**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 for 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.

**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 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 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 MEM 11P | 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 HSS 16 | 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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**Department of Chemical Engineering**

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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 MEM 21R | 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 MCH 23X | 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 | 16 MCH 36 | 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** |

| PLANT WIDE CONTROL OF CHEMICAL PROCESSES | | | | |
|---|---|---|---|---|
| **Course Code** | **16 MCH 31** | | **CIE Marks** | **100+50** |
| **Hrs/Week** | **L: T: P: EL** | **4:0:2:0** | **SEE Marks** | **100+50** |
| **Credits** | **05** | | **SEE duration** | **3 Hrs** |

**Course Learning Objectives:**

The students shall be able to:

1. Understand role of control systems in process performance achievement.
2. Apply input-output mapping for development of mathematical model of process.
3. Analyze direct and cross effects of manipulated variables on measured variables.
4. Evaluate choice of controller type on process stability/regulation.

| **UNIT – I** | **12 Hrs** |
|---|---|

**Review of process dynamics:** First order systems - Thermometer - Level tank - CSTR; Second order system - U-tube manometer - Mass vibrator.

**Feed back control:** Features and examples; PID controller design and tuning; Cohen-Coon tuning.

| **UNIT – II** | **11 Hrs** |
|---|---|

**Plant design and control:** Introduction; Extra capacity for process control; Controller limitations; False economy; Definitions of control modes; Control mode comparisons; Control mode vs. application; Pneumatic vs. electronic controls; Process chromatographs.

Stability: Concept and criterion; Routh test; Root locus.

| **UNIT – III** | **6 Hrs** |
|---|---|

**Advanced control techniques:** Cascade control; Feed forward and feed backward control; Ratio control; Selective and adaptive control; Smith predictor.

| **UNIT – IV** | **10 Hrs** |
|---|---|

**Multi-variable controller:** Features and examples of Multi-Input and Multi-Output processes; Design of cross controller; Relative Gain Array; Niederlinski index.

| **UNIT – V** | **13 Hrs** |
|---|---|

**"Snowball effects" in material recycle:** Series cascades of units; Effect of recycle on time constants; "Snowball effects" in recycle systems; Steady-state sensitivity analysis to screen plant wide control structures.

| **UNIT – VI (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
5. Second order under damped U-tube manometer
6. Level controller ON/OFF action
7. Level controller (P, PI, PID controllers)
8. Flow controller (P, PI, PID controllers)
9. Pressure controller (P, PI, PID controllers)
10. Control valve characteristics
11. Temperature controller (P, PI, PID controllers)
12. U tube manometer: second order system

**Course Outcome:**

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

CO1. Understand the effects of multiple inputs on multiple outputs in a process plant.

CO2. Apply mathematical abstraction to formulate multiple input - multiple output model.

CO3. Analyze response in open and closed loop systems.

| | |
|---|---|
| CO4. Design cascade, feedforward, and/or adaptive structures for plant-wide control. | |
| **Reference Booksu:** | |
| 1. | G. Stephanopoulos, Chemical Process Control: An Introduction to Theory and Practice, 1st ed. New Delhi: Prentice-Hall of India, 1984, ISBN 0-81-203-0665-1. |
| 2. | C. Branan, Rules of Thumb for Chemical Engineers: A manual of quick, accurate solutions to everyday process engineering problems, 4th ed. Noida: Elsevier, 2008; ISBN 978-0-7506-7856-8 |
| 3. | W.L. Luyben, M.L. Luyben, Essentials of Process Control, Int. ed. Singapore: McGraw-Hill, 1997; ISBN 978-0-0703-9172-7 |
| 4. | C.A. Smith, A.B. Corripio, Principles and Practice of Automatic Process Control, 1st ed. John Wiley & Sons, USA, 1991, ISBN 0-471-88346-8. |

**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** | M | M | M | - | - | - | - | - | - | - | - |
| **CO2** | H | H | L | M | M | - | - | - | - | - | - |
| **CO3** | - | H | L | - | - | L | - | - | - | - | - |
| **CO4** | H | M | H | M | M | - | - | - | - | - | - |

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

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

| ADVANCED POLYMER COMPOSITES | | | | |
|---|---|---|---|---|
| **Course Code** | **16MCH321** | | **CIE Marks** | **100** |
| **Hrs/Week** | **L: T: P: EL** | **4:0:0:0** | **SEE Marks** | **100** |
| **Credits** | **04** | | **SEE duration** | **03** |

**Course Learning Objectives:**

The students shall be able to:

1. Understand need for polymer matrix composites for specific applications.
2. Apply materials engineering to design polymer matrix composites.
3. Analyze the mechanical/thermal property attainment of polymer matrix composites
4. Evaluate alternatives in design using polymer matrix composites

| **UNIT – I** | **10 Hrs** |
|---|---|

Introduction to Advanced Polymer Composites (APC): Definition, Polymer matrices, Thermoplastics Matrices, Manufacture and properties of PP-PVC-Aramid-PEEK-PPS-Poly sulfone.

Thermosetting Matrices: Manufacture and properties of Isophthalic polyester, Epoxy and Polyimide.

