RAMAIAH
Institute of Technology

# CURRICULUM

**for the Academic year 2022 – 2023**

## CHEMICAL ENGINEERING

**VII & VIII SEMESTER B.E.**


**RAMAIAH INSTITUTE OF TECHNOLOGY**
(Autonomous Institute, Affiliated to VTU)
Bangalore – 560054.

## About the Institute:

Dr. M. S. Ramaiah a philanthropist, founded 'Gokula Education Foundation' in 1962 with an objective of serving the society. M S Ramaiah Institute of Technology (MSRIT) was established under the aegis of this foundation in the same year, creating a landmark in technical education in India. MSRIT offers 17 UG programs and 15 PG programs. All these programs are approved by AICTE. All eligible UG and PG programs are accredited by National Board of Accreditation (NBA). The institute is accredited with **'A$^{+}$' grade by NAAC in March 2021** for 5 years. University Grants Commission (UGC) & Visvesvaraya Technological University (VTU) have conferred Autonomous Status to MSRIT for both UG and PG Programs since 2007. The institute is also been conferred autonomous status for Ph.D program since 2021. The institute is a participant to the Technical Education Quality Improvement Program (TEQIP), an initiative of the Government of India. The institute has 380 competent faculty out of which 65% are doctorates. Some of the distinguished features of MSRIT are: State of the art laboratories, individual computing facility for all faculty members, all research departments active with sponsored funded projects and more than 300 scholars pursuing Ph.D. To promote research culture, the institute has established Centre of Excellence for Imaging Technologies, Centre for Advanced Materials Technology, Centre for Antennas and Radio Frequency systems (CARFS), Center for Cyber Physical Systems, Schneider Centre of Excellence & Centre for Bio and Energy Materials Innovation. **M S Ramaiah Institute of Technology has obtained "Scimago Institutions Rankings" All India Rank 107 & world ranking 600 for the year 2022.**

The Entrepreneurship Development Cell (EDC) and Section 8 company "Ramaiah Evolute" have been set up on campus to incubate startups. **M S Ramaiah Institute of Technology is recognized by Atal Ranking of Institutions on Innovation Achievements (ARIIA), MoE, Govt. of India.** MSRIT has a strong Placement and Training department with a committed team, a good Mentoring/Proctorial system, a fully equipped Sports department, large air-conditioned library with good collection of book volumes and subscription to International and National Journals. The Digital Library subscribes to online e-journals from Elsevier Science Direct, IEEE, Taylor & Francis, Springer Link, etc. MSRIT is a member of DELNET, CMTI and VTU E-Library Consortium. MSRIT has a modern auditorium and several hi-tech conference halls with video conferencing facilities. The institute has excellent hostel facilities for boys and girls. MSRIT Alumni have distinguished themselves by occupying high positions in India and abroad and are in touch with the institute through an active Alumni Association.

**As per the National Institutional Ranking Framework (NIRF), MoE, Government of India, M S Ramaiah Institute of Technology has achieved 67$^{th}$ rank among 1249 top Engineering Institutions & 17$^{th}$ Rank for School of Architecture in India for the year 2022 and is 1$^{st}$ amongst the Engineering Colleges affiliated to VTU, Karnataka.**

## About the Department:

Instituted in 1978, the Department was the first to offer a course in Chemical Engineering by a self-financing engineering institution in Bangalore and the fifth in RIT. Since its inception the department has moved steadily towards the fulfilment of its mission and is emerging as a significant player in the academic landscape of Chemical Engineering education in our country. The Department is certified four times in succession by the National Board for Accreditation. Over 2000 students have graduated in 34 batches. The Department offers excellent infrastructure and students have won various prestigious awards, international internships and high accolades for innovative projects. The expertise of the faculty covers a wide range of disciplines and they are engaged in cutting edge technological research. The average experience of faculty in the department is more than twenty years and they are alumni of IISc, IIT and NITs. Enriching insights by eminent dignitaries from the practicing world are arranged under the activities of IIChE Student Chapter at the Institute. The Department is approved as Research Centre by VTU for higher qualifications like M.Sc. Engg. (By Research) and Ph.D. degrees. Research Projects from DRDO, AICTE and DST have been successfully completed. The Annual Technical Symposium organized by the department for students – RASAYAN encompasses a plethora of events such as Paper presentations, Poster presentations, M.S. Ramaiah Memorial Technical Quiz etc. to challenge the young minds. The Bangalore Regional Centre of the Indian Institute of Chemical Engineers is functioning from this department for more than a decade. The country's most prestigious event in Chemical Engineering - Indian Chemical Engineering Congress - CHEMCON-2011 was organized here. The event invited the top chemical engineers of the nation to our Institute. A joint session with Canadian Universities in the area of Energy and Environment was also a part of this event.

# VISION OF THE INSTITUTE

To be an Institution of International Eminence, renowned for imparting quality technical education, cutting edge research and innovation to meet global socio-economic needs

## MISSION OF THE INSTITUTE

MSRIT shall meet the global socio-economic needs through

- Imparting quality technical education by nurturing a conducive learning environment through continuous improvement and customization
- Establishing research clusters in emerging areas in collaboration with globally reputed organizations
- Establishing innovative skills development, techno-entrepreneurial activities and consultancy for socio-economic needs

## QUALITY POLICY

We at M S Ramaiah Institute of Technology strive to deliver comprehensive, continually enhanced, global quality technical and management education through an established Quality Management System complemented by the synergistic interaction of the stake holders concerned

## VISION OF THE DEPARTMENT

To be a leading chemical engineering department for imparting quality technical education and progressive research at global level.

## MISSION OF THE DEPARTMENT

1. To provide a state of art environment and a rigorous academic program that train students to excel in fundamental sciences, chemical and allied engineering fields.
2. To offer a programme that inculcates creative thinking and lifelong learning contributing to the advancements in chemical sciences and its application.
3. To foster principles of sustainability and promote environmentally benign technologies for the benefit of society.

## PROGRAM EDUCATIONAL OBJECTIVES (PEOs):

The B.E. Chemical Engineering Program at Ramaiah Institute of Technology aims to provide a strong foundation of scientific and technical knowledge in a state of art learning ambience. It equips the graduates with problem solving abilities, teamwork, and communication skills necessary throughout their careers. They are consistent with the following Educational Objectives:

1. To produce graduates with a strong foundation and understanding of the fundamental principles of mathematics, science and engineering enabling graduates to pursue their careers as practicing chemical engineers in Chemical and Allied Engineering fields.
2. To produce graduates who are prepared to pursue their post-graduation and Research in the emerging and allied areas of Chemical Engineering and Business.
3. To produce graduates who possess skills with professional integrity and ethics to assume professional leadership roles and administrative positions.
4. To provide students with opportunities to integrate with multidisciplinary teams to develop and practice written and oral communication skills.

## PROGRAM OUTCOMES (POs):

**PO1: Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

**PO2: Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

**PO3: Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

**PO4: Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

**PO5: Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

**PO6: The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

**PO7: Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

**PO8: Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

**PO9: Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

**PO10: Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

**PO11: Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

**PO12: Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

**PROGRAM SPECIFIC OUTCOMES (PSOs):**

The Chemical Engineering graduate will be able to

**PSO1:** Acquire in-depth knowledge of chemical engineering, process economics, management, safety and environmental aspects required to pursue their career in chemical industry and allied engineering areas.

**PSO2:** Apply computational and simulation tools to solve, design and optimize chemical engineering problems/ processes.

**PSO3:** Design processes, perform experiments, prepare technical and management modules, economic evaluation and demonstrate professional engineering competence.

