Rashtreeya Sikshana Samithi Trust

R.V. College of Engineering

(Autonomous Institution Affiliated to Visvesvaraya Technological University, Belagavi)

Department of Chemical Engineering

Master of Technology (M.Tech.)

Chemical Engineering

Scheme and Syllabus of Autonomous System w.e.f 2016

R.V. College of Engineering, Bengaluru – 59
(An Autonomous Institution affiliated to Visvesvaraya Technological University, Belagavi)
Department of Chemical Engineering

Vision:

Imparting quality education that promotes leadership in Research, Innovation and Sustainable Technologies through teamwork and Entrepreneurship in Chemical Processes, Energy, Unit Operations and Computational Chemical Engineering to meet societal requirements.

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-the-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.

CHEMICAL ENGINEERING PROGRAM

Program Specific Criteria (PSC)

Lead Society: American Institute of Chemical Engineers

1. Curriculum

The curriculum provides a thorough grounding in the basic sciences including chemistry, physics, and/or biology, with some content at an advanced level, as appropriate to the objectives of the program. The curriculum also includes the engineering applications of these basic sciences to the design, analysis, and control of chemical, physical, and/or biological processes, including the hazards associated with these processes**.**

2. Faculty

The master's level engineering program must demonstrate that the faculty members are of sufficient number and that they have the competencies to cover all of the curricular areas of the program. The program must have sufficient faculty to accommodate adequate levels of student-faculty interaction, student advising and counseling, activities, professional development, and interactions with industrial and professional practitioners, as well as employers of students.

Program Educational Objectives (PEO)

M. Tech. in Chemical Engineering graduates will be able to:

PEO1 Use tools of Chemical Engineering in process and allied industries or in higher studies

PEO2 Design and develop sustainable Chemical Engineering systems in Energy, Environment, Materials and Biotechnology sectors

PEO3 Achieve professional success ethically both as individuals and in a team

PEO4 Pursue life-long learning to be a competent Chemical Engineer

Program Outcomes (PO)

M.Tech. in Chemical Engineering graduates will be able to:

PO1.Scholarship of Knowledge: Acquire in-depth knowledge in Chemical Engineering, including wider and global perspective, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.
PO2.Critical Thinking: Analyse complex chemical engineering problems critically, apply independent judgement for synthesising information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.
PO3.Problem Solving: Think laterally and originally, conceptualise and solve chemical engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.
PO4.Research Skill: Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyse and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering
PO5.Usage of modern tools: Create, select, learn 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.
PO6.Collaborative and Multidisciplinary work: Possess knowledge and understanding of group dynamics, recognise opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.
PO7.Project Management and Finance: Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after considerisation of economical and financial factors.
PO8.Communication : Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.
PO9.Life-long Learning: Recognise the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.
PO10.Ethical Practices: and Social Responsibility Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.
PO11.Independent and Reflective Learning: Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

Program Specific Outcomes (PSO)

M. Tech. in Chemical Engineering graduates will be able to:

PSO1. Gain comprehensive knowledge in Chemical Engineering and demonstrate research capabilities

PSO2. Analyse and solve engineering problems in materials,biotechnology, environment and energy domains

PSO3. Contribute to multidisciplinary research using relevant Chemical Engineering tools

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Department of Chemical Engineering
M. Tech. in Chemical Engineering

FIRST SEMESTER								
Sl. No	**Course Code**	**Course Title**	**BoS**	**CREDIT ALLOCATION**				**Total Credits**
				Lecture L	**Tutorial T**	**Practical P**	**Self Study S**	
1	16 MEM11P	Project Management	IM	3	1	0	0	4
2	16 MCH 12	Applied Mathematics in Chemical Engineering	CH	4	0	0	0	4
3	16 MCH 13	Modeling and Simulation of Processes(Theory & Practice)	CH	4	0	1	0	5
4	16 MCH 14	Process Equipment Design	CH	4	0	0	1	5
5	16 MCH 15X	Elective-1	CH	4	0	0	0	4
6	16 HSS16	Professional Skill Development	HSS	0	0	2	0	2
		Total		**19**	**1**	**3**	**1**	**24**

Elective Group 1			
16MCH151	Solid Waste Management	16MCH152	Fuel Cell Technology

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SECOND SEMESTER								
Sl. No	**Course Code**	**Course Title**	**BoS**	**CREDIT ALLOCATION**				**Total Credits**
				Lecture L	**Tutorial T**	**Practical P**	**Self Study S**	
1	16 MEM21R	Research Methodology	IM	3	1	0	0	4
2	16 MCH 22	Heterogeneous Reaction Systems(Theory & Practice)	CH	4	0	1	0	5
3	16 MCH23X	Elective-2	CH	4	0	0	0	4
4	16 MCH 24X	Elective -3	CH	4	0	0	0	4
5	16 MCH 25X	Elective -4	CH	4	0	0	0	4
6	16 MCH 26	Minor Project	CH	0	0	5	0	5
		Total		**19**	**1**	**6**	**0**	**26**

Elective Group 2			
16MCH231	Renewable Energy Resources and Systems	16MCH232	Industrial Wastewater Treatment
Elective Group 3			
16MCH241	Bioinstrumentation and Biosensors	16MCH242	Food Process Engineering and Technology
Elective Group 4			
16MCH251	Biomass Conversion Systems	16MCH252	Novel Separation Technology

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THIRD SEMESTER								
Sl. No	**Course Code**	**Course Title**	**BoS**	**CREDIT ALLOCATION**				**Total Credits**
				Lecture L	**Tutorial T**	**Practical P**	**Self Study S**	
1	16 MCH 31	Plant wide Control of Chemical Process (Theory & Practice)	CH	4	0	1	0	5
2	16 MCH 32X	Elective -5	CH	4	0	0	0	4
3	16 MCH 33X	Elective -6	CH	4	0	0	0	4
4	16 MCH 34X	Elective-7	CH	4	0	0	0	4
5	16 MCH 35	Internship/Industrial Training	CH	0	0	3	0	3
6	16MCH36	Technical Seminar	CH	0	0	2	0	2
		Total		**16**	**0**	**6**	**0**	**22**

Elective Group 5			
16MCH321	Advanced Polymer Composites	16MCH322	Nano Fabrication
Elective Group 6			
16MCH331	Computational Fluid Dynamics	16MCH332	Oil and Gas Processing
Elective Group 7			
16MCH341	Solar Photovoltaic Systems and Technology	16MCH342	Chemical Process Integration

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FOURTH SEMESTER								
Sl. No	**Course Code**	**Course Title**	**BoS**	**CREDIT ALLOCATION**				**Total Credits**
				Lecture L	**Tutorial T**	**Practical P**	**Self Study S**	
1	16 MCH 41	Major Project	CH	0	0	26	0	26
2	16 MCH 42	Seminar	CH	0	0	2	0	2
		Total		**0**	**0**	**28**	**0**	**28**

FIRST SEMESTER

PROJECT MANAGEMENT						
Course Code	:	16MEM11P		CIE Marks	:	100
Hrs/Week	:	L: T: P: S	3:2:0:0	SEE Marks	:	100
Credits	:	4		SEE Duration	:	3 hrs

Course Learning Objectives:

Graduates shall be able to

1. Understand the basic principles and components of project management
2. Appreciate the integrated approach to managing projects
3. Applythe appropriate project management tools and techniques
4. Prepare project schedules with reports

Unit – I	10 Hrs

Introduction:Project, Project management, relationships among portfolio management, program management, project management, and organizational project management, relationship between project management, operations management and organizational strategy, business value, role of the project manager, project management body of knowledge.

Unit – II	10Hrs

Generation and Screening of Project Ideas: Generation of ideas, monitoring the environment, corporate appraisal, scouting for project ideas, preliminary screening, project rating index, sources of positive net present value. Project costing,

Project Scope Management:Project scope management, collect requirements define scope, create WBS, validate scope, control scope.

Organizational influences & Project life cycle**:** Organizational influences on project management, project state holders & governance, project team, project life cycle.

