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

AEROSPACE ENGINEERING

BACHELOR OF ENGINEERING (B.E.)
2021 SCHEME

ACADEMIC YEAR 2023-24

AEROSPACE ENGINEERING

DEPARTMENT VISION

Emerge as a centre of excellence in Aerospace Engineering, Imparting Quality Technical Education, Interdisciplinary Research & Innovation with a focus on Societal empowerment through Sustainable & Inclusive Technologies.

DEPARTMENT MISSION

- Imparting Quality Technical Knowledge in Basic & Applied areas of Aerospace Engineering incorporating the principles of Outcome Based Education.
- Provide state-of-the art laboratories and infrastructure facilities, conducive to motivate Interdisciplinary Research and Innovation in Aerospace Engineering.
- Develop self-motivated engineers with a blend of Discipline, Integrity, Engineering Ethics and Social Responsibility.
- Strengthening collaboration with industries, research organizations and institutes for Internships, Joint Research and Consultancy.
- Focus towards Integrating Sustainable and Inclusive Technologies for Societal Symbiosis.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: To provide opportunities for successful professional career with a sound fundamental knowledge in Mathematics, Physical Science & Aerospace Engineering.

PEO2: Motivate innovative research in specialized areas of Aerospace Engineering viz Aerospace structural design, Aerodynamics, Aerospace Propulsion and Guidance & Control systems.

PEO3: Promoting development of problem solving abilities by adopting analytical, numerical and experimental skills with awareness on societal impact.

PEO4: Imbibing sound communication skills, team working ability, professional ethics and zeal for lifelong learning.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO	Description
PSO1	Utilization of the fundamental knowledge and skills of Aerospace Engineering to develop pragmatic solutions for complex Aerospace Engineering problems.
PSO2	Apply Professional Engineering practices and strategies in the development of systems and subsystems for Aerospace Applications.
PSO3	Exhibit Effective Communication skills and a Zeal to function with multi-disciplinary teams
PSO4	Demonstrate Professional Ethics and Responsibilities in Engineering practices towards the achievement of societal symbiosis.

ABBREVIATIONS

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

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Bachelor of Engineering in

AEROSPACE 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	21AS52	Aerodynamics and Flight Performance	3	0	1	4	AS	Theory+Lab	1.5	100	50	3	100	50
3	21AS53	Finite Element Methods	3	0	1	4	AS	Theory+Lab	1.5	100	50	3	100	50
4	21AS54	Aircraft Systems & Instrumentation	3	0	1	4	AS	Theory+Lab	1.5	100	50	3	100	50
5	21AS55BX	Professional Core Elective-I (Group-B)	3	0	0	3	AS	Theory	1.5	100	****	3	100	****
6	21AS56CX	Professional Core Elective-II (Group C)	2	0	0	2	AS	NPTEL	1.5	50	****	3	50	****
7	21ASI57	Summer Internship - II	0	0	2	2	AS	Internship	1	****	50	1	****	50
						22								

***For Circuit Branches -Intellectual Property Rights & Entrepreneurship / For Non-Circuit Branches - principles of Management & Economics**
*** In the 6th Semester both the courses will be interchanged between the Circuits & Non circuits branches**

Professional Core Elective-I (Group-B)			
Sl. No.	**Course Code**	**Course Title**	**Credits**
1	21AS55B1	Aerospace Manufacturing-I	03
2	21AS55B2	Introduction to Composite Materials	03
3	21AS55B3	Aircraft Maintenance, Repair and Overhauling	03
4	21AS55B4	Fundamentals of Satellite System	03

Professional Core Elective-II (Group-C) (NPTEL Elective)			
Sl. No.	**Course Code**	**Course Title**	**Credits**
1	21AS56C1	Aerospace Structural Analysis	02
2	21AS56C2	Introduction to Reliability Engineering	02
3	21AS56C3	Modelling And Simulation of Dynamic Systems	02
4	21IM56C4	Manufacturing Guidelines For Product Design	02
5	21AS56C5	Supply Chain Analytics	02

Bachelor of Engineering in
AEROSPACE ENGINEERING

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	21AS62	Gas Dynamics	3	0	1	4	AS	Theory+Lab	1.5	100	50	3	100	50
3	21AS63	Avionics	3	0	1	4	AS	Theory+Lab	1.5	100	50	3	100	50
4	21AS64DX	Professional Core Elective-III (Group – D)	3	0	0	3	AS	Theory	1.5	100	****	3	100	****
5	21AS65EX	Professional Core Elective (Cluster Elective) (Group- E)	3	0	0	3	Resp. BoS	Theory	1.5	100	****	3	100	****
6	21IE66FX	Institutional Electives – I (Group F)	3	0	0	3	Resp. BoS	Theory	1.5	100	****	3	100	****
						20								

* Summer Internship-II will be done after the VI sem for 06 Weeks (Will have CIE & SEE)

Professional Core Elective-III (Group-D)			
Sl. No.	**Course Code**	**Course Title**	**Credits**
1	21AS64D1	Aerospace Manufacturing-II	03
2	21AS64D2	Vibration Engineering	03
3	21AS64D3	Heat Transfer	03
4	21AS64D4	Computational Fluid Dynamics	03
5	21AS64D5	Product, Design and Development for Aerospace Applications	03

Professional Core Elective-III (Group-D)			
Sl. No.	**Course Code**	**Course Title**	**Credits**
1	21AS65E1	Airport Engineering	03
2	21AS65E2	Space Vehicle Design	03
3	21ME65E1	Hydraulics and Pneumatics	03
4	21ME65E2	Turbomachinery	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**	**Credits**
1	21IE6F1	CH	Industrial Safety and Risk Management	03
2	21IE6F2	EE	Renewable Energy Systems	03
3	21IE6F3	IM	Systems Engineering	03
4	21IE6F4	ME	Mechatronics	03
5	21IE6F5	MAT	Mathematical Modelling	03
6	21IE6F6	ME	Industry 4.0 – Smart Manufacturing for The Future	03
7	21IE6F7	HSS	Industrial Psychology for Engineers	03
8	21IE6F8	IM	Elements of Financial Management	03
9	21IE6F9	HSS	Universal Human Values-II	03
10	21IE6F10	EC	Human Machine Interface (Industry Offered Elective)	03

Semester: V						
PRINCIPLES OF MANAGEMENT & ECONOMICS **Category: PROFESSIONAL CORE COURSE** **(Theory)**						
Course Code	**:**	21HS51B		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**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:** SystemsTheory, 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. **MacroeconomicIndicators:** 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 theright 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 up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40MARKS.**	**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**) ADDING UPTO 40MARKS**.	**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 THREE 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: V						
AERODYNAMICS AND FLIGHT PERFORMANCE **Category: PROFESSIONAL CORE COURSE** **(Theory & Practice)**						
Course Code	**:**	21AS52		**CIE**	**:**	**100+50 Marks**
Credits: L:T:P	**:**	3:0:1		**SEE**	**:**	**100+50 Marks**
Total Hours	**:**	45L+28P		**SEE Duration**	**:**	**3.00 +3.00 Hours**

Unit-I	**11 Hrs**
Incompressible Flow over Airfoils: Kutta-Joukowski theorem and generation of Lift, D'Alembert's paradox, The Kutta Condition, Kelvin's circulation theorem and the starting vortex, Classical thin airfoil theory for symmetric Airfoil and cambered airfoil, Effect of Airfoil Thickness, Camber on the Airfoil Aerodynamic Characteristics.	
Unit – II	**11 Hrs**
Incompressible Flow Over Finite Wings : Downwash and induced drag on wings, Vortex Filament, Biot-Savart law and Helmholtz's theorems, Infinite and semi-infinite vortex filament, Prandtl's classical lifting line theory, Limitations of Prandtl's lifting line theory, Lifting surface theory: Vortex Lattice Method, Panel Method.	
Unit –III	**07 Hrs**
Introduction to Compressible Flow over Airfoils: The Velocity Potential Equation, Linearized Velocity Potential, Prandtl-Glauret Compressibility rules (No Derivation), Critical and Drag-Divergence Mach Number, Area Rule, Supercritical Airfoils.	
Unit –IV	**08 Hrs**
Unaccelerated Aircraft Performance: Unaccelerated steady level flight performance – Thrust and power required, Altitude effects, Rate of Climb, Gliding flight, Absolute and service ceilings, Time to climb. Range and Endurance-Propeller and Jet driven airplane.	
Unit –V	**08 Hrs**
Accelerated Aircraft Performance Take-off and landing Performance, Turning Flight Performance and V-n Diagram, Accelerated Rate of climb, Principles of Construction of Constraint Diagram.	

LABORATORY EXPERIMENTS
1. Calibration of a subsonic wind tunnel and test section.
2. Smoke and tuft flow visualization studies on a two-dimensional bluff and streamlined bodies at low speeds.
3. Surface pressure distributions on a two-dimensional circular cylinder at low speeds and calculation of pressure drag
4. Surface pressure distributions on a two-dimensional symmetric airfoil at zero incidences at low speeds
5. Surface pressure distributions on a two-dimensional cambered airfoil at different angles of incidence and calculation of lift and pressure drag.
6. Calculation of total drag of a two-dimensional cambered airfoil at low speeds at incidence using wake survey technique
7. Measurement of flow angularity
8. Atmosphere modelling and estimation of pressure, temperature and Lapse rate for change in altitude.
9. Estimation of Range and endurance for jet and propeller powered aircraft
10. Estimation of thrust required and available with change in velocity and altitude for unaccelerated flight

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Apply the principles of Fluid Mechanics in designing & developing highly efficient aerodynamic bodies
CO2	Signify the role of various fundamental potential flows in assessing the aerodynamic behaviour of various bodies
CO3	Determine the Aerodynamic characteristics of various bodies subjected to incompressible flows
CO4	Evaluate the parameters affecting the performance of an aircraft under various operating conditions.

