# UNIVERSITY OF KERALA

## B. TECH.  DEGREE COURSE

## (2013 SCHEME)

**SYLLABUS FOR**

**VIII SEMESTER**

**CHEMICAL ENGINEERING**

# SCHEME -2013
# VIII SEMESTER
# CHEMICAL ENGINEERING ( H )

| Course No | Name of subject | Credits | Weekly load, hours | | | C A Marks | Exam Duration Hrs | U E Max Marks | Total Marks |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | D/ P | | | | |
| 13.801 | Transport Phenomena (H) | 4 | 2 | 2 | - | 50 | 3 | 100 | 150 |
| 13.802 | Chemical Engineering Design II (H) | 4 | 2 | 2 | - | 50 | 3 | 100 | 150 |
| 13.803 | Environmental Pollution: Control, Design and Modelling (H) | 4 | 3 | 1 | - | 50 | 3 | 100 | 150 |
| 13.804 | Process Instrumentation (H) | 4 | 3 | 1 | - | 50 | 3 | 100 | 150 |
| 13.805 | Elective IV | 4 | 2 | 2 | - | 50 | 3 | 100 | 150 |
| 13.806 | Elective V | 4 | 2 | 2 | - | 50 | 3 | 100 | 150 |
| 13.807 | Project & Viva Voce (H) | 5 | - | - | 5 | 200 | - | 100 | 300 |
| | **Total** | **29** | **14** | **10** | **5** | **500** | | **700** | **1200** |

**13.805 Elective IV**

| | |
|---|---|
| 13.805.1 | Process Plant Safety and Hazard Assessment (H) |
| 13.805.2 | Bioinformatics (H) |
| 13.805.3 | Material Science (H) |
| 13.805.4 | Drugs and Pharmaceutical Technology (H) |
| 13.805.5 | Applied Statics for Chemical Engineers (H) |
| 13.805.6 | Multicomponent Distillation (H) |
| 13.805.7 | New Separation Processes (H) |

**13.806 Elective V**

| | |
|---|---|
| 13.806.1 | Process Utilities and Pipe line Design (H) |
| 13.806.2 | Design of Biological Waste Treatment Systems (H) |
| 13.806.3 | Biomaterials (H) |
| 13.806.4 | Surface Coatings (H) |
| 13.806.5 | Water and Waste Water Engineering (H) |
| 13.806.6 | Computational Fluid Dynamics (H) |
| 13.806.7 | Solid Waste Management (H) |
| 13.806.8 | Composite Technology (H) |

## 13.801 TRANSPORT PHENOMENA (H)

**Teaching Scheme:** 2(L) - 2(T) - 0(P) **Credits**: 4

**Course Objective:**

- *To give the knowledge of transport of momentum, heat and mass transport and provide insight into the dependence of temperature and pressure on the transport coefficients.*
- *To derive shell balances to formulate basic conservation equations of transport processes and impart the knowledge in arriving at solutions of selected engineering problems which can be solved analytically.*
- *To give basic axioms of conservations namely conservation of momentum, energy and mass and impart the knowledge in arriving at solutions of selected engineering problems which can be solved analytically.*

**Module – I**

Viscosity and the mechanisms of momentum transfer: Newton's law of viscosity, molecular momentum transport, generalization of Newton's law of viscosity, pressure and temperature dependence of viscosity of gases and liquids, prediction of viscosity of gases: Rigid sphere model and rigorous models, prediction of transport coefficients of liquids. Numerical problems

Shell momentum balances and velocity distributions in laminar flow: shell momentum balances and boundary conditions, flow of a falling film along a flat surface and on the surface of cylinders, flow of a Newtonian fluid in between two slits formed by two flat plates, flow through a circular tube, flow through annulus, and flow of two adjacent immiscible fluids. Flow of a Bingham fluid through a cylinder- Buckingham- Reiner Equation.