## Curriculum Course Credits Distribution

## Batch 2019-2020

| Course Category \ Semester | First | Second | Third | Fourth | Fifth | Sixth | Seventh | Eighth | Total Credits |
|---|---|---|---|---|---|---|---|---|---|
| **Basic Sciences (BSC)** | 9 | 8 | 4 | 4 | | | | | **25** |
| **Engineering Sciences (ESC)** | 11 | 10 | | | | | | | **21** |
| **Humanities, Social Sciences and Management (HSMC)** | | 2 | | | 3 | | 3 | | **8** |
| **Professional Courses – Core (PCC)** | | | 21 | 21 | 15 | 11 | 10 | | **78** |
| **Professional Courses– Elective (PEC)** | | | | | 3 | 6 | 6 | | **15** |
| **Other Open Elective Courses (OEC)** | | | | | 3 | 3 | | | **6** |
| **Project Work (PROJ), Internship (IN)** | | | | | | 4 | 1 | 17 | **22** |
| **Total Credits** | **20** | **20** | **25** | **25** | **24** | **24** | **20** | **17** | **175** |

## SCHEME OF TEACHING VII SEMESTER

| Sl. No. | Course Code | Course Name | Category | Credits | | | | Contact Hours |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | Total | |
| 1. | **CH71** | Process Integration | PCC | 4 | 0 | 0 | 4 | 04 |
| 2. | **CH72** | Transport Phenomena | PCC | 3 | 1 | 0 | 4 | 05 |
| 3. | **CH73** | Economics and Entrepreneurship | PCC | 3 | 0 | 0 | 3 | 03 |
| 4. | **CHE74x** | Professional Elective – IV | OE | 3 | 0 | 0 | 3 | 03 |
| 5. | **CHE75x** | Professional Elective – V | PCE | 3 | 0 | 0 | 3 | 03 |
| 6. | **CHL76** | Process Simulation Lab | PCE | 0 | 0 | 1 | 1 | 02 |
| 7. | **CHL77** | Process Control Lab | PCC | 0 | 0 | 1 | 1 | 02 |
| 8. | **CHSE** | Seminar | PCC | 0 | 0 | 1 | 1 | 02 |
| **Total** | | | | **16** | **1** | **3** | **20** | **24** |

**Professional Elective- IV**

| | | | |
|---|---|---|---|
| CHE741 | Biofuels | CHE744 | Chemical Process Optimization |
| CHE742 | Biochemical Engineering | CHE745 | Project Management |
| CHE743 | Advanced Thermodynamics | CHE746 | Solid Waste Management |

**Professional Elective- V**

| | | | |
|---|---|---|---|
| CHE751 | Non-Conventional Energy Sources and Technology | CHE754 | Metaheuristic Optimization |
| CHE752 | Systems Biology | CHE755 | Green Technology |
| CHE753 | Molecular Simulation | CHE756 | Pharmaceutical Technology |

**Note:**

**Professional Elective:** For the electives to be offered, a minimum of 10 students must register for the elective as per the VTU norms.

## SCHEME OF TEACHING

## VIII SEMESTER

| Sl. No. | Course Code | Course Name | Category | Credits | | | | | Contact Hours |
|---|---|---|---|---|---|---|---|---|---|
| | | | | **L** | **T** | **P** | | **Total** | |
| 1. | **CH81** | **Internship/NPTEL** | PCE | 0 | 0 | 3 | | 3 | 06 |
| 2. | **CHP** | **Project Work** | PW | 0 | 0 | 14 | | 14 | 28 |
| Total | | | | **0** | **0** | **17** | | **17** | **38** |
| 3. | +CHL81 | Technical seminar | | 0 | 0 | 1 | | 2 | 02 |
| 4. | +CHL82 | Technical report writing | | 0 | 1 | 1 | | 2 | 04 |
| 5. | ++CH831/CH 832 | Scale-up of chemical processes/ plant utilities | | 3 | 0 | 0 | | 3 | 06 |

**+ Optional for Old Scheme Students with credit shortage**

**++ Optional for Students with no Internship / NPTEL / Credit Shortage**

**Semester VII**

| PROCESS INTEGRATION | |
|---|---|
| **Course Code**:CH71 | **Credits**: 4:0:0 |
| **Pre-requisites:** Process Heat Transfer<br>Mass Transfer I and II | **Contact Hours**: 56L |
| **Course coordinator:** Dr. G. M Madhu | |

**Course content**

**Unit I**

**Introduction to Process Integration:** Graphical Techniques. Overall mass targeting.

**Unit II**

**Synthesis of Mass Exchange Network:** Graphical approach. Direct recycle strategies.

**Unit III**

**Visualization Strategies**: For development of mass integrated system. Algebraic approach to targeting direct recycles

**Unit IV**

**Algebraic Approach:** To targeting mass exchange. Network. Recycle strategies using property integration.

**Heat Integration:** Synthesis of Heat Exchange Networks (HENs), Heat Exchange Pinch Diagram, Screening of Multiple Utilities Using the Grand Composite Representation

**Unit V**

**Combined heat and power integration**.
**Optimization:** Mathematical approach to direct recycle. LINGO optimization software for solving process integration problems

**Text Books:**

1. Robin Smith, Chemical Process Design & Integration, Wiley, 2005.
2. Mahmoud. M., El – Hawalgi, Process Integration, Elsevier, 2006.

**Reference Book:**

1. Kemp I.C, Pinch Analysis and Process Integration - A user guide on process integration for efficient use of energy, $2^{nd}$ Edition, Butterworth – Heinneman, 2006.

**Course Outcomes (COs)**:

On successful completion of this course students will be able to

1. Explain the need for Mass and Heat integration in chemical industries and basic principles involved in process integration. (PO-1,4,6,7,8, PSO-1)
2. Calculate the minimum amount of heat required in heat integration. (PO-1, 2, 4,6,7,8, PSO-1, 2)
3. Calculate the minimum fresh solvent required in mass exchange networks by graphical and algebraic methods. (PO-1,2,3,4,6,7,8, PSO-1,2)
4. Calculate the minimum heating and cooling requirements for given process using pinch analysis by graphical and algebraic methods. (PO-1,2,3,4,6,7,8, PSO-1,2)
5. Able to find the quality heating requirements in process flow diagram and able to optimize mass and heat integration problems by Linear programming method. (PO-1,2,3,4, PSO-1,2)

# TRANSPORT PHENOMENA

| | |
|---|---|
| **Course Code:**CH72 | **Credits:** 3:1:0 |
| **Pre-requisites:** Momentum Transfer Process Heat Transfer, Mass transfer | **Contact Hours:** 42L+14T |
| **Course coordinator:** Dr. Rajeswari M Kulkarni | |

## Course content

### Unit I

**Introduction**: Fundamental laws of Transport phenomena – Newton's law of viscosity, Fourier's law of heat conduction and Fick's law of diffusion. Molecular theory of viscosity, thermal conductivity and diffusivity of gases at low density.

Molecular mechanisms for transport of momentum in liquids, and heat and mass in liquids and solids. Analogy between the laws. Types of fluids; Types of flow. Numerical problems on the application and use of NLV, FLHC and FLD.

### Unit II

**Shell Balances for Momentum transfer:** Steady state Shell momentum balances, Pressure driven fully developed laminar flow in a pipe and annulus, Gravity driven flow in a thin film on an inclined plane, Flow between parallel plates. Analytically solvable problems.

Non Newtonian flow in a tube and over flat plate (Power law and Bingham fluids).

### Unit III

**Shell balances for energy transfer:** Steady State Shell Energy Balances, Temperature profile in a single and composite slab. Steady state one dimensional heat conduction with temperature dependent thermal conductivity. Heat conduction with internal generation by electrical, nuclear, viscous energy sources. Analytically solvable problems. Free convection.

### Unit IV

**Concentration Distributions in Laminar Flow:** Concepts and definitions on transport velocities in a multicomponent system, Steady state Shell mass balances. Diffusion through stagnant gas and liquid films (isothermal and non-isothermal films). Equimolar counter diffusion. Diffusion with homogeneous and heterogeneous reaction. Diffusion and chemical reaction inside a porous catalyst.

## Unit V

**Equations of Change:** Equation of continuity. Equation of motion; Navier – Stokes equation. Application of these equations in solving simple steady state momentum transfer problems previously discussed**.**

**Analogies:** Analogies between Momentum, Heat and Mass Transport: Application of Reynold's, Prandtl's and Chilton & Colburn analogies.