Reference Books	
1	Fundamentals of Aerodynamics, Anderson J .D., 5th Edition, 2011, McGraw-Hill International Edition, New York ISBN:9780073398105.
2	Aircraft Performance and Design, J D Anderson, Indian Edition, McGraw Hill Education-2017, ISBN-10: 9780070702455,ISBN-13 : 978-0070702455
3	Aerodynamics for Engineers, John J. Bertin, Pearson, 9788177585445 (ISBN10: 8177585444)
4	Low-Speed Wind Tunnel Testing, Jewel B Barlow, William H Rae, Alan Pope. 3rd Edition, 1999, John Wiley & Sons, ISBN-10: 0471557749 ISBN-13: 978-0471557746.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY & PRACTICE)		
#	**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 adding up to 20 Marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of 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 up to 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. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**. **Some of Sample topics are** **Aerodynamics :**Experiments/ Numerical Simulation of airfoil characteristics for various flow conditions such as a) Fixing angle of attack and varying upstream Mach number b)Fixing Mach number and varying angle of attack / study on Wind Tunnel Testing/ Study on Measurement Techniques in Wind Tunnels: **Flight performance:** MAT Lab based experiments on flight mechanics: Some samples are Atmosphere modeling and estimation of pressure, temperature and Lapse rate for change in altitude/ Determination of Airspeed-TAS,CAS/ Estimation of Range and endurance for jet propelled aircraft/ propeller powered aircraft/ Estimation of thrust required and available with change in velocity and altitude for un accelerated flight/ Estimation of take -off distance/Landing distance of an aircraft	**40**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (20 Marks),lab test (10 Marks) and Innovative Experiment/ Concept Design and Implementation (20 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 THREE 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**

RUBRIC FOR SEMESTER END EXAMINATION (LAB)		
Q. NO	**CONTENTS**	**MARKS**
1	Write Up	**10**
2	Conduction of the Experiments	**30**
3	Viva	**10**
	TOTAL	**50**

Semester: V						
FINITE ELEMENT METHODS **Category: PROFESSIONAL CORE COURSE** **(Theory & Practice)**						
Course Code	**:**	21AS53		**CIE**	**:**	**100 +50 Marks**
Credits: L:T:P	**:**	3:0:1		**SEE**	**:**	**100 +50 Marks**
Total Hours	**:**	45L+28P		**SEE Duration**	**:**	**3.00 +3.00 Hours**

Unit-I	**10 Hrs**
Introduction: Introduction to FEM, Historical background, Difference between discrete and continuous system, Classification of common methods, Finite element method vs. Classical methods, General description in FEM, Steps in FEM, Applications of FEM, Types of elements based on geometry, advantages and disadvantages of FEM, Stiffness Matrix formula for a bar and Beam elements.	
Unit – II	**11 Hrs**
Interpolation Models and Higher Order Elements: Interpolation polynomials, Types of displacement functions for 1D and 2D elements, Shape function of three-noded Triangular Element (TRIA 3), Four-Noded Quadrilateral Element (QUAD 4), Shape Functions of 2, 3, and 4 Noded bar element, Serendipity family, Lagrange family, Shape functions for Higher Order Elements.	
Unit –III	**08 Hrs**
Solution of 1-D Bars and Beams: Derivation of element stiffness matrix & strain displacement matrix for a bar element, Solutions of bars with constant, tapered and stepped cross sections for displacements, reactions and stresses by using penalty approach and elimination approach. Iso-parametric, Sub parametric and Super parametric elements, Finite element method applied to 1-D bars and beams - Numericals.	
Unit –IV	**08 Hrs**
Beams & Trusses: Hermite shape functions for beam element, Derivation of element stiffness matrix, strain displacement and load vector for beam elements, numerical problems on beams carrying concentrated, UDL and linearly varying loads, Element stiffness matrix derivation for trusses, Numerical on Trusses.	
Unit –V	**08 Hrs**
Mathematical Preliminaries and Basic Procedure: Introduction to Calculus of Variation, Principle of Virtual Work, Principle of Minimum Potential Energy, Rayleigh- Ritz Method, Obtaining the Variational form from a differential equation- 1D Bar Element, Numerical on 1D Bar Elements using Rayleigh-Ritz and Galerkin's Method, Displacement method of finite element formulation. Convergence criteria, Discretisation process.	

LABORATORY EXPERIMENTS

1. Computation of deflection of Bars with Constant Cross-sectional Area (Case 1: Single Element; Case 2: Multiple Elements)
2. Computation of deflection of Stepped Bars (Case 1: Constant cross section in each step; Case 2: Tapered Cross sectional area; Case 3: Stepped bar having different materials)
3. Static analysis of a Simple Cantilever Beam (Using shell and Solid elements having different cross sections – Four cases)
4. Stress Analysis of a Cantilever beam subjected to UDL to interpret SFD and BMD
5. Interpreting SFD and BMD for a cantilever beam with a tapered C-Section under UVL.
6. Rectangular plate with Cut-Out and uniformly compressed in one direction.
7. Static Analysis of a composite sandwiched cantilever beam to determine the displacement and the stress.
8. Modal Analysis of a composite Laminated plate.
9. Modal Analysis of a wing (Case 1: Symmetrical Aerofoil; Case 2: Rectangular cantilever plate)
10. Flutter Analysis of a 2D wing
11. Divergence Speed prediction for a 2D wing

Course Outcomes: After completing the course, the students will be able to:-	
CO1	To comprehend the basic fundamentals of Finite Element Method by solving physical problems involving partial differential equations
CO2	Build mathematical formulations utilizing Principle of virtual work and Minimum potential energy
CO3	Understand the role and significance of shape functions in Finite Element Methods.
CO4	Apply the procedures of FEM to obtain the solutions for truss, beams and various real life problems.

Reference Books	
1	"The Finite Element Method: Its Basis and Fundamentals" by O.C. Zienkiewicz and R.L. Taylor
2	“Finite Element Procedures” by Klaus Jürgen Bathe
3	A first course in the Finite Element Method by Logan, D. L; Cengage Learning 6th Edition 2016
4	Finite Element Method in Engineering by Rao, S. S; Pergaman Int. Library of Science 5th Edition 2010
5	Concepts and Application of Finite Elements Analysis Cook R. D., et al. Wiley & Sons 4th Edition 2003
6	Finite Elements in Engineering by Chandrupatla T. R; PHI 2nd Edition 2013
7	"Finite Element Analysis: Theory and Application with ANSYS" by Saeed Moaveni

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY & PRACTICE)		
#	**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 adding up to 20 Marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of 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 up to 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. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (20 Marks), lab test (10 Marks) and Innovative Experiment/ Concept Design and Implementation (20 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 THREE 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**

RUBRIC FOR SEMESTER END EXAMINATION (LAB)		
Q. NO	**CONTENTS**	**MARKS**
1	Write Up	**10**
2	Conduction of the Experiments	**30**
3	Viva	**10**
	TOTAL	**50**

Semester: V						
AIRCRAFT SYSTEMS & INSTRUMENTATION **CATEGORY: PROFESSIONAL CORE COURSE** **(Theory & Practice)**						
Course Code	**:**	21AS54		**CIE**	**:**	**100 +50 Marks**
Credits: L:T:P	**:**	3:0:1		**SEE**	**:**	**100 +50 Marks**
Total Hours	**:**	45L + 28P		**SEE Duration**	**:**	**3.00 +3.00 Hours**

Unit-I	**14 Hrs**
Aircraft Power Generation Systems: **Aircraft Electrical System:** Aircraft Power Generation & Distribution System. Components of Aircraft Electrical System – Aircraft battery, Aircraft Generators (AC/DC Generators), Aircraft Alternators: Theory of operation Alternator regulation, Fundamentals of Constant speed drives (CSD) and Variable Speed Constant Frequency (VSCF) Integrated Drive Generators (IDG). **Aircraft Hydraulic & Pneumatic Systems** Components of a typical Hydraulic system, Working of Hydraulic system, Power packs, Hydraulic actuators. Aircraft, Landing gear and Wheel Braking and Anti-Skid & Shimmy System. Pneumatic system and its components, **Electrical, Hydraulic & Pneumatic system Instruments and information display.**	
Unit – II	**10 Hrs**
Gyroscopic Instruments & Magnetic Reference Heading System: Type of Gyroscopes, Principles of Mechanical, MEMS and Optical Gyroscopes, Properties of Mechanical Gyroscope-Rigidity & Precession, limitations of gyroscope, Artificial Horizon, Errors due to acceleration and turning, Turn and Bank indicator. Terrestrial magnetism, Aircraft magnetism, Direct Reading Compasses, Magnetic Heading Reference System & Remote Indicating Compass System Block Diagram - Flux Detector Valve, Direction Indicator.	
Unit –III	**04 Hrs**
Aero Engine Systems: Types of Starting and Ignition systems, Engine starting sequence, Engine Oils and a typical Engine Lubricating system. Engine Fuel System & functioning of a typical engine fuel control unit. **Aero Engine Instruments:** Pressure measurements & indicating systems, pressure switches, Temperature measurements & Indicating systems.	
Unit –IV	**07 Hrs**
Air-conditioning and Pressurisation Systems: Cockpit & Cabin Temperature control system, De-icing systems, Cold air units, Compact heat exchangers, Cockpit and Cabin Pressurization valves, filters, air bottles, capsules and bellows, indication and warnings. Systems & sensors	
Unit –V	**10 Hrs**
Air Data Systems: Pitot-static Sensing probes, Air Speed Indicator, Altimeter, Vertical speed indicator, Angle of Attack Sensing & indication, Mach meter, Air Data Computer and its functioning with respect to FBW system, Aerodynamic Alerting Systems. **Flight Control Systems:** Primary and secondary flight controls, Conventional Flight control linkage System, Power Assisted and fully powered flight controls. Fly By Wire Control System	

LABORATORY EXPERIMENTS

Part – I : Hydraulics & Pneumatic System Lab

1. Characteristic Curve of Variable Displacement Hydraulic Pump.
2. Study of Application of 4/3 Directional Control Valve (Tandem & Closed Centre).
3. Study of Operation of Hydraulic Motor Using 4/3 Directional Control Valve.
4. Study of Operation of Accumulator Using 4/3 Directional Control Valve.
5. Study of Application of Pressure Switch Using 4/2 Directional Control Valve.
6. Study of Position Dependent Control of a Double Acting Cylinder with Mechanical Limit Switches.
7. Study of Logical Control of Pneumatic circuit with 'AND' & 'OR' function using Electro pneumatics

Part – II : Aircraft Instrumentation Lab

8. **(A)** Measurement of Aircraft Pressure, using Sensor Test Bed.
   (B) Measurement of Aero-engine RPM using Sensor Test Bed.
   (C) Measurement of Aero-engine Temperature using Sensor Test Bed.

9. Measurement of Fuel Flow & Quantity of Fuel Consumed in Aero-Engine using Fuel Flow Transmitter using sensor Test Bed.
10. Study of Gyroscopic Behaviour of Rotating Masses and Verification of Gyroscopic Relationship (Using Electromechanical Gyroscope using Table Top Model).
11. Measurement of Roll, Pitch and Yaw with Artificial Horizon and Measurement of direction using Magnetometer.

Part – III : Air Data System Lab

1. 12. Measurement of Air Data Parameters Using Air Data test Set.

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Understand the requirement of aircraft systems in an aircraft. Develop understanding of basic design approach for aircraft systems.
CO2	Critically evaluate design and functioning of the aircraft systems and associated components.
CO3	Understand the concept, sensors, components, their integration and functioning in Digital Fly-By-Wire Flying Control System
CO4	Comprehend the complexities involved during design and development of instrumentation and displays of flight vehicle.

