safety engineering, major industrial accidents, safety and health issues, key concepts and terminologies, Hazard theory, Hazard triangle, Hazard actuation, Actuation transition, Causal factors, Hazard recognition.	
Unit – II	**08 Hrs**
Risk assessment and control: Individual and societal risks, Risk assessment, Risk perception, Acceptable risk, ALARP, Prevention through design. **Hazard Identification Methods:** Preliminary Hazard List (PHL): Overview, methodology, worksheets, case study. Preliminary Hazard Analysis (PHA), Fault tree and Event tree analyses.	
Unit –III	**08 Hrs**
Hazard analysis: Hazard and Operability Study (HAZOP): Definition, Process parameters, Guide words, HAZOP matrix, Procedure, Example. Failure Modes and Effects Analysis (FMEA): Introduction, system breakdown concept, methodology, example.	
Unit –IV	**08 Hrs**
Application of Hazard Identification Techniques: Case of pressure tank, heat exchanger, system breakdown structure, Accident paths, HAZOP application, risk adjusted discounted rate method, probability distribution, Hiller's model	
Unit –V	**08 Hrs**
Safety in process industries and case studies: Personnel Protection Equipment (PPE): Safety glasses, face shields, welding helmets, absorptive lenses, hard hats, types of hand PPE, types of foot PPE, types of body PPE. Bhopal gas tragedy, Chernobyl nuclear disaster, Chemical plant explosion and fire.	

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

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

4.	Industrial Safety, Health and Environment Management Systems, R K Jain, Sunil S Rao, 4th Edition, 2005, Khanna Publishers, New Delhi, ISBN: 8174092102.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
RENEWABLE ENERGY SYSTEMS **Category: Institutional Elective - I** **(Theory)**						
Course Code	**:**	21IE6F2		**CIE**	**:**	100Marks
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	100 Marks
Total Hours	**:**	40 L		**SEE Duration**	**:**	3 Hours

Unit-I	**08 Hrs**
Introduction: Energy systems model causes of Energy Scarcity, Solution to Energy Scarcity, Factors Affecting Energy Resource Development, Energy Resources and Classification, Renewable Energy – Worldwide Renewable Energy Availability, Renewable Energy in India. **Basics of Solar Energy:** Sun- earth Geometric Relationship, Layer of the Sun, Earth – Sun Angles and their Relationships, Solar Energy Reaching the Earth's Surface, Solar Thermal Energy Application. Block diagram of solar energy conversion.	
Unit – II	**08 Hrs**
Solar PV Systems: Basic Principle of SPV conversion – Types of PV Systems(Standalone, Grid connected, Hybrid system)- Types of Solar Cells, Photovoltaic cell concepts: Cell, module, array ,PV Module I-V Characteristics, Array design (different methodologies),peak-power operation, system components.Efficiency & Quality of the Cell, series and parallel connections, maximum power point tracking, Applications..	
Unit –III	**08 Hrs**
Wind Power Systems: **Wind speed and energy:** Introduction, history of wind energy, scenario- world and India. Basic principle of Wind energy conversion system (WECS), Classifications of WECS, part of a WECS. Derivation of power in the wind, electrical power output and capacity of WECS, wind site selection consideration, advantages and disadvantages of WECS. Maximum energy capture, maximum power operation, , environmental aspects.	
Unit –IV	**08 Hrs**
Geothermal and ocean energy systems: Geothermal well drilling, advantages and disadvantages, Comparison of flashed steam and total flow concept (T-S diagram). Associated Problems, environmental Effects. **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. Issues Faced in Exploiting Tidal Energy	
Unit –V	**08 Hrs**
Hydrogen Energy: Benefits of Hydrogen Energy, Hydrogen Production through block diagram, Use of Hydrogen Energy, Merits and Demerits, Problems Associated with Hydrogen Energy. **Biomass Energy:** Introduction-Biomass resources –Energy from Biomass: conversion processes-Biomass Cogeneration-Environmental Benefits. Biomass products – ethanol, biodiesel, biogas Electricity and heat production by biomass.	

Course Outcomes: After completing the course, the students will be able to: -	
CO 1	Understand the working principle and operation of various renewable energy sources and systems.
CO 2	Analyze the performance and characteristics of renewable energy sources and systems.
CO 3	Evaluate the parameters of wind and solar energy systems.
CO 4	Design and demonstrate the applications of renewable energy sources in a typical systems.

Reference Books	
1.	Non conventional energy sources, by G.D Rai, Khanna publishes, 19th Edition, 2017, ISBN: 978-81-7409-073-8
2.	Solar photo voltaic Technology and systems, by Chetan Singh Solanki, 3rd Edition, PHI, Learning private limited New Delhi, 2013, ISBN: 978-81-203-4711-3.
3.	Wind and solar power system design, Analysis and operation, Mukund R. Patel, 2nd Edition. CRC Group, Taylor and Francis group, New Delhi, ISBN 978-0-8493-1570-1.
4.	Renewable energy: Technology, Economics and Environment, Martin Kaltschmitt, Wolfgang Streicher Andreas Wiese, Springer Publication, 2007, ISBN 978-3-540-70947- 3

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	COMPONENTS	MARKS
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
SYSTEMS ENGINEERING **Category: Institutional Elective - I** **(Theory)**						
Course Code	**:**	21IE6F3		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**06 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	**10 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	**10 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	**10 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	**09 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.

