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

CHEMICAL ENGINEERING

BACHELOR OF ENGINEERING (B.E.)
2021 SCHEME

ACADEMIC YEAR 2023-24

CHEMICAL ENGINEERING

DEPARTMENT VISION

Imparting quality technical education in Chemical Engineering to promote leadership in research, innovation and sustainable technology through teamwork.

DEPARTMENT MISSION

- Impart quality education in basic and applied areas of Chemical Engineering.
- Enable students and faculty to achieve proficiency in the areas of Chemical Processes, Energy, Unit Operations and Computational Chemical Engineering using state-of-art laboratories and modern infrastructure.
- Encourage faculty and students to make career in research and contribute towards innovative processes and products.
- Develop inclusive technologies with a focus on new materials and sustainability.
- Collaborate with industries and research Institutes for academics and research.
- Inculcate leadership qualities, entrepreneurial skills, societal and ethical values in students and faculty.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO 1: Exhibit knowledge of basic sciences, concepts and principles of Chemical Engineering.

PEO 2: Comprehend, analyze, design and implement engineering systems with a focus on research,innovation and sustainability.

PEO 3: Work in multidisciplinary team and cater to the needs of process industries with appropriate safety, health and environmental regulations.

PEO 4: Demonstrate effective communication skills, leadership qualities and develop into successfulentrepreneurs.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO	Description
PSO1	Gain knowledge of Chemical Engineering fundamentals and demonstrate problem formulation capabilities
PSO2	Analyse and solve engineering problems with a focus on environment and sustainability
PSO3	Contribute to multidisciplinary research using relevant Chemical Engineering tools

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

INDEX

Bachelor of Engineering in CHEMICAL ENGINEERING

V SEMESTER													
Sl. No.	Course Code	Course Title	Credit Allocation				BoS	Category	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	**100**	****	**3**	**100**	****
2	21CH52	Process Dynamics and Control	3	0	1	**4**	CH	Theory + Lab	**100**	**50**	**3**	**100**	**50**
3	21CH53	Design of Water Systems	3	0	1	**4**	CH	Theory + Lab	**100**	**50**	**3**	**100**	**50**
4	21CH54	Mass Transfer-I	3	1	0	**4**	CH	Theory	**100**	****	**3**	**100**	****
5	21CH55BX	Professional Core Elective-I (Group-B)	3	0	0	**3**	CH	Theory	**100**	****	**3**	**100**	****
6	21CH56CX	Professional Core Elective-II (Group C)	2	0	0	**2**	CH	NPTEL	**50**	****	**2**	**50**	****
7	21CHI57	Summer Internship- II	0	0	2	**2**	CH	Internship	****	**50**	**2**	****	**50**
						22							

ELECTIVES		
GROUP-B		
Sl.No	**Course code**	**Course Title**
1	21CH55B1	Heterogeneous Reaction Systems
2	21CH55B2	Pilot Plant and Scale up Studies
3	21CH55B3	Design of Piping Systems
4	21CH55B4	Chemical Plant Utilities
GROUP-C (NPTEL) **(NPTEL courses are subject to change based on the availability of the course on the NPTEL Platform)**		
Sl. No.	**Course Code**	**Course Title**
1	21CH56C1	Electrochemical Technology in Pollution Control
2	21CH56C2	Biological Process Design for Wastewater Treatment
3	21CH56C3	Computational Process Design
3	21CH56C4	Physical and Electrochemical Characterizations in Chemical Engineering
4	21CH56C5	Waste to Energy Conversion

Bachelor of Engineering in
CHEMICAL ENGINEERING

VI SEMESTER													
Sl. No.	Course Code	Course Title	Credit Allocation				BoS	Category	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	**100**	****	**3**	**100**	****
2	21CH62	Process Simulation and Modeling	3	0	1	**4**	CH	Theory + Lab	**100**	**50**	**3**	**100**	**50**
3	21CH63	Mass Transfer-II	3	0	1	**4**	CH	Theory + Lab	**100**	**50**	**3**	**100**	**50**
4	21CH64DX	Professional Core Elective (Group – D)	3	0	0	**3**	CH	Theory	**100**	****	**3**	**100**	****
5	21CH65EX	Professional Core Elective (Cluster Elective) (Group- E)	3	0	0	**3**	CH/BT/ CV	Theory	**100**	****	**3**	**100**	****
6	21IE66FX	Institutional Electives – I (Group F)	3	0	0	**3**	Res.BoS	Theory	**100**	****	**3**	**100**	****
							20						

ELECTIVES		
GROUP-D Professional Core Elective		
Sl.No	**Course code**	**Course Title**
1	21CH64D1	Food Engineering
2	21CH64D2	Fuel Cell Technology
3	21CH64D3	Process Engineering and Economics
4	21CH64D4	Energy Storage Technology
GROUP-E Professional Core Elective (Cluster Elective)		
1	21BT65E1	Nanobiotechnology
2	21BT65E2	Nature Impelled Technologies
3	21CH65E1	Bioenergy Technology
4	21CH65E2	Hydrogen Technology
5	21CV65E1	Disaster Management
6	21CV65E2	Solid Waste Management

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

Semester: V						
PRINCIPLES OF MANAGEMENT & ECONOMICS (Common to All Programs) (Theory)						
Course Code	:	21HS51B		**CIE**	:	**100 Marks**
Credits: L:T:P	:	3:0:0		**SEE**	:	**100 Marks**
Total Hours	:	45Hrs		**SEE Duration**	:	**3Hours**

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

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

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

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

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
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						
PROCESS DYNAMICS AND CONTROL **Category: Professional Core** **(Theory and Practice)**						
Course Code	:	**21CH52**		**CIE Marks**	:	**100 + 50**
Credits: L:T:P	:	**3:0:1**		**SEE Marks**	:	**100 + 50**
Total Hours	:	**45L+30P**		**SEE Duration**	:	**3 Hours**

Unit-I	**09 Hrs**
First order Systems: Transfer functions, transient response, Forcing functions and responses, physical examples of first order systems: mercury in glass thermometer, liquid level system, mixing process in tanks and stirred tank reactors, Linearization of non-linear first order systems. **Response of first order system in series:** Interacting and non-interacting systems.	
Unit – II	**09 Hrs**
Second order Systems: Examples of second order systems: U-tube manometer, Damped vibrator. Overdamped, critically damped and terms for second order under damped process, Transportation lag	
Unit –III	**09 Hrs**
Controllers: Controllers, components of a control system, closed loop and open loop systems, Transfer functions for two position, proportional, Proportional +Reset (P+I), Proportional + Rate (P+D), Proportional + Reset +Rate controller (P+I+D) **Final Control element:** actuators, valve body, valve characteristics	
Unit –IV	**09 Hrs**
Closed Loop Systems: Control System, servo and regulator problem, Overall transfer function for single-loop systems and multi loop control system, overall transfer function for set-point change and load change. Transient response of simple control systems	
Unit –V	**09 Hrs**
Stability: Concept of Stability, Stability criterion, Routh Herwitz test for stability, Root Locus method. **Frequency Response:** Bode diagrams for first, second order systems and controllers, Bode stability criteria, Ziegler-Nichols tuning method.	

Laboratory Component

	List of experiments
1	Time constant determination and response to step change of thermometer: First order
2	Single tank system: First order
3	Non interacting First order elements in series
4	Interacting First order elements in series
6	Level Controller (P, I, D, PID controllers)
7	Flow controller (P, I, D, PID controllers
8	Pressure controller (P, I, D, PID controllers)
9	Temperature controller (P, I, D, PID controllers)
10	Control valve characteristics
11	Controller Tuning

Course Outcomes: After completing the course, the students will be able to	
CO 1	Recall the concepts of Laplace transforms and first & second order systems
CO 2	Compute transfer functions for first, second order and control systems
CO 3	Analyze the response of first & second order systems and controllers for various inputs
CO 4	Determine the overall transfer function of single and closed loop control system and evaluate the stability of control systems

Reference Books	
1	Process system Analysis and Control: Steven E. LeBlanc, Donald R. Coughanowr, Third Edition, 2017, McGraw Hill, ISBN- 978-1259098437
2	Chemical Process Control: George Stephanopoules, First Edition, 2015, Pearson Education, ISBN- 978-9332549463
3	Coulson and Richardson's Chemical Engineering: Richardson J. F. Et. Al, 4th Edition,2006, Elsevier, ISBN 978-8131204528
4	Process modeling, simulation and Control for Chemical Engineers: Luyben, 2nd Edition, 2013, McGraw Hill Education, 978-9332901681
	Process Dynamics and Control; Seborg, Edgar, Mellichamp, Doyle; 3rd Edition, Wiley, 2013, ISBN- 978-8126541263

RUBRICFOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. Each quiz is evaluated for 10 marks adding up to 20 MARKS	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50Marks**, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (10) Designing & Modeling (10) **Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (30 Marks), lab test (10 Marks) and Innovative Experiment/ Concept Design and Implementation (10 Marks) adding up to 50 Marks. THE FINAL MARKS WILL BE 50 MARKS	**50**
MAXIMUM MARKS FOR THE CIE (THEORY AND PRACTICE)		**150**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type of 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						
DESIGN OF WATER SYSTEMS **Category: Professional Core** **(Theory and Practice)**						
Course Code	**:**	**21CH53**		**CIE Marks**	**:**	**100 + 50**
Credits: L:T:P	**:**	**3:0:1**		**SEE Marks**	**:**	**100 + 50**
Total Hours	**:**	**40L+30P**		**SEE Duration**	**:**	**3Hours**

Unit-I	**08 Hrs**
Constituents of Wastewater: Physical Characteristics: solids, turbidity, colour, temperature. Chemical Constituents: pH, alkalinity, dissolved oxygen. Organic Constituents: BOD, modelling of BOD reaction, analysis of BOD data, limitations of BOD test, estimation of COD,	
Unit – II	**08 Hrs**
Design of Physical Unit Operations and Chemical Unit Processes: Coarse and fine screen, comminutors, flow equalization, mixing and flocculation, gravity separation theory, grit removal, design of primary sedimentation tank.	
Unit –III	**08 Hrs**
Design of Chemical Unit Processes: Chemical coagulation, Chemical precipitation, estimation of sludge volume from chemical precipitation, alum dosage for phosphorous removal, Chemical neutralization, scale control and stabilization	
Unit –IV	**08 Hrs**
Design Aspects in Biological Wastewater Treatment: Suspended growth systems, attached growth systems, hybrid system, anaerobic fermentation, carbon and hydrogen flow in anaerobic digestion, estimation of methane gas production, design of anaerobic digester.	
Unit –V	**08 Hrs**
Design aspects in Disinfection Processes: Disinfection theory, characteristics, and methods. Disinfection with chlorine, sizing of chlorination facilities, Design of chlorine contact basin, Disinfection with ozone and other disinfection methods.	

Laboratory Component

	List of experiments
1	Determination of Acidity and Alkalinity.
2	2. Determination of Chemical Oxygen Demand (COD)
3	3. Estimation of Suspended Solids and Dissolved Solids.
4	4. Estimation of Volatile Solids and Fixed Solids in Water Sample.
5	5. Estimation of settleable solids in Water Sample
6	6. Optimum Dosage of Coagulant by Jar Test Studies.
7	7. Determination of Biological Oxygen Demand (BOD)
8	8. Determination of pH
9	9. Determination Turbidity of Water
10	10. Determination of Coliform Count (MPN)

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Describe the technical aspects of modern systems for drinking water treatment.
CO2	Identify and choose the most appropriate treatment methods
CO3	Gain insight to smart water supply systems including automation.
CO4	Develop financial sustainability of water supply systems.