**Module – II**

General transport equation for momentum, derivation of continuity equation, Analysis of equation of motion in rectangular coordinates, Navier Stoke's equation and its development, deduction to Euler equation with significance of each terms, transport equation in curvilinear coordinates, application of transport equations to solve steady flow problems:- flow through a tube, tangential annular flow, rotating liquid, cone and plate viscometer, shape of the liquid surface in a rotating vessel.

Velocity distributions in turbulent flow: comparisons of laminar and turbulent flows, time-smoothed equations of change for incompressible fluids, and the time- smoothed velocity profile near a wall.

**Module – III**

**Energy Transport:** Thermal conductivity and the mechanism of energy transport- prediction of thermal conductivity of gases, effect of temperature and pressure on thermal conductivity of gases, relationship between thermal conductivity and viscosity of gases. Thermal conductivity of solids, relationship between thermal and electrical conductivity of solids, Numerical problems.

Shell energy balance:- Boundary conditions, application of shell balances to heat conduction problems with electric, nuclear and viscous heat sources and other similar heat conduction problems, use of shell heat balances in variable thermal conductivity systems to derive temperature and heat flux profiles, fixed bed flow reactor, cooling fins with insulated tip condition, heat transfer by free between two vertical plates and forced convection for flow through pipes with heat transfer at constant wall heat flux.

Equations of energy in rectangular coordinates (Derivation is not desired but analysis of the energy equation with significance of each term and the associated dimensionless parameters, their significance, energy equations in curvilinear coordinates, application to simple steady state heat transfer problems of practical importance to derive the heat flux and temperature distribution.

## Module – IV

**Diffusivity and the Mechanism of Mass Transport**: Definition of concentrations, velocities and mass/molar fluxes, Interrelationship between fluxes. Fick's law of diffusion, kinetic theory of diffusion in gases at low density, theory of ordinary diffusion in liquids. Prediction of diffusivity of gases

Fick's law of diffusion, Ways of expressing concentrations, velocities and fluxes in binary systems. Shell mass balances and obtaining concentration distributions and fluxes in binary diffusion systems of practical importance. Analogies between heat, mass and momentum transfer, Derivation of equation of continuity for binary mixtures in rectangular coordinates in mass and molar units, general study of equation of continuity in curvilinear coordinates (derivation not desired). Fick's second law of diffusion and its application, Application to combined heat and mass transfer for simple systems. Solution of mass transport problems for binary systems with analytical solutions derivable using the general conservation equations.

**References:**


1. Bird R. B., W. C. Stewart and F. N. Lightfoot*, Transport phenomena*, John Wiley & Sons.
2. Theodore L.*, Transport Phenomena for Engineers* by, International text book Company, U.S.A
3. Geankoplis, *Transport processes and unit operations*, 3/e, PHI, 1997.
4. Welty, Wicks and Wilson, *Fundamental of Heat, Momentum and Mass Transfer*, John Wiley.
5. John C. Slattery, *Momentum, Energy and Mass transfer in continua*, McGraw Hill, Co.
6. Robert S. Brodkey and Harry C. Hersing, *Transport Phenomena a Unified approach,* McGraw Hill Book Co.

7. Bennet C. U. and J. E. Myers, *Momentum, Heat and Mass Transfer,* Tata McGraw Hill Publishing Co.

**Internal Continuous Assessment** *(Maximum Marks-50)*

*50% - Tests (minimum 2)*
*30% - Assignments (minimum 2)*
*20% - Regularity in the class*

**University Examination Pattern:**

*Examination duration: 3 hours* *Maximum Total Marks: 100*

*The question paper shall consist of 2 parts.*

*Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be three questions each from modules I and II, and two questions each from modules III and IV.*

*Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.*

***Note:*** *The students are permitted to use the copy of the* ***tables of general equations of continuity, motion and energy in rectangular and curvilinear coordinates*** *inside the examination hall for the University examination.*