Elastomeric matrices: Manufacture and properties of PB-SBR

| **UNIT – II** | **10 Hrs** |
|---|---|

Reinforcement fibres: Manufacture and properties of PE fibre/ Nylon/Glass fibres/ Carbon fibres/CNT/Aramid**.**

Interface in PMC: Wettability, Types of bonding at the interface, Glass fibre-polymer, Aramid fibre-polymer, PE fibre-polymer

| **UNIT – III** | **10 Hrs** |
|---|---|

Processing of PMC: Thermoplastic matrix composite (Film stacking, Diaphragm forming, Tape laying, Injection moulding, Sheet Molding compound), Thermoset matrix composite (Hand lay-up and spray technique, Filament winding, Pultrusion, Resin transfer moulding, Prepregs).

| **UNIT – IV** | **10 Hrs** |
|---|---|

Designing with composites: Characteristics of composites, Design procedure, Hybrid composite systems, Carbon fibre composites. Fatigue and Creep behavior of PMC. Expressions for Thermal conductivity of composites

| **UNIT – V** | **08 Hrs** |
|---|---|

Testing of PMC: Flexural tests (Single fibre pull out test, Fragmentation test, Laser spallation test). Health and safety methods for PMC. Recycling and disposal methods.

Application of PMC: Aircraft, Automotive, and Construction industries, Military, Space and Medical devices.

**Course Outcome:**

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

1. Understand the properties of polymers and fibers
2. Apply the principles of interfacial science in polymer matrix composites
3. Analyze mechanical/thermal performance of polymer matrix composites
4. Design polymer composites for space, automotive, construction and medical applications

**Reference Books:**

After going through this course the student will be able to

1. K. K Chawla, “Composite Materials- Science and Engineering.” 3rd ed., Springer, 2012; ISBN 978-0-387-74364-6

2. M.H.Ferry, A.V. Becker, “Hand book of Polymer science and Technology”, CBS Publishers and Distributors, 2012; ISBN 978-81-239-1132-8

3.V.R. Gowarikar, N.V. Viswanathan, J. Sreedhar, “Polymer Science”, New Age International, 2015 (reprint); ISBN 978-81-224-3813-0

4. F.W.Billmeyer Jr., "Textbook of Polymer Science", John Wiley & Sons, 3rd ed., 2007; ISBN 978-81-265-1110-5

**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** | H | - | - | - | - | - | - | - | - | - | - |
| **CO2** | M | - | M | H | - | - | - | - | - | - | - |
| **CO3** | - | H | - | - | M | - | - | - | - | - | - |
| **CO4** | H | H | H | H | H | H | - | - | M | - | - |

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

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

| NANO FABRICATION | | | | |
|---|---|---|---|---|
| **Course Code** | **16MCH322** | | **CIE Marks** | **100** |
| **Hrs/Week** | **L: T: P: EL** | **4:0:0:0** | **SEE Marks** | **100** |
| **Credits** | **04** | | **SEE duration** | **03** |

**Course Learning Objectives:**

The students shall be able to:

1. Understand basic nomenclature, concepts and tools of nanofabrication.
2. Explain the differences between the surface and bulk dominated regimes and behavior.
3. Apply physical or chemical methods to develop layers on substrates.
4. Analyze the performance of fabricated structures

| UNIT – I | 08 Hrs |
|---|---|

**Introduction to microelectronics fabrication and Moore`s empirical law:** Limitation, Si processing methods - Cleaning/etching, oxidation, Gettering, doping, Epitaxy, Semiconductor device road map, Gate dielectrics, poly Si, High k dielectrics.

**Diffusion and Oxidation:** Junction depth, Concentration profile, Interstitial and substitutional diffusion, Constant source and limited source diffusion, Dopant redistribution, Lateral diffusion, Rapid thermal annealing, Gettering**.** Native oxide, Wet and dry oxidation, Electro-chemical oxidation, Solubility and diffusion of various species in oxide

| UNIT – II | 10 Hrs |
|---|---|

**Top-down Lithography techniques:** Necessity of clean room, Different types of clean rooms, Maintenance, Importance of Lithography techniques Photolithography, Electron Beam lithography, Extreme UV lithography, X-ray Lithography, Focused ion beam Lithography (FIB).

**Bottom - up approach**: Self-assembly and Lithography: self-assembly, self-assembled mono layers, directed assembly, layer-by layer assembly, patterned growth, control of position and diameter

| UNIT – III | 10 Hrs |
|---|---|

**Combinations of top-down and bottom-up techniques**:

Current state of the art - DNA self-assembly, Chemical vapour deposition of Nanostructures: Nanocrystals - Nanowires by catalytic (Au, Ni and Ag) and non-catalytic VLS approach, Patterned growth, Nanoimprint lithography (NIL), Soft polymer photoresistive moulding, Replica printing with stamp pads, RIE etching, Patterned growth, Control of position, Size and density. Dip-pen lithography (setup, working principle).

| UNIT – IV | 10 Hrs |
|---|---|

**Dry Etching :**

Plasma, anisotropic etch, equipment details and operation. Reactive ion etching (RIE), veil formation and de-veil, electrostatic discharge (ESD), aluminum etch, Chemical Mechanical planarization (CMP) basics, Dishing, Erosion, Issues in Shallow Trench Isolation. ,Oxide Polish and Copper Polish, Dummy fill, slotting.