Reference Books	
1.	Environmental Engineering (2015) by Peavy, Rowe and Tchobanoglous; Publisher - McGraw-Hill
2.	Water Quality Engineering: Physical / Chemical Treatment Processes (2013), by Lawler and Benjamin; Publisher - John Wiley & Sons
3.	Water Supply and Pollution Control (2008) by Warren Viessman Jr. and Mark J. Hammer; Publisher: Pearson Education.
4.	Unit Operations and Processes in Environmental Engineering (1996) by Reynolds and Richards Publisher - CL Engineering
5	Manual on Water Supply and Treatment (1999); Publisher - CPHEEO (MoUD)

RUBRICFOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. Each quiz is evaluated for 10 marks adding up to 20 MARKS	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50Marks**, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (10) Designing & Modeling (10) **Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (30 Marks), lab test (10 Marks) and Innovative Experiment/ Concept Design and Implementation (10 Marks) adding up to 50 Marks. THE FINAL MARKS WILL BE 50 MARKS	**50**
MAXIMUM MARKS FOR THE CIE (THEORY AND PRACTICE)		**150**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type of 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						
MASS TRANSFER-I **Category: Professional Core** **(Theory)**						
Course Code	**:**	**21CH54**		**CIE Marks**	**:**	**100**
Credits: L:T:P	**:**	**3:1:0**		**SEE Marks**	**:**	**100**
Total Hours	**:**	**45L+30T**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**09 Hrs**
Molecular and Eddy Diffusion in Fluids: Molecular and Eddy Diffusion in Fluids: Fick's Law of diffusion, N and J type fluxes, measurement and calculation of diffusivities in stationary fluid, equi-molar, counter diffusion, mass transfer coefficients, theories of mass transfer.	
Unit – II	**09 Hrs**
Inter Phase Mass Transfer: Interphase Mass Transfer: Equilibrium diffusion between phases, relationship between local and overall mass transfer co-efficients, Material balance for stages operations in co-current and counter current. processes, NTU and HTU concepts. **Crystallization:** Solubility and Equilibrium curve, theories of crystallization Material and energy balances, Swensen walker and vacuum crystallizers.	
Unit –III	**09 Hrs**
Humidification: Basic definitions, adiabatic saturation temperature, wet bulb temperature Humidification and dehumidification. Cooling towers-classification and design.	
Unit –IV	**09 Hrs**
Drying: Equilibria, drying rate curves, batch and continuous drying equipments, mechanism of drying, and calculation of drying period for batch and continuous operations.	
Unit –V	**09 Hrs**
Adsorption: Theories of adsorption, industrial adsorbents, single and multistage cross current and fixed bed adsorption operations and calculations.	

Course Outcomes: After completing the course, the students will be able to	
CO 1	Understand the basic concepts of the mass transfer
CO 2	Apply the principles of mass transfer to estimate interphases mass transfer co-efficient
CO 3	Estimate factors governing the transfer operation
CO 4	Identify the factors that influence the mass transfer operations

Reference Books	
1	Robert E. Treybal, "Mass Transfer Operation", Mc Graw Hill, New York, 3rd Edition, 1980, ISBN: 0070651760
2	Mc Cabe and Smith W L, "Unit Operations in Chemical Engineering", Mc Graw Hill, New York, 7th Edition, 2007, ISBN: 0072848235.
3	Coulson and Richardson, "Chemical Engineering – Volume 1", Elsevier (Indian reprint), New Delhi, 6th Edition, 2006, ISBN: 0750625570.
4	Geankoplis C J, "Transport Processes and Unit Operations", Prentice Hall, New Delhi, 4th Edition, 2000. ISBN: 8120326148.

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

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

Semester: V						
HETEROGENEOUS REACTION SYSTEMS **Category: Professional Elective** **(Theory)**						
Course Code	**:**	**21CH55B1**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**40L**		**SEE Duration**	**:**	**3Hours**

Unit-I	**08 Hrs**
Introduction to Heterogeneous Reaction Systems: Examples for heterogeneous catalytic reactions and heterogeneous non-catalytic reactions, contacting patterns for two phase systems, Rate equations for heterogeneous reactions, Overall rates for linear and nonlinear process. **Fluid Particle Reaction Kinetics:** Selection of a model, Rate of reaction for shrinking Spherical Particles, Determination of rate controlling mechanism	
Unit – II	**08 Hrs**
Catalysis: Introduction to catalyst, Promoters, inhibitors. Properties of catalysts, characterization of catalyst, mechanisms of catalysis, catalyst preparation, catalyst poisoning. **Catalyst Deactivation:** Mechanism of deactivation, activity, rate equations for deactivation reactions.	
Unit –III	**08 Hrs**
Catalyst Characterisation: Determination of the surface area of the catalyst (BET method), Pore volume distribution, Scanning Electron Microscopy, X-Ray Diffraction Technique. Rate Controlling Steps and Adsorption Isotherms: Langmuir adsorption Isotherms, Eliey-Rideal mechanism. Rate controlling steps, rates of adsorption, surface reaction and desorption. Wheelers model, Types of diffusion in porous catalysts, effectiveness of catalyst.	
Unit –IV	**08 Hrs**
Fluid-Fluid Reactions: Kinetic regimes for mass transfer and reaction, rate equation for Instantaneous reaction, Fast reaction, Intermediate rate, Rate equation for slow reaction, Film conversion parameter, clues for kinetic regimes, slurry reaction kinetics, Design of towers for fast and slow reactions.	
Unit –V	**08 Hrs**
Experimental Methods For Finding Rates: Differential and Integral Reactor. Differential and integral analysis. **Design of Reactors:** Fluid-particle, fluid- fluid reactor design, Slurry Reactor, Packed bed catalytic reactor, Trickle bed reactor, Three phase fluidized bed Reactor.	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Define the rate equations for heterogeneous reactions
CO2	Predict the rate controlling mechanism
CO3	Analyze adsorption isotherms by conducting adsorption studies
CO4	Interpret experimental data and determine rate equations, design the reactors for fluid-solid and fluid-fluid reactions

Reference Books	
1	Chemical Reaction Engineering, Levenspiel Octave, 3rd Edition, 2006, John Wiley and Sons, 1999, ISBN 978-812651000
2.	Chemical Engg Kinetics, J. M. Smith, 7th Edition, 2004, Mc Graw Hill, , ISBN 978-0070145870
3.	Elements of Chemical Reaction Engineering, 5th Edition, 2016, H. Scott Foggler, Prentice Hall, ISBN 978-8126510009
4.	Chemical and Catalytic Reaction Engineering, James J. Carberry, Dover Publications; Dover Edition, 2001, ISBN-13: 978-0486417363

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

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

Semester: V						
PILOT PLANT STUDIES AND SCALE UP STUDIES **Category: Professional Elective** **(Theory)**						
Course Code	**:**	**21CH55B2**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**42 Hrs**		**SEE Duration**	**:**	**3Hours**

Unit-I	**07 Hrs**
Introduction: Process development, Need for pilot plants, Scale-up procedures, basic terminologies-prototypes, models, scale ratios and elements **Principles of Similarity:** Geometric, Static, dynamic, kinematics, thermal and chemical similarity with examples	
Unit – II	**08 Hrs**
Dimensional Analysis: Significance of dimensionless numbers**,** Generalized dimensionless equations from differential equation for static systems, flow systems, thermal systems, mass transfer processes, homogeneous and heterogeneous chemical processes.	
Unit –III	**9 Hrs**
Regimes: Concept of static, dynamic, thermal, chemical and mixed regimes **Similarity criteria and scale equations:** Static-Load and Mass controlling, mixed regimes; Dynamic-viscosity, gravity and surface tension controlled dynamic regime; Thermal-Conduction, Convection and Radiation controlled; Chemical – Mass transfer controlled, Surface reaction controlled and mixed, extrapolation and boundary effects.	
Unit –IV	**9 Hrs**
Scale-up of mixing equipment – Scale-up based on Power number, Scale-up based on Peripheral speed, Scale–up of baffled and un-baffled mixers. **Scale-up of Heat Transfer Systems** – Scale –up for forced convection and natural convection, Scale-up of Overall heat transfer coefficients by Wilson's method and Regression analysis methods.	
Unit –V	**9 Hrs**
Scale-up of Chemical Reaction systems - Equality of RTD, Scale-up rules for homogenous reactions, Scale-up rules for heterogeneous reaction systems. **Scale-up of Mass Transfer Systems –** Scale-up rules for overall-Mass Transfer Coefficients, Analysis of parameters like Liquid distribution, Flooding Velocities, Pressure Drop and height of Packing ; Scale-up of Distillation systems, Absorption systems, Liquid Extraction systems	

Course Outcomes: After completing the course, the students will be able to	
CO 1	Identify the need for pilot plant.
CO 2	Explain the concept of Similitude and compare the regimes
CO 3	Perform Dimensional analysis on flow, heat and mass transfer processes
CO 4	Establish Similarity criteria and develop the scale equations for chemical processes

Reference Books	
1.	Dimensional Analysis and Scale-up in Chemical Engineering, Marko Zlokarnik,1991, Springer-Verlag, ISBN 9783540541028
2.	Scale up of Chemical Processes, Scale up of Chemical Processes, 1985, John Wiley & Sons, ISBN 0471057479
3.	Pilot Plants Models and scale up method in Chemical Engineering, Johnstone and Thring, 1957, McGraw Hill, ISBN: 978-0071422949
4.	Scale-up in Chemical Engineering, Marko Zlokarnik, 2006, Wiley-VCH, ISBN 9783527314218

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

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

Semester: V						
DESIGN OF PIPING SYSTEMS **Category: Professional Elective** **(Theory)**						
Course Code	**:**	**21CH55B3**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**40 Hrs**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**
Fundamentals for piping design: Pipes and tubes, Euler's equation of motion, continuity equation, Bernoulli's equation, gas laws. **Hydraulic Design Considerations:** Pipe sizing, Pressure drop in pipes, Calculation of pump head**Materials of Construction in Pipes and tubes:** Selection of piping materials, physical properties of pipe materials, recommended piping materials.	
Unit – II	**08 Hrs**
Pipe Fittings: Branching, Tees, Reducers, Elbows, Swage, Caps, Couplings, Socket Weld Fittings, Screwed Fittings, **Valves and allied Fittings**: Valves, functions of valves, valve materials and methods of construction, pressure drop in valves, valve size, types of valves, valve fittings	
Unit –III	**08 Hrs**
Pipe Supports: Rest Support, Hanger Support, Anchor Support, Dummy Leg Support, Guides, braces and spans, stiffening ribs, pipe clamping, flexible hanger supports **Standards and codes for Piping design :** American Standards - ASTM, ANSI, API, ASME, British Standards, DIN Standards , Indian Standards. **Fundamentals of Piping Layout :** Terminologies of piping layout , Considerations for piping layout,	
Unit –IV	**08 Hrs**
Piping Fabrication: Piping fabrication, welding joints in pipe lines, welding processes used in piping fabrication, preparation of pipe edges, welding electrodes, heat treatment of weld joints, inspection of weld joints, repair of defective weld joints, acceptance standards. **Expansion Effects and Compensating Methods:** Pipe expansions, methods of compensation, thermal force calculation, methods of compensation, permissible equivalent stresses caused by' additional external loads expansion devices calculation of anchor force using a bellow below material and life, use of hinged compensators.	
Unit –V	**08 Hrs**
Thermal Insulation: Functions of thermal insulators, modes of heat transfer, insulating materials, temperature drop in a pipeline, application of insulation, calculation of condensate, desuperheaters. **Corrosion Erosion in Pipelines:** Corrosion control in a critical task, corrosion process, corrosion reaction, types of corrosion, anticorrosive protective coatings, cathodic protection of pipelines, abrasion. Safety analysis and colour coding in Piping design.	