**Text Book:**

1. Bird, Stewart and Lightfoot, Transport Phenomena, I &II Edition, John Wiley, 1994& 2002.

**Reference Books:**

1. Welty, Wicks and Wilson**,** Fundamentals of Momentum, Heat and Mass Transport, 3rd Edition, John Wiley, 1983.

**Course Outcomes (COs)**:

On successful completion of the course students will be able to

1. Explain different fundamental laws of transport and understand the behavior of transport properties with changes in operating conditions. (PO-1, 2, 3, PSO-1)
2. Apply different analogies to common chemical engineering problems. (PO-1, 2, 3, PSO-1)
3. Derive mathematical equations by shell balance technique for different practical flow situations. (PO-1, 2, 3, PSO-1, 2)
4. Derive mathematical equations by shell balance technique for different practical mass transfer situations. (PO-1, 2, 3, PSO-1, 2)
5. Apply transport equations to any kind of physical problem and develop mathematical equations representing the process. (PO-1, 2, 3, PSO-1, 2)

# ECONOMICS AND ENTREPRENEURSHIP

| | |
|---|---|
| **Course Code:** CH73 | **Credits:** 3:0:0 |
| **Prerequisites:** Nil | **Contact Hours:** 56 |
| **Course Coordinator/s:** Dr. J Koteswara Rao | |

### Course content

### Unit I

**Cost Analysis:** Factors involved in project cost estimation, methods employed for the estimation of the capital investment. Estimation of working capital. Time value of money and equivalence.

### Unit II

**Depreciation and Taxes:** Depreciation calculation methods. Equivalence after Taxes. Cost comparison after taxes.

### Unit III

**Profitability:** Methods for the evaluation of profitability. Break-even analysis.

### Unit IV

**Entrepreneur:** Meaning of Entrepreneur; Evolution of the Concept, Functions of an Entrepreneur, types of Entrepreneur, Entrepreneurship qualities, entrepreneurship development.

**Small Scale Industry**: Definition; Characteristics; Need and rationale: Scope; role of SSI in Economic Development. Advantages of SSI. Steps to Start and SSI – Government policy towards SSI; Different Policies of S.S.I., Impact of Liberalization, Privatization, Globalization on S.S.I., IPR for entrepreneurs.

### Unit V

**Institutional Support:** Different Schemes; TECKSOK; KIADB; KSSICE; KSIMC; DIC Single Window Agency: SISI; NSIC; SIDBI; KSFC.

**Preparation of Project:** Meaning of Project; Project Identification; Project Selection; Project Report; Need and Significance of Report; Contents; formulation; Guidelines by Planning Commission, Identification & evaluation of Business Opportunities: Market Feasibility Study; Technical Feasibility Study; Financial Feasibility Study & Social Feasibility Study**.**

**Self-Study Topics:**
Estimation of capital investment for a specific plant.
Depreciation calculation for a specific equipment by various methods.
Selection of a process/equipment based on profitability analysis.
Writing the detailed process for starting an enterprise
Preparation of project report for applying financial support for starting an enterprise.

**Text Books:**

1. Peters and Timmerhaus, Plant Design and Economics for Chemical Engineers, McGraw Hill, 5th edition, 2003.
2. Charantimath, P.M., Entrepreneurship Development – Small Business Enterprises, Pearson Education, 2006.

**Reference Books:**

1. Desai, V., Dynamics of Entrepreneurial Development & Management, Himalaya Publishing House.
2. Schweyer, H. E., Process Engineering Economics, McGraw Hill, NY.
3. Gupta, C.B., Kanka, S.S., Entrepreneurship & Small Business Management, S Chand & Sons, 2007.
4. Donald E Garrett, Chemical engineering economics, 1989.

**Course Outcomes (COs)**:

On successful completion of the course students will be able to

1. Estimate various costs involved in a process industry. (PO-1, 6, 7, 9, 10, 12, PSO-3)
2. Calculate and analyze the costs of depreciation and taxes. (PO-1, 6, 7, 9, 10, 12, PSO-3)
3. Apply different tools to estimate profitability of a company. (PO-1, 6, 7, 9, 10, 12, PSO-3)
4. Demonstrate the ability to find an attractive market that can be reached economically. (PO- 6, 7, 8, 9, 10, 12, PSO-3)
5. Prepare project reports to obtain funding from different agencies. (PO- 6, 7, 8, 9, 10, 12, PSO-3)

# BIOFUELS

**Course Code:** CHE741 **Credits:** 3:0:0
**Prerequisites:** Nil **Contact Hours:** 56L
**Course Coordinator/s:** Chemical Engineering Faculty

## Course content

### Unit I

Fundamental concepts in understanding biofuels and bioenergy systems, biomass production, availability and attributes for bioenergy and biofuel production.

### Unit II

Types of biomass derived fuels and energy, Bioenergy Sources, Characteristics & Classification. Biofuel sources and properties.

### Unit III

Biogas production from organic matter and animal residues. Fermentation technology in biofuel production.

### Unit IV

Thermo-chemical and biochemical conversion of biomass to fuel, effect of different parameters on pyrolysis and gasification.

### Unit V

Environmental aspects of biofuel production. Sustainability of biofuels production.

**Text Books:**


1. G. N. Tiwari and M. K. Ghosal, *Fundamentals of Renewable Energy Sources*, Narosa Publishing House, 2007
2. Kishore V V N, *Renewable Energy Engineering and Technology, Principles and Practice*, The Energy and Resources Institute (TERI), 2009.


**Reference Books:**


1. Nijaguna, B.T., *Biogas Technology*, New Age International publishers (P) Ltd., 2002
2. Samir Kumar Khana, *Bioenergy and Biofuel from Biowastes and Biomass*, ASCE Publications, 2010

**Course Outcomes (COs)**:

On successful completion of the course students will be able to

1. Explain fundamental concepts in biofuels and bioenergy. (PO-1, 6, 7, 9, 10, 12, PSO-3)
2. Explain bioenergy source and their characterization. (PO-1, 6, 7, 9, 10, 12, PSO-3)
3. Demonstrate biogas production. (PO-1, 6, 7, 9, 10, 12, PSO-3)
4. Explain pyrolysis and gasification. (PO- 6, 7, 8, 9, 10, 12, PSO-3)
5. Explain environmental aspects of biofuel. (PO- 6, 7, 8, 9, 10, 12, PSO-3)

## BIOCHEMICAL ENGINEERING

| | |
|---|---|
| **Course Code:** CHE742 | **Credits:** 3:0:0 |
| **Prerequisites:** Nil | **Contact Hours:** 42L |
| **Course Coordinator/s:** Dr. Rajeswari M Kulkarni | |

### Course content

#### Unit I

**Introduction:** Bioprocess engineering and technology. Role of a Chemical engineer in bioprocess industry. An introduction to basic biological sciences. Microbiology: Structure of cells: Prokaryotes and Eukaryotes. Classification of micro-organisms. Characteristics and control of microorganisms. Environmental and Industrial microbiology.

**Biochemistry:** Chemicals of Life: Lipids, Sugars, Polysaccharides, Amino acids and proteins, Vitamins, Biopolymers, Nucleic Acids: RNA, DNA and their derivatives (Structure, Biological function and Importance for life only to be studied).

#### Unit II

**Enzymes and Proteins:** Detailed structure of proteins and enzymes: Primary, Secondary, Tertiary and quaternary. Functions. Production and purification of Enzymes (Methods only). Nomenclature and Classification of enzymes. Mechanism and Kinetics using various models. Kinetics of Enzyme action: Michaelis–Menten rate equation. Derivation with Equilibrium and Pseudo- (quasi-) steady state approximations. Experimental determination of rate parameters: Batch and continuous flow experiments.

#### Unit III

**Enzyme Inhibition:** Effect of Inhibitors (Competitive, noncompetitive, uncompetitive, substrate and product inhibitions), Temperature and pH on the rates enzyme catalyzed reactions.

#### Unit IV

**Fermentation Technology:** Ideal reactors: A review of Batch and Continuous flow reactors for bio kinetic measurements. Microbiological reactors: Operation and maintenance of typical aseptic aerobic fermentation processes. Formulation of medium: Sources of nutrients. Alternate bioreactor configurations. Introduction to sterilization of bioprocess equipment. Design of batch & continuous sterilization equipment.