Unit – III	10 Hrs

Project Integration Management**:** Develop project charter, develop project management plan, direct & manage project work, monitor & control project work, perform integrated change control, close project or phase.

Project Quality management: Plan quality management, perform quality assurance, control quality.

Unit – IV	8Hrs

Project Risk Management:Plan risk management, identify risks, perform qualitative risk analysis, perform quantitative risk analysis, plan risk resources, control risk.

Project Scheduling: Project implementation scheduling, Effective time management, Different scheduling techniques, Resources allocation method, PLM concepts. Project life cycle costing.

Unit-V	10 Hrs

Tools & Techniques of Project Management: Bar (GANTT) chart, bar chart for combined activities, logic diagrams and networks, Project evaluation and review Techniques (PERT) Planning, Computerized project management.

Syllabus includes tutorials for two hour per week:

- Case discussions on project management
- Numerical problems on PERT & CPM
- Computerized project management exercises using M S Project Software

Course Outcomes:

After going through this course the student will be able to:

CO1: Understand the concepts, tools and techniques for managing large projects
CO2: Analyze various sub processes in the project management frameworks
CO3: Develop project plans for various types of organizations
CO4: Evaluate risks and economic feasibility of projects

Reference Books:

1. Project Management Institute, A Guide to the Project Management Body of Knowledge (PMBOK Guide), 5th Edition, 2013, ISBN: 978-1-935589-67-9
2. Harold Kerzner, Project Management A System approach to Planning Scheduling & Controlling, John Wiley & Sons Inc., 11th Edition, 2013, ISBN 978-1-118-02227-6.
3. Prasanna Chandra, Project Planning Analysis Selection Financing Implementation & Review, Tata McGraw Hill Publication, 7th Edition, 2010, ISBN 0-07-007793-2.
4. Rory Burke, Project Management – Planning and Controlling Techniques, John Wiley & Sons, 4th Edition, 2004, ISBN: 9812-53-121-1

Scheme of Continuous Internal Evaluation (CIE)

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

Scheme of Semester End Examination (SEE)

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

Mapping of Course Outcomes (CO) to Program Outcomes (PO)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	L	-	L	-	L	M	H	-	-	L	-
CO2	L	L	L	L	-	M	M	-	L	L	-
CO3	M	M	M	M	L	M	H	L	L	M	-
CO4	H	H	H	M	M	M	H	L	M	M	-

Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)

	PSO1	PSO2	PSO3
CO1	L	L	L
CO2	M	M	L
CO3	H	M	L
CO4	L	L	M

APPLIED MATHEMATICS IN CHEMICAL ENGINEERING						
Course Code	**:**	16MCH12		**CIE Marks**	**:**	**100**
Hrs/Week	**:**	L:T:P:S	4:0:0:0	**SEE Marks**	**:**	**100**
Credits	**:**	04		**SEE Duration**	**:**	**3 Hrs**

Course Learning Objectives (CLO):

Graduates shall be able to

1. Understand the importance of using mathematical tools to solve chemical engineering problems
2. Apply differential equation technique to model different fluid flows
3. Analyze process performance for development of objective function
4. Evaluate alternative solutions and optimize

Unit – I	**11Hrs**

Linear ordinary differential equations: Overview of total differential equations for lumped parameter chemical engineering systems. Solution methods: characteristic equation for linear equations. Homogeneous and particular solutions, method of undetermined coefficients

Unit -II	**10 Hrs**

Linear O.D.E.s with singular coefficients Frobenius method for nonlinear second order O. D. E. and applications in Chemical Engineering.

Unit-III	**10 Hrs**

Partial Differential Equations: Types of second order P.D.E.s - elliptic, parabolic - used to model steady and unsteady transport. First order hyperbolic P.D.E. for inviscid flow.
Solution by separation of variables, method of moments (parabolic P.D.E.), d'Alembert's principle (hyperbolic P.D.E.). Applications in Chemical Engineering.

Unit-IV	**8 Hrs**

Dimensional Analysis and Scaling of Boundary Value Problems: Introduction. Classical approach to dimensional analysis. Finding the Πs. Scaling boundary value problems.

Unit-V	**10 Hrs**

Optimization: Objective function for process. Unconstrained optimization by steepest descent method. Constrained optimization and heuristics. Applications in Chemical Engineering

Reference Books:

1.	Richard G. Rice, Duang D. Do, Applied Mathematics and Modeling for Chemical Engineers, John Wiley, 2nd edition, 2012, ISBN: 978-1-118-02472-0
2	Ian N. Sneddon, Elements of Partial Differential Equations, Dover, Intl. edition, 2006, ISBN: 978-0-486-49876-8
3	Thomas F. Edgar, David M. Himmelblau, Leon S. Lasdon, Optimization of Chemical Processes, McGraw-Hill, 2nd edition, 2001, ISBN: 978-0-070-39359-2
4	Norman W. Loney, Applied Mathematical Methods for Chemical Engineers, CRC Press, 2nd edition, 2006, ISBN: 978-0849397783

	Course outcomes: After going through this course the student will be ableto
CO1	Understand inputs and outputs of system/process to be modeled
CO2	Apply mathematical abstraction to formulate model

CO3	Analyze model equation behavior using suitable mathematical tools
CO4	Develop simple correlations by comparison with literature results

Scheme of Continuous Internal Evaluation (CIE)
CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

Scheme of Semester End Examination (SEE)
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

Mapping of Course Outcomes (CO) to Program Outcomes (PO)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	-	L	L	-	-	-	-	-	-	-	-
CO2	L	M	M	-	-	-	-	-	-	-	-
CO3	H	H	M	-	M	-	-	-	L	-	-
CO4	H	M	M	M	M	L	-	-	L	-	-

Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)

	PSO1	PSO2	PSO3
CO1	L	L	L
CO2	M	M	L
CO3	M	H	M
CO4	M	M	M

MODELLING AND SIMULATION OF PROCESS (THEORY & PRACTICE)						
Course Code	:	16MCH13		CIE Marks	:	100+50
Hrs/Week	:	L:T:P:S	4:0:2:0	SEE Marks	:	100+50

Credits	:	05		SEE Duration	:	3 Hrs

Course Learning Objectives (CLO):

Graduates shall be able to

1. Understandchemical engineering system in term of modeling principle
2. Distinguish simulation from design of equipments
3. Apply software tools such as UNISIM to model chemical processes.
4. Develop algorithm for modeling & solve the model

Unit – I	**10Hrs**

Introduction:Models and model building. Lumped parameter models (steady-state and unsteady-state). Distribution parameter models (steady-state and unsteady state) Stochastic models- discrete state/continuous state. Parameter estimation

Unit – II	**09Hrs**

Modeling of Chemical Engineering Systems: Scope and coverage, scope and principle, equation of motion, transport equations, Equations of state, equilibrium and chemical kinetics.

Unit – III	**11Hrs**

Models for Chemical Engineering Systems:CSTR- Isothermal, constant and variable holdup, two heated tanks, pressurized CSTR, Batch Reactor, Reactor with Mass transfer

Unit – IV	**10Hrs**

Multivariable Processes**:** Matrix Properties and state properties, Transpose, inversion, Eigen Values, Canonical Transformation, Singular Values

Unit – V	**10Hrs**

Numerical analysis for simulation: Introduction to simulation, Role of computers and numerical methods in simulation, Iterative convergence methods, explicit convergence, Wegstein and Muller methods, explicit numerical integration algorithms, implicit methods. Numerical examples.