Reference Books	
1	E.H.J.Pallet, Aircraft Instruments, 1st Revised Edition, 1992, Prentice Hall of India, ISBN-9780273015390
2	Moir, I. and Seabridge, A.,Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration, 3rd Edition, 2008, Wiley Publications, ISBN- 978-0470059968
3	Harris, D., Ground Studies for Pilots: Flight Instruments and Automatic Flight Control Systems, sixth edition 2004, Blackwell Science, ISBN: 978-0632059515
4	Moir, I. and Seabridge, Civil Avionics Systems, AIAA (American Institute of Aeronautics & Astronautics) Wiley; 2 edition (October 14, 2013), ISBN: 978-1118341803

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY & PRACTICE)		
#	**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 adding up to 20 Marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of 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 up to 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. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (20 Marks), lab test (10 Marks) and Innovative Experiment/ Concept Design and Implementation (20 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 THREE 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**

RUBRIC FOR SEMESTER END EXAMINATION (LAB)		
Q. NO	**CONTENTS**	**MARKS**
1	Write Up	**10**
2	Conduction of the Experiments	**30**
3	Viva	**10**
	TOTAL	**50**

Semester: V						
AEROSPACE MANUFACTURING-I **Category: PROFESSIONAL CORE ELECTIVE-I GROUP B** **(Theory)**						
Course Code	**:**	21AS55B1		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**11 Hrs**
Limits, fits and tolerances: Definition of tolerance, Indian standards, concept of limits of size and tolerances, definition of fits, types of fits, hole basis system, shaft basis system, classification of gauges, brief concept of design of gauges (Taylor's principles), Wear allowance on gauges. **Geometric Dimensioning and Tolerance:** Introduction to GD &T, symbols, form tolerance-flatness, cylindricity, straightness, circularity, orientation tolerances-perpendicularity, parallelism and angularity. Elements of surface texture, factors affecting surface finish, methods of measuring surface finish, indication of surface roughness symbols used.	
Unit – II	**08 Hrs**
Introduction to Manufacturing principle and Processes of Major Aircraft Metal Product. Casting Processes: Sand moulding, Centrifugal casting, Pressure casting, Die Casting, Investment Casting, Evaporative Pattern Casting, Casting of Aluminum Billet for Extrusion or forging. **Metal Cutting:** Orthogonal and Oblique Cutting, Types of Chips, Thermodynamics in Metal Cutting, Cutting Parameters- Tool wear and Tool Life. Machining of Various Metals Used in aerospace materials-Aluminium, Titanium, Steel-composite.	
Unit –III	**08 Hrs**
Sheet Metal Working: Shearing mechanism, blanking, piercing, punching. Forming processes like bending, deep drawing, Rubber Pad forming, Stretch forming. Elements of die; punch and die clearances; Progressive, compound and combination dies. Applications of sheet formed products in Aerospace industries. **Welding & Joining Technologies: S**pecification of electrodes, Friction Welding - Rotary, Linear, Friction-Stir Welding. Laser beam welding, Electron Beam, Plasma Arc Welding, Gas Metal and Gas Tungsten Arc Welding, Welding Defects.	
Unit –IV	**08 Hrs**
Powder Metallurgy: Introduction. Production of metal powders. Compaction and sintering processes. Secondary and finishing operations. Economics, advantages, and applications of powder metallurgy in Aerospace Parts. **Introduction to Advanced Manufacturing Processes**: Rapid Prototyping, Direct Metal Deposition, Fine blanking, Immersive Virtual Reality.	
Unit –V	**10 Hrs**
Processing of Composite: Role of Composites in Major Aircraft Components, Hand Layup, Machine Layup, Filament Winding, Vacuum bagging, Tape Lamination, Fiber Placement, Drape Forming, Liquid Composite Molding -Resin Transfer Molding, Vacuum-Assisted RTM, Resin Film Infusion, Pultrusion. Thermoplastic composites – thermoplastic consolidation, thermoforming, thermoplastic joining.	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Understand the importance of geometric dimension and tolerance in the field of engineering, especially in Aerospace Engineering
CO2	Comprehend the various techniques and methodologies for producing Aerospace Components
CO3	Assess the influence of various parameters involved in each manufacturing technologies
CO4	Apply a particular technique for manufacturing a given Aerospace Component

Reference Books	
1	Manufacturing Technology for Aerospace structural Materials, F C Campbell, 2006 1st Edition, Elsevier, ISBN-13: 9781856174954
2	Aerospace Manufacturing Processes, Pradip K. Saha, 1st Edition, 2016, CRC Press – Taylor & Francis Group, ISBN: 9781315367965
3	Geometric Dimensioning and Tolerancing for Mechanical Design, Gene Cogorno, 2nd Edition 2011, McGraw-Hill, ISBN-13:978-0071772129
4	Manufacturing Engineering & Technology, Serope Kalpakjian, 7th Edition, 2018, Pearson Publishers ISBN-13: 9789332587908.
5	Metrology & Measurement, Anand K Bewoor, Vinay A Kulkarni, 4th Edition, 2009, McGraw-Hill. ISBN-13: 978-0070140004

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 adding up to 20 Marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of 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 up to 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. **Phase I (20) & Phase II (20) 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 THREE 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: V						
INTRODUCTION TO COMPOSITE MATERIALS **Category: PROFESSIONAL CORE ELECTIVE-I GROUP B** **(Theory)**						
Course Code	**:**	21AS55B2		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**12 Hrs**
Introduction To Composite Materials: Introduction and Classification of composites, Overview of Advantages and Limitations of Composite Materials, Micro mechanics, Macro mechanics, Homogeneity, Heterogeneity, Inhomogeneity, Isotropy, Anisotropy/Orthotropy. General Anisotropic Material, Specially Orthotropic Material, Transversely Isotropic Material, Orthotropic Material Under Plane Stress, Isotropic Material.	
Unit – II	**09 Hrs**
Strength Of Unidirectional Lamina-Micro mechanics: Elasticity approach, Ultimate strength of unidirectional lamina, strength of materials approach, Semi empirical Models.	
Unit –III	**08 Hrs**
Strength Of Composite Lamina-Macro mechanics: Hooke's Law for Different Types of Materials, Hooke's Law for a Two-Dimensional Unidirectional Lamina, Hooke's Law for a Two-Dimensional Angle Lamina, Invariant Form of Stiffness and Compliance Matrices for an Angle Lamina, Strength Failure Theories of an Angle Lamina.	
Unit –IV	**06 Hrs**
Failure, Analysis, and Design of Laminates: Introduction, Special Cases of Laminates, Failure Criterion for a Laminate, Design of a Laminated Composite, Other Mechanical Design Issues.	
Unit –V	**10 Hrs**
Experimental Methods For Testing Of Composite Materials: Characterization of Constituent Materials, Physical Characterization of Composite Materials, Determination of Tensile Properties of Unidirectional Lamina, Determination of Compressive Properties of Unidirectional lamina, Determination of Shear Properties of Unidirectional lamina.	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Identify, describe and evaluate the properties of fibre reinforcements, polymer matrix materials and commercial composites
CO2	Analyse the elastic properties and simulate the mechanical performance of composite laminates; and understand and predict the failure behaviour of fibre-reinforced composites
CO3	Apply knowledge of composite mechanical performance and manufacturing methods to a composites design project
CO4	Criticize the design and application of fibre-reinforced composites for various loading conditions

Reference Books	
1	Manufacturing Technology for Aerospace structural Materials, F C Campbell, 2006 1st Edition, Elsevier, ISBN-13: 9781856174954
2	Aerospace Manufacturing Processes, Pradip K. Saha, 1st Edition, 2016, CRC Press – Taylor & Francis Group, ISBN: 9781315367965
3	Geometric Dimensioning and Tolerancing for Mechanical Design, Gene Cogorno, 2nd Edition 2011, McGraw-Hill, ISBN-13:978-0071772129
4	Manufacturing Engineering & Technology, Serope Kalpakjian, 7th Edition, 2018, Pearson Publishers ISBN-13: 9789332587908.
5	Metrology & Measurement, Anand K Bewoor, Vinay A Kulkarni, 4th Edition, 2009, McGraw-Hill. ISBN-13: 978-0070140004

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 adding up to 20 Marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of 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 up to 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. **Phase I (20) & Phase II (20) 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 THREE 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: V						
AIRCRAFT MAINTENANCE, REPAIR & OVERHAULING **Category: PROFESSIONAL CORE ELECTIVE-I GROUP B** **(Theory)**						
Course Code	:	21AS55B3		**CIE**	:	**100 Marks**
Credits: L:T:P	:	3:0:0		**SEE**	:	**100 Marks**
Total Hours	:	45L		**SEE Duration**	:	**3.00 Hours**

Unit-I	**10 Hrs**
Fundamentals of Maintenance & Certification Types of maintenance, Redesign, Failure rate pattern, Other maintenance considerations. Aviation industry certification requirements, Type certificate (FAA form 8110.9), Airworthiness certificate (FAA form 8100-2), Aviation maintenance certifications, General, Airframe, Power plant, Avionics courses.	
Unit -II	**09 Hrs**
Documentation for Maintenance Manufacturers documentation, Airplane maintenance manual, Fault insulation manual, Illustrated parts catalogue, structural repair manual, wiring diagram manual, Master minimum equipment, Federal Aviation regulation (FAR), Advisory circulars, Airworthiness direction ATA document standards, Technical policies and procedure manuals (TPPM).	
Unit -III	**08 Hrs**
Aircraft Management Maintenance Structure, Role of aviation management, Line supervisory management, Management areas of concern in airlines, Manager of overhaul shops, Line maintenance control centre flight line (prefight & post flight), Aircraft Logbook, Maintenance crew skill requirements.	
Unit -IV	**09 Hrs**
Hanger Maintenance (on Aircraft) & Material Support Introduction, organization of hanger maintenance, Non- routine item, parts availability, cannibalization, Types of shops- sheet metal shop, Aircraft interior shop, Engine shop, Avionics shop, ground support equipment, outsourcing of shop maintenance work, operation of overhaul shops, Material support, Material management inventory control, Support functions of material, Parts ordering, Storage, Issue, control and handling, Parts receiving quality control, calibration program, stock level adjustments, shelf life, exchanges, warranty & modifications of parts.	
Unit -V	**09 Hrs**
Maintenance Safety & Trouble shooting Safety regulations, occupational safety and health standards maintenance safety program, Airlines safety management, General safety rules, Accident & injury reporting, Hazardous materials storage and handling aircraft furnishing practices trouble shooting, Knowledge of malfunctions.	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Understand core principles and regulations for aircraft maintenance and certification
CO2	Comprehend skills for effective documentation in compliance with industry standards
CO3	Apply knowledge to ensure safety, troubleshoot, and maintain airworthiness
CO4	Acquire expertise in hangar maintenance procedures, including facility upkeep, equipment management, and safety protocols to support efficient aircraft maintenance operations

Reference Books	
1	Aviation Maintenance Management, Harry A Kinnison, Tariq Siddiqui, Mc Graw Hill education, 2012, Private Ltd, ISBN: 9780071805032
2	Aircraft maintenance and repair, Kroes, Watkins, Delp, Mc Graw Hill, 2013 McGraw-Hill Education, 7th edition, 2013, ISBN: 978-0071801508
3	Aircraft Repair Manual, Larry Reithmaier, Palmar Books, Marquette, 1992, ISBN: 978-0932882028
4	Aircraft Maintenance, Brimm. DJ, Bogges, HE, Pitman publishing corp, London, 1952,. ASIN: B000NQ539E

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 adding up to 20 Marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of 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 up to 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. **Phase I (20) & Phase II (20) 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 THREE 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: V						
FUNDAMENTALS OF SATELLITE SYSTEM **Category: PROFESSIONAL CORE ELECTIVE-I GROUP B** **(Theory)**						
Course Code	**:**	21AS55B4		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**09 Hrs**
Introduction: Payloads & Missions, Objectives & Requirements of a Spacecraft, Overview of Spacecraft Subsystems. **Effect of Space Environment on Design :** Introduction, Pre-operational Spacecraft Environments, Operational Spacecraft Environments, Environmental Effects on Design.	
Unit – II	**09 Hrs**
Attitude Control Systems: Introduction, Overview of ACS, ACS block diagram, Torques And Torquers, Attitude Measurement, Measurement system fundamentals, Types of reference sensor & Inertial sensors. (No numerical and derivation)	
Unit -III	**09 Hrs**
Thermal Control Systems: The Thermal Environment: Types of Thermal Sources, Thermal Balance.Passive and Active thermal control **Electrical Power Systems :** Power System Elements, Primary & Secondary Power Systems.	
Unit -IV	**10 Hrs**
Telecommunication Systems: Role of Communication Systems, Radio Communications: Modulation, Multiple Access, Noise, Radio Propagation, Antennas, Communication Payload: Transponder System. **Telemetry :** System Architecture, Base Band Telemetry system, Modulation, TT&C RF system, Telecommand system, Ground Control Systems.	
Unit -V	**08 Hrs**
Small Satellite Engineering & Applications : Introduction, Small-satellite Design Philosophy, Small-satellite System Design, COTS Components in the Space Environment, Microsatellite Platforms, Minisatellite Platforms and Nanosatellite Platforms, Affordable Launches for Small Satellites, In-orbit Operations, Small-satellite Applications, Picosatellites and Recent Advances in Miniaturization.	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Understand the fundamental concepts of different satellite subsystems
CO2	Demonstrate the working principles of different types of subsystems
CO3	Identify and Classify the required subsystem and its type employed based on the mission
CO4	Compute and Evaluate the fundamental parameters involved in the satellite subsystem design

Reference Books	
1	Peter Fortescue, John Stark and Graham Swinerd, Spacecraft Systems Engineering, 4th edition, Wiley publications, ISBN : 978-0-470-75012-4
2	Space Mission Analysis and Design (Third Edition) by James R.Wertz and Wiley J.Larson,1999
3	James R.Wertz “Spacecraft Attitude Determination and Control”, Kluwer Academic Publisher, 1988.
4	Marcel J.Sidi “Spacecraft Dynamics and Control”, Cambridge University press, 1997.