## Unit V

**Growth Kinetics of Microorganisms:** Transient growth kinetics (Different phases of batch cultivation). Quantification of growth kinetics: Substrate limited growth, Models with growth inhibitors, Logistic equation, and Filamentous cell growth model. Continuous culture: Optimum Dilution rate, Critical Dilution rate in Ideal Chemostat. Introduction to Fed-batch reactors. Strategies and Steps involved in product purification.

**Self-Study Topics:**

Structure, biological function and importance of various biomolecules
Protein structures
Demonstration of enzyme inhibition using practical problem
Batch and continuous sterilization
Downstream processes.

**Text Book:**

1. Bailey and Ollis, Biochemical Engineering Fundamentals, 2ndEdition, McGraw Hill, 1976.
2. Shuler, M. L. and Kargi, F., Bioprocess Engineering, 2$^{nd}$ Edition, Prentice Hall, 2002.

**Reference Books:**

1. Pelczer, Microbiology Concept and Application, 5$^{th}$ Edition, McGraw Hill, 2001 Reprint.
2. Stanbury and Whittaker, Principles of Fermentation Technology, II Edition.

**Course Outcomes (COs)**:

On successful completion of the course students will be able to

1. Explain the basics of microbiology and role of Chemical Engineers in bioprocess industries. (PO-1, 2, 3, 9, 11, 12, PSO-1)
2. Perform kinetic studies of enzymatic reactions to have control over these processes and design such systems. (PO-1, 2, 3, 12, PSO-1)
3. Perform kinetic studies of enzymatic reactions in presence of inhibitors to design such systems to handle them. (PO-1, 2, 3, 12, PSO-1)
4. Explain in details about the fermentation technology, operation and maintenance of equipment in these industries. (PO-1, 2, 3, 12, PSO-1)
5. Explain the kinetics of microbial growth and control of bioreactors. (PO-1, 3, 6, 7, 9, 12, PSO-1)

# ADVANCED THERMODYNAMICS

**Course Code:** CHE743 **Credits:** 3:0:0
**Prerequisites:** Chemical Engineering Thermodynamics **Contact Hours:** 56L
**Course Coordinator/s:** Chemical Engineering Faculty

## Course content

### Unit 1

Classical Thermodynamics: Fundamental concepts & terminologies related to thermodynamics. Laws of thermodynamics: Conventional & Postulatory approaches. Analysis of different thermodynamic processes: Adiabatic, Isothermal, Isobaric, Isochoric, Polytropic. Concepts of Internal Energy, Enthalpy, Entropy, Free Energies (Gibbs & Helmholtz). Exact differentials and Maxwell's Relations. Concept of molecular degrees of freedom, relations for Cp and Cv, Clausius Clapeyron Equation.

### Unit II

Kelvin and Clausius statements for Second Law and their equivalence. Analysis of ideal heat cycle (Carnot cycle) and its applications to Heat Engines, Heat Pumps and Refrigerators. Different Equations of State: Ideal Gas Equation, Virial Equations, Van der Waals Equations, Peng Robinson & Soave Redlich Kwong Equations.

### Unit III

Fugacity, Compressibility, fugacity coefficient. Real gas mixtures, Ideal solution of real gases and liquids, Equilibrium in multi-phase systems, Gibbs phase rule for non-reactive components. Fundamental property relations for systems of variable composition, partial molar prosperities. Concept of chemical potential, chemical equilibrium and phase equilibrium.

### Unit IV

Macroscopic and microscopic descriptions of the state of a system. Comparative study of classical & statistical thermodynamics: Newtonian mechanics, Hamiltonian approach, Lagrangian approach. Concept of statistical ensembles, partition functions and thermodynamic properties

### Unit V

Thermodynamic probability and thermodynamic entropy. Microscopic interpretation of heat and work, evaluation of thermodynamic properties using partition functions. Introduction to molecular simulations.

**Text Books:**

1. Jefferson Tester & Michael Modell, Thermodynamics & Its Applications.
2. Donal A. McQuarrie, Statistical Mechanics, Edition I
3. Kenneth Wark Jr., Advanced Thermodynamics for Engineers, McGraw-Hill Inc., 2001.

**References**

1. Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Sons, 1998.
2. Holman, J.P., Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1998.
3. Smith, J.M and Van Ness., H.C., Introduction to chemical Engineering Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1987.
4. Sears, F.W. and Salinger G.I., Thermodynamics, Kinetic Theory and Statistical Thermodynamics, third Edition, Narosa Publishing House, New Delhi, 1993.
5. Thipse, S.S., Advanced Thermodynamics, Narosa Publishing, 2013.
6. Rao, Y.V.C., Postulational and Statistical thermodynamics, Allied Publisher Limited, New Delhi, 1994.
7. Sonntag, R.E., and Vann Wylen, G., Introduction to Thermodynamics, Classical and Statistical, third Edition, John Wiley and Sons, 1991.

**Course Outcomes (COs)**:

On successful completion of the course students will be able to

1. Understand second law, Maxwell relations and relation for entropy changes. (PO- 1, 2, PSO-1)
2. Comprehend the philosophical and mathematical interpretations of Second law and apply it to real life problems, and use the models for non-ideal gases for practical problems in chemical engineering. (PO- 1, 2, PSO-1)
3. Explain concept of fugacity, fugacity coefficient, and partial molar properties. (PO- 1, 2, PSO-1)
4. Explain and use the concepts of ensembles and statistical mechanics to develop the thermodynamic equations for a system of particles. (PO- 1, 2, PSO-1)
5. Analyze thermodynamic probability, degeneracy of energy levels and partition functions. (PO- 1, 2, PSO-1)

# CHEMICAL PROCESS OPTIMIZATION

**Sub Code:** CHE744 **Credit**: 3:0:0
**Pre-requisites**: Engineering Mathematics IV **Contact Hours:** 56L
**Course coordinator**: Chemical Engineering Faculty

## Course content

### Unit I

**The Nature and Organization of Optimization Problems:** Scope and Hierarchy, Applications, General procedure, obstacles.

**Developing models for optimization:** Classifications of models, building models, selecting functions to fit empirical data, factorial experimental design, and degrees of freedom.

**Basic concepts of optimization:** Function continuity, NLP programming, convexity and its application, quadratic approximation, conditions for extremum of an unconstrained function.

### Unit II

**Optimization of unconstrained function:** One dimensional search: Numerical methods for optimization a function with one variable, Region elimination methods, scanning and bracketing procedure, Methods using derivatives – Newton's method, Bisection method, Secant method, polynomial approximation methods.

### Unit III

**Unconstrained multivariable optimization:** Methods using functions values only- Random search, grid search, univariate search, Simplex Search, Hooke-Jeeves Pattern Search, and Powell's Conjugate Direction Search.

Gradient- Based Methods – Cauchy's Steepest Descent Method, Conjugate Gradient Method. Newton's method, Quasi Newton's method, Marquardt's Method.

### Unit IV

**Linear Programming and its applications:** Formulation of linear programs, Graphical solution, Simplex algorithm, Transportation problem.

### Unit V

**Nonlinear Programming with constraints:** Direct Substitution. First order necessary condition for a local extremum, Lagrange Multiplier Method, KKT Conditions, Quadratic Programming, Generalized Reduced Gradient Method.

**Text Book:**

1. Edgar, T.F., Himmelblau, D.M., Ladson, L.S., Optimization of Chemical Processes, McGraw Hill, 2nd Edition, 2001.
2. A Ravindran, KM Ragsdell, GV Reklitis, Engineering Optimization – Methods and Applications, John Wiley & Sons, 2nd Edition, 2006.

**Reference Book:**

1. SS Rao, Engineering Optimization – Theory and Practice, New Age International (P) Limited, 4th Edition.
2. Kenneth Lange, Optimization, Springer-Verlag, 2004.