Unit – VI (Lab Component)

1. Cooling Tower
2. Distillation Column
3. Ethanol Plant
4. Atmospheric crude distillation
5. Multistage Crosscurrent Adsorption System
6. Reactors in series
7. Reactors in parallel
8. Combination of reactors

Course Outcomes: After going through this course the student will be able to:

CO1: Understand the principles of modeling and simulation

CO2:Apply mathematical tools to solve model equations

CO3:Analyze chemical engineering systems for model development

CO4:Develop mathematical models for simple chemical engineering systems

Reference Books:

1.	William L. Luyben, Process Modeling, Simulation, and Control for Chemical Engineers, 2nd Edition, McGraw-Hill1989, ISBN:0070391599
2.	Ramirez W.F., Computational Methods for Process Simulation,2nd Edition,Butterworth, 1998,ISBN:9780080529691
3.	Franks R.E., Modeling and Simulation in Chemical Engineering, John Wiley, 1972,ISBN:0471275352
4.	Gaikwad R.W, and Dhirendra, Process Modelling and Simulation, 2nd Edition, Denetted &Co., 2006,ISBN: 8190322826

Scheme of Continuous Internal Evaluation (CIE) for Theory

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

Scheme of Continuous Internal Evaluation (CIE) for Practical

CIE for the practical courses will be based on the performance of the student in the laboratory, every week. The laboratory records will be evaluated for 40 marks. One test will be conducted for 10 marks. The total marks for CIE (Practical) will be for 50 marks.

Scheme of Semester End Examination (SEE) for Theory

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

Scheme of Semester End Examination (SEE) for Practical

SEE for the practical courses will be based on conducting the experiments and proper results for 40 marks and 10 marks for viva-voce. The total marks for SEE (Practical) will be 50 marks.

Mapping of Course Outcomes (CO) to Program Outcomes (PO)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	L	-	L	-	-	-	-	-	-	-	-
CO2	L	L	M	-	L	-	-	-	L	-	-
CO3	M	M	M	L	L	L	-	-	L	-	-
CO4	H	H	H	M	M	L	-	-	M	-	-

Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)

	PSO1	PSO2	PSO3
CO1	L	L	L
CO2	M	M	-
CO3	M	H	M
CO4	H	L	M

PROCESS EQUIPMENT DESIGN						
Course Code	:	16MCH14		CIE Marks	:	100
Hrs/Week	:	L:T:P:S	4:0:0:4	SEE Marks	:	100
Credits	:	5		SEE Duration	:	3 Hrs

Course Learning Objectives (CLO):

Graduates shall be able to

1. Understand the chemical engineering principles applicable to Design chemical engineering equipments
2. Applystandard codes for design of chemical plant equipment
3. Analyzethe specifications for process equipment
4. Design process equipments and its accessories

Each design to be taught for 8 hours	**48Hrs**

Detailed Engineering Process & Mechanical Design Aspects and sketching (The sketch shall include sectional front view, full Top/side view) of the following:

1. Shell and Tube Exchanger.
2. Horizontal and Vertical Condensers
3. Evaporator Single Effect
4. Dryers
5. Bubble Cap Distillation Column
6. Packed bed Absorption Column

In experiential learning / self study the students will prepare detailed drawing of individually allotted equipment using software's like Chem CAD/Solid edge and apply code for shell and tube heat exchangers and submit these results as part of the assignment which will be evaluated.

Course Outcomes: After going through this course the student will be able to:

1.Understanddesign procedure of process equipments
2.Apply chemical engineering principles to design process equipments
3.Estimate physical dimensions of various parts of chemical process equipments and accessories
4.Analyze various design options at all design stages

Reference Books:

1.	R.H.Perry and D.W.Green, Chemical Engineers Handbook, McGraw Hill, 7th Edition, 1998, ISBN 0-07-115982-7
2	J.M.Coulson and J.F.Richardson, Chemical Engineering, Pregman Press, Vol.6, 3rd Edition 1993,ISBN:10-0750641428
3	Brownell and Young: Process Equipment Design - Vessel Design, John Willey, Published 1951, ISBN:0471113190
4	M.V.Joshi, Process Equipment Design,3rd Edition, Macmillan and Co. India, Delhi, Reprint 1998, ISBN 023-063-810-4

Scheme of Continuous Internal Evaluation (CIE)

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The experiential learning will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

Scheme of Semester End Examination (SEE)

There should be two questions. Each question should be for maximum of 100 Marks. Students should answer anyone

Mapping of Course Outcomes (CO) to Program Outcomes (PO)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	L	L	-	-	-	-	-	-	M	-
CO2	H	H	M	M	L	L	-	-	L	-	-
CO3	L	L	M	M	M	L	M	-	-	-	-
CO4	H	H	M	H	M	M	H	L	M	M	L

Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)

	PSO1	PSO2	PSO3
CO1	L	L	L
CO2	M	L	L
CO3	M	M	L
CO4	M	H	M

SOLID WASTE MANAGEMENT (Elective group-1)						
Course Code	:	16MCH151		CIE Marks	:	100
Hrs/Week	:	L:T:P:S	4:0:0:0	SEE Marks	:	100

Credits	:	4		SEE Duration	:	3 Hrs

Course Learning Objectives (CLO):

Graduates shall be able to

1. Understand steps involved in solid waste management
2. Apply chemical engineering principles to treat solid waste
3. Analyze the energy conversion, recycle and reuse of solid waste
4. Evaluate health and environmental issues related to solid waste management

Unit – I	**10 Hrs**

Functional elements, Philosophy and organization, Status of solid waste management, Integrated waste management strategy. Legislation and Government agencies, Planning solid waste management. Transport - collection systems, collection equipment, transfer stations, collection route optimization, Onsite handling, Collection SCS, HCS, and separation processes, source reduction, Storage and processing, Transfer and transport

Unit – II	**10 Hrs**

Processing techniques and equipment. Biochemical Conversion: Composting - Aerobic composting. Sources of energy generation, Industrial waste, agro residues; Anaerobic Digestion: Biogas production; Types of biogas plants, Community biogas plants

Thermal conversion techniques Pyrolysis, Gasification, waste to energy Generation Sources of energy generation, Gasification; Types of gasifiers; Industrial applications of gasifiers; Briquetting; Utilization and advantages of briquetting; Refuse derived Fuel.

Unit – III	**09 Hrs**

Waste disposal options - Disposal in landfills - Landfill Classification, types and methods - site selection - design and operation of sanitary landfills, secure landfills - leachate and landfill gas management - landfill closure and environmental monitoring - closure of landfills - landfill remediation

Incineration; Furnace type & design; Medical / Pharmaceutical waste incineration; Environmental impacts; Measures of mitigate environmental effects due to incineration

Unit – IV	**11Hrs**

Hazardous waste and their management, Process management issues, Planning. Sources and Nature of Hazardous Waste - Impact on Environment - Hazardous Waste -Disposal of Hazardous Waste, Underground Storage Tanks Construction, Installation & Closure.

Biomedical (Handling and Management) Rules 2008, sources, treatment and disposal, E Waste Management

Unit – V	**10Hrs**

Case studies on major industrial solid waste generation units- Coal fired power plant, Textile industry, Brewery, Distillery, Oil refinery, Radioactive generation units. Oil spills. Recent Developments in Solid Wastes Reuse and Disposal: Power Generation, Blending with construction materials and Best Management Practices (BMP), Role of various organizations in Solid Waste Management – Governmental, Non-Governmental, Citizen Forums.

Course Outcomes: After going through this course the student will be able to:

CO1: Understand the importance of waste reduction at source.