Course Outcomes: After completing the course, the students will be able to	
CO 1	Recollect the fundamentals of fluid transport
CO 2	Choose appropriate materials of construction for piping.
CO 3	Size the pipelines adhering to appropriate standards and codes
CO 4	Determine the specific need and choose pipes/pipe fittings, supports, expansion devices for various processes.

Reference Books	
1.	G K. Sahu, "Handbook of Piping Design", 1st Edition, New Age Publishers, 1998.
2.	Mohinder L. Nayyar, "Piping Hand Book", 7th Edition, Mc. Graw Hill Publication, 1996.
3.	Don W. Green; Robert H. Perry. Perry's Chemical Engineers' Handbook, 8th Edition (McGraw-Hill: New York, Chicago, San Francisco, Lisbon, London, Madrid, Mexico City, Milan, New Delhi, San Juan, Seoul, Singapore, Sydney, Toronto, 2008, 1997, 1984, 1973, 1963, 1950, 1941, 1934)

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)	
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3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: V						
CHEMICAL PLANT UTILITIES **Category: Professional Elective** **(Theory)**						
Course Code	**:**	**21CH55B4**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**09 Hrs**
Introduction Utilities: Different utilities, Role of utilities in process plant operations and criteria for selection and estimation of suitable utilities. Water: Water resources, Process water, Cooling water, Drinking water and boiler feed water quality standards, Types and selection of pumps, piping and accessories. Air: Compressed air, Blower air, Fan air, Types of compressor and vacuum pumps and selection, Power requirements, Performance and related calculations.	
Unit – II	**09 Hrs**
Steam and Power Steam generation in chemical plants. Types of boilers and waste heat boilers. Fuels- types and characteristics, Calorific value, Proximate and ultimate analysis, cogeneration power plants. Boiler performance related calculations. Economy of steam generation with different fuels, related calculation	
Unit –III	**09 Hrs**
Refrigeration and Insulation Different refrigeration systems and their characteristics, Air-conditioning systems. Coefficient of performance, Power requirements and refrigeration effect- related calculations for each type of refrigeration system, Refrigerant properties and selection. Insulation materials, selection, economics of insulation, Insulating factors, Properties and classification, Cold insulation, and cryogenic insulation	
Unit –IV	**09 Hrs**
Compressors and Vacuum Pumps Types of compressors and vacuum pumps and their performance characteristics. Methods of vacuum development and their limitations, materials handling under vacuum, piping systems, lubrication and oil removal in compressors in pumps.	
Unit –V	**09 Hrs**
Air and Water Cooling Types of air coolers, construction and working of air coolers, cooling towers working principle, operating principles of cooling towers, types of cooling tower and their operation, hot water distribution systems, air flow distribution systems	

Reference Books	
2.	Industrial Hazards and Plant Safety, Banerjee S, 1st Edition, 2002, CRC press, ISBN: 1560320699
2.	Basic Refrigeration and Air Conditioning, P N Ananthanarayanan, 4th Edition, 2013, McGraw Hill Education (India) Private Limited, ISBN: 9383286563
3.	Mass Transfer Operations, Robert Treybal, 3rd Edition, 2017, McGraw Hill Education, ISBN: 1259029158
4.	Securing Utility and Energy Infrastructures, Larry Ness, 1st Edition, 2006, Wiley-Inter science, ISBN: 047170525X

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Recall the utilities necessary for chemical plant
CO2	Explain the energy utility requirement and material properties to safeguard chemical plants.
CO3	To gain knowledge on heating, cooling and air conditioning systems.
CO4	Identify and use utility equipment in process industries.

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	
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3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester V						
ELECTROCHEMICAL TECHNOLOGY IN POLLUTION CONTROL (NPTEL ELECTIVE) **Category: Professional Elective** **(Theory)**						
Course Code	:	**21CH56C1**		**CIE Marks**	:	**50**
Credits: L:T:P	:	**2:0:0**		**SEE Marks**	:	**50**
Total Hours	:	**30 L**		**SEE Duration**	:	

Unit - I	**08 Hrs**
Atomic and Molecular structure Introduction, Atomic and Molecular structure, Properties of solution, Introduction to Electrochemical technology in Pollution Control Atomic structure – 1, Atomic structure-2, Properties of solution-1 **Properties of solutions** Properties of solutions, Electrochemical method, Properties of solution-2, Properties of solution-, Electrogravimetry, Conductometry-1	
Unit - II	**11 Hrs**
Electrochemical methods-1 Conductometry-2, Potentiometry - Electrolytic cells 1, Potentiometry - Types of electrode-2, Potentiometry-3 **Electrochemical methods-2 ,** Potentiometry-4, Potentiometry-5, Potentiometry-6, Voltametry & Polarography -1 **Electrochemical method, Ion selective electrodes,** Voltametry & Polarography -2, Voltametry & Polarography -3, Voltametry & Polarography – 4, Karl -Fisher titration-1, Ion selective electrodes-1 Ion selective electrodes, Electrochemical sensors, Process waste handling, Ion selective electrodes-2, Ion selective electrodes-3, Electrochemical sensors-1, Electrochemical sensors-2, Process waste handling-1	
Unit - III	**11 Hrs**
Process waste handling and Electroplating Process waste handling, Electroplating, Process waste handling-2, Process waste handling-3,lectroplating-1, Electroplating-2, Electroplating-3 **Electroplating, Batteries and fuel cells,** Zero liquid discharge, Electroplating-4, Batteries and fuel cells -1, Batteries and fuel cells -2, Batteries and fuel cells -3, Zero liquid discharge	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Understand the properties of polymers and fibers
CO2	Apply the principles of interfacial interaction in polymer matrix composites
CO3	Analyze mechanical/thermal performance of polymer matrix composites
CO4	Design polymer composites for space, automotive, construction and medical applications

Reference Books	
3.	Krishnan K Chawla, "Composite Materials- Science and Engineering." 2nd Edition, Springer, ISBN 81-8128-490-9
2.	Christos Comninellis, Guohua Chen,"Electrochemistry for the Environment" 2009, Springer, ISBN 978-0387-36922-8

Semester: V						
BIOLOGICAL PROCESS DESIGN FOR WASTEWATER TREATMENT (NPTEL ELECTIVE) **Category: Professional Elective** **(Theory)**						
Course Code	**:**	**21CH56C2**		**CIE Marks**	**:**	**50**
Credits: L:T:P	**:**	2:0:0		**SEE**	**:**	**50**
Total Hours	**:**	30L		**SEE Duration**	**:**	

Unit-I	**10 Hrs**
Biological treatment fundamentals Microbiology and ecology, Fundamentals of Biochemical Operations; Conversion processes of organic and inorganic matter. Wastewater characterization **Modelling of biological treatment processes** Stoichiometry, reaction and bacterial growth kinetics; reactor hydraulics. Mass and heat balance	
Unit – II	**10 Hrs**
Aerobic Biological Treatment Processes Classification of biological treatment Processes. Biological nitrification, denitrification, and phosphorus removal. Aerated lagoon, activated sludge systems, trickling filter, rotating disc reactors; sequential batch reactor **Anaerobic Biological Treatment Processes** UASB, and hybrid UASB reactors, bio towers.	
Unit –III	**10 Hrs**
Advanced Biological Wastewater Treatment Fluidized bed bioreactors; Membrane bioreactors (MBRs); Moving bed biofilm reactor (MBBR), biological nitrogen removal. Sludge characteristics, production, stabilization; thickening and dewatering; pathogen removal; sludge transformation and disposal methods **Sustainability in wastewater treatment plant** Sustainability in wastewater treatment plant designing; greater water availability; lower energy and chemical consumption; resource recovery. Case studies on biological wastewater treatment	

Reference Books	
4.	Henze M., van-Loosdrecht M.C.M., Ekama G.A. and Brdjanovic D., "Biological Wastewater Treatment: Principles, Modelling and Design", IWA publishing, 2008.
2.	Davide Dionisi. Biological wastewater treatment processes: mass and heat balances. CRC Press, 2017.
3.	Tchobanoglous G., Burton F.L., Stensel H.D., "Metcalf and Eddy Inc.- Waste Water Engineering Treatment and Reuse", Tata McGraw-Hill, 2017
4.	C. P. Leslie Grady, Glen T. Daigger, Nancy G. Love, Carlos D. M. Filipe. Biological Wastewater Treatment. Co-published by IWA Publishing & CRC Press, 2011.

Semester V						
COMPUTATIONAL PROCESS DESIGN (NPTEL ELECTIVE) **Category: Professional Elective** **(Theory)**						
Course Code	:	**21CH56C3**		**CIE Marks**	:	**50**
Credits: L:T:P	:	**2:0:0**		**SEE Marks**	:	**50**
Total Hours	:	**30 L**		**SEE Duration**	:	**90 min**

Unit - I	**08 Hrs**
Flowsheet synthesis, mass and energy balance, design of batch plants, and simulations of process design	
Unit – II	**11 Hrs**
Process flowsheet optimization, Heat and power integration, reactor network analysis	
Unit - III	**11 Hrs**
Operability and process scheduling, quantifying sustainability for design, and sustainable process design	

Course Outcomes: After completing the course, the students will be able to	
CO 1	Understand the basic concepts of mass and energy balance
CO 2	Design and simulate batch plants
CO 3	Carry out flowsheet optimization and energy integration
CO 4	Quantify sustainability for design

Reference Book	
1	Systematic methods of chemical process design; Lorenz T Biegler, Ignacio E Grossmann, and Arthur E Westerberg; Prentice Hall International Series
2	Chemical process design and integration; Robin Smith; John Wiley and Sons, Ltd.
3	Sustainable Design Through Process Integration; Mahmoud M El-Halwagi; Elsevier
4	Sustainable engineering: principles and practice; Bhavik R Bakshi, Cambridge University Press.

Semester V						
PHYSICAL AND ELECTROCHEMICAL CHARACTERIZATIONS IN CHEMICAL ENGINEERING (NPTEL ELECTIVE) **Category: Professional Elective** **(Theory)**						
Course Code	:	**21CH56C4**		**CIE Marks**	:	**50**
Credits: L:T:P	:	**2:0:0**		**SEE Marks**	:	**50**
Total Hours	:	**30 L**		**SEE Duration**	:	**90 min**

Unit - I	**10 Hrs**
Spectroscopic Techniques Spectroscopic Techniques Physical and Chemical Absorption Methods	
Unit - II	**10 Hrs**
Rheological and Interfacial Measurements Rheological and Interfacial Measurements	
Unit - III	**10 Hrs**
Electron Spectroscopy for Surface Analysis Electrochemical Characterization Techniques Electrochemical Characterization Techniques	

Reference Book	
1	Y. Leng, Materials Characterization: Introduction to microscopic and spectroscopic methods, 1st Ed., John Wiley & Sons, 2008.
2	S. Zhang, Material Characterization Techniques, CRC Press , 2009
3	Pallab Ghosh. Colloid and Interfacial Science, PHI Publisher 2009

Semester V						
WASTE TO ENERGY CONVERSION **Category: Professional Elective** **(Theory)**						
Course Code	**:**	**21CH56C5**		**CIE Marks**	:	**50**
Credits: L:T:P	:	**2:0:0**		**SEE Marks**	:	**50**
Total Hours	:	**30 L**		**SEE Duration**	:	**90 min**

Unit - I	**08 Hrs**
Introduction, characterization of wastes, Energy production form wastes through incineration, energy production through gasification of wastes.	
Unit - II	**11 Hrs**
Energy production through pyrolysis and gasification of wastes, syngas utilization. Densification of solids, efficiency improvement of power plant and energy production from waste plastics. Energy production from waste plastics, gas cleanup.	
Unit - III	**11 Hrs**
Energy production from organic wastes through anaerobic digestion and fermentation, introduction to microbial fuel cells. Energy production from wastes through fermentation and transesterification. Cultivation of algal biomass from wastewater and energy production from algae.	