**Wet Etching:**

Isotropic etch, selectivity, anisotropic Si etch in KOH, cleaning, micro loading and process proximity correction (ppc)., Chemicals for oxide and nitride removal, effect of dopants, photoresist development

**Course Outcome:**

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

1. Understand how interfacial science affects nanofabrication.
2. Apply physical and chemical deposition techniques in nanofabricated structures.

| |
|---|
| 3. Compare the performance of fabrication techniques.<br>4. Develop nanofabrication processes for specific electronic devices |
| **Reference Books** |

| | |
|---|---|
| **1.** | A.A Tseng, "Nanofabrication: Fundamentals and applications," World Scientific, 2008; ISBN 978-981270542-6 |
| **2.** | S.A. Campbell, "The science and engineering of microelectronic fabrication," Oxford University Press, 2nd ed., 2001; ISBN 978-0195136050 |
| **3.** | M. Madou, "Fundamentals of microfabrication," CRC press, 2nd edition, 2007; ISBN 978-084-9308-26-0 |
| **4.** | G. Cao, "Nanostructures and nanomaterials: Synthesis, properties and applications," Imperial College Press, 2nd ed., 2011; ISBN 978-971-4322-50-8 |
| **5.** | M. di Ventra, S. Evoy, and J.B. Heflin, Jr., (Eds.), "Introduction to Nanoscale Science and Technology", Springer, 2009; ISBN 978-1-4020-7720-3. |

**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** | H | M | - | - | - | M | - | - | - | - | - |
| **CO2** | H | - | M | - | L | M | - | - | - | - | - |
| **CO3** | M | H | M | L | - | L | M | M | - | - | - |
| **CO4** | H | M | H | H | L | M | M | - | L | - | L |

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

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

| COMPUTATIONAL FLUID DYNAMICS | | | | |
|---|---|---|---|---|
| **Course Code** | **16MCH331** | | **CIE Marks** | **100** |
| **Hrs/Week** | **L: T: P: EL** | **4:0:0:0** | **SEE Marks** | **100** |
| **Credits** | **04** | | **SEE duration** | **03** |

**Course Learning Objectives:**

The students shall be able to:

1. Understand limitations of analytical and experimental fluid dynamics and the need for computers for fluid flow studies
2. Explain the differences between various discretization schemes in terms of their regimes of validity
3. Apply computational tools to solve discretized equations
4. Analyze performance of various discretization schemes

| **UNIT -1** | **10 Hrs** |
|---|---|

**Introduction to CFD**

Introduction to CFD, CFD Applications, Numerical vs Analytical vs Experimental analysis, Modeling vs Experimentation.

Fundamental principles of conservation, Reynolds transport theorem, Conservation of mass, Conservation of linear momentum: Navier-Stokes equation, Conservation of Energy, General scalar transport equation.

| **UNIT – II** | **10-Hrs** |
|---|---|

**Differential Equations and Physical Behavior**

Mathematical classification of Partial Differential Equation, , Physical examples of elliptic, parabolic and hyperbolic partial differential equations, Error Minimization Principles, Approximate solution of differential equations through variational formulation, Boundary conditions in the variational form: Primary and secondary variables, Essential and natural boundary conditions, Properties of variational form, Weighted residual approach: trial function and weighting function, Requirement of trial function and weighting function, Least square method, Point Collocation method, Galerkin's method, Rayleigh-Ritz method

| **UNIT- III** | **10Hrs** |
|---|---|

**Discretization**

Discretization principles: Pre-processing, Solution, Post-processing, Finite Element Method, Finite difference method, Well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportiveness, Finite volume method (FVM), Illustrative examples: 1-D steady state heat conduction without and with constant source term , Discretization of Unsteady State Problems, Discretization of Time Dependent Problems,.

Discretization of the Momentum Equation: Stream Function-Vorticity approach and Primitive variable approach, Staggered grid and Collocated grid, SIMPLE Algorithm, SIMPLER Algorithm

| **UNIT – IV** | **10 Hrs** |
|---|---|

**Introduction to Turbulence Modeling**

Important features of turbulent flow, Vorticity transport equation, Statistical representation of turbulent flows: Homogeneous turbulence and isotropic turbulence, General Properties of turbulent quantities, Reynolds average Navier stokes (RANS) equation, Closure problem in turbulence: Necessity of turbulence modeling, Different types of turbulence model: Eddy viscosity models, Mixing length model, Turbulent kinetic energy and dissipation, The κ-ε model, Advantages and disadvantages of κ-ε model, More two-equation models: RNG κ-ε model and κ-ω model, Reynolds stress model (RSM),Large eddy Simulation (LES),Direct numerical simulation (DNS)

| UNIT – V | 10 Hrs |
|---|---|

Numerical grid generation; basic ideas; transformation and mapping.
About the CFD softwares for different applications and construction of geometry and Discretions using available commercial CFD solvers. Creating and meshing a basic geometry. Any 5 Basic problems ( eg. Basic flow studies in pipe Modeling a mixing elbow (2-D). Modeling a three-pipe intersection (3-D).Modeling flow in a tank,Modeling a combustion chamber (3-D).

**Course Outcome:**

After going through this course, students will be able to

1. Understand basic concepts and use of tools of computational fluid dynamics.
2. Apply engineering approximation to obtain discretized fluid dynamics equations
3. Explain characteristics of regimes covered by various discretized schemes.
4. Develop computer code to solve the discretized equations.