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 THREE 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: V						
AEROSPACE STRUCTURAL ANALYSIS **Category: PROFESSIONAL CORE ELECTIVE-II GROUP C (NPTEL ELECTIVE)** **(Theory)**						
Course Code	**:**	21AS56C1		**CIE**	**:**	**50 Marks**
Credits: L:T:P	**:**	2:0:0		**SEE**	**:**	**50 Marks**
Hours	**:**	30 L		**SEE Duration**	**:**	**1.5 Hours**

Unit-I	**10 Hrs**
Introduction: Introduction to aircraft structures and their uniqueness. A brief history on evolution of aircraft structures Structural components of an aircraft and their functionalities. Recap of theory of elasticity.	
Unit – II	**10 Hrs**
Torsion of thin-walled structures: Torsion of non-circular cross-section. St. Venant's theory and Prandtl's stress function. Torsion: Membrane analogy. Torsion of thin walled structures with single and multiple cells, Bi-directional bending. Sectional properties of thin walled cross-sections. Bending of thin-walled structures	
Unit –III	**10 Hrs**
Shear forces on thin walled structures. Analysis of single and multiple cells cross-section under shear load, Shear center. Shear center of different thin-walled crosssection, Skin-stringer idealization. Skin-stringer idealization of different structural components, Buckling of columns. Introduction to buckling of plates	

Reference Books	
1	Aircraft Structures for Engineering Students, T H G Megson
2	Analysis of Aircraft Structures, B. K. Donaldson
3	Aircraft Structures, D. J. Peery and J. J. Azar

Semester: V						
INTRODUCTION TO RELIABILITY ENGINEERING **Category: PROFESSIONAL CORE ELECTIVE-II GROUP C (NPTEL ELECTIVE)** **(Theory)**						
Course Code	**:**	21AS56C2		**CIE**	**:**	**50 Marks**
Credits: L:T:P	**:**	2:0:0		**SEE**	**:**	**50 Marks**
Hours	**:**	30 L		**SEE Duration**	**:**	**1.5 Hours**

Unit-I	**10 Hrs**
Introduction and Definitions, Constant Failure Rates Models, Time Dependent Failure Rate Models.	
Unit – II	**10 Hrs**
System Reliability Modeling: Series, parallel, series-parallel, and k-out-of-m modeling., Markov Modeling: standby, shared systems etc.	
Unit –III	**10 Hrs**
Reliability Estimation (Non-Parametric), Reliability Estimation (Distribution Fitting), Maintainability and Availability Analysis.	

Reference Books	
1	Charles E. Ebeling (2019) "An Introduction to Reliability and Maintainability Engineering", 3rd edition, Publisher: McGraw Hill Education.
2	Patrick D. T. O'Connor, Andre Kleyner (2012) "Practical Reliability Engineering", 5th edition, Publisher: Wiley.
3	Roy Billinton, Ronald N. Allan (1992) "Reliability Evaluation of Engineering Systems: Concepts and Techniques", 2nd edition, Publisher: Springer.
4	Mohammad Modarres, Mark P. Kaminskiy, VasiliyKrivtsov (2016) "Reliability Engineering and Risk Analysis: A practical guide", 3rd edition, Publisher: CRC Press.
5	Krishan B. Misra, "reliability analysis and prediction: a methodology oriented treatment", Publisher: Elsevier.

Semester: V						
MODELLING AND SIMULATION OF DYNAMIC SYSTEMS **Category: PROFESSIONAL CORE ELECTIVE-II GROUP C (NPTEL ELECTIVE)** **(Theory)**						
Course Code	**:**	21AS56C3		**CIE**	**:**	**50 Marks**
Credits: L:T:P	**:**	2:0:0		**SEE**	**:**	**50 Marks**
Hours	**:**	30 L		**SEE Duration**	**:**	**1.5 Hours**

Unit-I	**12 Hrs**
Introduction to Modelling and Simulation, Bond Graph Modelling of Dynamic Systems, Basic System Models	
Unit – II	**10 Hrs**
System Models of Combined Systems, Dynamic Response and System Transfer Function	
Unit –III	**08 Hrs**
Block diagram/Signal flow diagram/State Space formulation and Frequency response. Simulation and Simulation application, Parameter Estimation, System Identification and Optimization	

Reference Books	
1	NA

Semester: V						
MANUFACTURING GUIDELINES FOR PRODUCT DESIGN **Category: PROFESSIONAL CORE ELECTIVE-II GROUP C (NPTEL ELECTIVE)** **(Theory)**						
Course Code	**:**	21IM56C4		**CIE**	**:**	**50 Marks**
Credits: L:T:P	**:**	2:0:0		**SEE**	**:**	**50 Marks**
Hours	**:**	30 L		**SEE Duration**	**:**	**1.5 Hours**

Unit-I	**10 Hrs**
Product Design: Basics, Introduction of Manufacturing Processes, Manufacturing Processes : Advantages and Limitations-I, Manufacturing Processes :Advantages and Limitations-II, Process Capabilities: Basics. Engineering Materials, Properties of Materials, Selection of Materials – I, Selection of Materials – II, Applications of Engineering Material.	
Unit – II	**10 Hrs**
Robust Design, Design for X, Product Design for Manual Assembly, DFMA Guidelines, Ergonomics in Product Design. Selection of Processes-I, Selection of Processes-II, Process Capabilities, Design Guidelines for Sand Casting, Design Guidelines for Die Casting Process. Product Design Guidelines: Compression Molding and Extrusion, Design Guidelines for Extrusion and Injection Molding, Design Guidelines for Sheet Metal Working, Design Guidelines for Machining, Design Guidelines for Powder Metal Processing.	
Unit –III	**10 Hrs**
Assembly Processes: Introduction, Adhesive Joining: Guidelines, Design Guidelines for Mechanical Fasteners, Design Guidelines for Welding, Design Guidelines: Brazing and Soldering. Induction Welding: Plastics, Ultrasonic Welding: Plastics, Vibration and Spin Welding: Plastics, Microwave Joining, Hole Making : Guidelines. Design for Environment, Design for Environment: Steps, Product Architecture, Rapid Prototyping, Product Design : Manufacturing Perspective.	

Reference Books	
1	.Product Design for Manufacture and Assembly, G. Boothroyd, P. Dewhurst, W. Knight, Marcel Dekker, University of Rhode Island Kingston, New York, USA.
2	Product Design and Development, Karl T. Ulrich, Steven D. Eppinger, McGraw-Hill companies, New York, USA.
3	Design for Manufacturability Handbook, James G. Bralla, McGraw-Hill companies, New York, USA.
4	Manufacturing Processes: Casting, Forming and Welding: H. S. Shan, Cambridge University Press.

Semester: V						
SUPPLY CHAIN ANALYTICS **Category: PROFESSIONAL CORE ELECTIVE-II GROUP C (NPTEL ELECTIVE)** **(Theory)**						
Course Code	**:**	21AS56C5		**CIE**	**:**	**50 Marks**
Credits: L:T:P	**:**	2:0:0		**SEE**	**:**	**50 Marks**
Hours	**:**	30 L		**SEE Duration**	**:**	**1.5 Hours**

Unit-I	**10 Hrs**
Context of today's supply chains (SC) analytics, Understanding and defining the supply chain analytics (SCA) Revisions of Basic Lessons of Supply Chain Management, Why is Analytics Important in a supply chain?, Relating Operations Management with Supply chain concepts with SC Analytics, The importance of supply chain analytics in the flows involving material, money, information and ownership. Supply chain analytics, Key issues in supply chain analytics, What involves in supply chain analytics, Concept of Descriptive Analytics in a Supply Chain, Discussion on a Few Supply Chains Analytics applications in India (students participation is expected), Decision Domains in in supply chain analytics	
Unit – II	**10 Hrs**
Foundation of Business Anlaytics (BA), E2: Introduction to Modeling, Approaches for Optimization and Simulation, Modeling software, Supply Chain (SC), Decisions that requires mathematical or interpretative modelingUnderstanding of Data and its role in Analytics, Analytics of a Transportation problem in a Supply Chain, Managerial implication of results of analytics, A case study of supply chain analytics.	
Unit –III	**10 Hrs**
Foundation of prescriptive analytics in network planning in a supply chain, Network Planning in a Supply Chain, Importance of Network Planning, Design of Logistics Network using Heuristics/optimization (Exercise 3.4 Levi (2008)), Concept of 3PL/4PL in a Supply Chain, Case Study: GATI, Foundation of Modeling Coordination Decisions in Supply Chain Management, Foundation of performance management in supply chain management, it enablement of supply chains, role of ICT in supply chains	

Reference Books	
1	Supply chain management by Sunil Chopra, and Peter Meindl, Pearson
2	Jeremy F. Shapiro. Modeling the Supply Chain. Duxbury Thomson Learning
3	D. Simchi-Levi, P. Kaminsky, E. Simchi-Levi, and Ravi Shankar, Designing and Managing the Supply Chain concepts, Strategies and Case studies, Third Edition, Tata McGraw Hill, New Delhi, 2008.
4	Rahul Saxena • Anand Srinivasan, Business Analytics

Semester V						
SUMMER INTERNSHIP-II **Category: Professional Core Course** **(Practical)**						
Course Code	:	21ASI57		**CIE Marks**	:	50 Marks
Credits: L:T:P	:	0:0:2		**SEE Marks**	:	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/CoCs will 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.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**REVIEW I:** Explanation of the application of engineering knowledge in industries, abilityto 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	Presentation of Internship Details	**20**
3	Viva	**20**
	TOTAL	**50**

Semester: VI						
INTELLECTUAL PROPERTY RIGHTS AND ENTREPRENEURSHIP (Common to all Programs) (Theory)						
Course Code	**:**	21HS61A		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**SEE Duration**	**:**	**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. **Trade Marks:** Concept, function and different kinds and forms of Trademarks, 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.	
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.	

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 ofengineering domain.
CO2	Knowledge and competence related exposure to the various Legal issues pertaining to Intellectual PropertyRights 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.