CO2: Apply the principles of existing and emerging technologies to convert waste to value added products

CO3: Analyzeand select appropriate waste management techniques

CO4: Develop solid waste management scheme for an urban area

Reference Books:

1.	George Tchobanoglous,Integrated Solid Waste Management, McGraw-Hill Publishers, 2003,ISBN:0070632375
2.	B.Bilitewski, G.HardHe, K.Marek, A.Weissbach, and H.Boeddicker, Waste Management, Springer, 2004, ISBN:9783642082122
3.	Jagbir Singh, and A.L. Ramanathan, Solid Waste Management Present and Future Challenges, I.K. International House Pvt. Ltd., New Delhi, 2010,ISBN:9789380026428
4.	R.E.Landreth and P.A.Rebers, Municipal Solid Wastes – problems and Solutions, Lewis Publishers, 2002,ISBN:9781566702157

Scheme of Continuous Internal Evaluation (CIE)

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

Scheme of Semester End Examination (SEE)

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

Mapping of Course Outcomes (CO) to Program Outcomes (PO)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	H	L	-	-	L	-	-	L	H	-
CO2	M	H	M	L	M	L	M	-	M	M	-
CO3	M	M	M	M	M	M	M	-	M	H	-
CO4	M	H	H	H	M	M	M	M	M	H	-

Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)

	PSO1	PSO2	PSO3
CO1	-	L	-
CO2	L	M	L
CO3	L	M	M
CO4	M	H	M

FUEL CELL TECHNOLOGY (Elective group-1)						
Course Code	:	16MCH152		CIE Marks	:	100
Hrs/Week	:	L:T:P:S	4:0:0:0	SEE Marks	:	100
Credits	:	4		SEE Duration	:	3 Hrs

Course Learning Objectives (CLO):

Graduates shall be able to

1. Understand the importance and the need of fuel cells
2. Apply thermodynamic principles of a fuel cell and compare it with other energy storage devices
3. Analyze the construction of the fuel cell, its operation and kinetics.
4. Evaluate the performance of the fuel cells

Unit – I	**10Hrs**

Hydrogen characteristics and importance, conventional and non-conventional methods of hydrogen production, hydrogen storage, handling and safety

Unit – II	**09Hrs**

Introduction, fuel cell definition, historical developments, working principle of fuel cell, components of fuel cell, open circuit voltage, fuel cell reactions, fuels for cells and their properties, balance of plant and Fuel Cell reaction kinetics, activation kinetics and electrode kinetics

Unit – III	**10Hrs**

Classification of fuel cells, alkaline fuel cell, direct methanol fuel cell, phosphoric acid fuel cell, fabrication, advantages, disadvantages and applications

Unit – IV	**11Hrs**

Solid oxide fuel cell, proton exchange membrane fuel cell, molten carbonate fuel cell, fabrication, advantages, disadvantages and applications

Unit – V	**10Hrs**

Fuel Cell Characterization, current – voltage curve, in-situ characterization, current – voltage measurement, current interrupt measurement, cyclic voltammetry, electrochemical impedance spectroscopy and ex-situ characterization techniques

Course Outcomes: After going through this course the student will be able to:

CO1: Understand the concepts of fuel cells and their kinetics.
CO2 : Apply thermodynamics and chemical engineering principles to evaluate performance of a fuel cell
CO3: Analyze the performance of various fuel cells based on efficiencies and characteristics
CO4 : Develop new components or alternative materials for existing fuel cells

Reference Books:

1.	Viswanathan and M AuliceScibioh; Fuel Cells – Principles and Applications, Universities Press; First Edition, reprinted in 2009,ISBN 9781420060287
2.	James Larminie and Andrew Dicks, Fuel Cell Systems Explained; John Wiley & Sons; Second Edition, 2003,ISBN 9780768012590
3.	O 'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, Fuel Cell Fundamentals, Wiley, NY, First Edition (2006),ISBN 9780470258439
4.	Basu, S. (Ed) Fuel Cell Science and Technology, Springer, N.Y. First Edition (2007),ISBN 9780387688152

Scheme of Continuous Internal Evaluation (CIE)
CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

Scheme of Semester End Examination (SEE)
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

Mapping of Course Outcomes (CO) to Program Outcomes (PO)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	-	-	-	-	-	-	-	-	-	-
CO2	M	M	L	-	-	-	-	-	L	-	-
CO3	M	H	L	M	M	M	-	-	L	-	-
CO4	H	H	H	H	M	M	M	L	M	L	-

Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)

	PSO1	PSO2	PSO3
CO1	L	L	-
CO2	L	L	L
CO3	M	L	M
CO4	L	M	M

PROFESSIONAL SKILL DEVELOPMENT						
Course Code	**:**	**16HSS16**		CIE Marks	**:**	**50**
Hrs/Week	**:**	**L:T:P:S**	**0:0:4:0**	**Credits**	**:**	**2**

Course Learning Objectives (CLO):

Graduates shall be able to

1. Understand the importance of verbal and written communication
2. Improve qualitative and quantitative problem solving skills
3. Apply critical and logical think process to specific problems
4. Manage stress by applying stress management skills

Unit-I	**5 Hrs**

Communication Skills: Basics of Communication, Personal Skills & Presentation Skills, Attitudinal Development, Self Confidence, SWOC analysis.

Resume Writing: Understanding the basic essentials for a resume, Resume writing tips Guidelines for better presentation of facts.

Unit-II	**6 Hrs**

Quantitative Aptitude and Data Analysis: Number Systems, Math Vocabulary, fraction decimals, digit places etc. Reasoning and Logical Aptitude, - Introduction to puzzle and games organizing information, parts of an argument, common flaws, arguments and assumptions. Verbal Analogies – introduction to different question types – analogies, sentence completions, sentence corrections, antonyms/synonyms, vocabulary building etc. Reading Comprehension, Problem Solving

Unit-III	**4 Hrs**

Interview Skills: Questions asked & how to handle them, Body language in interview, Etiquette, Dress code in interview, Behavioral and technical interviews, Mock interviews - Mock interviews with different Panels. Practice on Stress Interviews, Technical Interviews, General HR interviews

UnitIV	**5 Hrs**

Interpersonal and Managerial Skills:Optimal co-existence, cultural sensitivity, gender sensitivity; capability and maturity model, decision making ability and analysis for brain storming; Group discussion and presentation skills;

Unit-V	**4 Hrs**

Motivation and Stress Management: Self motivation, group motivation, leadership abilities Stress clauses and stress busters to handle stress and de-stress; professional ethics, values to be practiced, standards and codes to be adopted as professional engineers in the society for various projects**.**

Note: The respective departments should discuss case studies and standards pertaining to their domain

Course Outcome:

The Graduate will be able to :

CO1: Develop professional skill to suit the industry requirement

CO2: Solve quantitative and reasoning problems with confidence

CO3: Demonstrate leadership and interpersonal working skills in various situations

CO4: Display verbal communication skills with appropriate body language

Scheme of Continuous Internal Examination (CIE)
Evaluation will be carried out in TWO Phases.

Phase	Activity	Weightage
I	After 5 weeks - Unit 1, 2 & Part of Unit 3	50%
II	After 10 weeks – Unit 3, 4, 5	50%

CIE Evaluation shall be done with weightage as follows:

1. Writing skills 10%
2. Logical Thinking 25%
3. Verbal Communication & Body Language 35%
4. Leadership, Interpersonal and Stress Bursting Skills 30%

Mapping of Course Outcomes (CO) to Program Outcomes (PO)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	L	L	M	L	M	H	M	M	M	L
CO2	H	H	L	M	M	M	H	M	M	M	H
CO3	H	H	M	H	M	M	H	L	M	M	L
CO4	H	H	H	H	H	H	H	H	H	H	M

Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)

	PSO1	PSO2	PSO3
CO1	L	L	L
CO2	M	M	L
CO3	H	M	L
CO4	L	L	M

SECOND SEMESTER

RESEARCH METHODOLOGY						
Course Code	:	16MEM21R		CIE Marks	:	100
Hrs/Week	:	L: T: P: S	3:2:0:0	SEE Marks	:	100
Credits	:	4		SEE Duration	:	3 hours

Course Learning Objectives:

Graduates shall be able to:

1. Understand of the underlying principles of quantitative and qualitative research
2. Perform the gap analysis and identify the overall process of designing a research study
3. Choose the most appropriate research methodology to address a particular research problem
4. Gain an overview of a range of quantitative and qualitative approaches leading to data analysis and suggesting solution.

Unit – I **10 Hrs**

Overview of Research

Meaning of Research, Types of Research, Research and Scientific Method, Defining the Research Problem, Defining the Research Problem, Research Design, Different Research Designs.