**Reference Books :**


1. Anderson Jr., J.D., "Computational Fluid Dynamics: The Basics with Application", McGraw Hill, 6th ed., 1995; ISBN 978-0070016859
2. Anderson, D.A., Tannehill, J.C. and Pletcher, R.H., "Computational Fluid Mechanics and Heat Transfer", CRC Press, 3rd ed., 2012; ISBN 978-159169037
3. Patankar, S.V., "Numerical Heat Transfer and Fluid Flow", CRC Press, 1st ed., 1980; ISBN 978-0891165224
4. Ferziger, J.H. and Peric, M., "Computational Methods for Fluid Dynamics", Springer, 3rd ed., 2002; ISBN 978-3-642-56026-2
5. Versteeg, H.K. and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", Prentice-Hall India, 2nd ed., 2007; ISBN 978-0131274983


**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** | **H** | **-** | **-** | **-** | **L** | **-** | **-** | **-** | **-** | **-** | |
| **CO2** | **H** | **M** | **H** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | |
| **CO3** | **H** | **H** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | |
| **CO4** | **H** | **H** | **H** | **H** | **H** | **-** | **-** | **-** | **-** | **-** | **-** |

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

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

| OIL AND GAS PROCESSING | | | | |
|---|---|---|---|---|
| **Course Code** | **16MCH331** | | **CIE Marks** | **100** |
| **Hrs/Week** | **L:T: P: EL** | **4:0:0:0** | **SEE Marks** | **100** |
| **Credits** | **04** | | **SEE duration** | **03** |

**Course Learning Objectives:**

The students shall be able to:

1. Understand basic concepts and applications of Natural Gas Engineering.
2. Analyze the processes of separation and treatment of produced oil
3. Apply onshore and offshore oil processing technology.
4. Evaluate corrosion and performance of preventive methods

| **UNIT -1** | **10 Hrs** |
|---|---|

Lube oil processing, Propane de-asphalting, Solvent extraction, Dewaxing, Finishing processes, Lube oil additives, Properties of bitumen, Methods of manufacture of bitumen product blending, Hydrogen production, Sulphur recovery.

| **UNIT – II** | **10-Hrs** |
|---|---|

Two phase oil and gas separation equipment, types, construction detail, working principle, internal sizing, theory of separation and detail design of separator. Three phase separators, types, construction detail, working principle, vessel internal and control equipment. Theory and sizing of three phase separator. Filters, Vacuum towers

| **UNIT- III** | **10Hrs** |
|---|---|

Theory of emulsions: De-emulsifiers, treating systems, equipment sizing and heat calculations. Skimmer tanks, operations and sizing.

Crude stabilization unit. Storage of crude oil, evaporation losses and safety.

Safety systems for onshore and offshore oil and gas processing.

| **UNIT – IV** | **10 Hrs** |
|---|---|

Gas liquid separations: dehydration processes, physical and chemical absorption, adsorption by gas permeation, solid bed sweetening process, acid gas removal.

Integrated natural gas processing, Compressor selection and application.

| **UNIT – V** | **10 Hrs** |
|---|---|

Corrosion mechanism and influencing factors, corrosion prevention methods and materials, chemical inhibitors, cathodic protection, protective coatings - use of polymers, removal of corrosive gases.

**Course Outcome:**

At the end of the course the students will be able to

1. Understand working principle of oil and gas processing equipments.
2. Apply techniques for oil and natural gas processing.
3. Analyze performance of processing equipments in oil and natural gas processing.
4. Develop systems for corrosion prevention, safety and integrated gas processing

**Reference Books :**


1. Bhaskararao, B.K, 'Modern Petroleum Refining Processes', Oxford and IBH Publishing Co. Pvt. Ltd., Fifth Edition, 2008, ISBN: 9788120417151.
2. Gary, J.H and Handework, G.E., *'Petroleum Refining Technology and Economics'*, Marcel Dekker, Inc., 5th ed., 2007, ISBN 9780849370380.
3. Ram Prasad, 'Petroleum Refining Technology', Khanna Publishers, 1st ed., 2015, ISBN-10: 8174090649
4. Bahaduri Alireza, 'Natural Gas Processing: Theory and Engineering Design', Gulf Publishing Company, 1st ed., 2014; ISBN 9780080999715.
   Fahim, M.A., Alsahhaf, T.A. and Elkilani, A. 'Fundamentals of Petroleum Refining', Elsevier, 1st ed., 2010, ISBN 9780444527851.

**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** | **H** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| **CO2** | **H** | **-** | **M** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| **CO3** | **H** | **H** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| **CO4** | **H** | **-** | **H** | **M** | | **H** | **M** | **-** | **L** | **-** | **-** |

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

| | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| **CO1** | H | H | - |
| **CO2** | H | H | - |
| **CO3** | H | H | - |
| **CO4** | H | H | H |

| SOLAR PHOTOVOLTAIC SYSTEMS AND TECHNOLOGY | | | | |
|---|---|---|---|---|
| **Course Code** | **16MCH341** | | **CIE Marks** | **100** |
| **Hrs/Week** | **L: T: P: EL** | **4:0:0:0** | **SEE Marks** | **100** |
| **Credits** | **04** | | **SEE duration** | **03** |

**Course Learning Objectives:**

1. Understand need for solar photovoltaic systems in current energy scenario
2. Apply basic semiconductor theory for characterization of solar photovoltaic systems
3. Analyze performance of solar photovoltaic systems
4. Evaluate feasibility of solar photovoltaic energy grid technology

| **UNIT – I** | 10Hrs |
|---|---|

**Introduction**

Types of material- classification of semiconductor-Crystals structures, atomic bonding, energy band diagram – direct & indirect band gap semiconductors. Doping and carrier concentration - Hall effect in semiconductors – diffusion and drift of carriers, continuity equation – optical absorption – carrier recombination-Effect of temperature. P-N junctions-I-V characteristics-Types of junctions-homojunction-heterojunctions-Rectifying- Schottky barriers, MIS, and its characteristics.