**Course Outcome:**

*On successful completion of the course, the student will be able to:*

- *Describe molecular transport of momentum, heat and mass*
- *Develop and solve shell balances for conservation of momentum, heat and mass balance to derive solutions for realistic chemical engineering problems*
- *Develop and solve differential momentum, heat and mass balances for simple steady one dimensional problem using general equation of continuity, momentum and energy balance equations.*

## 13.802 CHEMICAL ENGINEERING DESIGN II (H)

**Teaching Scheme:** 2(L) - 2(T) - 0(P) **Credits**: 4

**Course Objectives:**

*In this course, the students will be introduced to the design of heat and mass transfer operations equipments.*

**Design of Heat Transfer Equipments**: Design and Drawing of Heat Transfer Equipments such as Double pipe heat exchangers, shell and tube heat exchangers, condensers- tubular horizontal and tubular vertical, evaporators- single effect and multiple effect.

**Design of Mass Transfer Equipments**: Design and Drawing of mass transfer equipments such as distillation columns and absorption columns.

**References:**


1. Standards : IS 403 (1967), 803 (1963) & 2825 & TEMA
2. Perry and Chilton, *Chemical Engineers' Handbook*, McGraw Hill, 8th Edition.
3. Bhattacharya B.C., *Introduction to Chemical Equipment Design.*
4. Joshi M.V., *Process Equipment Design*, McMillan India Ltd.
5. Vilbrandt and Dryden, *Chemical Engineering Plant Design*.
6. Peters and Timmerhaus, *Plant Design and Economics for Chemical Engineers.*
7. Brownell and Young, *Process Equipment Design.*
8. Harvey, *Process Vessel Design.*
9. Ludwig E.E., *Applied Process Design in Chemical and Petrochemical Plants.*


**Internal Continuous Assessment** *(Maximum Marks-50)*

*50% - Tests (minimum 2)*

*30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.*

*20% - Regularity in the class*

**University Examination Pattern:**

*Examination duration: 3 hours* *Maximum Total Marks: 100*

***Open Book University Examination***: *The following text books or attested copies of the books may be permitted in the examination hall. Apart from this attested copy of Moody charts and other charts/plots required for design of equipments may also be permitted in the exam hall. The copy of the relevant pages of the text book containing* *the empirical correlations and other monographs duly attested by the faculty member applicable for design may also be permitted in the examination hall.*

1. Steam tables and Psychometric Charts
2. Process Engineer's Equipment Design by M.V. Joshi, McMillan and Co., India, Delhi
3. Perry's Hand Book of Chemical Engineering, McGraw Hill (Relevant Editions)
4. Introduction to Chemical Equipment Design- Mechanical Aspects by B.C. Bhattacharya
5. IS Code for Unfired Pressure Vessels IS 4503, BIS, New Delhi, 1969.

***Note:*** *The above information may be provided as instructions in the question paper and is to be given at the top of the question by the question paper setter.*

*The Question paper shall contain two design questions of 100 Marks each. Candidates have to answer one full question out of the two. For each question, out of 100 marks, 90 marks will be allotted for the design and 10 marks for a representative sketch of the design.*

**Course Outcome:**

*On successful completion of the course, the student will be able to:*

- *Propose a design of the heat transfer process equipments.*
- *Propose a design of the mass transfer process equipments.*
- *Prepare the drawings of major heat and mass transfer equipments.*

## 13.803 ENVIRONMENTAL POLLUTION: CONTROL, DESIGN AND MODELLING (H)

**Teaching Scheme:** 3(L) - 1(T) - 0(P) **Credits**: 4

**Course Objectives:**

*This course is aimed at imparting an overall understanding of the source and nature of various kinds of pollutants as well as their impact on humans and environment. The course further lays down the design aspects of measurement and control methods and components while emphasizing on the legal aspects of pollution control.*

### Module – I

Impact of man on the environment : an overview, the biosphere. The hydrologic cycle and measurement of precipitation- the nutrient cycle- Mathematics for Growth - Consequence of population growth. - Energy problem.