**Course Outcomes (COs)**:

On successful completion of this course students will be able to

1. Develop objective function and constraint equations for chemical engineering problems. (PO-1, 2, PSO-2)
2. Optimize functions with single variable using numerical methods. (PO-1, 2, PSO-2)
4. Optimize unconstrained functions. (PO-1, 2, 12, PSO-2)
5. Optimize multivariable problems using numerical methods. (PO-1, 2, 12, PSO-2)
6. Apply linear programming methods in optimization. (PO-1, 2, 12, PSO-2)

# PROJECT MANAGEMENT

| | |
|---|---|
| **Course Code:** CHE745 | **Credits:** 3:0:0 |
| **Prerequisites:** Nil | **Contact Hours:** 56L |
| **Course Coordinator/s:** Chemical Engineering Faculty | |

## Course content

### Unit I

Project management- an overview, project identification and Screening; Project Appraisal. Introduction to Production Systems and a Generalized Model of Production. Life cycle of a Production System and Major Managerial Decisions.

### Unit II

Project Planning- Development of Project Network; Project Representation; Consistency and Redundancy in Project Networks; Project Scheduling- Basic Scheduling with A-O-A Networks; Basic Scheduling with A-O-N Networks; Project Scheduling with Probabilistic Activity Times.

### Unit III

Time/Cost Tradeoffs in Projects -Linear Time - Cost Tradeoffs in Projects: A Heuristic Approach; Resource Considerations in Projects - Resource Profiles and leveling. Limited Resource Allocation. Project Monitoring and Control with PERT / Cost. Team Building and Leadership in Projects; Project Completion, Review and Future directions.

### Unit IV

Financial Evaluation of Production Related Decisions- Performance Measures of a Production System. Financial Evaluation of Capital Decisions. Decision Trees and evaluation of risk; Designing Products & Services - Introducing New Products and Services, Product Mix Decisions.

### Unit V

Fundamentals of MRP I & MRP-II, Toyota production system - evolution of JIT - Waste elimination techniques - Pull control - kanban, kaizen. Lean manufacturing - agile manufacturing, Value chain analysis, Theory of Constraints (TOC) - bottleneck vs constrained resource - bottleneck identification and elimination - drum buffer rope systems.

**Text Books:**


1. Shtub A., Bard J. F. & Globerson S., "Project management: engineering, technology, and implementation", 2nd Edition Prentice Hall, 2004.
2. Lock D., "Project management", Gower Publishing Ltd., 9th Edition, 2007.
3. Kerzner H., "Project Management: A Systems Approach to Planning, Scheduling and Controlling", John Wiley & Sons, 11th Edition, 2013.


**Reference Books:**


1. Murthy P.R., "Production and Operations Management", New Age International (P) Ltd. Publishers, 2nd Edition, 2006.
2. Mayer R.R., "Production management", McGraw-Hill, 1968.
3. Harding H.A., "Production management", Macdonald and Evans Ltd, 1974


**Course Outcomes (COs)**:

On successful completion of the course students will be able to

1. Evaluate and select the most desirable projects. (PO-1, 6, 7, 9, 10, 11, 12, PSO-1, 3)
2. Identify desirable characteristics of effective project managers (PO-1, 6, 7, 9, 10, 11, 12, PSO-1, 3)
3. Apply appropriate approaches to plan a new project and develop a project schedule (PO-1, 6, 7, 9, 10, 11, 12, PSO-1, 3)
4. Develop a suitable budget for a new project and Identify important risks. (PO- 6, 7, 8, 9, 10,11, 12, PSO-1, 3)
5. Apply appropriate techniques to assess ongoing project performance. (PO- 6, 7, 8, 9, 10, 11, 12, PSO-1, 3)

# SOLID WASTE MANAGEMENT

**Sub Code**: CHE746 **Credits**: 3:0:0
**Pre-requisites:** Environmental Engineering **Contact Hours**: 56L
**Course coordinator***:* Dr. Ramasivakiran Reddy

**Course content**

**Unit I**

**Introduction:** Definition, characteristics and perspectives of solid waste. Types of solid waste. Physical and chemical characteristics. Variation of composition and characteristics. Municipal, industrial, special and hazardous wastes.

**General aspects:** Overview of material flow in society. Reduction in raw material usage. Reduction in solid waste generation. Reuse and material recovery. General effects on health and environment. Legislations.

**Unit II**

**Engineered systems:** Typical generation rates. Estimation and factors effecting generation rates. On site handling. Storage and processing. Collection systems and devices. Transfer and transport.

**Unit III**

**Processing Techniques:** Mechanical volume reduction. Thermal volume reduction. Component separation. Land filling and land forming. Deep well injection.

**Unit IV**

**Material recovery:** Mechanical size alteration. Electromagnetic separation. Drying and dewatering. Other material recovery systems. Recovery of biological conversion products. Recovery of thermal conversion products.

**Energy recovery:** Energy recovery systems and efficiency factors. Determination of output and efficiency. Details of energy recovery systems. Combustion incineration and heat recovery. Gasification and pyrolysis. Refuse derived fuels (RDF).

**Unit V**

**Case studies:** Major industries and management methods used in typical industries – Coal fired power stations, textile industry, oil refinery, distillery, sugar industry, and radioactive waste generation units.

**Text Books:**

1. Howard S. Peavy, Environmental Engineering, McGraw Hill International Edition, 1986.
2. Dutta, Industrial Solid Water Management and Land Filling Practice, Narose Publishing House, 1999.

**Reference Books:**

1. Sastry C.A., Waste Treatment Plants, Narose Publishing House, 1995.
2. Lagrega, Hazardous Waste Management, McGraw Hill, 1994.

**Course Outcomes (COs)**:

On successful completion of this course students will be able to

1. Apply knowledge to characterize the solid waste. (PO-1, 2, 4, 9, PSO-1)
2. Understand various components of solid waste and perform calculations. (PO-1, 2, 4, 9, PSO-1)
3. Apply various processing techniques and suitable design considerations for land filling sites. (PO-1, 2, 4, PSO-1)
4. Apply techniques of material recovery and energy recovery from solid waste. (PO-1, 2, 3, 4, PSO-1)
5. Develop a management plan for handling solid waste for various process industries and municipalities. (PO-1, 2,3,4,9, PSO-1)

# NON-CONVENTIONAL ENERGY SOURCES AND TECHNOLOGY

| | |
|---|---|
| **Course Code:** CHE751 | **Credits:** **3**:0:0 |
| **Prerequisites:** Nil | **Contact Hours:** 56 |
| **Course Coordinator/s:** Chemical Engineering Faculty | |

## Course content

### Unit I

**Introduction to conventional & non-conventional energy sources:** Conventional energy sources; non-conventional energy sources; advantages; limitations. Classification of fuels. Calorific value. Characteristics of good fuels. Comparison between solid, liquid and gaseous fuels.

**Solar Energy:** Solar radiation and its measurement – solar constant, solar radiation at earth's surface, solar radiation geometry, solar radiation measurement. Introduction to solar energy. Applications – solar water heating, space heating, space cooling, solar thermal electric conversion. Agriculture and industrial process heating, solar distillation, solar pumping, solar cooking.

### Unit II

**Energy from biomass (bio – energy):** Introduction. Biomass conversion Technologies. Wet processes. Dry processes. Biogas generation. Factors affecting bio digestion or generation of gas. Classification of biogas plants. Advantages and disadvantages of floating drum plant. Advantages and disadvantages of fixed dome type plant. Types of biogas plants (KVIC model & Janata model). Selection of site for biogas plant.

### Unit III

**Bio – Energy (Thermal Conversion):** Methods of obtaining energy from biomass. Thermal gasification of biomass. Classification of biomass gasifiers. Chemistry of gasification process. Applications of the gasifiers.

### Unit IV

**Wind Energy:** Introduction. Basic components of WECS (wind energy conversion system). Classification of WECS. Types of wind machines- horizontal axis machines, vertical axis machines. Applications of wind energy.

**Energy from the oceans:** Introduction. Ocean thermal electric conversion (OTEC). Methods of ocean thermal electric power generation. Open cycle OTEC system. Closed or Anderson OTEC cycle, hybrid cycle. Application of energy from oceans.

## Unit V

**Fuel Cells Basics:** Fuel Cells, Difference between batteries and fuel cells. Components of fuel cells. Principle of working of fuel cells. Performance characteristics and efficiency of fuel cells, Fuel cell stack, Fuel cell power plant.