| **UNIT – II** | 10 Hrs |
|---|---|

**Photovoltaic Fundamentals**

Photovoltaic effect - Choice of semiconductor materials for fabrication of homojunction solar cells - equivalent circuit of a solar cell. Solar cell output parameters -Fill-factor, conversion efficiency, quantum efficiency. Effect of series and shunt resistance on the efficiency of solar cells. Variation of Open-circuit voltage and short circuit current with intensity of incident light. Effect of temperature on I-V characteristics. p-n heterojunction solar cells - criteria for choosing absorber and window layers.

| **UNIT – III** | 10Hrs |
|---|---|

**Silicon Photovoltaics**

Single crystal silicon (c-Si) ingot growth – Float Zone and Czochrolski methods – silicon wafer fabrication – wafer to cell formation - I-V characteristics and spectral response of c-Si solar cells. Factors limiting the efficiency - Polysilicon wafer fabrication methods – EFG and SRG methods. Amorphous Silicon - differences in properties between crystalline silicon and amorphous (a-Si) silicon. a-Si deposition by glow discharge method – Electrical and optical properties of a-Si. Outline of a-Si solar module processing steps. Heterojunction Intrinsic Thin film solar cell – fabrication by PECVD - I-V characteristics

| **UNIT – IV** | 10Hrs |
|---|---|

**Thin Film Solar Cells**

Principle of multi-junction cells– Structure and fabrication of GaInP/GaAs/Ge triple junction solar cell –Metamorphic solar cells. CdTe/CdS and CuInGaSe/CdS (CIGS) solar cells - Cell configuration – techniques used for the deposition of each layer- cell characteristics. Organic solar cells – Configuration and principle – Types of organic solar cells, Dye-sensitized (DS) solar cells – Principle – Configuration and performance, Basic concept of quantum dot, nano wire (NW), hot carrier and plasmonic solar cells

| **UNIT – V** | 10Hrs |
|---|---|

**Solar Photovoltaic Systems**

Photovotaic Module Assembly: Description of steps involved in the fabrication of Silicon Photovoltaic Module - Performance of photovoltaic module - Module protection - Modules in series

and in parallel - Use of bypass and blocking diodes, Solar photovoltaic system - components – PV Array, battery, invertor and load. Applications of solar photovoltaic systems. Stand alone, Hybrid and Grid connected PV systems

**Course Outcome:**

At the end of the course the students will be able to

1. Understand the principles for conversion of solar energy to electrical energy.
2. Apply semiconductor theory to develop solar photovoltaic systems.
3. Evaluate performance of solar photovoltaic devices.
4. Develop technology for integrated solar modules and grid connectivity.

**Reference Books :**

1. M. S. Tyagi, "Introduction to semiconductor materials and devices", John Wiley & Sons, 2008; ISBN: 978-812-6518-678
2. C.S. Solanki, "Solar photovoltaics: Fundamentals, technologies and applications", Prentice Hall India, 2015; ISBN: 978-812-0343-863
3. A.L. Farenbruch, R.H. Bube, "Fundamentals of solar cells", Elsevier, 1st ed., 1983; ISBN 9780323145381
4. T. Bhattacharya, "Terrestrial solar photovoltaics", Narosa, 1998; ISBN 978-8173192067

**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 | H | - | - | | | M | | | | | |
| CO2 | H | H | L | | | M | | | | | |
| CO3 | - | H | - | - | | - | | | | | L |
| CO4 | H | H | H | H | M | H | H | | M | | H |

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

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

| CHEMICAL PROCESS INTEGRATION | | | | |
|---|---|---|---|---|
| **Course Code** | **16MCH342** | | **CIE Marks** | **100** |
| **Hrs/Week** | **L: T: P: EL:** | **4:0:0:0** | **SEE Marks** | **100** |
| **Credits** | **04** | | **SEE duration** | **03** |

**Course Learning Objectives:**

1. Understand the possibilities of mass and energy integration
2. Target a specific task by quantification
3. Apply alternative routes for integration
4. Analyze the alternatives and generate optimal solution

| **UNIT – I** | 10Hrs |
|---|---|

**Introduction to Process Integration:** Process Synthesis, Process Analysis, Targeting minimum waste, minimum purchase, strategies for targets.

| **UNIT – II** | 10Hrs |
|---|---|

**Graphical Techniques:** Sources, sinks, recycle routes, Direct-Recycle, pinch diagram, design rules, multi component mapping diagram

| **UNIT – III** | 10Hrs |
|---|---|

**Synthesis of Mass Exchange Networks:** design of Individual mass exchangers, mass exchange networks, pinch diagram for development of mass integrated system

| **UNIT – IV** | 10Hrs |
|---|---|

**Algebraic Approach:** Algebraic approach to targeting direct recycles and targeting mass exchange.

**Heat Integration:** Thermal Pinch Diagram, minimum utility targeting, cascade diagrams for heat integration.

| **UNIT – V** | 08Hrs |
|---|---|

**Combined Heat and Power Integration:** Heat engines, heat pumps, vapor compression, vapor absorption, placement of heat engines, heat cogeneration targeting, case study

**Course Outcomes:**

At the end of the course the student's will be able to

1. Understand the fundamentals, strategies and approaches of process integration.
2. Apply process integration strategies on chemical engineering systems for mass and utility targeting.
3. Analyze chemical engineering processes to identify limits on process integration.
4. Evaluate purchase, waste, energy minimization in chemical engineering processes.