Reference Books:	
1.	Alexander Kossoaikoff, William N Sweet, "Systems Engineering – Principles and Practice" John Wiley & Sons, Inc, edition: 2012, ISBN: 978-81-265-2453-2
2.	Andrew P. Sage, William B. Rouse, "Handbook of Systems Engineering And Management" John Wiley & Sons, Inc., edition:1999, ISBN 0-471-15405-9
3.	Ludwig von Bertalanffy, "General System Theory: Foundation, Development, Applications", Penguin University Books, 1973, Revised, ISBN: 0140600043, 9780140600049.
4.	Blanchard, B., and Fabrycky, W. Systems Engineering and Analysis, Saddle River, NJ, USA: Prentice Hall, 5th edition, 2010.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	COMPONENTS	MARKS
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only; wherein one sub division will be a caselet in the related topics)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
MECHATRONICS **Category: Institutional Elective - I** **(Theory)**						
Course Code	**:**	21IE6F4		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**3 Hours**

Unit-I	**09 Hrs**
Overview of Mechatronic Systems Traditional and mechatronic design, automatic washing machine, automatic door, dishwasher, compact disc drive copy machine, camera, and temperature control. Principle and working of hall sensor, displacement sensor, absolute and incremental encoders, photoelectric sensors, inductive and capacitive proximity sensors, Relays and solenoids, Brushless DC, AC and servo motors, pulse width modulation by basic transistor circuit, H bridge circuit, Stepper motor: variable reluctance and permanent magnet, stepper motor control circuits, selection of motors.	
Unit – II	**10 Hrs**
Signal Conditioning Operational Amplifiers – circuit diagrams and derivation – Numerical, filtering, multiplexers, 4:1 MUX, time division multiplexing -seven segment display, data acquisition, Analog and digital signals, analog to digital converters. Introduction to Digital signal processing – difference equation (Numericals). **Programmable logic controllers** Components, principle of operation, modifying the operation, basic PLC instructions, and concepts of ladder diagram, latching, timer instructions, counter instructions.	
Unit –III	**10 Hrs**
Ladder Diagram for PLCs Examples with ladder logic programs, simple programs using Boolean logic, word level logic instructions. Relay to ladder conversion examples., **Industrial applications of PLCs** Central heating system, valve sequencing, traffic light control in one direction, water level control, overhead garage door, sequential process, continuous filling operation, Fluid pumping with timers, parking garage counter, can counting in assembly line.	
Unit –IV	**08 Hrs**
Microcontrollers Components of a full featured microcontroller, Memory, I/O Ports, Bus, Read & Write Cycle, Architecture of Intel 8051 microcontroller, Pin diagram, simple instructions for a microcontroller. – Data transfer, arithmetic functions, logical operations, Jump and branching operation. **Digital circuits** Digital representations, Combinational logic – Case studies: BCD to 7 segment decoder, calendar subsystem in a smartwatch., timing diagrams, Karnough maps – 3 variable and 4 variable, design of logic networks, flip-flops, Counters.	

Unit –V	08 Hrs
Dynamic Responses of Systems Closed loop system, Terminology, transfer functions, step response of first order and second order systems, performance measures for first and second order systems, - Numerical **Mechanical Actuation Systems** Four bar chain, slider crank mechanism, Cams and followers, gear trains – Numerical	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Select appropriate sensors and transducers and devise an instrumentation system for collecting information about processes
CO2	Apply the electrical and logic concepts and inspect the functioning of mechatronic systems.
CO3	Evaluate a control system for effective functioning of Mechatronics systems using digital electronics, microprocessors, microcontrollers and programmable logic controllers
CO4	Develop conceptual design for Mechatronics products based on potential customer requirements

Reference Books	
1	Nitaigour Premchand, 'Mechatronics-Principles, Concepts & Applications', TMH 1st Edition, 2009, ISBN: 9780070483743
2.	Bolton W., 'Mechatronics-Electronic Control System in Mechanical and Electrical Engineering', Pearson Education, 4th Edition, 2012; ISBN:9788131732533
3.	Tilak Thakur 'Mechatronics', Oxford University Press, I Edition, 2016, ISBN: 9780199459329
4.	Petruzella, Frank D, Programmable logic controllers, McGraw-Hill, 4th Edition, 2013, ISBN-13: 978-0-07-351088-0

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
PART A		
1	Objective type questions covering entire syllabus	20
PART B (Maximum of TWO Sub-divisions only)		
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

Semester: VI						
MATHEMATICAL MODELLING **Category: Institutional Elective - I** **(Theory)**						
Course Code	**:**	21IE6F5		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**09 Hrs**
Continuous Models Using Ordinary Differential Equations: Basic concepts, real world problems (Science and Engineering), approximation of the problem, steps involved in modelling, formation of various continuous models.	
Unit – II	**09 Hrs**
Mathematically Modelling Discrete Processes: Difference equations – first and second order, introduction to difference equations, introduction to discrete models-simple examples, mathematical modelling through difference equations in economics, finance, population dynamics, genetics and other real-world problems.	
Unit –III	**09 Hrs**
Markov modelling: Mathematical foundations of Markov chain, applications of Markov modelling.	
Unit –IV	**09 Hrs**
Modelling through graphs: Graph theory concepts, modelling situations through different types of graphs.	
Unit –V	**09 Hrs**
Variational Problem and Dynamic Programming: Optimization principles and techniques, mathematical models of variational problem and dynamic programming and applications.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Explore the fundamental concepts of mathematical models arising in various fields of engineering.
CO2:	Apply the knowledge and skills of discrete and continuous models.
CO3:	Analyze the appropriate mathematical model to solve the real-world problem and optimize the solution
CO4:	Distinguish the overall knowledge gained to demonstrate the problems arising in many practical situations.