**Fuel cell types:** Alkaline fuel cells. Polymer electrolyte fuel cells. Phosphoric acid fuel cells. Molten carbonate fuel cells. Solid oxide fuel cells. Types of solid acid fuel acid fuel cells. Applications. Problems with fuel cells.

**Text Books:**


1. Rai, G.D., Non-Conventional Energy Sources, Khanna Publications, 1st Edition, Second Reprint, 2010.
2. Sukhatme, S.P., Solar Energy, Third Edition, 1st Reprint, Tata McGraw Hill, New Delhi, 2008.


**Reference Books:**


1. Jain, P.C., Jain, M., Engineering Chemistry, Dhanpat Rai & Sons, 10th Edition, 3rd Reprint, 1995.
2. Rai, G.D., Solar Energy Utilization, 4th Edition, Khanna Publications.


**Course Outcomes (COs)**:

On successful completion of the course students will be able to

1. Compare different types of fuels and elucidate the application of solar energy. (PO-1, 7, PSO-1)
2. Understand biomass conversion technologies and types of biogas plants. (PO-1, 3, 7, PSO-1)
3. Understand thermal gasification of biomass and chemistry of gasification. (PO-1, 7, PSO-1)
4. Explain technologies of Wind energy and ocean. (PO-1, 7, PSO-1)
5. Apply latest technology like fuel cell. (PO-1, 3, 7, PSO-1)

# SYSTEMS BIOLOGY

| | |
|---|---|
| **Course Code**: CHE752 | **Credits**: 3:0:0 |
| **Pre-requisites**: NIL | **Contact Hours:** 56L |
| **Course coordinator:** Chemical Engineering Faculty | |

**Course content**

**Unit I**

Properties of biomolecules, Biomolecular Forces, Single molecule experimental techniques.

**Unit II**

Molecular motors, Molecular heterogeneity, Self-organization,

**Unit III**

Enzyme kinetics, Modeling cellular reactions and processes.

**Unit IV**

Fluctuations and noise in biology, Cellular variability, Biological networks.

**Unit V**

Modeling dynamics of bioprocesses and Cellular signaling.

**Text Books:**

1. Philip Nelson, Biological Physics: Energy, Information, Life, W. H. Freeman, 2007, ISBN-13: 978-0716798972.

**Reference Books**:

1. Edda Klipp, Wolfram Liebermeister, Christoph Wierling, Axel Kowald, Hans Lehrach, Ralf Herwig, Systems Biology, Wiley-Vch, 2009, ISBN: 978-3527318742.
2. Uri Alon, An Introduction to Systems Biology: Design Principles of Biological Circuits, Chapman & Hall/CRC Mathematical & Computational Biology, 2006, ISBN: 978-1584886426.

**Course Outcomes (COs)**:

On successful completion of this course students will be able to

1. Explain properties and experimental techniques for measurement. (PO-1, 4, 6, 7, PSO-1)
2. Understand the principles of molecular heterogeniety. (PO-3, 4, 6,7,12, PSO-1)
3. Explain cellular and enzymatic reactions (PO-3, 4, 6,7,12, PSO-1)
4. Explain fluctuations and biological networks (PO-3, 4, 6, 7, 12, PSO-1)
5. Explain modeling dynamics of bioprocesses. (PO-3, 4, 6,7,12, PSO-1)

# MOLECULAR SIMULATION

**Course Code**: CHE753 **Credits**: 3:0:0
**Pre-requisites**: NIL **Contact Hours:** 56L
**Course coordinator:** Chemical Engineering Faculty

**Course content**

**Unit I**

Statistical Mechanics: Basics of statistical mechanics, ideal monoatomic gas, canonical ensemble, grand-canonical and isobaric-isothermal ensemble

**Unit II**

Molecular dynamics: Basics of molecular dynamics, force field and integrating algorithms, periodic box and minimum image convention, non-bonded interactions, estimation of pure component properties.

**Unit III**

Introduction to Monte-Carlo methods. Case studies like Monte Carlo simulation in polymers.

**Unit IV**

Metropolis algorithm; NVT, NPT and GCMC simulations; estimation of pressure, chemical potential, radial distribution function, auto-correlation function.

**Unit V**

Ewald summation; umbrella sampling; Gibbs Ensemble technique; configuration bias technique.

**Text Books:**


1. Leach, R. (2001) Molecular Modelling: Principles and Applications, Pearson Education.
2. M. P. Allen and D. J. Tildesley, Computer simulation of Liquids, Oxford University Press, New York, 1987
3. D. Frenkel and B. Smit, Understanding Molecular Simulation: From Algorithms to Applications, 2nd Ed., Academic Press, San Diego, 2002

**Reference Books**:


1. Mike Lancaster, Green Chemistry- An Introductory Text, Royal Society of Chemistry Publishing, 2010
2. Boyle, Godfrey, Bob Everett, Janet Ramage, Energy Systems and Sustainability: Power for a Sustainable Future, Oxford University Press, 2004.


**Course Outcomes (COs)**:

On successful completion of this course students will be able to

1. Explain Statistical mechanics. (PO-1, 4, 6, 7, PSO-1)
2. Understand the principles of molecular dynamics. (PO-3, 4, 6,7,12, PSO-1)
3. Explain Monte Carlo method. (PO-3, 4, 6,7,12, PSO-1)
4. Estimation of pressure, chemical potential using molecular simulation. (PO-3, 4, 6, 7, 12, PSO-1)
5. Conduct Ewald summation. (PO-3, 4, 6,7,12, PSO-1)

# METAHEURISTIC OPTIMIZATION

**Course Code**: CHE754 **Credits**: 3:0:0
**Pre-requisites**: NIL **Contact Hours:** 56L
**Course coordinator:** Chemical Engineering Faculty

## Course content

### Unit I

Introduction, optimization problem formulation, and applications in the area of industrial engineering.

### Unit II

Local search vs. global search. Optimization methods for single-variable functions. Optimization in continuous domain.

### Unit III

Convexity, Necessary and sufficient conditions of optimality, Gradient methods, Constrained problems. The method of Lagrange. Kuhn-Tucker conditions. Dual problem. Optimization in discrete domain.

### Unit IV

Enumeration methods and dynamic programming. Applications of dynamic programming.

### Unit V

Simulated annealing method. Neural-network based methods. Genetic algorithms. Properties of the heuristic methods.

**Text Books:**

1. Sean Luke: Essentials of Metaheuristics, Lulu, second edition, 2013.
2. A. Engel Brecht: Computational Intelligence. An Introduction, Wiley, 2007

**Reference Books**:

1. Z. Michalewicz, D. Fogel: How to Solve It. Modern Heuristics. Springer, 1999
2. Coello C.A., van Veldhuizen D.A., Lamont, G.B.: Evolutionary Algorithms for Solving Multi objective Problems, Kluwer, 2002

**Course Outcomes (COs)**:

On successful completion of this course students will be able to

1. Explain basic principles of metaheuristic techniques. (PO-1, 4, 6, 7, PSO-1)
2. Describe local and global search algorithms. (PO-3, 4, 6,7,12, PSO-1)
3. Understand dynamic optimization (PO-3, 4, 6,7,12, PSO-1)
4. Explain application of dynamic programming (PO-3, 4, 6, 7, 12, PSO-1)
5. Implement e heuristic methods (PO-3, 4, 6,7,12, PSO-1)

# GREEN TECHNOLOGY

| | |
|---|---|
| **Course Code**: CHE755 | **Credits**: 3:0:0 |
| **Pre-requisites**: Engineering Chemistry | **Contact Hours:** 56L |
| **Course coordinator:** Sri Sagar J S | |

## Course content

### Unit I

**Introduction:** Green chemistry and technology for sustainable development, Environmental laws, carbon credits, environmental management system standards- ISO 14000 series.

### Unit II

**Green Chemistry:** Principles of Green Chemistry, Atom efficiency, Energy conservation, Waste minimization, Substitution.