**Reference Books :**


1. Mahmoud M El-Halwagi, “Process Integration”, 1st ed., Elsevier Academic Press, 2006, ISBN – 13: 978 0 12 370532 7
2. Ian C. K, "Pinch Analysis and Process Integration", 2nd ed., Elsevier BH, 2007, ISBN – 13: 978 0 75068 260 2
3. Robin Smith, “Chemical Process Design and Integration”, 2nd ed., John Wiley & Sons, 2005, ISBN – 0 471 48681 7
4. Shenoy U. V. "Heat Exchanger Network Synthesis", 1st ed., Gulf Professional Publishing, 1995, ISBN – 0 884 15391 6


**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 | L | L | L | L | - | - | - | - | - | - |
| **CO2** | M | M | M | M | M | L | L | - | - | - | M |
| **CO3** | M | M | M | M | M | M | M | - | - | - | M |
| **CO4** | H | H | H | H | H | M | H | - | - | - | H |

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

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

| INTERNSHIP / INDUSTRIAL TRAINING | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **16MCH35** | | **CIE Marks** | **:** | **100** |
| **Hrs/Week** | **:** | **L:T:P:S** | **0:0:6:0** | **SEE Marks** | **:** | **100** |
| **Credits** | **:** | **3** | | **SEE Duration** | **:** | **30 min** |

**GUIDELINES FOR INTERNSHIP**

**Course Learning Objectives (CLO):**

The students shall be able to:

(1) Understand the process of applying engineering knowledge to produce product and provide services.

(2) Explain the importance of management and resource utilization

(3) Comprehend the importance of team work, protection of environment and sustainable solutions.

(4) Imbibe values, professional ethics for life long learning.

1) The duration of the internship shall be for a period of 8 weeks on full time basis between II semester final exams and beginning of III semester.
2) The student must submit letters from the industry clearly specifying his / her name and the duration of the internship on the company letter head with authorized signature.
3) Internship must be related to the field of specialization or the M.Tech program in which the student has enrolled.
4) Students undergoing internship training are advised to use ICT tools such as skype to report their progress and submission of periodic progress reports to the faculty members.
5) Every student has to write and submit his/her own internship report to the designated faculty.
6) Students have to make a presentation on their internship activities in front of the departmental committee and only upon approval of the presentation should the student proceed to prepare and submit the hard copy of the internship final report. However interim or periodic reports and reports as required by the industry / organization can be submitted as per the format acceptable to the respective industry /organizations.
7) The reports shall be printed on bond paper – 80GSM, back to back print, with soft binding – A4 size with 1.5 spacing and times new roman font size 12.
8) The broad format of the internship final report shall be as follows
    - Cover Page
    - Certificate from College
    - Certificate from Industry / Organization
    - Acknowledgement
    - Synopsis
    - Table of Contents
    - Chapter 1 - Profile of the Organization – Organizational structure, Products, Services, Business Partners, Financials, Manpower, Societal Concerns, Professional Practices,
    - Chapter 2 - Activities of the Department -
    - Chapter 3 – Tasks Performed – summaries the tasks performed during 8 week period
    - Chapter 4 – Reflections – Highlight specific technical and soft skills that you acquired during internship

- References & Annexure

**Course Outcomes:**
After going through the internship the student will be able to:
CO1: Apply engineering and management principles
CO2: Analyze real-time problems and suggest alternate solutions
CO3: Communicate effectively and work in teams
CO4: Imbibe the practice of professional ethics and need for lifelong learning.

**Scheme of Continuous Internal Evaluation (CIE):**

A committee comprising of the Head of the Department / Associate Dean, Associate Professor, Assistant Professor and Guide would review the presentation and the progress reports in two phases. The evaluation criteria shall be as per the rubrics given below:

**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) Explanation of the application of engineering knowledge in industries 35%
(2) Ability to comprehend the functioning of the organization/ departments 20%
(3) Importance of resource management, environment and sustainability 25%
(4) Presentation Skills and Report 20%

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

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

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

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

## GUIDELINES FOR INDUSTRIAL TRAINING

**Course Learning Objectives (CLO):**
The students shall be able to:
(1) Understand the process of applying engineering knowledge to industrial products & processes
(2) Explain the importance of skilling, training and resource management.
(3) Comprehend the importance of team work, communication and sustainable solutions.
(4) Imbibe values, professional ethics for life long learning.

1) The duration of industrial training must be for a minimum of 1 week and maximum of 8 weeks on full time basis.
2) Industrial Training in which students pays a fee to the organization / industry will not be considered.
3) He/she can undergo training in one or more industry /organization.
4) The student must submit letters from the industry clearly specifying his / her name and the duration of the training provided by the company with authorized signatures.
5) Industrial training must be related to the field of specialization or the M.Tech program in which the student has enrolled.
6) Students undergoing industrial training are advised to use ICT tools such as skype to report their progress and submission of periodic progress reports to the faculty members.
7) Every student has to write and submit his/her own industrial training report to the designated faculty.
8) Students have to make a presentation on their industrial training in front of the departmental cmmittee and only upon approval of the presentation should the student proceed to prepare and submit the hard copy of the final report.
9) The reports shall be printed on bond paper – 80GSM, back to back print, with soft binding – A4 size with 1.5 spacing and times new roman font size 12.
10) The broad format of the industrial training report shall be as follows
    - Cover Page
    - Certificate from College
    - Training Certificate from Industry / Organization
    - Acknowledgement
    - Executive Summary
    - Table of Contents
    - Chapter 1 - Profile of the Organization –Organizational structure, Products, Services, Business Partners, Financials, Manpower, Societal Concerns, Professional Practices
    - Chapter 2 – Details of the Training Modules
    - Chapter 3 – Reflections – Highlight specific technical and soft skills that you acquired

    References & Annexure

**Course Outcomes:**

After going through the industrial training the student will be able to:

CO1: Understand the process of applying engineering knowledge to solve industrial problems
CO2: Develop skills through training relevant to industrial requirement
CO3: Communicate effectively and work in teams
CO4: Imbibe ethical practices and develop it as life skill.