Reference Books	
1	Mathematical Modeling, J. N. Kapur, 1st Edition, 1998, New Age International, New Delhi, ISBN: 81-224-0006-X.
2	Mathematical Modeling: Models, Analysis and Applications, Sandip Banerjee, 2014, Chapman and Hall/CRC Textbook, ISBN 9781439854518.
3	Case Studies in Mathematical Modeling, D. J. G. James and J. J. Mcdonald, 1981, Stanly Thames, Cheltonham, ISBN: 0470271779, 9780470271773.

4	Modeling with Difference Equations, D. N. Burghes, M. S. Borrie, Ellis Harwood, 1981, ISBN 13: 9780853122869.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
INDUSTRY 4.0 – SMART MANUFACTURING FOR THE FUTURE **Category: Institutional Elective - I** **(Theory)**						
Course Code	**:**	21IE6F6		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	42 L		**SEE Duration**	**:**	**3 Hours**

Unit-I	**07 Hrs**
Introduction: The Various Industrial Revolutions, Need – Reason for Adopting Industry 4.0, Definition, Goals and Design Principles – Interoperability, Virtualization, Decentralization, Real-time Capability, Service Orientation, Modularity. Individualization, Volatility, Energy and resource efficiency. Road to Industry 4.0 – Internet of Things (IoT), Architecture of IoT, Technologies for IoT & Industrial Internet of Things (IioT), Internet of Services, Standardization, Cyber-Physical Systems, Smart Manufacturing, Network via Ethernet/ Wi-Fi for high-speed data transmission, Mobile technologies	
Unit – II	**10 Hrs**
Opportunities and Challenges Lack of resources, Availability of skilled workers, Broadband infrastructure, Policies, Future of Works and Skills in the Industry 4.0 Era, Disruption as manufacturing's greatest modern challenge **Robotics in Industry 4.0** Robotic Automation and Collaborative Robots, Human-Machine Interaction **Big Data** Evolution**,** Essential of Big Data in Industry 4.0, Big Data Merits, Data transparency, Business Intelligence, Production planning, Quality, Acquisition of Automation Data, Digital Traceability, Radio-Frequency Identification (RFID), GPS, Data transformation, Big Data Characteristics, Data as a new resource for organizations, Data driven applications, Harnessing and sharing knowledge in organizations, Data analytics – Descriptive Analytics, Diagnostic analytics, Predictive Analytics, Prescriptive analytics	
Unit –III	**10 Hrs**
Cloud Computing Fundamentals, Cloud/Edge Computing and Industry 4.0, The IT/OT convergence, Cyber Security **Horizontal and Vertical integration** End-to-end engineering of the overall value chain, Digital integration platforms, Role of machine sensors, Sensing classification according to measuring variables, Machine-to-Machine communication **Artificial Intelligence/Machine Learning in Industry 4.0** Fundamentals, Case Studies, Technology paradigms in production logistics – Intelligent conveyor system, Intelligent commissioning system, Intelligent production machine, Intelligent load carrier, Application-specific demand on Intelligent Objects (user-oriented functions), Technological realization of Intelligent Objects (product-oriented functions)	

Unit –IV	08 Hrs
Augmented Worker Augmented and Virtual Reality, softwares, Industrial Applications – Maintenance, Assembly, Collaborative operations, Training **Digital-to-Physical** Additive Manufacturing technologies, Advantages, impact on environment, Applications – Automotive, Aerospace, Electronics and Medical	
Unit –V	**07 Hrs**
Digital twin, Virtual factory, Total Productive Maintenance, Industry 4.0 case studies, Understanding I 4.0 in MSMEs, What's Next: Industry 5.0/Society 5.0	

Course Outcomes: After completing the course, the students will be able to:	
CO1	Identify the basic components of Industry 4.0
CO2	Analyse the role of Big data for modern manufacturing
CO3	Create AR/VR models for industrial scenario
CO4	Create simple Additive manufactured parts

Reference Books	
1.	Industry 4.0: Managing the Digital Transformation, Alp Ustundag, Emre Cevikcan, 2017, Springer, ISBN: 978-3-319-57869-9, ISBN: 978-3-319-57870-5
2.	The Concept Industry 4.0 - An Empirical Analysis of Technologies and Applications in Production Logistics, Christoph Jan Bartodziej, 2017, Springer Gabler, ISBN 978-3-658-16501-7 ISBN 978-3-658-16502-4
3.	Industry 4.0 - The Industrial Internet of Things, Alasdair Gilchrist, 2016, APRESS, ISBN-13 978-1-4842-2046-7 ISBN-13: 978-1-4842-2047-4
4.	Digitizing the Industry – Internet of Things connecting the Physical, Digital and Virtual Worlds, Ovidiu Vermesan, 2016, River Publishers, ISBN 978-87-93379-81-7 ISBN 978-87-93379-82-4