### Unit III

**Life-Cycle Assessment:** History, Process, Methodology, Streamlining and Application.

### Unit IV

**Pollution prevention planning:** Structure of the pollution prevention process, Environmental Audits, toxic release inventory

### Unit V

Design for the environment and improvement in manufacturing operations, design for disassembly/DE manufacturing, Packaging, case studies.

**Text Books:**


1. Paul L. Bishop, Pollution Prevention: Fundamentals and Practice, McGraw Hill, 2000.
2. Anastas P.T., Warner J.C., Green Chemistry: Theory and Practice. Oxford Science Publications, Oxford, 1998.


**Reference Books**:


1. Mike Lancaster, Green Chemistry- An Introductory Text, Royal Society of Chemistry Publishing, 2010
2. Boyle, Godfrey, Bob Everett, Janet Ramage, Energy Systems and Sustainability: Power for a Sustainable Future, Oxford University Press, 2004.

**Course Outcomes (COs)**:

On successful completion of this course students will be able to

1. Explain environment laws, carbon credits, ISO 14000 series. (PO-1, 4, 6, 7, PSO-1)
2. Understand the principles of green chemistry. (PO-3, 4, 6,7,12, PSO-1)
3. Explain the importance of green technology in sustainable development. (PO-3, 4, 6,7,12, PSO-1)
4. Apply tools of green technology and life cycle assessment. (PO-3, 4, 6, 7, 12, PSO-1)
5. Conduct pollution prevention planning and environment friendly design. (PO-3, 4, 6,7,12, PSO-1)

# PHARMACEUTICAL TECHNOLOGY

**Course Code**: CHE756 **Credits**: 3:0:0
**Pre-requisites***:* NIL **Contact Hours:** 56L
**Course coordinator*:*** Chemical Engineering Faculty

**Course content**

**Unit I**

Concept of fine and bulk drugs and their salient features, Research and development strategies in pharmaceutical industries. Discovering the best synthetic route; Selecting the best route for scale-up, Choice of raw materials, reagents etc

**Unit II**

Diffusion and dissolution, kinetics and drug stability, Viscosity and rheology, Polymer science and applications.

**Unit III**

Formulations and development, Packaging, Introduction to industrial processing, Transport Phenomena (Fluid Flow, Heat Transfer and Mass Transfer).

**Unit IV**

Particulate Technology (Particle Size, Size reduction, Size Separation, Powder Flow and Compaction), Unit Operations (Mixing, Evaporation, Filtration, Centrifugation, Extraction, Distillation, and Drying).

**Unit V**

Materials of Pharmaceutical Plant Construction, Good Manufacturing Practice (GMP's) Guidelines, process safety considerations.

**Text Books:**

Remington: The Science and Practice of Pharmacy ,21$^{st}$ edition, June 2005

**Reference Books**:


1. Alfred N. Martin, "Physical Chemical and Biopharmaceutical Principles in the Pharmaceutical Sciences", 6th Edn., Lippincott Williams & Wilkins, 2006.
2. David B. Troy, Paul Beringer, "Remington: The Science and Practice of Pharmacy", 21st Edn., Lippincott Williams & Wilkins.

3. Sidney James Carter, “Cooper and Gunn's Tutorial Pharmacy”, CBS Publishers & Distributors, 1986.

**Course Outcomes (COs)**:

On successful completion of this course students will be able to

1. Acquire basic knowledge of pre-formulation and formulation of drugs, pharmaceutical unit operations and manufacturing, packaging and quality control of pharmaceutical dosage forms. (PO-1, 2, 3, PSO-1)
2. Acquire a knowledge on pharmaceutical unit operations and manufacturing, packaging and quality control of pharmaceutical dosage forms. (PO-1, 2, 3, 4, 6, 8, 10, 11, 12, PSO-1)
3. Trained to conceptualize, design, build up, maintain and operate various industrial processes and machineries involved in the process. (PO-1, 2, 3, 4, 5, 6,7, 8, 9, 10, 11, 12, PSO-1)
4. Understanding and apply the various processing and manufacturing techniques. (PO-1, 2, 3, 4, 5, 7, 8, 9, 11, 12, PSO-1)
5. Conduct formulate a pure drug substance into a dosage form. (PO-1, 2, 3, 4, 5, 7, 8, 9, 11, 12, PSO-1)

# PROCESS SIMULATION LABORATORY

**Course Code**: CHL76 **Credits**: 0:0:1
**Pre-requisites**: Nil **Contact Hours**: 14P
**Course coordinator**: Dr. Rama Sivakiran Reddy

## Course content

**List of simulations suggested:**

a. Flowsheet simulation and Optimization of parameters
b. Sensitivity analysis
c. Azeotropic distillation
d. Reactive distillation
e. Batch distillation
f. Bioprocess simulation
g. Crude refining
h. Heat exchanger design HTFS/EDR
i. Dynamic simulation
j. Solids operations
k. User model and MS EXCEL integration

**Software Suggested:** ASPEN ONE, ASPEN HYSYS, CHEMCAD, DESIGN-II, gPROM, UNISIM

**Course Outcomes (COs)**:

On successful completion of this course students will be able to

1. Use any chemical process simulation software. (PO-2,3,5,12, PSO-2)
2. Simulate a chemical engineering process. (PO-2,3,5,12, PSO-2)
3. Optimize the parameters in a process using simulation software. (PO-2,3,5,12, PSO-2)

# PROCESS CONTROL LABORATORY

| | |
|---|---|
| **Course Code**: CHL77 | **Credits**: 0:0:1 |
| **Pre-requisites**: Nil | **Contact Hours**: 14P |
| **Course coordinator**: Dr. Jaya Prasanna Kumar | |

**Course content**

**List of experiments:**

1. Thermometer
2. Single tank - Step Response
3. Non Interacting Tanks – Step Response
4. Interacting Tanks – Step Response
5. Pressure Tank
6. U – Tube Manometer
7. Single tank - Impulse Response
8. Non Interacting Tanks – Impulse Response
9. Interacting Tanks – Impulse Response
10. Level/Flow/Pressure/pH/Temperature control – P controller
11. Level/Flow/Pressure/pH/Temperature control – PI controller
12. Level/Flow/Pressure/pH/Temperature control – PD controller
13. Level/Flow/Pressure/pH/Temperature control – PID controller
14. Valve characteristics.
15. Flapper Nozzle System
16. Valve Positioner.

**Course Outcomes (COs)**:

On successful completion of this course students will be able to

1. Analyse various control systems. (PO-2,4,10, PSO-1,3)
2. Evaluate their performance. (PO-2,3,4,10, PSO-1,3)
3. Suggest their applications in process industry. (PO-1,10, PSO-1)

| SEMINAR | |
|---|---|
| **Course Code**: CHSE | **Credits**: 0:0:1 |
| **Pre-requisites**: NIL | **Contact Hours**: - |
| **Course coordinator:** Chemical Engineering Faculty | |

**Course content**

The students are required to give a presentation on detailed literature survey on selected topic of final year project CHP and submit a brief report.

**Course Outcomes (COs):**

The student will be able to

1. Communicate orally, give presentation. (PO-10, PSO-3)
2. Address certain societal issues. (PO-1, 6)
3. Present recent solutions for sustainable development. (PO-2,7, PSO-3)

# Semester VIII

| INTERSHIP/ NPTEL | |
|---|---|
| **Course Code**: CH81 | **Credits**: 0:0:3 |
| **Pre-requisites**: Nil | **Contact Hours**: - |
| **Course coordinator**: Chemical Engineering Faculty | |

### Course content

Students are required to carry out training in a chemical industry or research in any organisation for not less than four weeks after 4$^{th}$ or 6$^{th}$ semester OR attend industry course organised at the department between sixth and seventh semester. Students are required to submit a report on the same in the format provided by the industrial training committee. The students will be evaluated by the industrial training committee based on the rubrics informed to students by the committee.