Reference Books	
1	Rogoff, M.J. and Screve, F., "Waste-to-Energy: Technologies and Project Implementation", Elsevier Store, ISBN:978-1-4377-7871-7, 2011
2	Young G.C., "Municipal Solid Waste to Energy Conversion processes", John Wiley and Sons, ISBN: 9780470539675, 2010
3	Harker, J.H. and Backhusrt, J.R., "Fuel and Energy", Academic Press Inc. ISBN: 978-0123252524, 1981
4	EL-Halwagi, M.M., "Biogas Technology- Transfer and Diffusion", Elsevier Applied Science.
5	Hall, D.O. and Overeed, R.P.," Biomass - Renewable Energy", John Willy and Sons, OSTI: 5187569, 1987
6	Mondal, P. and Dalai, A.K. eds., 2017. *Sustainable Utilization of Natural Resources*. CRC Press, ISBN: 9781315153292, 2017

Semester: V						
SUMMER INTERNSHIP - II (Practical)						
Course Code	:	21CHI57		**CIE**	:	50 Marks
Credits: L: T: P	:	0:0:2		**SEE**	:	50 Marks
Total Hours	:	4 Weeks		**SEE Duration**	:	02 Hrs
Students can opt the internship with the below options						4 Weeks

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

B. At RVCE Center of Excellence/Competence

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

C. At InternShala

Intern Shala is India's no.1 internship and training platform with 40000+ paid internships in Engineering. Studentscan 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 officialletter head.

E. At Industry or Research Organizations

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

Procedures for the Internship:

1. Request letter/Email from the office of respective departments should go to Places where internships are intended to be carried out with a clear mention of the duration of Three Weeks. Colleges/Industry/ CoEs/CoCswill confirm the training slots and the number of seats allotted for the internship via confirmation letter/ Email.
2. Students should submit a synopsis of the proposed work to be done during internship program. Internship synopsis should be assessed or evaluated by the concerned Colleges/Industry/CoEs/CoC. Students on joininginternship 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 careeropportunities prior to graduation.
CO3	Explore and use state of art modern engineering tools to solve the societal problems with affinity towardsenvironment and involve in ethical professional practice.
CO4	Compile, document and communicate effectively on the internship activities with the engineeringcommunity.

RUBRICS FOR THE CONTINUOUS INTERNAL EVALUATION		
#	**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 inreport writing, oral presentation.	**30**
	MAXIMUM MARKS FOR THE CIE THEORY	**50**

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

Semester: 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	**:**	40L		**SEE Duration**	**:**	**3Hours**

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

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

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

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

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

Semester: VI						
PROCESS SIMULATION AND MODELING **Category: Professional Core** **(Theory and Practice)**						
Course Code	**:**	**21CH62**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:1**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**42L+30P**		**SEE Duration**	**:**	**3Hours**
Unit-I						**8 Hrs**
Modeling in Chemical Engineering: Introduction, Fundamental laws, scope of coverage, principles of formulation, modeling aspects, classification of models. Continuity equation, equations of motion, transport equations, equations of state, equilibrium, and chemical kinetics with examples.						
Unit – II						**8 Hrs**
Models in Separation processes: Steady state single and multiple stage solvent extraction, unsteady state single stage solvent extraction, multistage gas absorption, single component vaporizer and ideal binary distillation column, batch distillation, multi-component flash drum.						
Unit –III						**9 Hrs**
Models in reactors: Series of Isothermal, constant hold-up CSTRs, CSTRs with variable hold-ups, Non-isothermal CSTR, Batch reactor and reactor with mass transfer, gas phase pressurized CSTR**.**						
Unit –IV						**9 Hrs**
Models in heat transfer operation: Cooling of tanks, unsteady state heat transfer by conduction, unsteady state steam heating of Liquid. **Models in fluid flow operation:** Fluid through packed bed column, flow of a film on the outside of a circular tube, Basic tank model –Level V/s time, Two-heated tanks**.**						
Unit –V						**8 Hrs**
Numerical methods: Introduction to simulation, Role of computers and numerical methods in simulation, iterative convergence methods – interval halving, Newton-Raphson method, False-position, Wegstein and Muller methods, numerical integration of ODEs – Euler and Runge- Kutta.						

List of experiments:

1. Simulation of Shell and Tube Heat Exchanger
2. Simulation of Centrifugal Pump/Compressor
3. Simulation of Flash drum/Separator
4. Simulation of single stream gas heater/cooler
5. Simulation of CSTR
6. Simulation of Distillation Column
7. Simulation of Atmospheric distillation of crude oil
8. Simulation of aromatic stripper with recycling
9. Simulation of Benzene production
10. Simulation of methanol-water separation using RADFRAC
11. Simulation of various reactor types to model a single reaction
12. Simulation of cyclo hexane production

Course Outcomes: After completing the course, the students will be able to	
CO1:	Recall the fundamental laws in modeling chemical engineering systems
CO2:	Explain modeling and simulation of simple chemical engineering systems
CO3:	Apply mathematical tools to solve model equations

CO4:	Analyze chemical engineering systems for model development

Reference Books	
1	Process Modeling, Simulation and Control for Chemical Engineers, William L. Luyben McGraw Hill 2nd Edition, 1999, ISBN: 978-0070391598.
2	Process Plant Simulation, B V Babu, 1st Edition, 2004, Oxford University Press, ISBN: 978-0-19-566805-6.
3	Elements of Chemical Reaction Engineering, H Scott Fogler, 3rd Edition, Prentice Hall of India, 2004, ISBN: 7502741003.
4	Process Heat Transfer, D.Q.Kern, 1st Edition, 2012, Tata McGraw Hill, ISBN: 007034190.

RUBRICFOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. Each quiz is evaluated for 10 marks adding up to 20 MARKS	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50Marks**, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (10) Designing & Modeling (10) **Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (30 Marks), lab test (10 Marks) and Innovative Experiment/ Concept Design and Implementation (10 Marks) adding up to 50 Marks. THE FINAL MARKS WILL BE 50 MARKS	**50**
	MAXIMUM MARKS FOR THE CIE (THEORY AND PRACTICE)	**150**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type of 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						
MASS TRANSFER-II **Category: Professional Core** **(Theory and Practice)**						
Course Code	**:**	21CH63		**CIE**	**:**	**100 + 50 Marks**
Credits: L:T:P	**:**	3:0:1		**SEE**	**:**	**100 + 50 Marks**
Total Hours	**:**	40L + 30P		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**
Gas liquid contacting systems and packed tower absorption Types, construction and working of plate and packed columns. Types and properties of industrial packing, plate efficiencies. Liquid phase holdup and pressure drop in absorption towers. Problems encountered in packed towers.	
Unit – II	**08 Hrs**
Distillation Introduction, vapor liquid equilibria, relative volatility, prediction of VLE from vapor pressure data using Raoult's law, non-ideal systems, azeotropes, immiscible systems, and flash distillation.	
Unit –III	**08 Hrs**
Distillation Multi-stage rectification column. Design using McCabe Thiele method for binary mixtures. side stream in distillation columns, multiple feed to distillation columns. Plate to plate calculations by Lewis Sorel method, extractive, azeotropic, molecular and vacuum distillations.	
Unit –IV	**08 Hrs**
Liquid-liquid Extraction Ternary equilibrium, solvent selection, single stage, multistage cross current, counter current extraction. Equipment for liquid-liquid extraction and numerical problems.	
Unit –V	**08 Hrs**
Leaching Equipment for leaching, preparation of solids for leaching, equilibrium and phase diagrams. Calculations for single stage, multistage leaching operations and numerical problems.	

Laboratory Experiments
1. Diffusion of Organic vapors in Air
2. Simple /Differential Distillation
3. Packed Column distillation
4. Steam Distillation
6. Solid Liquid Leaching
7. Surface Evaporation
8. Tray Dryer
9. Adsorption Studies
10. Liquid Liquid/Vapor Liquid Equilibrium
11. Liquid Extraction (Cross Current: Single and multi-Stages)
12. Holdup Studies in Packed Columns
13. Wetted Wall Column/Mass Transfer Coefficient Estimation

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the concepts of equilibrium, stage operations and carryout material balance
CO2	Explain the working principles of mass transfer operations
CO3	Analyse separation under various mass transfer operations and their graphical representations
CO4	Design various mass transfer equipment and evaluate the performance of the mass transfer equipment

Reference Books	
1	Mass Transfer Operations, Robert E Treybal, McGraw Hill, 3rd Edition, 1981, ISBN:978007065760
2.	Unit Operations in Chemical Engineering, McCabe & Smith, McGraw Hill, 6th Edition, 2001, ISBN:9780072848236
3.	Coulson and Richardson, Chemical Engineering Volume 1 and Volume 2, Pergemen Press, 4th Edition, 1998 ISBN: 0750644451
4.	Badger and Banchero, Introduction to Chemical Engineering, Tata McGraw Hill, 1st Edition 1997, ISBN:9780070850279.

RUBRICFOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	COMPONENTS	MARKS
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. Each quiz is evaluated for 10 marks adding up to 20 MARKS	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50Marks**, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (10) Designing & Modeling (10) **Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (30 Marks), lab test (10 Marks) and Innovative Experiment/ Concept Design and Implementation (10 Marks) adding up to 50 Marks. THE FINAL MARKS WILL BE 50 MARKS	**50**
	MAXIMUM MARKS FOR THE CIE (THEORY AND PRACTICE)	**150**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type of 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						
FOOD ENGINEERING **Category: Professional Elective** **(Theory)**						
Course Code	**:**	**21CH64D1**		**CIE**	**:**	100 Marks
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	100 Marks
Total Hours	**:**	**40L**		**SEE Duration**	**:**	3 Hours

UNIT-I	**08 Hrs**
Introduction to Food Engineering: Introduction: general aspects of food industry, world food demand and Indian scenario, Physical properties of food materials: Rheological models, Water activity, Fluid Flow in Food Processing: Liquid Transport Systems; Pipes for Processing Plants, Pumps for food plants; Numerical on fluid flow in food processing.	
UNIT-II	**08 Hrs**
Food processing and preservation: Food deterioration – Causes, Aims and objectives of preservation and processing. **High-temperature preservation**: Introduction to Thermal Processing; Pasteurization; Commercial Sterilization Kinetics of Microbial Death; Thermal Death Time; Heat Transfer in Thermal Processing; Integrated F Value; Batch & continuous Retorts for Thermal Processing **Non-thermal preservation**: Cold sterilization: Gamma irradiation; Microwave & Ohmic heating, Pulsed Electric Field, High Pressure Processing	
UNIT-III	**08 Hrs**
Low-temperature preservation: Principles of low temperature preservation; freezing rate & freezing point; physical properties of frozen food; food quality during frozen storage; freezing equipment, plate freezer, blast freezer, fluidized bed freezer, scraped surface freezer; cryogenic and immersion freezing; prediction of freezing time using Plank's equation & Nagaoka's equation. **Food contamination and adulteration**: Types of adulterants and contaminants, Intentional adulterants, incidental adulterants and its effects, food laws and standards, Hazard analysis and critical control points or HACCP, Food Safety and Standards Authority of India (FSSAI).	
UNIT-IV	**08 Hrs**
Food additives: Introduction and need for food additives. Types of additives – antioxidants, chelating agents, coloring agents, curing agents, emulsions, flavors and flavor enhancers, flavor improvers, humectants and anti-caking agents, leavening agents, nutrient supplements, non - nutritive sweeteners, pH control agents, stabilizers and thickeners, other additives. Additives and food safety	
UNIT-V	**08 Hrs**
Extrusion processes: Introduction to Extrusion, Basic Principles, Extrusion Systems, Cold Extrusion, Extrusion Cooking, Single Screw Extruders, Twin-Screw Extruders. **Packaging concepts**: Introduction to packaging, food protection, product containment, commutation, convenience, mass transfer in packaging materials, and permeability of packaging material to fixed gases, innovations in food packaging, passive packaging, active packaging, intelligent packaging, food packaging and product shelf-life. Advances in aseptic processing and packaging, nutrition labelling.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Identify sources of contaminants, adulterants and hazard analysis to ensure the safe food processing.
CO2:	Comprehend the engineering solutions involved in the packaging improvements for sustainable development of food industry
CO3:	Apply biocompatible additives and packaging for food products
CO4:	Evaluate different food processing and preservation technologies

Reference Books	
1	R.Paul Singh and Dennis R. Introduction to Food Engineering, Elsevier Science & Technology, 5th Edition, ISBN: 9780123985309, 2013.
2	P.G. Smith, Introduction to Food Process Engineering Second Edition, Springer Press, ISBN 978-1-4419-7661-1, 2009
3	Subbulakshmi G. and Shobha A. Udupi, Food Processing and Preservation, New Age International Pvt. Ltd., ISBN: 8122412831, 2001
4	Food Engineering 1, Gustavo V. Barbosa-Canovas & Pablo Juliano http://www.eolss.net/ebooklib/ebookcontents/e5-10-themecontents.pdf (ebook)

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

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

Semester: VI						
FUEL CELL TECHNOLOGY **Category: Professional Elective** **(Theory)**						
Course Code	**:**	**21CH64D2**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**40L**		**SEE Duration**	**:**	**3Hours**

Unit-I	**08 Hrs**
Introduction to Fuel Cells Definition, components of a fuel cell, working principle of fuel cell, historical developments of fuel cells, Fuel cell thermodynamics, advantages of fuel cells over conventional energy systems, fuels for cells and their properties.	
Unit – II	**08 Hrs**
Types of Fuel Cells Classification of fuel cells, alkaline fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, polymer electrolyte fuel cell, advantages and disadvantages of each.	
Unit –III	**08 Hrs**
Efficiencies, losses and kinetics of Fuel Cells Various fuel cell efficiencies – intrinsic maximum efficiency, voltaic efficiency, faradaic efficiency, overall efficiency, losses – activation losses, fuel crossover and internal current, ohmic losses, mass transport/concentration losses, and activation/electrode/reaction kinetics	
Unit –IV	**08 Hrs**
Characterization of Fuel Cells In-situ characterization: I-V curve, current voltage measurement, current interrupt measurement, cyclic voltammetry, and electrochemical impedance spectroscopy Ex-situ characterization: Proton conductivity, flexural strength, electrical conductivity, electrochemical surface area and electrochemical activity	
Unit –V	**08 Hrs**
Applications of fuel cells Applications of fuel cells in air, road and rail transport, hydrogen storage, handling and safety issues	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the fundamentals and characteristics of fuel cells
CO2	Apply chemical engineering principles to distinguish fuel cells from conventional energy systems
CO3	Analyze the performance of fuel cells using different characterization techniques
CO4	Evaluate the possibility of integrating fuel cell systems with conventional energy systems

Reference Books	
1	Fuel Cell Systems Explained, James Larminie and Andrew Dicks, John Wiley & Sons, 2nd Edition, 2003, ISBN 978 0470 848579
2.	Fuel Cells Principles and Applications, Viswanathan and M Aulice Scibioh, Universities Press, 1st Edition, 2009, ISBN 13: 978 1420 060287
3.	Fuel Cell Fundamentals, O 'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, Wiley, New York, 1st Edition, 2006, ISBN 978 0470 258439
4.	Recent Trends in Fuel Cell Science and Technology, Basu. S, Springer, 1st Edition, 2007, ISBN 978 0387 688152

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

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

Semester: VI						
PROCESS ENGINEERING ECONOMICS **Category: Professional Elective** **(Theory)**						
Course Code	**:**	**21CH64D3**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**40L**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**
Process Design Development: Process development – Feasibility survey, Material & Energy Balance, Equipment design & selection, Analysis of Process flow sheet, Plant location and layout, Factors affecting plant design.	
Unit – II	**08 Hrs**
Basics of Engineering Economics: Elements of project cost – cost information, total capital investment and total capital cost, operation cost, interest, project financing, cost estimation, investment costs, taxes and insurance, depreciation, time value of money	
Unit –III	**08 Hrs**
Profitability, Alternative Investments and Replacements: Profitability, Cash flow diagrams, break even analysis , measures of process profitability, methods of evaluation of profitability – Rate of return on investment , Discounted cash flow based on full-life performance , Net present worth , Capitalized costs, Payout period , Simplified model for economic analysis of process design, Alternative investments and Replacement.	
Unit –IV	**08 Hrs**
Optimum design and design strategy : Procedures for determining optimum conditions- Single and multi-variable procedures, graphical and analytical procedures, Significance of breakeven chart for optimum analysis, Optimum rate of production- concept of minimum cost of the product, maximum cost of the product and case of maximum profit. Economics of material selection and fabrication selection	
Unit –V	**08 Hrs**
Equipment cost: Heat transfer equipment costs, Mass transfer equipment costs, Plate and packed towers, dryers, cost estimation for reactor equipment components, cost of piping Design report: types of report, organization of the report.	

Reference Books	
1.	Plant Design and Economics for Chemical Engineers, M.S. Peters and K.D. Timmerhaus – 4th Edition, 2003, McGraw Hill, ISBN: 0072392665.
2.	Industrial Organization and Engineering Economics, T.R.Banga and S.C. Sharma, 22nd Edition, 2007, Khanna Publishers, ISBN: 81-7409-078-9.
3.	Chemical Process Economics, J. Happel and D.J. Jordan, 2005, Marcal Dekker Inc., ISBN: 0824761553

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Define the basic terminologies of process development and economics.
CO2	Explain concepts of process development, elements of project costing
CO3	Calculate various cost elements and draw cash flow diagrams and determine optimum cost.
CO4	Analyze process flow sheets, design reports and do break even analysis.

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

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

Semester: VI						
ENERGY STORAGE TECHNOLOGY **Category: Professional Elective** **(Theory)**						
Course Code	**:**	**21CH64D4**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**40L**		**SEE Duration**	**:**	**3Hours**

Unit-I	**06 Hrs**
Introduction: Origin of energy storage, Fossil Fuels and the Carbon Cycle, necessity of energy storage systems, Classification of energy storage systems -physical, temporal and economic classification.	
Unit – II	**9 Hrs**
Electrical Energy Storage: General principle of electrical energy storage, principle of double layer capacitor, concept of charging and discharging, pseudo-capacitance, process of charging and discharging. Super capacitor materials for energy storage, distinction between energy and power Storage,, application of Supercapacitors, concept of efficiency, losses and ageing.	
Unit –III	**8 Hrs**
Electrochemical energy storage: Redox reactions in batteries, Nernst equation, current and capacity in electrochemical storage, Lead-acid batteries, Li-ion batteries – reactions, electrode materials, electrode and electrolyte requirements, ageing an degradation of Li-ion batteries.	
Unit –IV	**9 Hrs**
Chemical Energy Storage: Carbon neutral chemical fuels, hydrogen for energy strorage, Hydrogen production methods – electric methods, steam reforming, gasification, thermochemical water splitting, photolytic and electrolytic methods, Fuel cell – basics and types, Hydrogen storage, biomethanation.	
Unit –V	**8 Hrs**
Thermal Energy Storage: Thermal energy storage - principles and types , principle of sensible thermal storage and materials used, principle of latent thermal storage and materials used, concept of thermochemical Storage, Materials for thermal energy storage.	

Course Outcomes: After completing the course, the students will be able to	
CO 1	Explain principles of energy storage technologies
CO 2	Comprehend the science, economics and engineering of renewable energy storage
CO 3	Understand various energy storage materials
CO 4	Evaluate assess the efficiencies of energy storage systems.

Reference Books	
1.	Energy Storage- Fundamentals, Materials and Applications, Robert Huggins, 2016, Springer International Publishing, ISBN- 978-3-319-33108-9, https://doi.org/10.1007/978-3-319-21239-5
2.	Energy Storage Technologies and Applications, C. Michael Hoff, 2022, Artech House, ISBN- 9781630819095
3.	Energy Storage Systems - Volume 1, EOLSS- UNESCO, ISBN: 978-1-84826-162-4
4.	Energy Storage Systems - Volume 2, EOLSS- UNESCO, ISBN: 978-1-84826-163-1

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

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : 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						
NANOBIOTECHNOLOGY **Category: Professional Core Elective (Cluster Elective)** **(Common to CH, CV, & BT)** **(Theory)**						
Course Code	**:**	**21BT65E1**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**39 Hrs**		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**07 Hrs**
Introduction to nanomaterials History, Types of nanomaterials: Fullerenes (Grephene, Bucky ball, Nano tubes, Diamond like carbon, DLC), Nanoshells, Quntum dots, Dendrimers, Nanocarriers. Nanowires. **Nanobiomaterials:** Introduction & overview of 1st generation 2nd generation & 3rd generation biomaterials, DNA and Protein based Nano structures, array nanostructures. Function and application of DNA and protein based nanostructures.	
Unit – II	**08 Hrs**
Nanomaterials, Synthesis and Characterization: Approaches of Fabrication: Top-Down and Bottom-up methods of nanofabrication and Nanosynthesis: Ball milling, CVD, Sol gel, Plasma arching. Biosynthesis of Nanoparticles. Nanolithography: hard (Optical, UV, EUV, X-ray) and soft lithography. Characterization of nanomaterials using spectroscopic (UV-VIS, FTIR and Raman) and microscopic methods Atomic Force Microscopy, Scanning & Tunneling Microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy (AFM, STM, SEM and TEM).	
Unit –III	**07 Hrs**
Nanosensors and Nanobiosensors: Overview of nanosensors, prospects and market. Types of Nanosensors and their applications. Electromagnetic nanosensors: Magnetic nanosensors. Mechanical nanosensors. Types of nanobiosensors: Cantilever, nanotube, nanowire and nanoparticle based sensor, Nanosensors, Biosensors in modern medicine.	
Unit –IV	**07 Hrs**
Micro & Nano Electromechanical systems and Microfluidics: MEMS/NEMS: Nanotransducers: Nano- mechanical, electrical, electronic, Magnetic and Chemical Transducers. Nano sensors and Nano Actuators: types of actuators. Microfludics: Laminar flow, Hagen- Peouiselle equation, basic fluid ideas, Special considerations of flow in small channels, mixing, microvalves & micropumps.	
Unit –V	**10 Hrs**
Medical Nano Technology: Diagnostics, therapeutics, drug delivery, Nano Surgery and Tissue Engineering. Diagnostics: Resonance Light Scattering (RLS) Technology, Nano chips, gene and protein chips. Therapeutic: Drug delivery: Bioavailability, Drug Delivery Applications, Bioavailability, Sustained and targeted release. Benefits of Nano drug delivery system. Use of Microneedles and nanoparticles for targeted and highly controlled drug delivery. Nano robots in drug delivery and cleaning system. Design of nanoparticles for oral delivery of peptide drugs, Tissue Engineering.. Nanotoxicity assessment: In-vitro laboratory tests on the interaction of nanoparticles with cells. Body on a chip and lab on a chip.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Remember, understand and apply knowledge about nanomaterials and their uses. Interpret and apply the techniques of manufacturing and characterization processes.
CO2	Understand the Micro & Nano Electromechanical systems and Microfluidics Interpret and apply the techniques and processes.
CO3	Understand and apply knowledge of nanosensors and nanobiosensors applications like electronics, mechanical, chemical, and biological systems
CO4	Apply knowledge of nanosensors and nanobiosensors to create and evaluate nano- design, devices and systems applicable to various medical disciplines.