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

Semester: VI						
Industrial Psychology for Engineers **Category: Institutional Elective - I** **(Theory)**						
Course Code	**:**	21IE6F7		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**
Introduction to Psychology: Definition and goals of Psychology: Role of a Psychologist in the Society: Today's Perspectives (Branches of psychology- Clinical, Industrial). Psychodynamic, Behavioristic, Cognitive, Humanistic, Psychological Research and Methods to study Human Behavior: Experimental, Observation, Questionnaire and Clinical Method.	
Unit – II	**08 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	**10 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.	
Unit –IV	**10 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.	
Unit –V	**09 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. **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. Type A and Type B.**Psychological Counseling** - Need for Counseling, Types – Directed, Non- Directed, Participative Counseling.	

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.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	COMPONENTS	MARKS
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only; wherein one sub division will be a caselet in the related topics)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
ELEMENTS OF FINANCIAL MANAGEMENT **Category: Institutional Elective - I** **(Theory)**						
Course Code	**:**	21IE6F8		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**06 Hrs**
Financial Management-An overview: Financial Decisions in a firm, Goals of a firm, Fundamental principle of finance, Organization of finance function and its relation to other functions, Regulatory framework. **The financial System:** Functions, Assets, Markets, Market returns, Intermediaries, regulatory framework, Growth and trends in Indian financial system. **Financial statements, Taxes and cash flow:** Balance sheet, statement of profit and loss, items in annual report, manipulation of bottom line, Profits vs Cash flows, Taxes. **(Conceptual treatment only)**	
Unit – II	**10 Hrs**
Time Value of Money: Future value of a single amount, future value of an annuity, present value of a single amount, present value of an annuity. **Valuation of securities:** Basic valuation model, bond valuation, equity valuation-dividend capitalization approach and other approaches. **Risk and Return:** Risk and Return of single assets and portfolios, measurement of market risk, relationship between risk and return, implications **(Conceptual and Numerical treatment)**	
Unit –III	**10 Hrs**
Techniques of Capital Budgeting: Capital budgeting process, project classification, investment criteria, Net present value, Benefit-Cost ratio, Internal Rate of return, Payback period, Accounting rate of return. **Cost of Capital:** Preliminaries Cost of debt and preference, cost of retained earnings, cost of external equity, determining the proportions, weighted average cost of capital, weighted marginal cost of capital schedule. **Capital structure and cost of capital:** Assumptions and concepts, net income approach, net operating income approach, traditional position, Modigliani and Miller Position, Taxation and Capital structure, Other imperfections and Capital structure **(Conceptual and Numerical treatment)**	
Unit –IV	**10 Hrs**
Long term finance: Sources- Equity capital, Internal accruals, preference capital, term loans, debentures. Raising long term finance- Venture capital, Initial Public Offer, Follow on Public Offer, Rights Issue, Private Placement, Term Loans, Investment Banking **Securities Market:** Primary market vs Secondary market, Trading and Settlements, Stock market quotations and Indices, Govt. securities market, Corporate debt market. **Working Capital – Policy and Financing:** Factors influencing working capital requirements, Current assets financing policy, operating cycle and cash cycle. Accruals, trade credit, banks, public deposits, inter-corporate deposits, short term loans, right debentures, commercial paper, Factoring **(Conceptual treatment only)**	
Unit –V	**09 Hrs**
Contemporary topics in Finance: Reasons and Mechanics of a merger, Takeovers, Divestures, Demergers, World monetary system, Foreign exchange markets, raising foreign currency finance, International capital budgeting, Options market, Futures market, Warrants, Venture capital financing framework, Indian venture capital scenario. (Conceptual treatment only)	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Explain the features of financial system and basic principles of financial management.
CO2	Describe the processes and techniques of capital budgeting and theories of capital structure.
CO3	Demonstrate an understanding of various sources of long term and working capital financing by organizations.
CO4	Analyze the trends in global financial scenarios.

Reference Books:	
1.	Fundamentals of Financial Management, Prasanna Chandra, 6th Edition, 2018, McGraw Hill
2.	Education(India) Pvt. Ltd, ISBN: 978-93-392-0313-9, 93-392-0313-5
3.	Financial Management-Text, Problems and Cases, Khan M Y & Jain P K, 8th Edition, 2018,
4.	McGraw Hill Education(India) Pvt. Ltd, ISBN: 9353162181 , 9789353162184