Students who fails to complete Inplant training has to take up an industry course offered by the department for 03 credits. [Scale up of chemical process OR Hazard analysis and risk management]

**Course Outcomes (COs)**:

On successful completion of this course students will be able to

1. Understand functioning of chemical process industry, gain knowledge on the recent developments in the area and integrate his theoretical knowledge with practical processes. (PO-2,4,7,11,12, PSO-1,2,3)
2. Enhance his communication skills to work in interdisciplinary teams in industry. (PO-9, 10)
3. Realize his professional and ethical responsibility. (PO-6, 7, 8)

# PROJECT WORK

**Course Code**: CHP **Credits:** 0:0:14
**Pre-requisites:** NIL **Contact Hours**: -
**Course coordinator**: Chemical Engineering Faculty

**Course content**

A group of students will be assigned an experimental work, case study, or an analytical problem to be carried out under the supervision of a guide. The group shall not contain more than four students. Guides are allocated in the beginning of sixth semester. The students are required to give three comprehensive presentations in the on the progress of their project work during the eighth semester and submit the report at the end of the semester. During the semester, performance of the students is evaluated by the guide and project co-ordination committee to award the CIE marks as per the rubrics defined by the committee. The final project report will be evaluated and examined at the end of the eighth semester for SEE.

**Course Outcomes (COs)**:

On successful completion of this course students will be able to

1. Carry out literature review on selected topics from peer review journals and magazine. (PO-2,3,6,7,8, PSO-3)
2. Write protocols and perform the experiments and theoretical analysis. (PO-1,2,3,4,6,7,12, PSO-1,3)
3. Carry out computational analysis and analyze the results obtained. (PO-2,3,4,5,12, PSO-1,2,3)
4. Write precise project reports with appropriate references. (PO-8,10,11,12, PSO-3)
5. Present the work progress from time to time with the results obtained and contribute as a team member. (PO-8,9,10, PSO-3)

## TECHNICAL SEMINAR

| | |
|---|---|
| **Course Code**: CHL81 | **Credits**: 0:0:1 |
| **Pre-requisites**: NIL | **Contact Hours**: - |
| **Course coordinator:** Chemical Engineering Faculty | |

**Course content**

**+ Optional for Old Scheme Students with credit shortage**

The students are required to give a presentation and submit a brief report on any topic related to upcoming areas of chemical engineering.

**Course Outcomes (COs):**

The student will be able to

1. Communicate orally, give presentation. (PO-10, PSO-3)
2. Address certain societal issues. (PO-1, 6)
3. Present recent solutions for sustainable development. (PO-2,7, PSO-3)

## TECHNICAL REPORT WRITING

| | |
|---|---|
| **Course Code**: CHL82 | **Credits**: 0:1:1 |
| **Pre-requisites**: NIL | **Contact Hours**: 14T+14P |
| **Course coordinator:** Chemical Engineering Faculty | |

**Course content**

**+ Optional for Old Scheme Students with credit shortage**

The students are required to give a presentation and submit a detailed technical report on a research topic assigned by the faculty in-charge of the course.

**Course Outcomes (COs):**

The student will be able to

1. Communicate orally, give presentation. (PO-10, PSO-3)
2. Address certain societal issues. (PO-1, 6)
3. Present recent solutions for sustainable development. (PO-2,7, PSO-3)

| SCALE UP OF CHEMICAL PROCESSES | |
|---|---|
| **Sub Code**:CH831 | **Credit**: 3:0:0 |
| **Pre-requisites**: Nil | **Contact Hours**: 56 |
| **Course coordinator**: Dr. Brijesh | |

**Unit I**

**Introduction:** Concept of prototypes, models, scale ratios, element. Principles of similarity**:** Geometric similarity. Distorted similarity. Static, dynamic, kinematics, thermal and chemical similarity with examples.

**Unit II**

**Dimensional analysis:** (Review of Rayleigh's, Buckingham ∏ methods), Differential equation for static systems, flow systems, thermal systems, mass transfer processes, chemical processes-homogeneous and heterogeneous.

**Unit III**

**Regime concept:** Static regime. Dynamic regime. Mixed regime concepts. Criteria to decide the regimes. Equations for scale criteria of static, dynamic processes, Extrapolation. Boundary effects.

**Unit IV**

**Scale up:** Mixing process, agitated vessel, Chemical reactor Systems-Homogeneous reaction systems. Reactor for fluid phase processes catalysed by solids. Fluid-fluid reactors.

**Unit V**

Stage wise mass transfer processes. Continuous mass transfer processes. Scale up of heat transfer equipments. Environmental challenges of scale up.

**Text Books:**

1. Attilio Bisio, Robert L. Kabel., Scale up of Chemical Processes, John Wiley & Sons, 1985
2. Johnstone and Thring, Pilot Plants, Models and scale up method in Chemical Engineering.

**Reference Book:**

1. Ibrahim and Kuloor, Pilot Plants and Scale up Studies, IISc.

**Course Outcomes (COs)**:

On successful completion of this course students will be able to

1. Apply similitude principles. (PO-1,2,3,4,5, PSO-1)
2. Develop relations in terms of dimensionless parameters. (PO-1,2,3,4,5, PSO-1)
3. Identify process regimes and develop equations for static and dynamic processes. (PO-1,2,3,4,5, PSO-1)
4. Develop scale up criteria for mixing processes and reactors. (PO-1,2,3,4,5,10, PSO-1, 2, 3)
5. Develop scale up relations for mass transfer operations and assess environmental challenges. (PO-1,2,3,4,5,10, PSO-1,2,3)

# PLANT UTILITIES

**Sub Code**: CH832 **Credit:** 3:0:0
**Pre-requisites:** Nil **Contact Hours:** 42
**Course coordinator:** Chemical Engineering Faculty

### Unit I

**Introduction:** Different utilities. Role of utilities in process plant operations and criteria for selection and estimation of suitable utilities.

**Water:** Water resources. Process water, cooling water, drinking water and boiler feed water Quality Standards. Water treatment processes for drinking, process and boiler feed. Storage and handling of water. Types and selection of pumps, piping and accessories. Water pre-treatment, reuse and recycling.

### Unit II

**Steam and Power:** Steam generation in chemical plants. Types of boilers and waste heat boilers. Fuels-types, emissions and global warming, green fuels. Calorific value. Proximate and ultimate analysis. HHV, LHV and related calculations. Cogeneration power plants. CHPs and Boiler performance. Related Calculations. Economy of steam generation with different fuels, related calculation. Steam storage and handling-piping and accessories.

### Unit III

**Air:** Compressed air, blower air, fan air. Types of compressor and vacuum pumps and selection. Power requirements, performance and related calculations. Booster and receivers. Quality of compressed air for instruments and processes. Compressed air distribution system- piping and accessories. Air-water vapour system: humidification/ dehumidification and evaporative cooling-related calculations.

### Unit IV

**Refrigeration:** Different refrigeration systems and their characteristics. Air-conditioning systems. Coefficient of performance. Power requirements and refrigeration effect- related calculations for each type of refrigeration system. Refrigerant properties and selection. Some commonly used refrigerants and secondary refrigerants. Air-conditioning.

## Unit V

**Insulation:** Insulation Materials and Selection- Economics of insulation. Insulating factors. Properties & Classification. Cold insulation and cryogenic insulation.

**Text / Reference Books:**


1. Fair, G.M., Geyer, J.C. and Okun, D. A., Water and Waste Water Engineering, Vol 2, Wiley, 1966.
2. Narayan and Viswanathan, Chemical and Electrochemical Energy Systems, University Press, 1998.
3. Perry, Chemical Engineers Handbook, $8^{th}$ Edition, McGraw Hill.
4. Sinnot, R.K., Coulson and Richardson's Chemical Engineering- Vol 6, Pergamon, 1996.
5. Abbi, Handbook of Energy Audit, Environmental Management, TERI Press, 2002.


**Course Outcomes (COs)**:

On completion of course, students will be able to

1. Understand the role of various utilities in process industry. (PO-1, 3, 4, 7, PSO-1)
2. Evaluate the quality of water, its requirements in process industries. (PO-1, 3, PSO-1)
3. Explain about steam properties, usage in industry and types of boilers (PO-1, 3, PSO-1)
4. Assess requirements of air in industry and mode of its supply. (PO-1, 3, PSO-1)
5. Apply refrigeration principles and decide insulators for a process. Perform energy audits in plants. (PO-1, 3, 5, 7, PSO-1)