Unit – II **09 Hrs**

Methods of Data Collection

Collection of Primary Data, Observation Method, Interview Method, Collection of Data through Questionnaires, Collection of Data through Schedules, Collection of Secondary Data, Selection of Appropriate Method for Data Collection.

Unit – III **10 Hrs**

Sampling Methods

Sampling process, Non-probability sampling, probability sampling: simple random sampling, stratified sampling, cluster sampling systematic random sampling, Determination of sample size, simple numerical problems.

Unit – IV **10 Hrs**

Processing and analysis of Data

Processing Operations, Types of Analysis, Statistics in Research, Measures of: Central Tendency, Dispersion, Asymmetry and Relationship, correlation and regression, Testing of Hypotheses for single sampling: Parametric (t, z and F) Chi Square, ANOVA, and non-parametric tests, numerical problems.

Unit-V **09 Hrs**

Essential of Report writing and Ethical issues:

Significance of Report Writing,Different Steps in Writing Report,Layout of the Research Report, Precautions for Writing Research Reports.

Syllabus includes 2 hours per week of tutorials in which:

- Faculty is expected to discuss research methodology for specializations under consideration
- Numerical problems on statistical analysis as required for the domains in which students are studying must be discussed
- Statistical analysis using MINITAB/MatLab and such other softwares can be introduced

Course Outcomes:

After going through this course the student will be able to

CO1: Understand various principles and concepts of research methodology to address research problems

CO2: Apply appropriate methods of data collection and analyze using statistical methods

CO3: Analyze research outputs in a structured manner and prepare report as per the technical and ethical standards

CO4: Formulate research methodology for a given engineering and management problem situation

Reference Books

1. Kothari C.R., Research Methodology Methods and techniques by, New Age International, 2004, ISBN: 9788122415223 – Unit I, II, IV & V
2. Krishnaswami, K.N., Sivakumar, A. I. and Mathirajan, M., Management Research Methodology, Pearson Education India, 2009, ISBN:9788177585636 – Unit III
3. Levin, R.I. and Rubin, D.S., Statistics for Management, 7th Edition, Pearson Education: New Delhi, ISBN-13: 978-8177585841 – Unit III, IV

Scheme of Continuous Internal Evaluation (CIE)

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

Scheme of Semester End Examination (SEE)

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

Mapping of Course Outcomes (CO) to Program Outcomes (PO)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	-	-	L	L	-	L	L	L	-	-	-
CO2	-	-	L	H	M	L	L	H	L	M	-
CO3	-	-	L	H	L	L	L	H	L	M	-
CO4	-	-	L	H	M	L	M	H	M	H	-

Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)

	PSO1	**PSO2**	**PSO3**
CO1	M	L	-
CO2	M	M	-
CO3	M	M	L
CO4	H	M	M

HETEROGENEOUS REACTION SYSTEMS (Theory & Practice)						
Course Code	:	16MCH22		CIE Marks	:	100+50
Hrs/Week	:	L:T:P:S	4:0:2:0	SEE Marks	:	100+50
Credits	:	5		SEE Duration	:	3 Hrs

Course Learning Objectives (CLO):

Graduates shall be able to

1. Understand fundamental principles and experimental techniques of heterogeneous reaction systems
2. Apply principles of transferoperation in kinetics studies of heterogeneousreaction systems
3. Analyzethe rate controlling step in heterogeneous reaction systems
4. Evaluate the catalytic activity and selectivity influenced by the physical and surface properties of the catalyst.

Unit – I	10Hrs

Non ideal reactor analysis, mixing concepts, Residence Time Distribution, response measurements, segregated flow model, Dispersion model, series of stirred tanks model, analysis of non-ideal reactors and two parameter model

Unit – II	10Hrs

Non-catalytic Heterogeneous Reactions, **i**ntroduction, fluid-fluid reactions, fluid-solid reactions & models to determine time of conversion

Industrial catalysis, **c**lassification of catalysts, typical industrial catalytic processes, preparation of catalysts, catalyst supports

Unit – III	10Hrs

Catalyst Characterization, **s**urface area measurements, BET theory, pore size distribution,porosity - chemisorption techniques, crystallography and surface analysis techniques, XRD, XPS, NMR, Molecular spectroscopy

Unit – IV	10Hrs

Catalytic Heterogeneous Reactions, **c**atalytic reactions, rate controlling steps,Langmuir - Hinshelwood model, Eiley - Riedel mechanism

Catalyst deactivation, poisons, sintering of catalysts, kinetics of deactivation, catalyst regeneration

Unit – V	10Hrs

External diffusion effects in Heterogeneous Reactions,surface kinetics and pore diffusioneffects, evaluation of effectiveness factor

Design of reactors for heterogeneous catalytic & non-catalytic reactions

Unit – VI (Lab Component)	

1. Packed bed catalytic reactor
2. Effect of temperature on rate of reaction
3. Fluidized bed reactor
4. Absorption with reaction
5. Reactors in series
6. Reactors in parallel
7. Combination of reactors
8. Adsorption with reaction
9. Hydrogenation studies

Course Outcomes:

After going through this course the student will be able to:

CO1: Understand the concepts of catalytic reactions

CO2: Apply principles of transfer operation in kinetics studies of heterogeneous reaction systems

CO3: Analyze complex chemical reaction mechanisms and kinetics

CO4:Develop rate equations for catalytic reaction systems

CO5: Evaluate the performance of reactors for multiphase reaction systems

Reference Books:

1.	Smith J.M, Chemical Engineering Kinetics, 3rd Edition, McGraw- Hill, 1984, ISBN:0071247084
2	Bischoff and Froment, Chemical Reactor Design and Analysis, Addision Wesley, 1982, ISBN:9780471024477
3	Fogler H.S, Elements of Chemical Reaction Engineering, Prentice Hall, 1986.ISBN: 978-0137146123
4	Octave Levenspiel, Chemical Reaction Engineering 3 rd Edition ,John wiley and sons, ISBN: 9780471254249

Scheme of Continuous Internal Evaluation (CIE) for Theory

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

Scheme of Continuous Internal Evaluation (CIE) for Practical

CIE for the practical courses will be based on the performance of the student in the laboratory, every week. The laboratory records will be evaluated for 40 marks. One test will be conducted for 10 marks. The total marks for CIE (Practical) will be for 50 marks.

Scheme of Semester End Examination (SEE) for Theory

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

Scheme of Semester End Examination (SEE) for Practical

SEE for the practical courses will be based on conducting the experiments and proper results for 40 marks and 10 marks for viva-voce. The total marks for SEE (Practical) will be 50 marks.

Mapping of Course Outcomes (CO) to Program Outcomes (PO)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	L	-	-	-	-	-	-	-	-	-	-
CO2	M	M	-	L	-	-	-	-	-	-	-
CO3	M	M	M	M	L	L	-	-	-	-	-
CO4	H	M	M	M	M	L	-	-	-	-	-
CO5	H	H	H	H	M	M	-	-	L	-	-

Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)

	PSO1	PSO2	PSO3
CO1	L	L	
CO2	L	L	L
CO3	M	M	L
CO4	H	H	M
CO5	H	H	M

Course Code	:	16MCH231		CIE Marks	:	100
Hrs/Week	:	L:T:P:S	4:0:0:0	SEE Marks	:	100
Credits	:	4		SEE Duration	:	3 Hrs

Course Learning Objectives (CLO):

Graduates shall be able to

1. Understand the fundamentals and characteristics of renewable energy sources
2. Apply chemical engineering principlesto use renewable energy sources
3. Analyze various renewable energy conversion systems for energy efficiency
4. Evaluate the performance of energy conversion system

Unit – I	10Hrs

Introduction: Current energy requirements, growth in future energy requirements, Review of conventional energy resources- Coal, gas and oil reserves and resources, Tar sands and Oil Shale, Nuclear energy Option

Unit – II	11Hrs

Solar Energy: Solar radiation: measurements and prediction. Solar thermal collectors- flat plate collectors, concentrating collectors. Basic theory of flat plate collectors, solar heating of buildings, solar still, solar water heaters, solar driers; conversion of heat energy in to mechanical energy, solar thermal power generation systems. Solar Photovoltaic: Principle of photovoltaic conversion of solar energy, types of solar cells and fabrication.