Reference Books	
1	Intellectual Property Rights: Unleashing Knowledge Economy, Prabuddha Ganguly, 1st Edition, 2001, TataMcGraw 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

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 TH 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 up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40MARKS.**	**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**) ADDING UPTO 40MARKS**.	**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 THREE 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						
GAS DYNAMICS **Category: PROFESSIONAL CORE COURSE** **(Theory & Practice)**						
Course Code	**:**	21AS62		**CIE**	**:**	**100 +50 Marks**
Credits: L:T:P	**:**	3:0:1		**SEE**	**:**	**100 +50 Marks**
Total Hours	**:**	45L+28P		**SEE Duration**	**:**	**3.00 +3.00 Hours**

Unit-I	**12 Hrs**
Basics of Compressible Flows: Bernoulli's equation for Compressible Flows, Effect of Mach number on Compressibility, Area velocity relation, Isentropic flow in variable area Duct,-Area ratio as a function of Mach number, Impulse function. **Introduction to Shock Waves :** Shock wave introduction, Flow through Convergent nozzle, C-D nozzle and C-D diffuser, Variation of mass flow through Nozzles, Governing Equations of Normal Shock Wave, Prandtl Meyer relation and Rankine-Hugoniot equation.	
Unit – II	**10 Hrs**
Oblique Shock Waves: Oblique shocks and corresponding relations (No Derivations), Shock polar & Hodograph plane, Supersonic flow over a wedge and cone, Regular reflection from a solid boundary, Intersection of Oblique shock waves of same and opposite families, pressure deflection diagrams, Mach reflection, Detached shock wave	
Unit –III	**08 Hrs**
Expansion waves: Supersonic compression and supersonic expansion waves, Prandtl-Meyer Expansion Function (No Derivation), Shock expansion theory, Wave reflection and wave intersection shock system	
Unit –IV	**07 Hrs**
Fanno Flow : Flow with friction in constant area duct, Fanno lines, Fanno equation, Definition of friction constant, Friction loss, Effect of wall friction on flow properties, Local flow properties in terms of local, Mach number (No Derivation-Only Numericals) **Rayleigh Flow :** Flow with heating or cooling in ducts, Governing equations, Slope of Rayleigh line, Entropy considerations. Maximum heat transfer (No Derivation-Only Numericals)	
Unit –V	**08 Hrs**
High Speed Wind Tunnel Testing: Types of High Speed Wind Tunnels, Components and Operation Methods, Method of Characteristics-Concepts of Characteristics, Compatibility relations, Moving Normal Shock Waves, Principle of operation of Shock Tubes.	

LABORATORY EXPERIMENTS
1. Calibration of supersonic wind tunnel test section.
2. Determination of shock pattern and pressure distribution over a flat plate at various angles of attack.
3. Supersonic flow studies over a varying concave ramp and determination of flowfield properties.
4. Supersonic flow studies over a varying convex ramp and determination of flowfield properties.
5. Flow visualization through a supersonic inlet and measurement of surface pressure distribution.
6. Flow visualization over delta wing aircraft and measurement of surface pressure distribution at various angles of attack.
7. Determination of oblique shock angle for flow over a wedge and measurement of surface pressure distribution.
8. Determination of oblique shock angle for flow over a cone and measurement of surface pressure distribution.
9. Determination of shock pattern and pressure distribution over a diamond shaped airfoils at various angles of attack.
10. Determination of shock pattern and pressure distribution over a biconvex airfoils at various angles of attack
11. Estimation of aerodynamic characteristics of a missile configuration at various angles of attack.
12. Flow visualization over fore body configurations.

Course Outcomes: After completing the course, the students will be able to:-

CO1	Apply the thermodynamics concepts in relation to compressible flows and derive relationships between various compressible flow parameters
CO2	Summarize the various properties of compressible flow
CO3	Conclude the behaviour of compressible flows for various aerospace applications
CO4	Evaluate the characteristics of the compressible flows through suitable measuring equipment's.

Reference Books	
1	Modern Compressible Flow with Historical Perspective, Anderson, J. D., 3 edition (1 August 2002) McGraw-Hill Education; ISBN- 978-0072424430
2	Elements of Gas Dynamics, Liepmann, H. W. and Roshko, A., (January 11, 2002), Dover Publications, ISBN- 978-0486419633
3	Gas Dynamics, John, J. E. A. and Keith, T., Prentice Hall (2006) ISBN- 978-0131206687
4	Fundamentals of Gas Dynamics, Zucker, R. D. and Biblarz, O., 2nd Revised edition (13 September 2002), John Wiley & Sons; ISBN- 978-0471059677
5	Fundamentals of compressible flow with Aircraft and Rocket propulsion , S M Yahya, New age international publishers, ISBN-81-224-1468-0

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY & PRACTICE)		
#	**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 adding up to 20 Marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of 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 up to 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. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**. Some of sample topics are: a)Numerical simulation of supersonic bodies at fixed angle of attack with varying Mach number b)Numerical simulation of supersonic bodies at variable angle of attack for a given Mach number	**40**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (20 Marks),lab test (10 Marks) and Innovative Experiment/ Concept Design and Implementation (20 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 THREE 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**

RUBRIC FOR SEMESTER END EXAMINATION (LAB)		
Q. NO	**CONTENTS**	**MARKS**
1	Write Up	**10**
2	Conduction of the Experiments	**30**
3	Viva	**10**
	TOTAL	**50**

Semester: VI						
AVIONICS **Category: PROFESSIONAL CORE COURSE** **(Theory & Practice)**						
Course Code	**:**	21AS63		**CIE**	**:**	**100 +50 Marks**
Credits: L:T:P	**:**	3:0:1		**SEE**	**:**	**100 +50 Marks**
Total Hours	**:**	45L+28P		**SEE Duration**	**:**	**3.00 +3.00 Hours**

Unit-I	**10 Hrs**
Principle of Avionics: Need for Avionics in civil and military aircraft and space systems, Typical avionics sub systems. **Display and Control systems**– Fundamentals of Head Up Display for Military & Civil aircraft, Helmet Mounted Display & Sights (HMDS), Cockpit Displays - MFD, EFIS & Concept of Glass Cockpit. **Avionic Data Buses** & **Avionic Architectures -** For Civil & Military Aircraft: ARINC-429, Mil-Std-1553, AFDX and CAN Bus. Federated and IMA Architectures.	
Unit – II	**10 Hrs**
Radar and Tracking: Fundamentals of Primary and Secondary Radars, FMCW Radar & Radio Altimeter System, Pulse Doppler Radar, Moving Target Indicator Radar, Limitation of MTI performance. MTI from a moving platform (AMTI), Conical Scan and Sequential lobbing, Mono Pulse Tracking, Airborne Weather Radar, Phased Array Radar (AESA & PESA). **Secondary Radar Systems**-Traffic Collision and Avoidance System (TCAS), Identification of friend or Foe(IFF), Automatic Dependant Surveillance – Broadcast(ADS-B)	
Unit –III	**10 Hrs**
Navigation Systems: **Position Fixing & Dead Reckoning, C**lassification of various Navigation systems, Principle of operation & Components of Inertial Navigation System, Strap down navigation system. **Radio Navigation** - Principle, operation and characteristics of: Radio Direction finder, ADF system, VOR and DVOR, DME & TACAN, Instrument Landing System (ILS), Doppler Navigational System, **Satellite Navigational System** – Basics of Satellite Communication System, Fundamentals of Satellite Navigation, - GNSS architecture, Positioning, Signals & range measurements; GPS, ADS-B, NAVSAT, DGPS, **Integrated Navigation** – INS & GNSS Integration	
Unit –IV	**07 Hrs**
Avionic Systems of UAVs: Sensors used in UAVs, Electrical Power sources, Drone Gyro Stabilisation, IMU and Flight Controllers, Actuators; Command & control Telemetry link**.**	
Unit –V	**08 Hrs**
Air Traffic Control: Air Traffic Control, Various Zones, IFR & VFR Routes, **Guidance Systems:** Basic Guidance system, Types of Guidance systems.	

LABORATORY EXPERIMENTS
1. To learn ARINC 429 Avionic Data Buses and its Terminologies. Understanding ARINC 429 Bus Transmission and Reception using Labels .
2. Understanding ARINC 429 Bus Communication between Simple Tx and Rx. Study of Different Avionics Data Buses and Configuration with Message Transfer with ARINC-429.
3. Understanding ARINC 429 Bus Real time sensor Data Transmission and Reception using Labels.
4. To learn MIL-Std – 1553 Data Buses and its Terminologies Bus Controller, Remote terminal, & Bus Monitor.
5. To understand the programming and Configuration involved in Data Transmission with Mil-1553 Data

Bus between Remote Terminal & Bus Controller.

6. Study of Working of Doppler Radar. Using Doppler Radar principle, understand the measurement of Time & frequency measurement with the help of moving pendulum.
7. Using principle of radar, Conduct the study for (i) Alarm system (ii) Detection of Vibrations of Tunning Forks, (iv) Counting of Objects (v) Measuring RPM of a moving Object
8. Study the effect of different types of materials on Radar receiving or detection.
9. Establishing a satellite digital audio/video link between Up-link transmitter & Down-link Receiver, through Satellite Transponder.
10. Verify test digital data transmission and reception using Satellite Transponder Link; Also demonstrate the Directivity of Dish Antenna in Satellite Communication Link.
11. Study of Digital Base band modulation Scheme (BPSK & QPSK), its Time domain analysis & Frequency domain analysis.
12. To perform the bit error rate measurement using internal test data mode and calculate the Carrier to Noise ratio for a satellite link.

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Understand the need and evolution of Avionics and Avionic Architectures
CO2	Understand the fundamentals of cockpit displays, cockpit layouts and various techniques of data transfer in avionic systems.
CO3	Understand the fundamental functioning of various ground & airborne Radio Navigational and Satellite navigational aids as employed in aviation in association with Air Traffic Control.
CO4	Develop the understanding of navigation and control of Unmanned Aerial Vehicles.