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). TWO tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only; wherein one sub division will be a caselet in the related topics)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
Universal Human Values - II **Category: Institutional Elective - I** **(Theory)**						
Course Code	**:**	21IE6F9		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 L		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**10 Hrs**
Introduction-Basic Human Aspiration, its fulfillment through All-encompassing Resolution. The basic human aspirations and their fulfillment through Right understanding and Resolution, Right understanding and Resolution are the activities of the Self, Self is central to Human Existence; All-encompassing Resolution for a Human Being, its details and solution of problems in the light of Resolution.	
Unit – II	**10 Hrs**
Right Understanding (Knowing)- Knower, Known & the Process. The domain of right understanding starts from understanding the human being (the knower, the experiencer and the doer); and extends up to understanding nature/existence – its interconnectedness and co-existence; and finally understanding the role of human being in existence (human conduct).	
Unit –III	**08 Hrs**
Understanding Existence (including Nature). A comprehensive understanding (knowledge) about the existence, which certainly includes the Nature. The need and the process of inner evolution (through self-exploration, self-awareness and self-evaluation)- particularly awakening to activities of the Self: Realization, Understanding and Contemplation in the Self (Realization of Co-Existence, Understanding of Harmony in Nature and Contemplation of Participation of Human in this harmony/ order leading to comprehensive knowledge about the existence).	
Unit –IV	**08 Hrs**
Understanding Human Being. Understanding the human being comprehensively is the first step and the core theme of this course; human being as co-existence of the self and the body, the activities and potentialities of the self, Reasons for harmony/contradiction in the self.	
Unit –V	**08 Hrs**
Understanding Human Conduct, All-encompassing Resolution & Holistic Way of Living. Understanding Human Conduct, Understanding different aspects of All-encompassing Resolution (understanding, wisdom, science etc.), Holistic way of living for Human Being with All-encompassing Resolution covering all four dimensions of human endeavour viz., realization, thought, behavior and work (participation in the larger order) leading to harmony at all levels from self to Nature and entire Existence.	

Course Outcomes: After completion of the course the students will be able to	
CO1	Understand the basic human aspiration with program of its fulfilment and meaning of resolution in the complete expanse of human living.
CO2	Understand human being in depth and see how self is central to human being
CO3	Understand existence in depth and see how coexistence is central to existence
CO4	Understand human conduct and the holistic way of living leading to human tradition

Reference Books	
1	A foundation course in human values and professional ethics, R. R. Gaur, R Asthana, G P Bagaria, 2nd revised Edition, excel books, New Delhi – 2019, ISN 978-93-87034-47-1
2	Avartansheel Arthshastra, A Nagraj, Divya Path Sansthan, Amarkantak, India, ISBN 978-8-174-46781-2
3	Economy of Performance- a quest for social order based on non – violence, J C Kumarappa, 2010, Sarva-Seva-Sangh-Prakashan, Varanasi, India
4	Energy and Equity, Ivan Illich, 1974, The Trinity Press, Worcester & Harper Collins, USA, ISBN, 0060803274, 9780060803278

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
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3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
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3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20) **Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

Semester: VI						
Human Machine Interface **Category: Institutional Elective - I** **(Theory)**						
Course Code	**:**	21IE6F10		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	42 L		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**10 Hrs**
Foundations of HMI: The Human: History of User Interface Designing, I/O channels, Hardware, Software and Operating environments, The Psychopathology of everyday Things, Psychology of everyday actions, Reasoning and problem solving. The computer: Devices, Memory, processing and networks. Interaction: Models, frameworks, Ergonomics, styles, elements, interactivity, Paradigms. Introduction to HMI and domains- Automotive, Industrial, CE, Medical, ECUs within car and their functionalities. Interaction between ECUs. Communication protocols for ECUs(CAN, LIN, Most, FlexRay,Ethernet etc)	
Unit – II	**10 Hrs**
Automotive Human-Machine Interfaces: Automotive infotainment system - Evolution road map, Feature sets, System architecture, Trends, Human factors and ergonomics in automotive design, Automotive User Experience (UX) Design Principles, In-Vehicle Information Systems (IVIS), Driver-Assistance Systems (DAS) Interfaces, HMI design for adaptive cruise control, Voice and Gesture Recognition in Automotive HMIs, Touchscreen Interfaces and Controls, Usability Testing and Evaluation in Automotive HMIs, Safety Considerations and Regulations in Automotive HMIs, Emerging Technologies in Automotive HMIs, Human-Machine Interfaces for Autonomous Vehicles	
Unit –III	**08 Hrs**
UX and Guidelines: Introduction to UX design - stages, theory, Design thinking, UX Study, Interaction concepts, Graphic design tools - Adobe Photoshop, Adobe XD, Blender, GIMP, Asset Design - Overview , Guidelines and norms, 2D/3D rendering, OpenGL, OSG.	
Unit –IV	**08 Hrs**
HMI User Interface: User-centered HMI development process, Basics of Web-Server. Web-based HMI: Basics of TwinCAT and HTML, CSS, JavaScript. HMI on Mobile: Four Principles of Mobile UI Design, Benefits of Mobile HMIs, Mobile HMI Development Suites.	
Unit –V	**08 Hrs**
HMI Control Systems: Introduction to Voice-Based HMI, Gesture-Based HMI, Sensor-Based UI controls.**Haptics in Automotive HMI:** Kinesthetic Feedback Systems, Tactile Feedback Systems, Haptics in Multimodal HMI, Automotive Use-Cases **HMI Testing:** Limitations of Traditional Test Solutions, Case - Study: Bosch's HMI validation tool -Graphics Test Systems (GTS), **UI analytics:** Usage patterns,Debugging, Performance Profiling, Use Cases.	