Photovoltaic applications :battery charger, domestic lighting, street lighting, water pumping, power generation schemes

Unit – III	09Hrs

Wind Energy: Atmospheric circulations, classification, factors influencing wind, wind shear, turbulence, wind speed monitoring, Betz limit, WECS: classification, characteristics, and applications

Unit – IV	10Hrs

Ocean Energy: Ocean energy resources-ocean energy routes - Principles of ocean thermal energy conversion systems- ocean thermal power plants- Principles of ocean wave energy conversion and tidal energy conversion.

Unit – V	10Hrs

Other Sources: Hydropower, Nuclear fission and fusion-Geothermal energy: Origin, types of geothermal energy sites, site selection, geothermal power plants; Magneto-hydro-dynamic (MHD) energy conversion.

Course Outcomes:

After going through this course the student will be able to:

CO1: Understand the importance of various renewable energy sources
CO2: Apply the principles of existing and emerging technologies to harness renewable energy
CO3: Analyze the performance of renewable energy systems
CO4: Develop power generation schemes using renewable energy systems

Reference Books:

1.	D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia 2000,ISBN: 9781560327141
2.	C. S. Solanki, Solar Photovoltaics: Fundamental Applications and Technologies, Prentice Hall of India, 2009, ISBN:9788120343863
3.	L.L. Freris, Wind Energy Conversion Systems, Prentice Hall, 1990, ISBN:9780139605277
4.	David &Spera, Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press,1994, ISBN:9780791812051
5.	S.P. Sukhatme, Solar Energy: principles of Thermal Collection and Storage, Tata McGraw-Hill ,1984, ISBN: 1259081966

Scheme of Continuous Internal Evaluation (CIE)

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

Scheme of Semester End Examination (SEE)

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

Mapping of Course Outcomes (CO) to Program Outcomes (PO)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	L	-	-	-	-	-	-	-	-	-	-
CO2	M	L	L	M	-	L	L	-	L	-	-
CO3	M	M	M	L	L	M	L	-	L	-	-
CO4	H	M	H	H	M	H	M	L	M	L	-

Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)

	PSO1	PSO2	PSO3
CO1	L		L
CO2	L	M	L
CO3	L	M	M
CO4	H	H	H

INDUSTRIAL WASTEWATER TREATMENT						
Course Code	:	16MCH232		CIE Marks	:	100
Hrs/Week	:	L:T:P:S	4:0:0:0	SEE Marks	:	100
Credits	:	4		SEE Duration	:	3 Hrs

Course Learning Objectives (CLO):

Graduates shall be able to:

1. Understand characteristics of industrial wastewater
2. Apply physical and chemical principles to treatindustrial waste water
3. Analyze suitable treatment method for any industrial waste water
4. Evaluate the performance of waste water treatment methods

Unit – I 10Hrs

Characteristics of Industrial Wastewater:

Physical characteristics: color, odor, temperature, turbidity, total solids. Chemical characteristics: inorganic and organic characteristics and their determination. Biological characteristics: Classification of microorganisms, pathogenic organisms, Toxicity, Analysis of solids data. Measurement of organic matter, Modeling of BOD reaction, Estimation of BOD, COD.

Unit – II 10Hrs

Physico - Chemical Treatment:

Introduction to wastewater treatment methods and steps. Screens, Grit chamber, Comminutors, Flow Equalisation. Selection of treatment process and basic design considerations. Sedimentation: theory, types and design. Principle of Coagulation and Flocculation: types of coagulants, coagulant aids, coagulation theory, optimum dose of coagulant, design criteria and numerical examples.

Unit – III 09Hrs

Bio - Chemical Treatment:

Biological process for wastewater treatment. Microbial growth kinetics, Suspended and attached growth processes - Aerobic and Anaerobic. Activated Sludge Process, Extended Aeration, Contact Stabilization, sludge blanket systems, Rotating Biological Contactors. Management of sludge: Thickening, Digestion, Dewatering, Sludge drying and Composting.

Unit – IV 11Hrs

Advanced Treatment:

Disinfection: different methods, disinfectants, factors affecting disinfection. Chlorination: classification, dechlorination. Water Softening – Ions causing hardness, Membrane Technologies; Microfiltration, Ultra filtration, Nanofiltration and Reverse Osmosis, Solar Evaporation Pans, Ion Exchange process, Nitrogen and phosphorous removal

Unit – V 10Hrs

Effluent Treatment Plants:

CPCB guidelines and standards for effluent treatment and disposal, Effluent treatment plant of typical chemical industries: Sugar, Dairy, Distillery, Textile, and Pharmaceutical industries.

Operation and Maintenance of ETPs: Factors affecting operation and Maintenance of ETPs, Control and Monitoring of ETPs

Course Outcomes:

After going through this course the student will be able to:

CO1: Understand the importance of wastewater management

CO2: Apply the physico-chemical and biological principles to treat industrial wastewater

CO3: Analyze the performance of various wastewater treatment techniques

CO4: Develop scheme for treating typical industrial effluents

Reference Books:	
1.	Patwardhan, A.D., Industrial Waste Water Treatment, 2009,Edition, PHI learning, ISBN: 978-81-203-3350-5
2.	Metcalf and Eddy, Wastewater Engineering: Treatment and Reuse, 2013 Edition, McGraw-Hill Science/Engineering/Math ISBN:978 0073401188
3.	Wesley Eckenfelder, W Industrial water pollution control, 2000 Edition, Tata McGraw-Hill Publishing Company Ltd., ISBN:7302051348
4.	NG Wun Jern, Industrial Wastewater Treatment, 2006 Edition, Imperial College Press, ISBN 1-86094-580-5

Scheme of Continuous Internal Evaluation (CIE)

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

Scheme of Semester End Examination (SEE)

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

Mapping of Course Outcomes (CO) to Program Outcomes (PO)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
CO1	L	-	-	-	-	-	-	-	-	-	-
CO2	M	L	L	M	-	L	L	-	L	-	-
CO3	M	M	M	L	L	M	L	-	L	-	-
CO4	H	M	H	H	M	H	M	L	M	L	-

Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)

	PSO1	**PSO2**	**PSO3**
CO1	-	L	L
CO2	L	M	L
CO3	M	M	-
CO4	M	M	M

BIOINSTRUMENTATION AND BIOSENSORS						
Course Code	:	16MCH241		CIE Marks	:	100
Hrs/Week	:	L:T:P:S	4:0:0:0	SEE Marks	:	100
Credits	:	4		SEE Duration	:	3 Hrs

Course Learning Objectives (CLO):

Graduates shall be able to

1. Understand the principles of various spectrophotometry and choose an appropriate method for analysis of organic /inorganic compounds
2. Able to select suitable chromatographic, centrifugal or electrophoretic technique for separation of desired substance from a mixture
3. Evaluate the suitability of Biosensor to a given problem in the fields of chemistry or biology

Unit – I	12Hrs

Chromatography: TLC, Column chromatography- Adsorption column chromatography, Gel filtration chromatography, Ion exchange chromatography, Affinity chromatography.
Electrophoresis - PAGE – Native and SDS, Agaroseelectrophoresis, Two-dimensional electrophoresis, DNA sequencing gel, Capillary electrophoresis.

Unit – II	10Hrs

Spectroscopy: Electromagnetic Radiation- properties of, Principles, Instrumentation and applications of UV, Vis, IR, Fluorescence, CD,, GC, HPLC, NMR, ESR, MS
Light and Electron microscopes. – TEM & SEM

Unit – III	8Hrs

Centrifugation:. Centrifugation and Rotors angle / vertical, zonal /continuous flow buoyant density centrifugation. Ultra centrifuge - principle and application,
Other techniques: Lyophilization, Flow cytometry.