Reference Books	
1	Textbook of Nanosciences and Nanotechnology, B.S. Murty, P. Shankar, B. Raj, B. B. Rath and J. Murday, 2013, Springer, Co-publication with University Press (India) Pvt. Ltd. VCH, XII. ISBN- 978-3-642-28030-6.
2	Springer Handbook of Nanotechnology**,** Editors: Bhushan, Bharat (Ed.), 2017, Springer, ISBN 978-3-662-54357-3.
3	Nanotechnology and Nanomaterial Applications in Food, Health, and Biomedical Sciences (Innovations in Agricultural & Biological Engineering), Deepak Kumar Verma, Megh R. Goya, Hafiz Anasr Rasul Suleria, 2019, Apple Academic Press, CRC Press, Taylor & Francis Group**,** ISBN-10 1771887648.
4	Nanotechnology Trends and Future Applications, Tahir, Muhammad Bilal, Rafique, Muhammad, Sagir, Muhammad, 2021, Springer, (Eds.), ISBN 978-981-15-9437-3.

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

Semester: VI						
NATURE IMPELLED TECHNOLOGIES **Category:Professional Core Elective (Cluster Elective)** **(Common to CH, CV, & BT)** **(Theory)**						
Course Code	**:**	**21BT65E2**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**39 L**		**SEE Duration**	**:**	**03 Hours**

Unit-I	**06 Hrs**
Nature-inspired materials: Bioinspiration, bio-imitation and biomimicry. Emerging trends and prospects: Nature-inspired processes, Nature-inspired design approach, nature-inspired materials by virtue of the gain; Design and functionality, engineering and manufacturing and materials.	
Unit – II	**08 Hrs**
Plant inspired Technologies: Photosynthesis and Photovoltaic cells, Bionic/Artificial leaf. Lotus leaf effect for super hydrophobic surfaces. Flectofin®, a new façade-shading system inspired by flower of the Bird-of-Paradise, Plantoid ; Robotic Solutions Inspired by Plant Root. Plant cockleburs and Velcro.	
Unit –III	**08 Hrs**
Nature inspired technologies for medical applications: Organ system- Circulatory- artificial blood, artificial heart, pacemaker. Respiratory- artificial lungs. Excretory- Artificial kidney and skin. Artificial Support and replacement of human organs: artificial liver and pancreas. Total joint replacements- artificial limbs. Visual prosthesis -optical tweezers.	
Unit –IV	**08 Hrs**
Nature driven technologies for industrial applications: Biosensors, Thermal insulation and storage materials. Bio-robotics; design, control actuation and sensing. Human inspired hyper dynamic manipulation. Humanoid Robot.	
Unit –V	**08 Hrs**
Nature inspired computing: Cellular automata, evolutionary computing, swarm intelligence, artificial life and complex networks. Genetic Algorithms, Artificial Neural Networks. Artificial intelligence and MEMS.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Elucidate the concepts and phenomenon of natural processes
CO2	Apply the basic principles for design and development of nature inspired structures
CO3	Analyse and append the concept of bio-mimetics for diverse applications
CO4	Designing technical solutions by utilization of natured-inspiration modules.

Reference Books	
1	Yoseph Bar-Cohen. Biomimetics: Biologically Inspired Technologies D. Floreano and C. Mattiussi, "Bio-Inspired Artificial Intelligence", CRC Press, 2018. ISBN: 1420037714, 9781420037715.
2	Guang Yang, Lin Xiao, and Lallepak Lamboni. Bioinspired Materials Science and Engineering. John Wiley, 2018. ISBN: 978-1-119-390336.
3	M.A. Meyers and P.Y. Chen. Biological Materials, Bioinspired Materials, and Biomaterials Cambridge University Press, 2014 ISBN 978-1-107-01045.
4	Tao Deng. Bioinspired Engineering of Thermal Materials. Wiley-VCH Press, 2018. ISBN: 978-3-527-33834-4.

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 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 TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
BIO-ENERGY TECHNOLOGY **Category: Professional Core Elective (Cluster Elective)** **(Common to CH, CV, & BT)** **(Theory)**						
Course Code	**:**	**21CH65E1**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**40L**		**SEE Duration**	**:**	**3Hours**

Unit-I	**08 Hrs**
Introduction: Bioresources: Definition, examples, and classification. Opportunities and challenges. Global trends in bioresource technology. Classification of bioresource technology. Biomass: Synthesis, significance, world energy scenario, physico-chemical properties, composition, and characteristics.	
Unit – II	**08 Hrs**
Dry Conversion processes Introduction, conversion technologies for biomass into energy. Comparison between various thermochemical conversion technologies, Combustion, Pyrolysis and Gasification.	
Unit –III	**08 Hrs**
Wet Conversion processes Anaerobic Digestion: Introduction, potential benefits, process and pathway, Factors affecting, Advantages and disadvantages, Anaerobic co-digestion, Bio gasification of cow dung. Design of anaerobic digester	
Unit –IV	**08 Hrs**
Biofuels Introduction, Pre-treatment of LCB, biofuel types, relevance of biofuel technology. Sources of liquid biofuels for automobiles. Bioethanol, Bio-aviation Turbine Fuel, Bio-pulping. biogas.	
Unit –V	**08 Hrs**
Case studies Ethanol production from starchy crops and lignocellulosic biomass. Bio methanation of water hyacinth for biogas production, Butanol production from lignocellulosic biomass. Biodiesel from Jatropa	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Describe the nature and principle of different biomass energy extraction systems.
CO2	Identify how to choose the suitable biomass fuels for different bio-energy applications
CO3	Recognize drivers and barriers for biofuel production
CO4	Develop sustainable biofuel production considering ecological and socio-economic criteria

Reference Books	
1	Mark Crocker (Ed.), 2010. Thermochemical Conversion of Biomass to Liquid Fuels and Chemicals. RSC Publishing, ISBN:9781849730358
2.	Donald L. Klass, 1998. Biomass for Renewable Energy, Fuels and Chemicals. Academic Press, San diego, CA. ISBN: 978-0-12-410950-6
3.	Daizo Kunii and Octave Levenspiel. Fluid ization Engineering, 2nd Edition. Butterworth-Heinemann series in Chemical Engineering. ISBN 0-409-90233-0 1
4.	Charles E. Wyman (Ed.), 1996. Handbook on Bioethanol: Production and Utilization.CRC Press, New York. ISBN 1-56032055304
5	Brigit Kamm, Patrick R. Gruber and Michael Kamm (Ed.), 2008. Biorefineries -Industrial Processes and Products: Status Quo and Future Directions, Vol. 1 & 2. Wiley-VCH, Weinheim, Germany.

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 TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
HYDROGEN TECHNOLOGY **Category: Professional Core Elective (Cluster Elective)** **(Common to CH, CV, & BT)** **(Theory)**						
Course Code	**:**	21CH65E2		**CIE**	**:**	**100**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100**
Total Hours	**:**	40L		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**
Hydrogen: Peculiarity and Types Salient features of hydrogen, properties of hydrogen, terminology and types of hydrogen, advantages, disadvantages, comparison with other fuels, and global status of supply and demand	
Unit – II	**08 Hrs**
Hydrogen Generation Generation of different types of hydrogen, conventional methods, nonconventional methods, generation from non-renewable sources, generation from renewable sources and challenges	
Unit –III	**08 Hrs**
Hydrogen Storage Storage as compressed gas, storage as cryogenic liquid, storage as metal hydrides, storage through liquid organic hydrogen carriers, and storage in carbon nano tubes	
Unit –IV	**08 Hrs**
Hydrogen Handling and Safety Classification of hydrogen hazards, compressed and liquid hydrogen related hazards, regulation, codes and standards related to hydrogen handling and transport, personal protective equipment	
Unit –V	**08 Hrs**
Hydrogen Applications Applications of hydrogen in various sectors such as refineries, petrochemicals, fertilizer industries, steel industries, transport and automotive sectors	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the importance of hydrogen and its use as an energy carrier
CO2	Explain the production, storage and handling of hydrogen
CO3	Analyze the need for hydrogen as an alternate fuel and the associated challenges
CO4	Appraise the importance of safety, regulations and codes

Reference Books	
1	Hydrogen Fuel: Production, Transport and Storage, Gupta, R. B., CRC Press, Taylor & Francis Group, 1st Edition, 2009, ISBN: 9780429147364
2.	Hydrogen Production: Electrolysis, Agata Godula-Jopek, Wiley-VCH, 1st Edition, 2015, ISBN:9783527333424
3.	Handbook of Hydrogen Storage, Michael Hirscher, Wiley-VCH, 1st Edition, 2010, ISBN:9783527322732
4.	Fuel Cell Systems Explained, James Larminie and Andrew Dicks, John Wiley & Sons, 2nd Edition, 2003, ISBN 978 0470 848579

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 TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

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Semester: VI						
DISASTER MANAGEMENT **Category: Professional Core Elective (Cluster Elective)** **(Common to CH, CV, & BT)** **(Theory)**						
Course Code	**:**	**21CV65E1**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	36L		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**08 Hrs**
Natural disasters and Disaster management -Introduction to natural and Industrial Hazards- floods, landslides, earthquakes, volcanoes, avalanche, cyclones, drought, fire, release of effluents, harmful gases, Blast etc. Prediction and perception. Environmental risk due to project activities. Preparation of on-site and off-site disaster management plans - Pre disaster, actual disaster, Post disaster plans. Relief camp organization. Role of voluntary organization and armed forces during disasters.	
Unit – II	**08 Hrs**
Risk analysis and assessment Basic concept. Purpose of risk analysis. Analytical techniques and tools of risk assessment. Toxicology. Significance of risk. Risk characterization. Risk communication and Management, AI in emergency responses	
Unit –III	**08 Hrs**
Environmental Impact Assessment (EIA) Definition, Basic concepts and principles of EIA, Regulatory framework in India, Environmental inventory, Base line studies. Over view of EIA studies. **Assessment and Methodologies** Physical, Biological, Natural resources, Socio economic and cultural environmental assessment, Checklist approaches, Public participation in environmental decision making. Procedures for reviewing EIA analysis and statement. Decision methods for evaluation of alternatives.	
Unit –IV	**08 Hrs**
Disaster Mitigation Measures Basic principles, early warning systems, building design and construction in highly seismic zones, retrofitting of building, Usage of Remote sensing and GIS techniques, Awareness programs, Assessment on preparedness for disaster, Regional and global disaster mitigation, Mitigation Plans and Guidelines	
Unit –V	**08 Hrs**
Disaster Management Techniques Introduction, types, modes of disaster management, tools and techniques, primary and secondary data. Natural disasters its causes and remedies-Earthquake hazards-Causes and remedies, Flood and Drought assessment, causes and remedies, Landslides-causes and remedies. Fire hazards in buildings, Fire hazard management, Traffic management, inter department cooperation.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Study the environmental impact of natural and manmade calamities
CO2	Learn to analyse and assess risk involved due to disasters.
CO3	Understand the role of public participation.
CO4	Learn the management and mitigation tools and techniques