Reference Books	
1	Brain Kendal, "Manual of Avionics", The English Book Hause, 3rd Edition, New Delhi, 1993, ISBN:978-0632034727.
2	Spitzer, C.R., "Digital Avionic Systems", Prentice Hall, Englewood Cliffs, N.J., USA., 1987, ISBN:978-1930665125
3	Civil Avionic Systems, Ian Moir, Allan Seabridge, Malcolm Jukes,
4	Middleton, D.H., Ed., "Avionics Systems, Longman Scientific and Technical",Longman Group UK Ltd., England, 1989, ISBN- 9780582018815
5	Military Avionics Systems, Ian Moir, Allan G Seabridge, John Wiley & Sons, 2006 ISBN-13 978-0-470-01632-9,
6	Introduction to Avionics, R P G Collins, 3rd Edition, Springer Dordrecht Heidelberg London, ISBN 978-94-007-0707-8.
7	Principles of GNSS, Inertial, and Multi-sensor Integrated Navigation Systems, Paul D. Groves, 2008, Artech House, ISBN-13: 978-1-58053-255-6

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY & PRACTICE)		
#	**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 adding up to 20 Marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analysing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 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. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (20 Marks),lab test (10 Marks) and Innovative Experiment/ Concept Design and Implementation (20 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 THREE 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**

RUBRIC FOR SEMESTER END EXAMINATION (LAB)		
Q. NO	**CONTENTS**	**MARKS**
1	Write Up	**10**
2	Conduction of the Experiments	**30**
3	Viva	**10**
	TOTAL	**50**

Semester: VI						
AEROSPACE MANUFACTURING-II **Category: PROFESSIONAL CORE ELECTIVE-III (GROUP-D)** **(Theory)**						
Course Code	**:**	21AS64D1		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**10 Hrs**
Surface treatment: Scope, Cleaners, Methods of cleaning, Surface coating types, and ceramic and organic methods of coating, economics of coating. Electro forming, Chemical vapour deposition, thermal spraying, Ion implantation, diffusion coating, Diamond coating and cladding.	
Unit – II	**10 Hrs**
Non-Traditional Machining: Introduction, need ,AJM, Parametric Analysis, Process capabilities, USM – Mechanics of cutting, models, Parametric Analysis, WJM –principle, equipment ,process characteristics, performance, EDM – principles, equipment, generators, analysis of R-C circuits, MRR , Surface finish, WEDM.	
Unit –III	**09 Hrs**
Laser Beam Machining – Principle of working, equipment, Material removal rate, Process parameters, performance characterization, Applications. Plasma Arc Machining – Principle of working, equipment, Material removal rate, Process parameters, performance characterization, Applications. Electron Beam Machining - Principle of working, equipment, Material removal rate, Process parameters, performance characterization, Applications. Electro Chemical Machining – Principle of working, equipment, Material removal rate, Process parameters, performance characterization, Applications.	
Unit –IV	**08 Hrs**
Processing of ceramics: Applications, characteristics, classification .Processing of particulate ceramics, Powder preparations, consolidation, Drying , sintering, Hot compaction, Area of application , finishing of ceramics.	
Unit –V	**08 Hrs**
Additive Manufacturing: Introduction, Need for Additive Manufacturing, Advantages and Limitations of AM, Classification, Distinction between AM and CNC, other related technologies, Stereo lithography Apparatus (SLA), Laminated Object Manufacturing (LOM), Selective laser sintering (SLS): Process, working principle, Layering technology.	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Understand the scope and importance of surface treatment, including methods of cleaning and various surface coating techniques, including ceramic and organic methods.
CO2	Describe the principles, equipment, and process characteristics of Non-Traditional Machining
CO3	Possess in-depth knowledge of ceramic processing and additive manufacturing technologies in aerospace manufacturing
CO4	Familiar with working principles and layering technology of specific additive manufacturing technologies

Reference Books	
1	Manufacturing Engineering and Technology, S. Kalpakjian, and S.R. Schmidt, 7 th Edition, Pearson India, 2009
2	Additive manufacturing technologies, I. Gibson, D. W. Rosen, and B. Stucker New York: Springer. 2010
3	Principles of Modern Manufacturing, M. P. Groover, 5'' Edition, Wiley, India, 20143
4	Rapid prototyping: Principles and Applications - Chua C.., Leong K.F and LIM C.S World Scientific publications , 3rd 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 THREE 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						
VIBRATIONS ENGINEERING **Category: PROFESSIONAL CORE ELECTIVE-III (GROUP-D)** **(Theory)**						
Course Code	**:**	21AS64D2		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**09 Hrs**
Introduction: Types of vibrations, Definitions, Derivations for spring mass systems, Simple Harmonic Motion (S.H.M.), Work done by harmonic force, Principle of super position applied to SHM, Beats phenomenon, Fourier series applied to vibration problems, Numerical on Fourier series, superposition of SHM and beats.	
Unit – II	**09 Hrs**
Damped and Undamped Vibrations: Methods of Analysis, Natural frequencies of simple systems, Springs in series and parallel, Torsional and transverse vibrations and Problems. Derivations for over, critical and under damped systems, Logarithmic decrement and Problems.	
Unit -III	**09 Hrs**
Forced Vibrations (1DOF): Introduction, Analysis of forced vibration with constant harmonic excitation - Magnification factor, rotating and reciprocating unbalances, excitation of support (relative and absolute amplitudes), force and motion transmissibility, Energy dissipated due to damping and Problems.	
Unit -IV	**09 Hrs**
Systems with two degrees of Freedom: Principle modes of vibrations, Normal mode and natural frequencies of systems (without damping) – Masses on tightly stretched strings, double pendulum, torsional systems, combined rectilinear and angular systems, Undamped dynamic vibration absorber and Problems.	
Unit -V	**09 Hrs**
Numerical Methods for multi degree freedom of systems: Introduction, Maxwell's reciprocal theorem, Influence coefficients, Rayleigh's method, Dunkerley's method, Stodola method, Holzer's method, Orthogonality of principal modes.	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	State and classify the principle of vibrations, thus comprehending the importance of damping and its influence based on damping ratio.
CO2	Demonstrate the effect of external excitation on a 1D system and identify their critical parameters using appropriate force vector diagram.
CO3	Comprehend the underlying principles and procedures in computing the natural frequencies of two degree of freedom system.
CO4	Evaluate a Multi DOF system by understanding modal analysis of a vibrating system using Matrix Method, Dunkerley's method and Stodola method,

Reference Books	
1	Principles of Vibration, Benson H Tongue, 2nd Edition, 2002, Oxford University Press, ISBN: 978-0195106619
2	Fundamentals of Vibrations by Leonard Meirovitch
3	Theory of Vibration with Applications, Thomson, W.T., 5th Edition, 28 August 1997, Pearson , 978-0136510680
4	Fundamentals of Mechanical Vibrations, Kelly, Har/Dsk Edition, 2000, McGraw Hill Publications, ISBN: 978-0079116611
5	Mechanical Vibrations, Singiresu S. Rao,6th Edition, 2003, Pearson, ISBN: 978-0134361307
6	Mechanical Vibration by V P Singh| Dhanpat Rai, 2nd Edition ISBN 8177000314, 9788177000313

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 THREE 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						
HEAT TRANSFER **Category: PROFESSIONAL CORE ELECTIVE-III (GROUP-D)** **(Theory)**						
Course Code	**:**	21AS64D3		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**09 Hrs**
Introduction: Modes of heat transfer-conduction, convection and radiation, Material properties of importance in heat transfer, Thermal conductivity, Specific heat capacity. **Conduction Heat Transfer:** Derivation of general three dimensional conduction equation in Cartesian coordinate, special cases, discussion on 3-D conduction in cylindrical and spherical coordinate systems (No derivation), Numericals. **Transient Conduction:** Lumped parameter analysis, Use of Transient temperature charts (Heisler's charts) for transient conduction in slab, long cylinder and sphere, Numerical problems	
Unit – II	**09 Hrs**
Convective Heat Transfer: Principle of heat flow in fluids, heat transfer coefficient, overall heat transfer coefficient, Velocity boundary layer, Thermal Boundary layer, Significance of dimensionless numbers for internal and external flow (discussion only), Numerical problems. **Forced Convection:** Momentum and Energy equations for hydrodynamic and thermal boundary layer over a flat plate, Dimensional analysis for forced and natural convection, Numerical problems. **Natural Convection:** Empirical correlations of flow around flat vertical plate, horizontal flat surface, horizontal cylinder, sphere and enclosure, Numerical problems	
Unit -III	**09 Hrs**
Radiation Heat Transfer: Introduction to radiation heat transfer, Properties of radiation, Shape factor, Relation between shape factors, radiation heat transfer between non – black bodies, Infinite parallel plates, Radiation shields, Transmissivity, absorptivity and reflectivity, Specular and diffuse surfaces Numericals	
Unit -IV	**10 Hrs**
Introduction to Combustion: Introduction, Applications of Combustion, Types of fuels and various modes of combustion, review of basic thermodynamics, thermodynamic properties, Stoichiometry, Thermo-chemistry, adiabatic temperature, chemical equilibrium, theoretical air – fuel ratio, Numerical problems.	
Unit -V	**08 Hrs**
Chemical Kinetics: Introduction, Rates of reactions and their temperature dependence - The Arrhenius rate expression & Transition state and recombination rate theories, Simultaneous interdependent reactions, Chain reactions, the partial equilibrium assumption, Pressure effect in fractional conversion, Chemical kinetics of large reaction mechanisms – Sensitivity analysis, Rate of production analysis, Coupled thermal and chemical reacting systems & Mechanism simplification	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Understand the fundamental concepts of different satellite subsystems
CO2	Demonstrate the working principles of different types of subsystems
CO3	Identify and Classify the required subsystem and its type employed based on the mission
CO4	Compute and Evaluate the fundamental parameters involved in the satellite subsystem design

Reference Books	
1	Heat Transfer, Holman B.K.,McGraw Hill, 9th Edition., 2002, ISBN: 978-0078447853
2	Heat Transfer: Principles and Applications, Dutta B.K., PHI, 2001, ISBN:978-8120316256
3	Heat Transfer, Chapman, A.J, 4th Edition. Maxwell Macmillan International Edition, 1984, ISBN: 978-0023214509
4	Fundamentals of Combustion, D.P. Mishra, 3rd Edition Prentice Hall of India, New Delhi, 2008. ISBN: 978-8120333482

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 THREE 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						
COMPUTATIONAL FLUID DYNAMICS **Category: PROFESSIONAL CORE ELECTIVE-III (GROUP-D)** **(Theory)**						
Course Code	**:**	21AS64D4		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**10 Hrs**
Fundamentals: Application of CFD, Models of flows, Substantial derivative, Divergence of velocity, Continuity, Momentum and Energy equations, derivation in various forms, Integral versus Differential form of equations, Comments on governing equations.	
Unit – II	**10 Hrs**
Mathematical Behaviour of Partial Differential Equations : Classification of partial differential equations, Cramer rule and Eigen value method, Hyperbolic, parabolic and elliptic forms of equations, Impact on physical and computational fluid dynamics, case studies: steady inviscid supersonic flow, unsteady inviscid flow, steady boundary layer flow and unsteady thermal conduction.	
Unit –III	**09 Hrs**
Discretization: Introduction, Finite differences, difference equations, Explicit and implicit approaches, Errors and analysis of stability (FTCS, CTCS & Dufort-Frankel schemes). **Transformations:** Introduction, transformation of the governing partial differential equations, Matrices and the Jacobian of transformation.	
Unit –IV	**08 Hrs**
Numerical Grid Generation : Body–fitted coordinate system, Need for grid generation, Essential properties of grids, Various grid generation techniques - Algebraic, and Numerical grid generation, Elliptic grid generation, Structured, Un-structured grids, Adaptive grids, Grid Stretching.	
Unit –V	**08 Hrs**
Finite Volume Techniques & Solving Techniques: Finite Volume Discretization - Cell Centered Formulation, High resolution finite volume upwind Scheme, Runge - Kutta Time Stepping, Multi - Time –Step Integration scheme, Cell Vertex Formulation, LAX-WENDROFF Technique, Relaxation technique, Point iterative method, Successive over-relaxation/under relaxation, Aspects of numerical dissipation and dispersion, artificial viscosity, The Alternating-Direction- (ADI) Implicit Technique, Approximate factorization scheme, Upwind schemes, Flux vector splitting.	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Understand the fundamental concepts of computational fluid dynamics
CO2	Derive, formulate and apply suitable governing expressions and methods for solving Physical problems
CO3	Classify the physical problem and convert the same to computational domain with appropriate mathematical conditions
CO4	Evaluate the flow field using different numerical methods of computation and interpret the solution results