Unit – IV	10Hrs

Biosensors: Introduction, Types of Bioreceptors (Enzyme, antibodies, Nucleic Acids, Whole cells) and Transducers (Optical, Electrochemical, Piezoelectric) Quartz crystal Microbalance, Surface Plasmon resonance, Specificity, sensitivity and stability of biosensors.

Unit – V	8 Hrs

Applications of Biosensors: in food Quality (mycotoxins), detection of pathogens, Health care, Glucometers in Diabetes Management, Environmental: pollution monitoring, Industrial: Fermentation, Military: Bioagents detection, Agriculture: Fruit ripening.

Course Outcomes:

After going through this course the student will be able to:

CO1: Understand the principle, instrumentation and applications of various spectro-photometric techniques

CO2: Apply chromatographic, electrophoretic and centrifugal techniques to effectively separate desired target compounds from a given mixture

CO3: Analyze applicability of bio sensors to specific needs

CO4: Develop prototypes of Biosensors for applications in chemical or biological domains

Reference Books:

1.	Keith Wilson and John Walker, Practical Biochemistry: Principle and Techniques, Cambridge University Press, 5th ed. 2005
2.	Yang, V.C. and T.T Ngo, Biosensors and Their Applications, Kluwer Academic/ Plenum Publishers, 2000,ISBN978 0070654152
3.	Ligler, F.S. and Rowe Taitt, C.A, Optical Biosensors: Present & Future, Elsevier, Netherlands, 2002,ISBN 978-0444509741
4.	Ashok Mulchandani and Kim R. Rogers (Eds.), Enzyme and Microbial Biosensors: Techniques and Protocols, Humana Press, Totowa, NJ, 1998,ISBN 0-896031-410-0

Scheme of Continuous Internal Evaluation (CIE)

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

Scheme of Semester End Examination (SEE)

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

Mapping of Course Outcomes (CO) to Program Outcomes (PO)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	-	-	-	-	-	-	-	-	-	-
CO2	M	L	-	L	H	M	-	-	-	-	-
CO3	M	M	M	M	-	M	-	-	-	-	-
CO4	H	H	M	M	M	M	L	M	M	L	-

Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)

	PSO1	PSO2	PSO3
CO1	L	-	L
CO2	M	-	M
CO3	-	M	M
CO4	M	M	M

FOOD PROCESSING ENGINEERING AND TECHNOLOGY

Course Code	:	16MCH242		CIE Marks	:	100
Hrs/Week	:	L:T:P:S	4:0:0:0	SEE Marks	:	100
Credits	:	4		SEE Duration	:	3 Hrs

Course Learning Objectives (CLO):

Graduates shall be able to

1.Understand the need for food processing
2.Apply chemical engineering principles in foodprocessing
3.Analyze separation technologies in food processing
4.Design and develop food preservation and packaging techniques

Unit – I	10Hrs

Introduction - general aspects of food industry, world food demand and Indian scenario, constituents of food, quality and nutritive aspects. Food additives, standards, deteriorative factors and their control, preliminary processing methods, conversion and preservation operation.
Energy Engineering in Food Processing - Generation of Steam, Fuel Utilization, Electric Power Utilization, Process Controls in Food Processing, Systems for Heating and Cooling Food Products. Thermal Properties of Foods , Modes of Heat Transfer - Freezing Systems , Frozen-Food Properties , Freezing Time refrigeration system for food products.

Unit – II	10Hrs

Separation processes in food processing- Electro-dialysis Systems, Reverse Osmosis Membrane Systems, Membrane Performance, Ultra filtration Membrane Systems, Concentration Polarization. Types of Reverse-Osmosis and Ultra filtration Systems, Drying Processes, Dehydration System, Dehydration System Design, Sedimentation, Centrifugation

Unit – III	10Hrs

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-choking agents, leavening agents, nutrient supplements, non-nutritive sweeteners, pH control agents. Preservatives – types and applications. Stabilizers and thickeners, other additives. Additives and food safety.

Unit – IV	10Hrs

Food contamination and adulteration - Types of adulterants and contaminants. Intentional adulterants. Metallic contamination. Incidental adulterants. Nature and effects. Food laws and standards.
Packaging - Introduction, Food Protection, Product Containment, Product Communication, Product Convenience, Mass Transfer in Packaging Materials. Innovations in Food Packaging, Food Packaging and Product Shelf-life, Food canning technology, fundamentals of food canning technology. Heat sterilization of canned food, containers - metal, glass and flexible packaging. Canning procedures for fruits, vegetables, meats, poultry marine products.

Unit – V	10Hrs

Modern trends in food science - Biotechnology in food. Bio-fortification, Nutraceuticals. Organic foods. Low cost nutrient supplements. Packaging of foods and nutrition labelin. Careers in food science and food industries.

Course Outcomes:

After going through this course the student will be able to:
CO1: Understand the importance of food processing
CO2: Apply chemical engineering principles in developing food processing and preservation techniques
CO3: Analyze food processing techniques for energy efficiency
CO4: Evaluate various methods for food processing and preservation

Reference Books:

1. B. Srilakshmi, Food Science –4thEdn-New Age International-2007 ISBN:8122414818
2. N. Shakuntala Manay and M. Shadaksharamurthy Foods: Facts and Principles –New Age Publishers – 2005, ISBN:9788122422153
3. Rick Parker, Introduction to Food Science– Thomsan Detmer-2001, ISBN:0766813150
4. G. Subbulakshmi and Shobha A. Udupi, Food Processing and Preservation New Age International-2001,ISBN: 97881224-12833
5. Norman N. Potter and Joseph H. Hotchkin, Food Science –Avi Publishing Co 1968,ISBN: 9781461372639

Scheme of Continuous Internal Evaluation (CIE)

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

Scheme of Semester End Examination (SEE)

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

Mapping of Course Outcomes (CO) to Program Outcomes (PO)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	L	-	-	-	-	-	-	-	-	-	-
CO2	M	L	-	L	H	M	-	-	-	-	-
CO3	M	M	M	L	L	M	L	-	L	-	-
CO4	H	M	H	H	M	H	M	L	M	L	-

Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)

	PSO1	PSO2	PSO3
CO1	L	-	L
CO2	L	L	L
CO3	M	M	L
CO4	M	H	H

BIOMASS CONVERSION SYSTEMS						
Course Code	:	16MCH251		CIE Marks	:	100
Hrs/Week	:	L:T:P:S	4:0:0:0	SEE Marks	:	100
Credits	:	4		SEE Duration	:	3 Hrs

Course Learning Objectives (CLO):

Graduates shall be able to

1. Understand energy balances and thermodynamics in biomass conversion
2. Apply principlesof unit operations in biofuel production
3. Analyze the need for biomass energy conversion
4. Evaluatethe performance of biological and chemical conversion methods

Unit – I	09Hrs

Biomass and Bioenergy: Biomass resources; classification and characteristics; Generation and utilization, Properties of biomass, Agriculture Crop and Forestry residues used as fuels.

Unit – II	11Hrs

Thermo chemical Conversion: Different processes, direct combustion, incineration, pyrolysis, gasification and liquefaction

Unit – III	10Hrs

Biological Conversion: Biodegradation and biodegradability of substrate; Process parameters of biomethanation; chemical kinetics and mathematical modeling of biomethanation process, Different Types of Biogas Plants; bioconversion of substrates into alcohol: ethanol production.

Unit – IV	10Hrs

Chemical Conversion: Hydrolysis & hydrogenation; solvent extraction of hydrocarbons; solvolysis of wood; biodiesel production via chemical process; catalytic distillation; transesterification methods

Unit – V	10Hrs

Power generation: Utilization of gasifier for electricity generation; ethanol and biogas; biomass integrated gasification. Sustainable co-firing of biomass with coal. Biomass productivity: Energy plantation and power programme. Economical impacts; food security and environmental impacts of biomass conversion to energy- energy from waste.