Reference Books	
1	Environmental Impact Analysis Hand Book, John G Rau and David C Wooten, Edition: 2013, ISBN: 978-0070512177.
2	Introduction to environmental Impact assessment, John Glasson, RikiTherivel, Andrew Chadwick, Edition: 2012, Research Press, ISBN:000-0415664705.2005, Reliance Publishing House, New Delhi
3	Natural Disaster Reduction, Girish K Mishrta, G C Mathew (eds), Edition, 2005, Reliance Publishing House, New Delhi
4	Remote Sensing and Image Interpretation, Thomas M. Lillisand and R.W. Keifer, 6th Edition, 2002, John Wiley, ISBN:9780470052457

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 TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

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Semester: VI						
SOLID WASTE MANAGEMENT **Category: Professional Core Elective (Cluster Elective)** **(Common to CH, CV, & BT)**						
Course Code	**:**	**21CV65E2**		**CIE**	**:**	**100 Marks**
Credits: L:T:P		**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**40L**		**SEE Duration**	**:**	**3.00 Hours**

Unit – I	**08 Hrs**
Introduction: Land Pollution due to improper solid waste management. Merits and demerits of present and scientific solid waste disposal methods. Scope and importance of solid waste management. Definition and functional elements of solid waste management. **Sources**: Sources of Solid waste, types of solid waste, composition of municipal solid waste. Generation rate, Numerical Problems.	
Unit – II	**08 Hrs**
Collection and transportation of municipal solid waste: Collection of solid waste- services and systems, Primary and secondary collection and transportation equipments. Route optimization. Solid waste management rules with amendments. Site visit to collection system. Numerical problems	
Unit –III	**08 Hrs**
Composting Aerobic and anaerobic composting - process description, process microbiology, Vermicomposting, Numerical problems, Site visit to compost plant. **Sanitary landfilling:** Definition, advantages and disadvantages, site selection, methods, reaction occurring in landfill- Gas and Leachate movement, Control of gas and leachate movement, Site visit to landfill site.	
Unit –IV	**08 Hrs**
Hazardous waste management: Definitions, Identification of hazardous waste, Classification of hazardous waste, onsite storage, collection, transfer and transport, processing, disposal, Recent hazardous waste (management, handling) rules with amendments. Site visit to hazardous landfill site	
Unit –V	**08 Hrs**
Bio medical waste management: Impact of improper biomedical waste on health and environment. Classification of bio medical waste, collection, transportation, disposal of bio medical waste, Recent Bio medical waste management rules with amendments. site visit to hospital to see the collection and transportation system and visit to biomedical waste incineration plant **Plastic waste management:** Types of plastic and its uses. Impact of plastic waste on land, marine and wild life, Greener alternatives to plastic, Recent Plastic waste management rules with amendments.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the existing waste management system and to identify their drawbacks.
CO2:	Identify the adverse effects of improper waste management on environment.
CO3:	Evaluate and monitor the flow of waste as per the rules laid by Ministry of Environment and Forest.
CO4:	Design Recycling and scientific disposal options for different types of waste.

Reference Books	
1	Integrated Solid Waste Management: Engineering principles and management issues George Tchobanoglous, Hilary Theisen , Samuel A Vigil, published by M/c Graw hill Education . Indian edition 2014. ISBN – 13: 978- 9339205249, ISBN-10 : 9339205243
2	Environmental Engineering, Howard S Peavy, Donald R Rowe and George Tchobanoglous, Tata Mcgraw Hill Publishing Co ltd., 2013, ISBN-13 9789351340263.
3	Municipal Solid waste (Management & Handling Rules). Ministry of Environment & Forest Notification, New Delhi.
4	Hazardous waste (Management& Handling Rules). Ministry of Environment & Forest Notification, New Delhi.
5	Bio medical waste management rules. Ministry of Environment & Forest Notification, New Delhi.
6	Plastic waste management rules. Ministry of Environment & Forest Notification, New Delhi.

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 TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

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

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

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

Reference Books	
1	Functional Safety in the Process Industry: A Handbook of practical Guidance in the application of IEC61511 and ANSI/ISA-84, Kirkcaldy K.J.D Chauhan, 2012, North corolina,Lulu publication, ISBN:1291187235.
2.	Safety Instrumented Systems Verification Practical probabilistic calculations, Goble and William M., 2005, Pensulvania ISA publication, ISBN:155617909X.
3.	Industrial safety and risk Management, Laird Wilson and Doug Mc Cutche, 1st Edition, 2003,The University of alberta press,Canada, ISBN: 0888643942.
4.	ndustrial Safety, Health and Environment Management Systems, R K Jain, Sunil S Rao, 4th Edition, 2005, Khanna Publishers, New Delhi, ISBN: 8174092102.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks 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 TWO Sub-divisions only)	
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3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

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

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

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

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

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks 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
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2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
SYSTEMS ENGINEERING **Category: Institutional Elective** **(Theory)**						
Course Code	**:**	**21IE6F3**		**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**
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 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**
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7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

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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	**:**	45L		**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 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**

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3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

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 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**
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7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

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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	**:**	42L		**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**

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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**

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Semester: VI						
INDUSTRIAL PSYCHOLOGY FOR ENGINEERS **Category: Institutional Elective** **(Theory)**						
Course Code	**:**	21IE6F7		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**
Introduction to Psychology: Definition and goals of Psychology: Role of a Psychologist in the Society: Today's Perspectives (Branches of psychology- Clinical, Industrial). Psychodynamic, Behavioristic, Cognitive, Humanistic, Psychological Research and Methods to study Human Behavior: Experimental, Observation, Questionnaire and Clinical Method.	
Unit – II	**08 Hrs**
Intelligence and Aptitude: Concept and definition of Intelligence and Aptitude, Nature of Intelligence. Theories of Intelligence – Spearman, Thurston, Guilford Vernon. Characteristics of Intelligence tests, Types of tests. Measurement of Intelligence and Aptitude, Concept of IQ, Measurement of Multiple Intelligence – Fluid and Crystallized Intelligence.	
Unit –III	**10 Hrs**
Personality: Concept and definition of personality, Approaches of personality- psychoanalytical, Socio-Cultural, Interpersonal and developmental, Humanistic, Behaviorist, Trait and type approaches. Assessment of Personality: Self- report measures of Personality, Questionnaires, Rating Scales and Projective techniques, its Characteristics, advantages & limitations, examples. Behavioral Assessment.	
Unit –IV	**10 Hrs**
Learning: Definition, Conditioning – Classical Conditioning, Basics of Classical Conditioning (Pavlov), the process of Extinction, Discrimination and Generalization. Operant Conditioning (Skinner expt). The basics of operant conditioning, Schedules of reinforcement. Cognitive – Social approaches to learning – Latent Learning, Observational Learning, Trial and Error Method, Insightful Learning.	
Unit –V	**09 Hrs**
Application of Psychology in Working Environment: The present scenario of information technology, the role of psychologist in the organization, Selection and Training of Psychology Professionals to work in the field of Information Technology. **Psychological Stress**: a. Stress- Definition, Symptoms of Stress, Extreme products of stress v s Burnout, Work Place Trauma. Causes of Stress – Job related causes of stress.Sources of Frustration, Stress and Job Performance, Stress Vulnerability-Stress threshold, perceived control. Type A and Type B.**Psychological Counseling** - Need for Counseling, Types – Directed, Non-Directed, Participative Counseling.	

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

CO4	Apply the theories into their own and others' lives in order to better understand their personalities and experiences.
CO5	Understand the application of psychology in engineering and technology and develop a route to accomplish goals in their work environment.

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

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks 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 TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
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	**:**	45L		**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 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**

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

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Semester: VI						
UNIVERSAL HUMAN VALUES - II **Category: Institutional Elective** **(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 theme of this course; human being as co-existence of the self and the body, the activities and potentialities of the self, Reasons for harmony/contradiction in the self.	
Unit –V	**08 Hrs**
Understanding Human Conduct, All-encompassing Resolution & Holistic Way of Living. Understanding Human Conduct, Understanding different aspects of All-encompassing Resolution (understanding, wisdom, science etc.), Holistic way of living for Human Being with All-encompassing Resolution covering all four dimensions of human endeavour viz., realization, thought, behavior and work (participation in the larger order) leading to harmony at all levels from self to Nature and entire Existence.	

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

CO3	Understand existence in depth and see how coexistence is central to existence
CO4	Understand human conduct and the holistic way of living leading to human tradition

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

RUBRIC FOR 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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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 (HMI) **Institutional Elective** **Industry Assisted Elective-BOSCH**						
Course Code	:	21IE6F10		**CIE**	:	100 Marks
Credits: L:T:P	:	3:0:0		**SEE**	:	100 Marks
Total Hours	:	45L		**SEE Duration**	:	3Hours

Unit-I	**09 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	**09 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	**09 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	**09 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	**09 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 Analyze the car multimedia system free software and hardware evolution
CO4	Design and evaluate the graphic tools and advanced techniques for creating car dashboard multimedia systems
Reference Books	
1	Shuo gao, Shuo Yan, Hang Zhao, Arokia Nathan "Touch based HMI; Principles and Applications" Springer Nature Switzerland AG, 1st Edition.
2	Robert Wells, " Unity 2020 by Example: A Project based guide to building 2D, 3D augumented reality and Virtual reality games from sratch" Packt Publishing ltd , Edition 2020.
3	Ryan Cohen, Tao Wang, "GUI Design and Android Apps" Apress, Berkley, CA,2014.