Reference Books	
1	John D Anderson Jr., Computational Fluid Dynamics, the Basics with Applications, 1st July, 4th Edition McGraw Hill International Edn, ISBN: 978-1259025969
2	Oleg Zikanov, Essential Computational Fluid Dynamics, 2nd Edition, Willey ,ISBN: 978-1-119-47462-3
3	Date, A. Introduction to Computational Fluid Dynamics, Cambridge University Press. (2005).
4	S. V. Patankar, Numerical Heat Transfer and Fluid Flow, 1st Edition, 1980, CRC Press, ISBN: 978-0891165224

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 THREE 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						
PRODUCT, DESIGN AND DEVELOPMENT FOR AEROSPACE APPLICATIONS **Category: PROFESSIONAL CORE ELECTIVE-III (GROUP-D)** **(Theory)**						
Course Code	**:**	21AS64D5		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**10 Hrs**
Design and Development Process & Systems Engineering Overview: - Overview of current industry trends, Overview of MBE and Significance of Digital Twin - Fundamentals of Systems Engineering, Common Technical Processes - Overview of the general design and development process, Release processes, Configuration Management, ChangeManagement	
Unit – II	**10 Hrs**
Requirements Management & System Safety Assessment: - Need for requirements, Writing good requirements, , Kano model, Context Diagram, Mind Map - Industry Standards, General requirements, Functional requirements, Design specific requirements, Performancerequirements - Requirement Tier, Validation & Verification, Compliance Matrix - System Safety Overview, FHA, FTA, FMEA, PRA, CMA	
Unit –III	**09 Hrs**
Design & Development: - Design conceptualization, Preparation of conceptual layouts, Guidelines from Industrial-standards pertaining tothe design requirements - Finalizing a layout design, Sizing of components from the finalized layout design, Material Selection, heattreatment and finishes, Types of fits - Preparation of detail and assembly drawings, GD&T, Tolerance stack up - Design review, Uploading in PLM database, Release of drawings for production	
Unit –IV	**08 Hrs**
Analysis: - Understanding the Structure and Its Design Requirements, Structural Reduction, Understanding Material - Structural Parameters, Load Calculations and Load Path, Analysis Requirements, Initial Sizing, Performing DetailedAnalysis Process, Structural Changes Using Analysis Outputs - Structural Analysis Reports/ Strength Check Notes, Structural Tests / Analysis Validation	
Unit –V	**08 Hrs**
Verification: - Qualification Plan, Qualification Procedure, Analysis & Significance, Qualification Report – Test, Similarity, Analysis,Inspection - Certification and its significance - In-service Issues	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Apply Modern Engineering Practices and Digital Technologies
CO2	Develop and Manage Comprehensive System Requirements
CO3	Execute Comprehensive Design and Development Processes
CO4	Ensure System Safety and Compliance Through Analysis and Verification

Reference Books	
1	NASA, Systems Engineering Handbook, NASA Headquarters, Washington, D.C., Fourth Edition, June 2019, 9781626830453.
2	Systems Engineering Fundamentals, Defense Acquisition University Press, January 2001, 9780160732904
3	SAE ARP4754A - (R) Guidelines for Development of Civil Aircraft and Systems, SAE International, December 2010, 9780768074154
4	Dassault Systèmes, Strategic Systems Engineering for Functional and Logical Structures, Take Control, , Dassault Systèmes, Whitepaper, 2012,
5	SAE ARP5580 - Recommended Failure Modes and Effects Analysis (FMEA) Practices for Non-Automobile Applications, 2001, SAE International, 9780768022469
6	SAE ARP4761 - Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment, December 1996, SAE International, 9780768004922
7	Michael F. Ashby, Elsevier Science, Materials Selection in Mechanical Design, 2000, Elsevier, 9780081005996
8	ASME Y14.5.2, Certification of Geometric Dimensioning and Tolerancing Professionals, 2000, American Society of Mechanical Engineers (ASME) 0791825167
9	J. Keith Nisbett & Richard G. Budynas, Mechanical Engineering Design, J. Keith Nisbeth & Richard G. Budynas, Tenth Edition, 2014, McGraw-Hill Education, 9780073398204
10	Klaus-Jürgen Bathe, Finite Element Procedures, Second Edition, 1996, Prentice Hall, 9780133014582
11	J.N. Reddy, An Introduction to the Finite Element Method, Third Edition, 2005 McGraw-Hill Education, 9780072466850.
12	Completing the Certification Process, FAA URL: https://www.faa.gov/licenses_certificates/airline_certification/air_carrier/complete_cert_process

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 THREE 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						
AIRPORT ENGINEERING **CATEGORY: PROFESSIONAL CORE ELECTIVE (CLUSTER ELECTIVE) (GROUP- E)** **Common to AS, IEM and ME** **(Theory)**						
Course Code	**:**	21AS65E1		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**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 adding up to 20 Marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of 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 up to 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. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**. Some sample topics are a)Demonstration of working principle of various aircraft systems through physical models. b) Crash investigation of various aircraft system failures	**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 THREE 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						
SPACE VEHICLE DESIGN **Category: PROFESSIONAL CORE ELECTIVE (CLUSTER ELECTIVE) (GROUP- E)** **Common to AS, IEM and ME** **(Theory)**						
Course Code	**:**	21AS65E2		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**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, 3rd Edition Elsevier, 2016, ISBN 9780128044254.
4	Elements of Space Technology, R. Meyer, 3rd Edition , Academic Press, 1999, ISBN 0124929400
5	Astronautics, U. Walter, 2nd Edition 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 adding up to 20 Marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of 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 up to 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. **Phase I (20) & Phase II (20) 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 THREE 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						
HYDRAULICS AND PNEUMATICS **Category: PROFESSIONAL CORE ELECTIVE (CLUSTER ELECTIVE) (GROUP- E)** **Common to AS, IEM and ME** **(Theory)**						
Course Code	**:**	21ME65E1		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**07 Hrs**
Introduction to hydraulic power Pascal's law and its application, components of a fluid power system, applications of fluid power, positive displacement hydraulic pump , 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	**09 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 – constructional features. **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 (properties and types), reservoir construction, sealing devices, filters and strainers, accumulators.	
Unit –III	**09 Hrs**
Hydraulic Circuit Design Control of single acting and double acting cylinder and motors, Pump unloading circuit, Counterbalance Valve Application, Hydraulic Cylinder Sequencing circuit, locked, Cylinder using Pilot Check Valve, 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	**08 Hrs**
Design of pneumatic circuits ISO 5599 symbolic representations, structure of pneumatic circuits, component designations – lettering and numbering type, 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.
4	R. Srinivasan, 'Hydraulic and Pneumatic controls', McGraw Hill Education, 2nd Edition, 2010, ISBN: 978818209138–2.

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 adding up to 20 Marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of 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 up to 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. **Phase I (20) & Phase II (20) 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 THREE 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						
TURBOMACHINERY **Category: PROFESSIONAL CORE ELECTIVE (CLUSTER ELECTIVE) (GROUP- E)** **Common to AS, IEM and ME** **(Theory)**						
Course Code	**:**	21ME65E2		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**10 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	**07 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, 2009, McMillan Company, ISBN: 078623241-2
2	Turbine Compressors and Fans, Yahya. S.M., 2nd Edition, 2002, 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 adding up to 20 Marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of 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 up to 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. **Phase I (20) & Phase II (20) 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 THREE 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						
LEAN MANUFACTURING SYSTEMS **Category: PROFESSIONAL CORE ELECTIVE (CLUSTER ELECTIVE) (GROUP- E)** **Common to AS, IEM and ME** **(Theory)**						
Course Code	**:**	21IM65E1		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**SEE Duration**	**:**	**3.00 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 adding up to 20 Marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of 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 up to 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. **Phase I (20) & Phase II (20) 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 THREE 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						
TOTAL QUALITY MANAGEMENT **Category: PROFESSIONAL CORE ELECTIVE (CLUSTER ELECTIVE) (GROUP- E)** **Common to AS, IEM and ME** **(Theory)**						
Course Code	**:**	21IM65E2		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**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 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 adding up to 20 Marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of 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 up to 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. **Phase I (20) & Phase II (20) 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 THREE 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						
INDUSTRIAL SAFETY AND RISK MANAGEMENT **Category: Institutional elective – I (Group F)** **(Theory)**						
Course Code	**:**	21IE6F1		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**SEE Duration**	**:**	**3.00 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, 1st Edition 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, 4thEdition, 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 adding up to 20 Marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of 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 up to 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. **Phase I (20) & Phase II (20) 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 THREE 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 (Group F)** **(Theory)**						
Course Code	**:**	21IE6F2		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**SEE Duration**	**:**	**3.00 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:-	
CO1	Understand the working principle and operation of various renewable energy sources and systems.
CO2	Analyze the performance and characteristics of renewable energy sources and systems.
CO3	Evaluate the parameters of wind and solar energy systems.
CO4	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 privatelimited 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 adding up to 20 Marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of 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 up to 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. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
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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** **(Theory)**						
Course Code	**:**	21IE6F3		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 Hrs		**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 up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40MARKS.**	**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**) 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** **(Theory)**						
Course Code	**:**	21IE6F4		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 Hrs		**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** **(Theory)**						
Course Code	**:**	21IE6F5		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**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 up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40MARKS.**	**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**) 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						
INDUSTRY 4.0 – SMART MANUFACTURING FOR THE FUTURE **Category: Institutional Elective** **(Theory)**						
Course Code	**:**	21IE6F6		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	42 Hrs		**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; 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						
Industrial Psychology for Engineers (Theory - Institutional Electives – I)						
Course Code	**:**	21IE6F7		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 Hrs		**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, 3rd edition (1995) Prentice Hall India.
3.	Organizational Behaviour , Stephen P Robbins Pearson Education Publications, 13th Edition,ISBN – 81-317 – 1132 – 3
4.	Organisational Behaviour : Human Behaviour at Work ,John W.Newstrem and Keith Davis. TataMcGraw Hill India, 10th Edition, ISBN 0-07-046504-5
5	Psychology-themes and variations , Wayne Weiten, 4th 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 up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40MARKS.**	**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**) 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** **(Theory)**						
Course Code	**:**	21IE6F8		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45 Hrs		**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 up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40MARKS.**	**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**) 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 Electives – I** **(Theory)**						
Course Code	**:**	21IE6F9		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	42L		**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 completing 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 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 adding up to 20 Marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of 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 up to 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. **Phase I (20) & Phase II (20) 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 THREE 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						
Human Machine Interface **Category - Institutional Electives – I** **(Industry Offered Elective)** **(Theory)**						
Course Code	**:**	21IE6F10		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	42L		**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.	