**Scheme of Continuous Internal Evaluation (CIE):**

A committee comprising of Head of the Department / Associate Dean, Associate Professor, Assistant Professor and Guide would review the presentation and the progress reports in two phases. The evaluation criteria shall be as per the rubrics given below:

**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) Explanation on the application of engineering knowledge | 25% |
| (2) Ability to comprehend the importance of skilling and training | 25% |
| (3) Importance of communication, professional ethics, sustainability | 20% |
| (4) Oral Presentation and Report | 30% |

## GUIDELINES FOR INDUSTRIAL VISITS

**Course Learning Objectives (CLO):**

The students shall be able to:

(1) Understand the role of industries and service organization in meeting the demands of the society.
(2) Explain the working of different industries and organizations with an engineering perspective
(3) Comprehend the importance of team work, communication and sustainable solutions.
(4) Imbibe values, professional ethics for life long learning.

1) Student must visit a minimum of THREE organizations/industry. The duration of the visit per organization must be for ONE full day, during which he/she must comprehend the importance of organization structure, function of various departments, application of engineering knowledge, resource management, importance to environment and safety, professional ethics.
2) It is mandatory to visit ONE private multi-national company or public sector industry / organization, ONE medium-small enterprise and ONE rural based or NG organization.
3) The student must submit letter from the industry clearly specifying his / her name and the date of visit to the industry with authorized signatures.
4) Industrial visit must be related to the field of specialization or the M.Tech program in which the student has enrolled.
5) Every student has to write and submit his/her own report on each industrial visit and submit the report to the designated faculty advisor for evaluation.
6) A photograph outside the industry with the name and logo of the industry in the background along with the students and faculty members could be included in the report.
7) Students have to make a presentation on their industrial visit in front of the departmental committee and only upon approval of the presentation should the student proceed to prepare and submit the hard copy of the final report.
8) The reports shall be printed on bond paper – 80GSM, back to back print, with soft binding – A4 size with 1.5 spacing and times new roman font size 12.
9) The broad format of the industrial visit report shall be as follows
    - Cover Page
    - Certificate from College
    - Acknowledgement
    - Synopsis / Executive Summary
    - Table of Contents
    - Chapter 1 - Profile of the PSU or MNC – must include Organizational structure,

Products, Services, Financials, Manpower, Societal Concerns, Professional Practices

- Chapter 2 – Profile of the SME – must include Organizational structure, Products, Services, Financials, Manpower, Societal Concerns, Professional Practices
- Chapter 3 - Profile of the NGO – must include Organizational structure, services, Manpower, Societal Concerns, Professional Practices
- Chapter 4 – Comparative Analysis of PSU/MNC – SME – NGO
- References & Annexure (Permission letters from the organizations for the visit & photographs)

**Course Outcomes:**

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

CO1: Classify the role of different industries and organization in addressing the needs of the society.

CO2: Explain the process of applying engineering knowledge in industries and organizations.

CO3: Describe the importance of communication and team work

CO4: Recognize the importance of practicing professional ethics and need for life skills.

**Scheme of Continuous Internal Evaluation (CIE):**

A committee comprising of Head of the Department / Associate Dean, Associate Professor, Assistant Professor and Guide would review the presentation and the progress reports in two phases. The evaluation criteria shall be as per the rubrics given below:

**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) Explanation of the application of engineering knowledge in industries 25%
(2) Ability to comprehend the functioning of the organization/ departments 30%
(3) Importance of resource management, environment and sustainability 20%
(4) Presentation Skills and Report 25%

| TECHNICAL SEMINAR | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **16MCH36** | | **CIE Marks** | **:** | **50** |
| **Hrs/Week** | **:** | **L:T:P:S** | **0:0:4:0** | **SEE Marks** | | **50** |
| **Credits** | **:** | **2** | | **SEE Duration** | | **30 min** |

**Course Learning Objectives (CLO):**

The students shall be able to:

(1) Understand the technological developments in their chosen field of interest
(2) Explain the scope of work and challenges in the domain area
(3) Analyze these engineering developments in the context of sustainability and societal concerns.
(4) Improve his/her presentation skills and technical report writing skills

**GUIDELINES**

1) The presentation will have to be done by individual students.
2) The topic of the seminar must be in one of the thrust areas with in-depth review and analysis on a current topic that is relevant to industry or on-going research.
3) The topic could be an extension or complementary to the project
4) The student must be able to highlight or relate these technological developments with sustainability and societal relevance.
5) Each student must submit both hard and soft copies of the presentation.