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**
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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**

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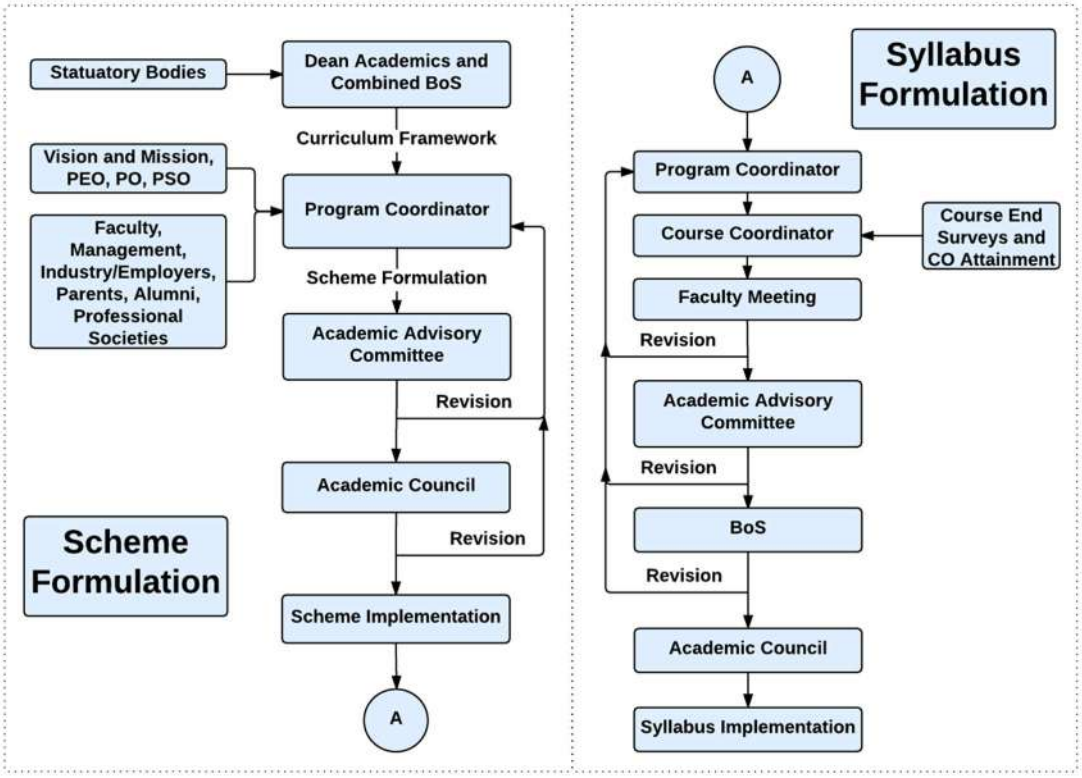
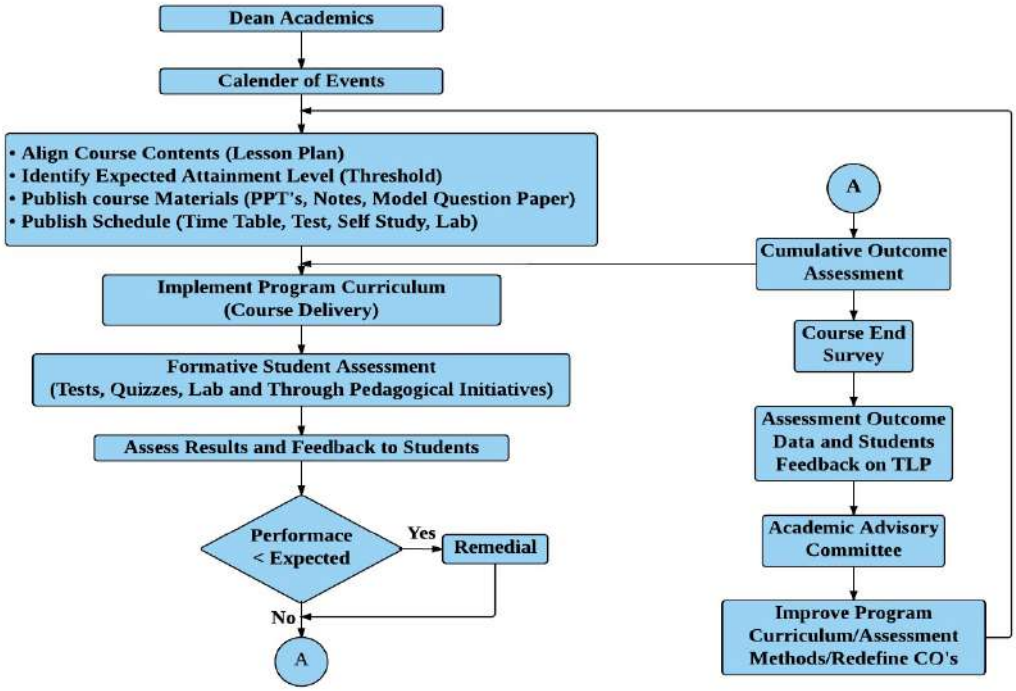
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

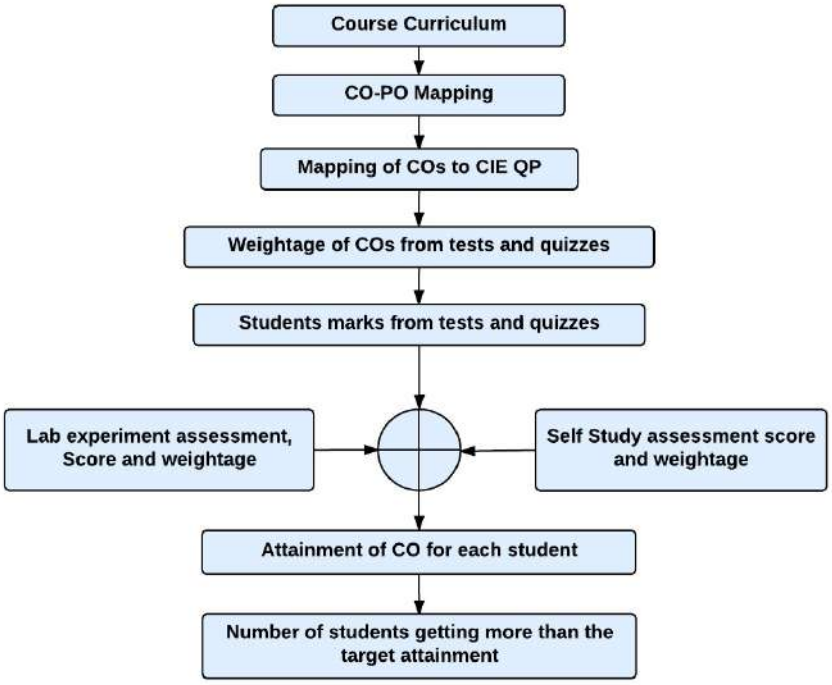
Curriculum Design Process



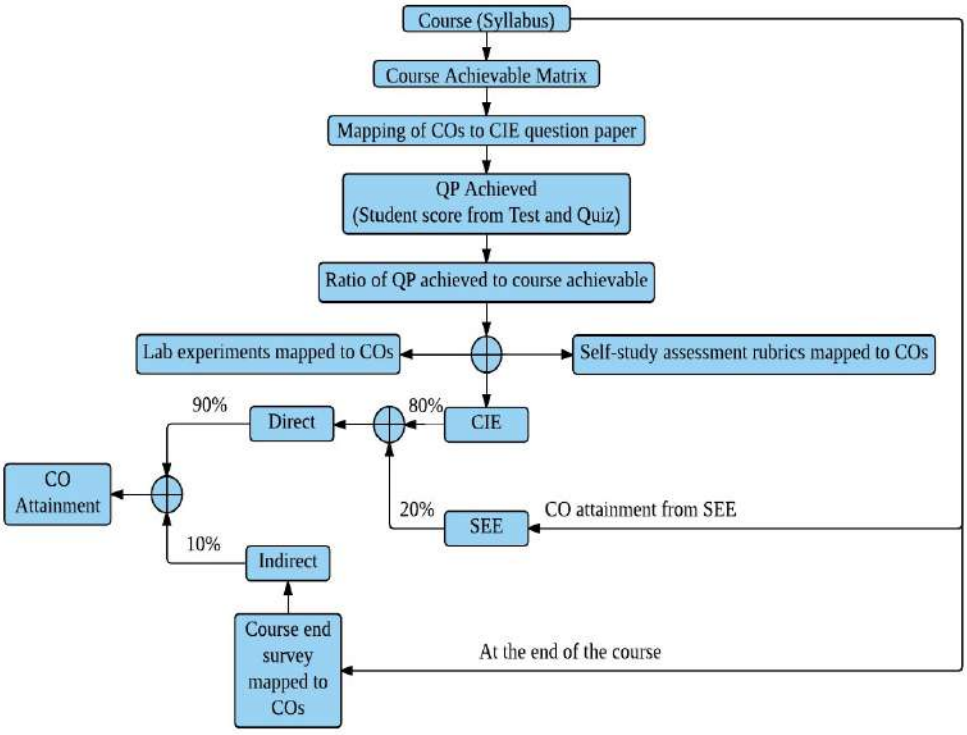
Academic Planning and Implementation



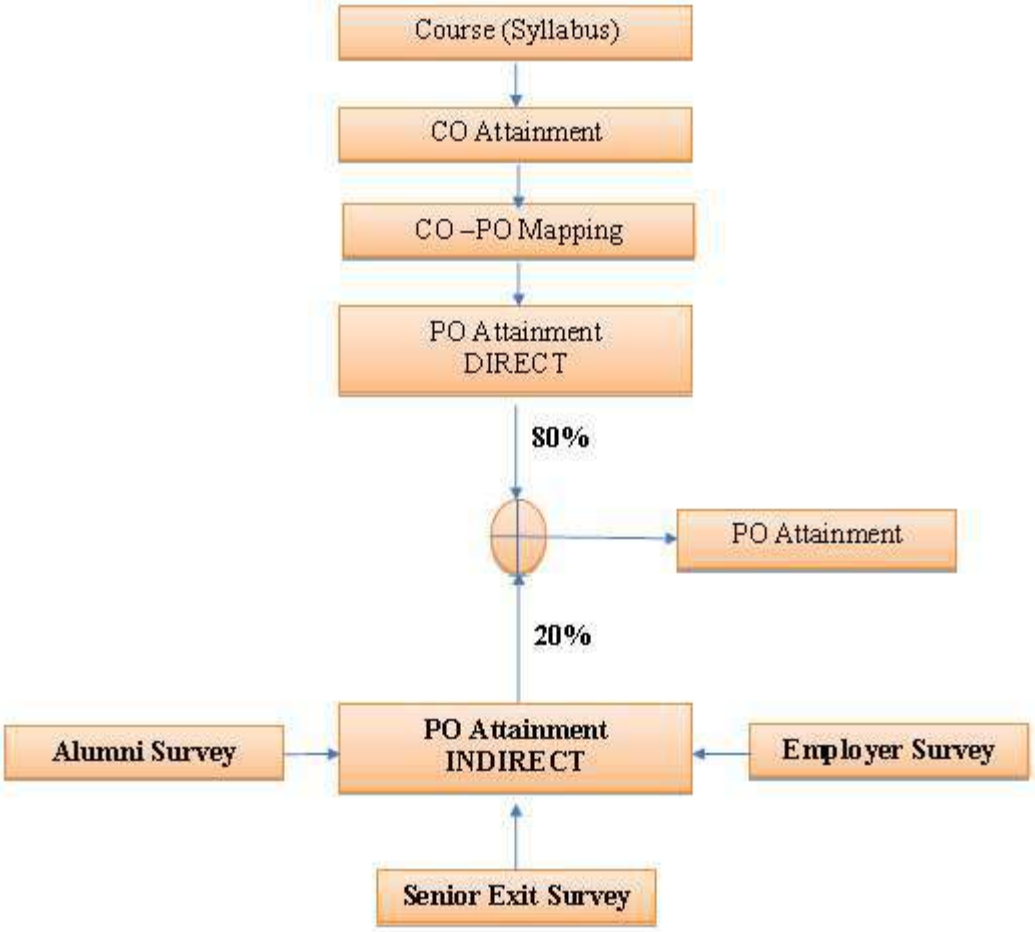
Process For Course Outcome Attainment



Final CO Attainment Process



Program Outcome Attainment Process



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