Course Outcomes: After completion of the course the students will be able to	
CO1	Understanding the application of HMIs in various domain
CO2	Comparison of various communication protocols used in HMI development.
CO3	Apply and Analyse the car multimedia system free software and hardware evolution
CO4	Design and Evaluate the graphic tools and advanced techniques for creating car dashboard multimedia systems

Reference Books	
1	Shuo gao, Shuo Yan, Hang Zhao, Arokia Nathan " Touch based HMI; Principles and Applications" Springer Nature Switzerland AG, 1" Edition
2	Robert Wells, " Unity 2020 by Example: A Project based guide to building 2D, 3D augumented reality and Virtual reality games from sratch" Packt Publishing ltd , edition 2020
3	Ryan Cohen, Tao Wang, "GUI Design and Android Apps" Apress, Berkley, CA,20l4

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
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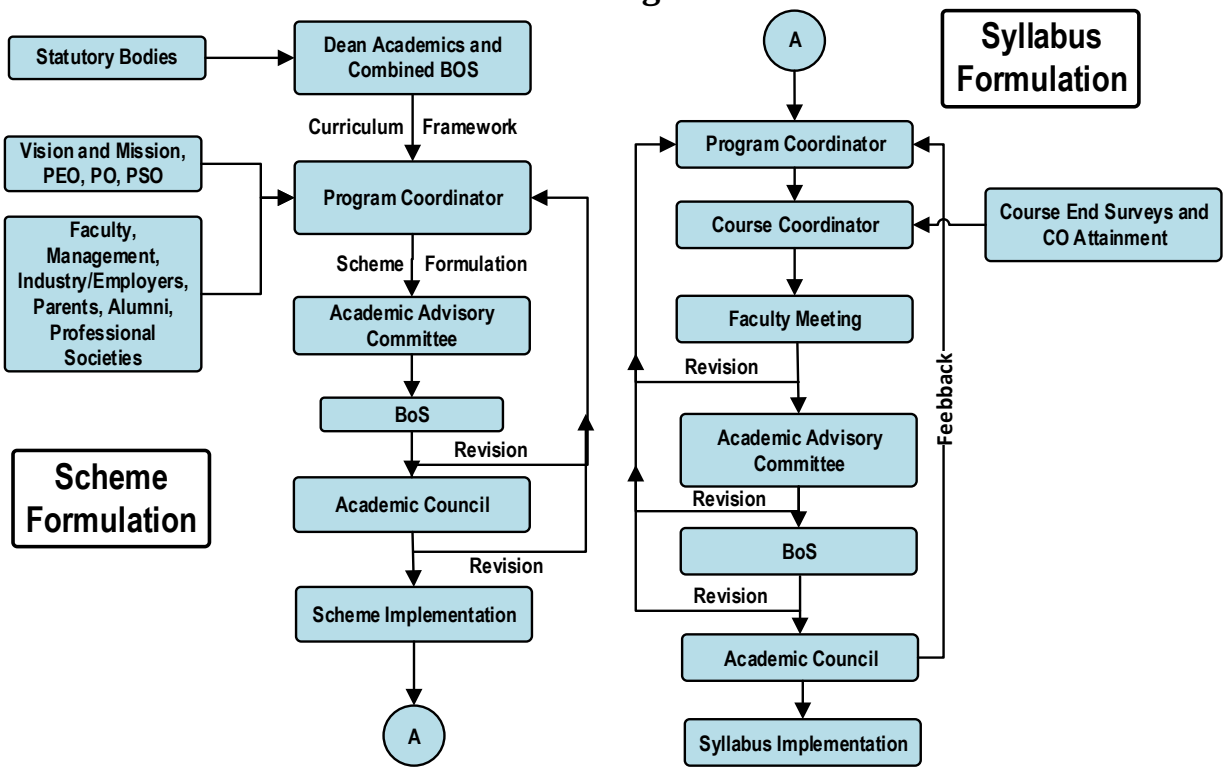
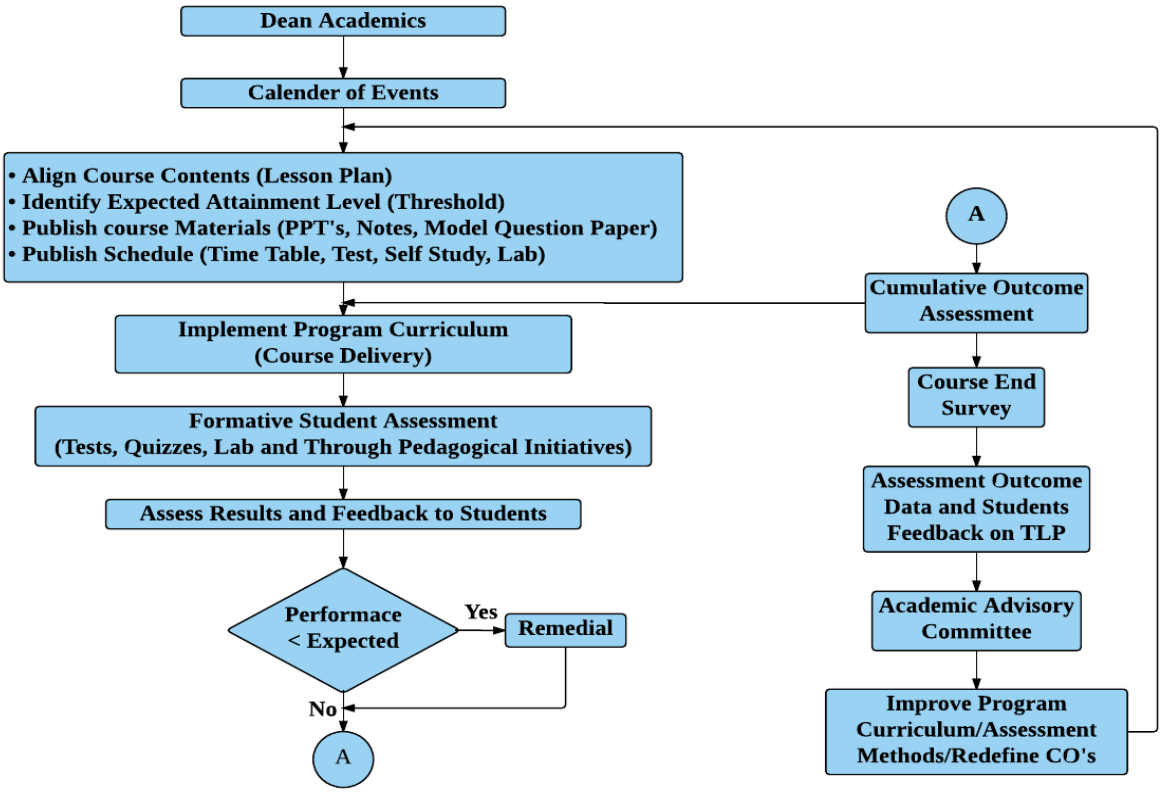
	TOTAL	**100**