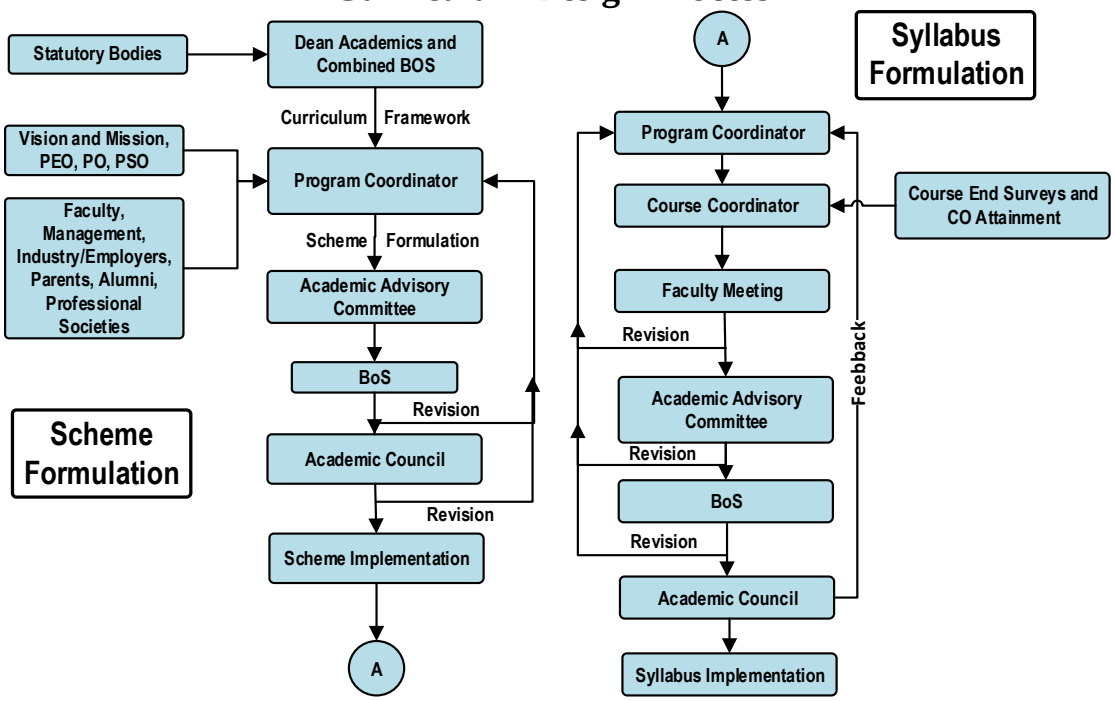
Course Outcomes: After completing the course, the students will be able to:-	
CO1	Understanding the application of HMIs in various domain
CO2	Comparison of various communication protocols used in HMI development.
CO3	Apply and Analyse the car multimedia system free software and hardware evolution
CO4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

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

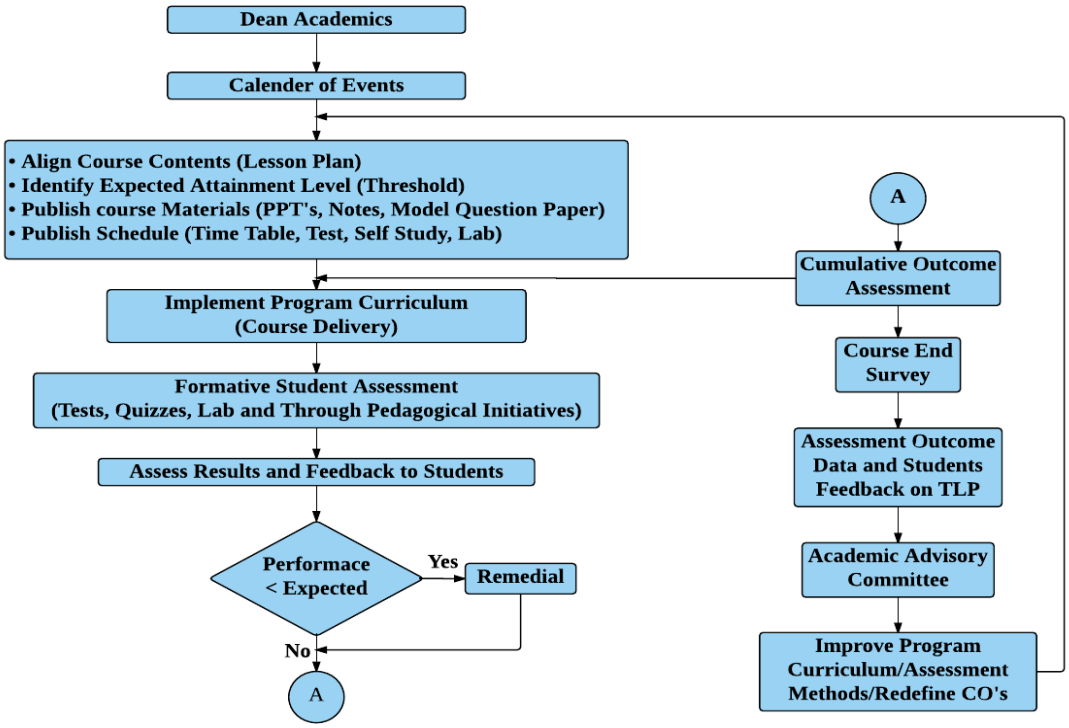
RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks adding up to 20 Marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of 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 up to 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. **Phase I (20) & Phase II (20) 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 THREE 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**

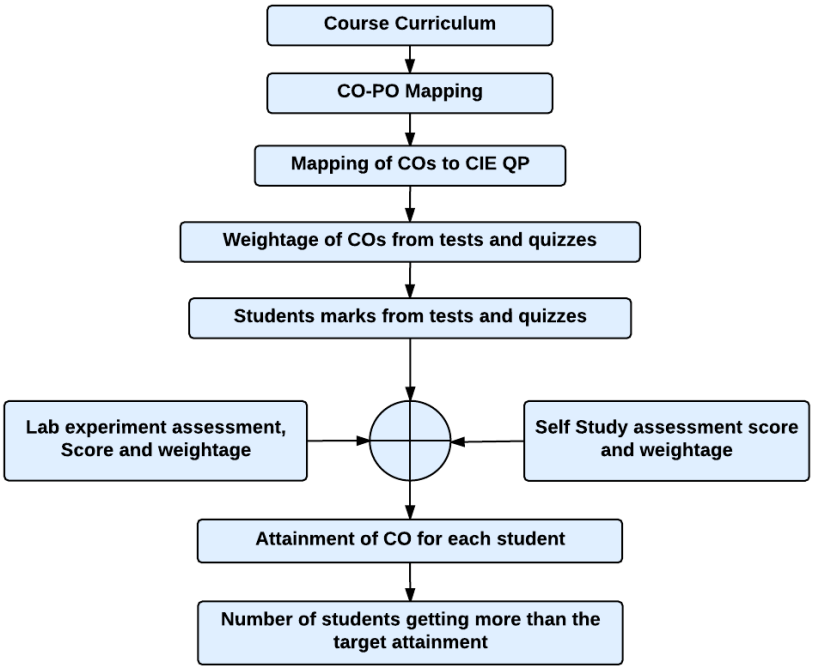
Curriculum Design Process



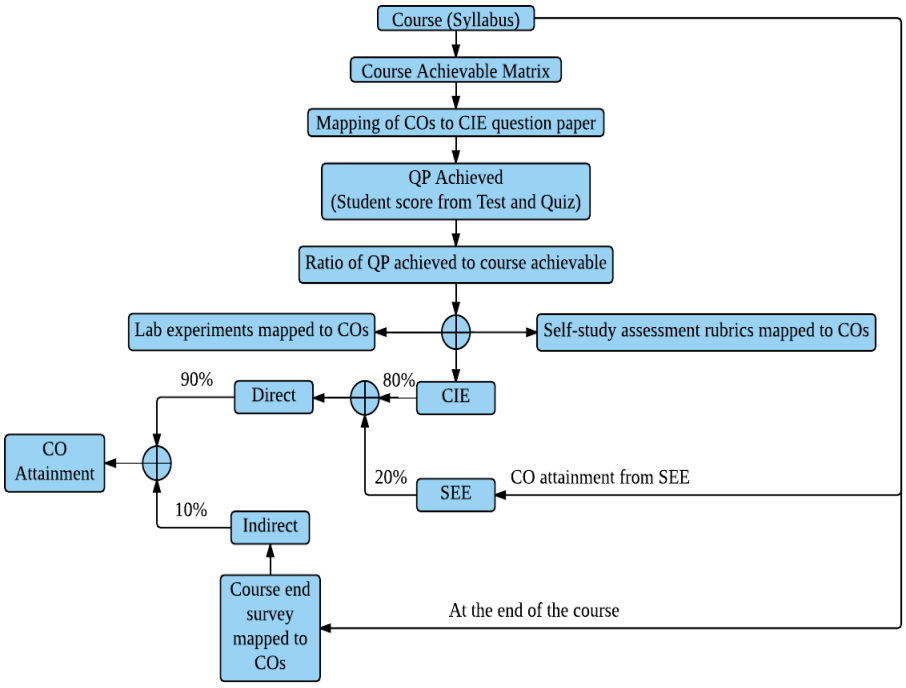
Academic Planning And Implementation



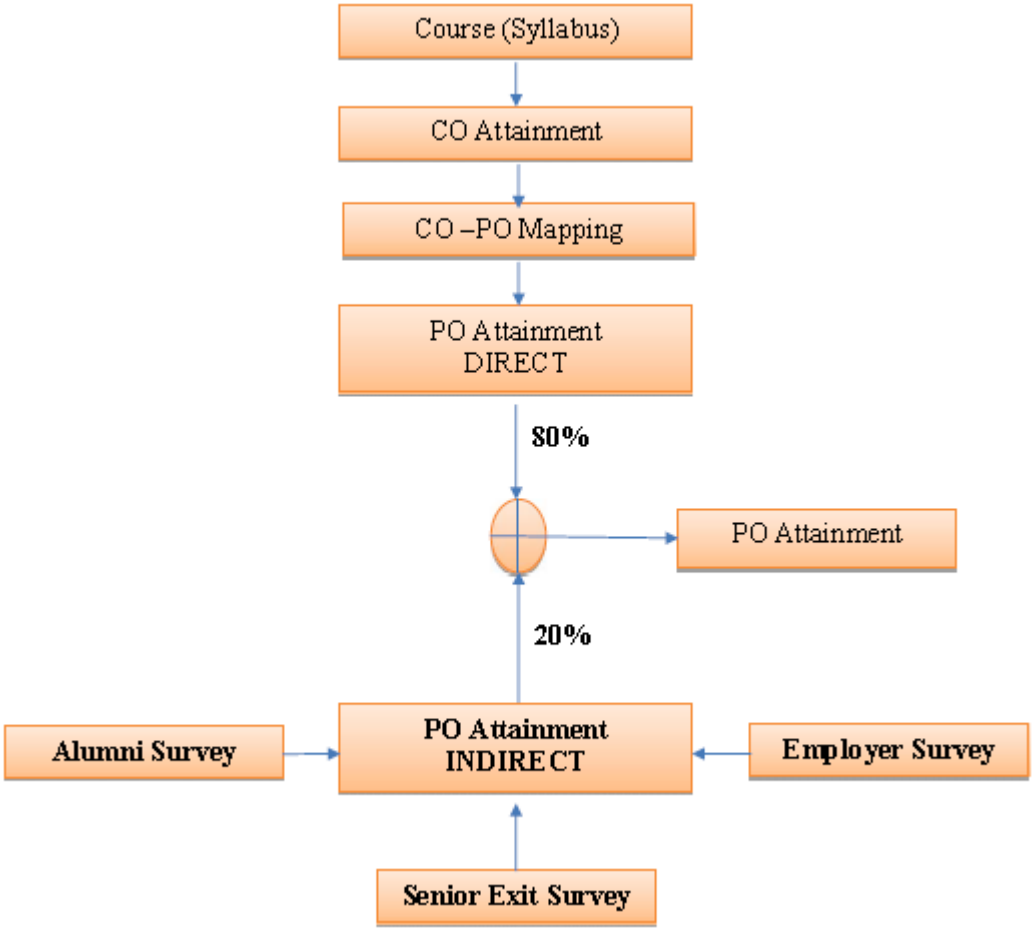
Process For Course Outcome Attainment



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

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