Course Outcomes:

After going through this course the student will be able to:

CO1:Understand the principles of various biomass to energy conversion methods
CO2:Apply chemical and biological principles in bio-energy conversion
CO3:Analyse biomass conversion system and compare with conventional energy sources
CO4:Select cost effective biomass conversion system

Reference Books:

1.	James J Winebrake, Alternate Energy: Assessment & Implementation Reference Book, Springer January 2007 ISBN:0881734365
2.	A Demirbas, Biofuels - Securing the Planet's Future Energy Needs, Edited by Springer 2009,ISBN: 9783319405513
3.	Frank Rosillo-Calle, Sarah Hemstock, Peter de Groot and Jeremy Woods, Biomass Assessment Handbook - Bioenergy for a sustainable environment Edited by, Earthscan November 2006.ISBN: 9781138019652

Scheme of Continuous Internal Evaluation (CIE)

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

Scheme of Semester End Examination (SEE)

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

Mapping of Course Outcomes (CO) to Program Outcomes (PO)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	L	-	-	-	-	-	-	-	-	-	-
CO2	M	L	-	L	-	-	-	-	-	-	-
CO3	M	M	M	L	L	L	M	-	-	-	-
CO4	M	M	M	M	M	M	H	-	L	-	-

Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)

	PSO1	PSO2	PSO3
CO1	L	-	-
CO2	L	-	-
CO3	L	M	M
CO4	M	M	M

NOVEL SEPARATION TECHNOLOGY						
Course Code	:	16MCH252		CIE Marks	:	100
Hrs/Week	:	L:T:P:S	4:0:0:0	SEE Marks	:	100

Credits	:	4		SEE Duration	:	3 Hrs

Course Learning Objectives (CLO):

Graduates shall be able to

1. Understand the need for novel separation techniques
2. Apply various novel separation techniques in process industries
3. Analyze the performance of various separation techniques
4. Select appropriate separation technique for specific applications

Unit – I	10Hrs

Fundamentals of Separation Processes, Basic definitions of relevant terms. Separation by Adsorption Techniques, their mechanism, types and choice of adsorbents, normal adsorption techniques, Affinity chromatography and immuno chromatography. Types of equipment and commercial processes, recent advances and process economics.

Unit – II	10Hrs

Membrane Separations: Fundamentals and various terms. Classifications. Design aspects: various models and their applicability. Classification, structure and characteristics of membranes .Types and choice of membranes, Plate and frame, tubular, spiral wound and hollow fiber membrane and their relative merits, Commercial, pilot plant and laboratory membrane permeators involving dialysis, reverse osmosis, Nano filtration, ultra filtration, Micro filtration and Donnan dialysis, Economics of membrane operations, Ceramic membranes.

Unit – III	10Hrs

External Field Induced Separations: External field induced membrane separation processes for colloidal particles, Fundamentals of various colloid separations. Derivation of profile of electric field strength. Coupling of membrane separation and electrophoresis. Electric and magnetic field separations. Centrifugal separations

Surfactant Based Separations: Surfactant based separation processes, Liquid membranes- fundamentals and modeling, Micelles enhanced separation processes. Cloud point extraction. Fundamentals of surfactants at surfaces and in solutions. Liquid membrane permeation, foam separations, micellar separations.

Unit – IV	10Hrs

Super Critical Fluid Extraction: Physicochemical principles, thermodynamics, process synthesis and energy analysis. Concept, modeling, design aspects and applications

Separation by thermal diffusion, electrophoresis and crystallization.

Unit – V	10Hrs

Other separation techniques: Separations involving Lyophilization, Pervaporation and permeation techniques for solids, liquids and gases. Industrial viability and examples, Zone melting, adductive crystallization.

Course Outcomes:

After going through this course the student will be able to:

CO1: Understand the fundamentals of separation processes

CO2: Apply chemical engineering principles to explain separation mechanism

CO3: Analyze various separation techniques based on separation factors

CO4: Select appropriate separation process for a specific application

Reference Books:

1.	Kaushik Nath , Membrane separation Processes, PHI Pvt. Ltd., 2008 ISBN 978-81-203-3532-5
2.	King, C.J, Separation Processes, Tata McGraw Hill Publishing Co., Ltd., 2013 ISBN 978-0486491738
3.	E. J. Hoffman, Membrane Separations Technology: Single-Stage, Multistage, and Differential Permeation , Gulf professional publishing, April 2003 ISBN: 075 0677104
4.	Richard W. Baker, Membrane Technology and applications Second Edition, 2004 ISBN: 007 1354409

Scheme of Continuous Internal Evaluation (CIE)
CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

Scheme of Semester End Examination (SEE)
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

Mapping of Course Outcomes (CO) to Program Outcomes (PO)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	L	-	-	-	-	-	-	-	-	-	-
CO2	M	L	-	L	-	-	-	-	-	-	-
CO3	M	M	M	L	L	L	M	-	-	-	-
CO4	H	M	M	M	M	M	M	-	L	-	-

Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)

	PSO1	PSO2	PSO3
CO1	L	L	-
CO2	M	L	L
CO3	H	M	L
CO4	H	H	H

MINOR PROJECT						
Course Code	:	16MCH26		CIE Marks	:	100
Hrs/Week	:	L:T:P:S	0:0:10:0	SEE Marks	:	100

Credits	:	5		SEE Duration	:	3 Hrs

Course Learning Objectives (CLO):

Graduates shall be able to

1) Create interest in innovative development.
2) Apply engineering knowledge to practical problems
3) Inculcate the skills for good presentation and technical report writing skills.
4) Apply management principles while executing the project

GUIDELINES

1. Each project group will consist of maximum of two students.
2. Each student / group has to select a contemporary topic that will use the technical knowledge of their program of study after intensive literature survey.
3. Allocation of the guides preferably in accordance with the expertise of the faculty.
4. The number of projects that a faculty can guide would be limited to four.
5. The minor project would be performed in-house.
6. The implementation of the project must be preferably carried out using the resources available in the department/college.

Course Outcomes: After completion of the course the student will be able to**:**

CO1: Understand a specific problem and outline the problem statement

CO2: Summarize information gathered through literature survey

CO3: Apply appropriate (computational) tools/ (characterization) techniques to find feasible solutions

CO4: Analyze obtained experimental/numerical/analytical results and draw effective conclusions

CO5: Design/optimize a process or develop a material/product and communicate the solutions effectively

Scheme of Continuous Internal Examination (CIE)

Evaluation will be carried out in THREE Phases. The evaluation committee will comprise of FOUR members: guide, two senior faculty members and Head of the Department.

Phase	Activity	Weightage
I	Synopsis submission, Preliminary seminar for the approval of selected topic and Objectives formulation	20%
II	Mid-term seminar to review the progress of the work and documentation	40%
III	Oral presentation, demonstration and submission of project report	40%

****Phasewise rubrics to be prepared by the respective departments**

CIE Evaluation shall be done with weightage / distribution as follows:

- Selection of the topic & formulation of objectives 10%
- Design and simulation/ algorithm development/experimental setup 25%
- Conducting experiments / implementation / testing 25%
- Demonstration & Presentation 15%
- Report writing 25%

Scheme for Semester End Evaluation (SEE):

The evaluation will be done by ONE senior faculty from the department and ONE external faculty member from Academia / Industry / Research Organization. The following weightages would be given for the examination. Evaluation will be done in batches, not exceeding 6 students.

1. Brief writeup about the project 5%
2. Presentation / Demonstration of the project 20%
3. Methodology and Experimental Results & Discussion 25%
4. Report 20%
5. Viva Voce 30%

Mapping of Course Outcomes (CO) to Program Outcomes (PO)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	M	L	L	-	-	-	L	-	-	-
CO2	L	L	L	H	M	-	-	M	-	-	-
CO3	M	M	H	M	H	M	M	M	H	L	L
CO4	H	H	M	M	M	M	-	M	-	-	M
CO5	H	H	H	H	H	H	H	H	H	H	H

Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)

	PSO1	PSO2	PSO3
CO1	L	L	H
CO2	M	M	H
CO3	H	M	M
CO4	L	L	M