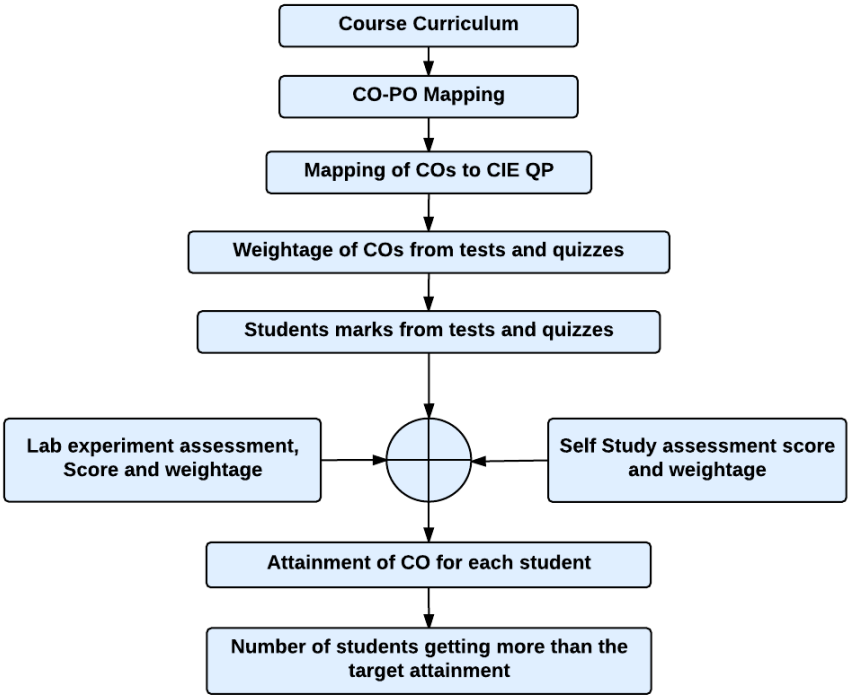
Curriculum Design Process



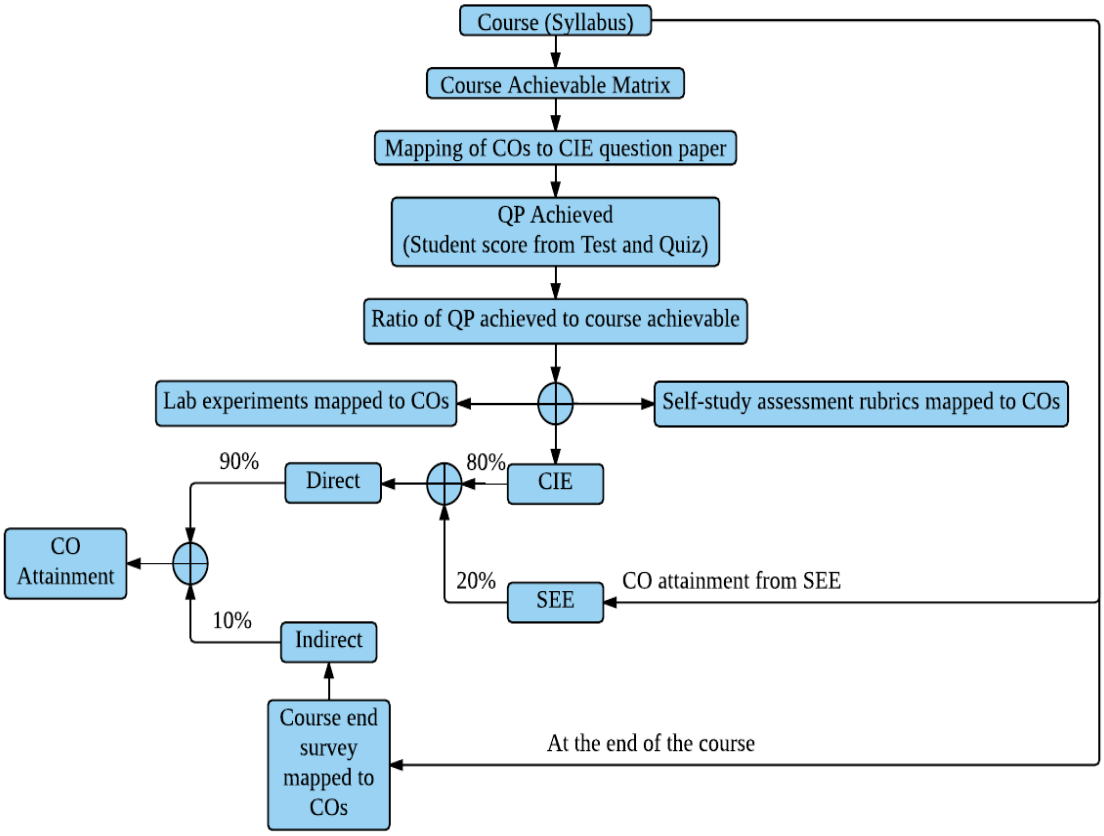
Academic Planning and Implementation



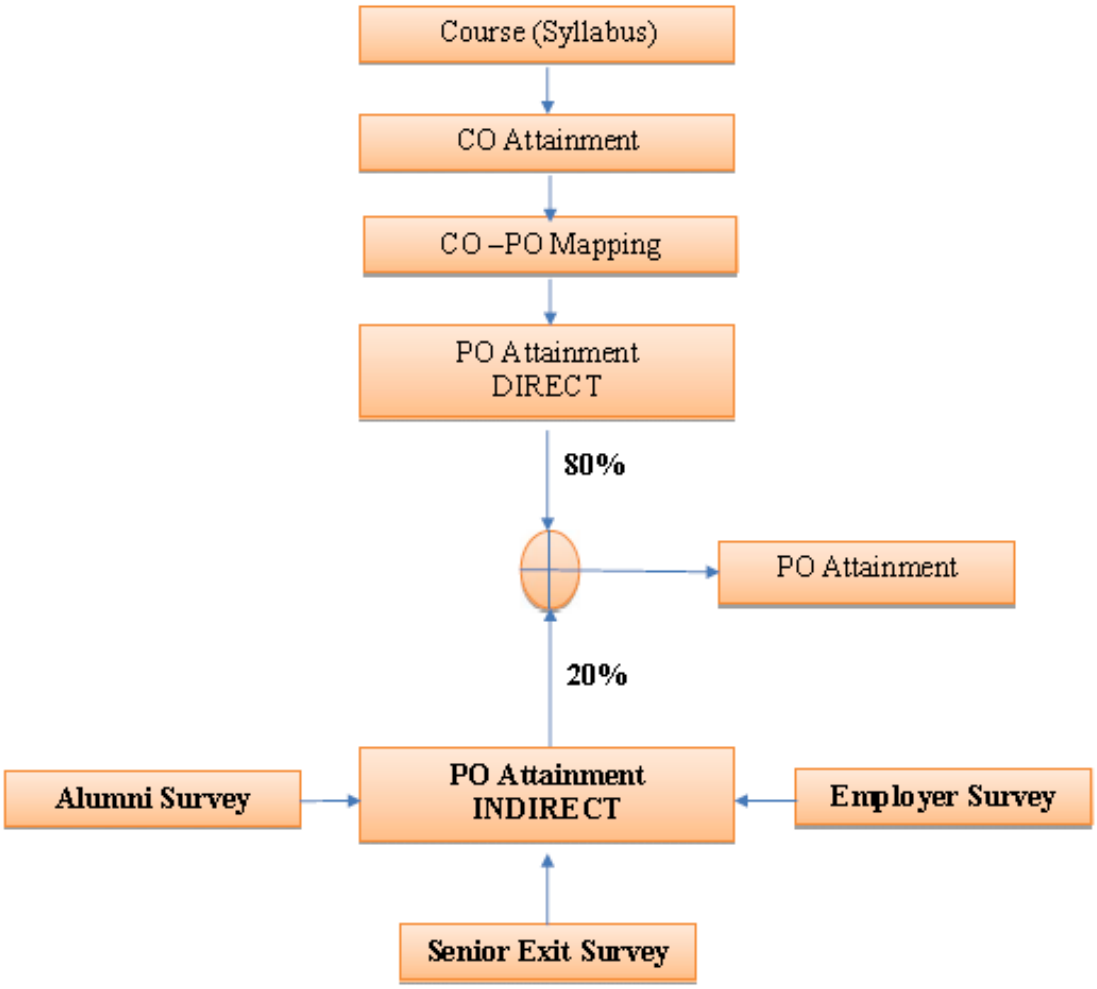
Process For Course Outcome Attainment



Final CO Attainment Process



Program Outcome Attainment Process



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PROGRAM OUTCOMES (POs)

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

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

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

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

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

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

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

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

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

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

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

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