**Course Outcomes:**

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

CO1:Identify topics that are relevant to the present context of the world
CO2: Perform survey and review relevant information to the field of study.
CO3: Enhance presentation skills and report writing skills.
CO4: Develop alternative solutions which are sustainable

**Scheme of Continuous Internal Evaluation (CIE):** Evaluation would be carried out in TWO phases. The evaluation committee shall comprise of Head of the Department / Associate Dean, Associate Professor, Assistant Professor and Guide. The evaluation criteria shall be as per the rubrics given below:

**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.

**Rubrics for Evaluation:**

1) Topic – Technical Relevance, Sustainability and Societal Concerns 15%
2) Review of literature 25%
3) Presentation Skills 35%
4) Report 25%

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

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

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

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

# IV SEMESTER

| MAJOR PROJECT | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **16MCH41** | | **CIE Marks** | **:** | **100** |
| **Hrs/Week** | **:** | **L:T:P:S** | **0:0:52:0** | **SEE Marks** | **:** | **100** |
| **Credits** | **:** | **26** | | **SEE Duration** | **:** | **3 Hours** |

**Course Learning Objectives:**

The students shall be able to

1. Understand the method of applying engineering knowledge to solve specific problems.
2. Apply engineering and management principles while executing the project
3. Demonstrate good verbal presentation and technical report writing skills.
4. Identify and solve complex engineering problems using professionally prescribed standards.

**GUIDELINES**

1. Major project will have to be done by only one student in his/her area of interest.
2. Each student has to select a contemporary topic that will use the technical knowledge of their program of specialization.
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 three.
5. The project can be carried out on-campus or in an industry or an organization with prior approval from the Head of the Department.
6. The standard duration of the project is for 16 weeks, however if the guide and the evaluation committee of the department, after the assessment feel that the work is insufficient and it has to be extended, then the student will have to continue as per the directions of the guide and the committee.
7. It is mandatory for the student to present his/her work in one of the international conferences or publish the research finding in a reputed unpaid journal with impact factor.

**Course Outcomes:**

After going through this course the students will be able to

**CO1:** Conceptualize, design and implement solutions for specific problems.

**CO2:** Communicate the solutions through presentations and technical reports.

**CO3:** Apply project and resource managements skills, professional ethics, societal concerns

**CO4:** Synthesize self-learning, sustainable solutions and demonstrate life long learning

**Scheme of Continuous Internal Examination (CIE)**

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

| Phase | Activity | Weightage |
|---|---|---|
| **I** 5th week | Synopsis, Preliminary report for the approval of selected topic along with literature survey, objectives and methodology. | 20% |
| **II** 10th week | Mid-term progress review shall check the compliance with the objectives and methodology presented in Phase I, review the work performed. | 40% |

| | | |
|---|---|---|
| **III** 15th week | Oral presentation, demonstration and submission of project report. After this presentation, the student will have one week time to correct / modify his report to address the issues raised by the committee members. | 40% |

**CIE Evaluation shall be done with marks distribution as follows:**

- Selection of the topic & formulation of objectives 10%
- Design and simulation/ algorithm development/experimental setup 25%
- Conducting experiments / implementation / testing / analysis 25%
- Demonstration & Presentation 20%
- Report writing 20%

**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 write-up about the project 5%
2. Formulation of Project Objectives & Methodology 20%
3. Experiments / Analysis Performed; 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 | H | H | M | H | H | M | M | L | L | L | L |
| CO2 | M | M | M | M | M | M | M | H | L | L | L |
| CO3 | L | L | L | M | M | L | H | L | L | L | L |
| CO4 | L | L | M | M | M | H | M | L | H | H | H |

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

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

| SEMINAR | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **16MCH42** | | **CIE Marks** | **:** | **50** |
| **Hrs/Week** | **:** | **L:T:P:S** | **0:0:4:0** | **SEE Marks** | | **50** |
| **Credits** | **:** | **2** | | **SEE Duration** | | **30 min** |

**Course Learning Objectives (CLO):**

The students shall be able to:

1) Understand the technological developments in their chosen field of interest
2) Explain the scope of work and challenges in the domain area
3) Analyze these engineering developments in the context of sustainability, societal concerns and project management.
4) Improve his/her verbal presentation and report writing skills

**GUIDELINES**

1) The presentation will have to be done by individual students.
2) The topic of the seminar must be in one of the thrust areas with in-depth review and analysis on a current topic that is relevant to industry or on-going research.
3) The topic could be an extension or complementary to the project topic.
4) Topics could be in multidisciplinary areas and strongly address the technical design issues.
5) The student must be able to highlight or relate these technological developments with sustainability and societal relevance.
6) The students must mandatorily address legal, ethical issues as related to the topic of study.
7) The student shall make an attempt to perform financial / cost analysis or apply project management tools as related to his/her topic of study.
8) Each student must submit both hard and soft copies of the presentation.

**Course Outcomes:**

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

CO1: Identify topics that are relevant in the present context of the world and relate it to sustainability and societal relevance.

CO2: Perform literature/market/product survey and analyse information to the field of study.

CO3: Enhance presentation and report writing skills.

CO4: Develop creative thinking abilities.

**Scheme of Continuous Internal Evaluation (CIE):** Evaluation would be carried out in TWO phases. The evaluation committee shall comprise of TWO senior faculty members. The evaluation criteria shall be as per the rubrics given below:

**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.

**Rubrics for Evaluation:**

- Topic – Technical Relevance, Sustainability and Societal Concerns 15%
- Literature Review 25%
- Presentation Skills 35%
- Report 25%

**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 | H | L | M | L | L | M | |
| **CO2** | M | H | M | M | L | L | L | L | L | | |
| **CO3** | L | L | M | - | L | H | L | H | L | | |
| **CO4** | L | L | - | L | L | L | L | L | H | | |

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

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