Air pollution : Sources and effects - Nature of air pollution classification, properties and sources of pollutants. Acid rain - Greenhouse effect- Ozone depletion - Effects on man, animal, vegetation and material dangers.

Atmospheric stability- lapse rates- inversions- plume behavior and theory of pollutant dispersion

Air quality criteria and standards- methods of pollutant sampling and measurement. Control methods for particulate emulsions and pollutants - Design aspects of Cyclone separator, Electrostatic precipitator- Bag house filter - Indoor Air Pollution Control.

### Module – II

Water pollution: Sources and classification of water pollutants and their effects. Sampling and analysis.

Waste water treatment: Design aspects of preliminary, primary, secondary and tertiary treatment of waste water- Recovery of materials from process effluents. -Anaerobic and aerobic Sludge treatment and disposal- Cake filtration and composting -Methods of physicochemical and biological treatment of industrial effluents from fertilizer, petrochemical, pulp and paper, caustic soda, tanning and sugar industries- Alternate routes of manufacture and sequencing of operations as a means of pollution control- Alternate use for by product as means of pollution control- Advanced treatment methods reverse osmosis and carbon adsorption.

### Module – III

Solid waste management : Sources, classification and microbiology of solid waste. Solid waste characteristics- Health aspects, methods of collection and disposal, Solid waste processing and recovery - composting. Sanitary land filling, thermal processes, regeneration and recycling. City waste and industrial wastes management

Nuclear waste : Sources and nature of nuclear waste, treatment, storage technology for liquid, solid and gaseous (radioactive) wastes.

**Module – IV**

Noise control: Noise control programme, noise control criteria, administrative and engineering controls, acoustical absorptive materials.

Legislation : Legislative aspects including water (Prevention and control of pollution) Act 1974, Air (prevention and control of pollution) Act 1981, Environmental protection Act 1986 and effluent standards

Environmental Management - ISO standards - Ecomark - Green production - Kyoto protocol- Montreal Protocol - Euronorms etc

Environmental Impact assessment - Environmental agencies - standards and legal aspects in Environmental Managementride.

**References:**


1. Metcalf and Eddy, *Waste Water Engineering*, TMH
2. Venkateswaralu, *CHEMTECH-1*, CEED, IIT Madras.
3. Rao C. S., *Environmental Pollution Control Engineering*, Wiley Eastern Ltd.
4. Bhide A. D. and B. B Sundaresan, *Solid Waste Management in Developing Countries*, INSDOC, New Delhi - 67.
5. Arcadio P. Sincero and Gregoria A.Sincero, *Environmental Engineering - A Design Approach*, Eastern Economy Edition- PHI.
6. Berthe R. M., Van Nostrand Reinhold, *Air Pollution Control Technology*, 1978.
7. Rao M. N. and H.V.N. Rao, *Air pollution*, Tata McGraw Hill.
8. Straus W., *Industrial Gas Cleaning*, Pergamon Press Ltd.
9. Cunniff P. F., *Environmental Noise Pollution*, John Wiley.
10. Mantell C. L., *Solid Wastes: Origin, Collection, Processing, Disposal*, John Wiley.
11. Mahajan S. P, *Pollution Control in Process Industries*, TMH.
12. Trivedi R. K., *Pollution Management in Industries*, Environmental Publications
13. Bhatia S. C., *Environmental Pollution and Control in Chemical Process Industries*, Khanna Publishers.
14. Santhosh Kumar Garg, *Environmental Engineering*, (Vol I and II) Khanna Publishers, New Delhi, 2004.
15. Venugopal Rao P., *Text book of Environmental Engineering*, PHI
16. Sharma J. P., *Comprehensive Environmental Studies*, Laxmi Publications, 2004.

**Internal Continuous Assessment** *(Maximum Marks-50)*

*50% - Tests (minimum 2)*

*30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.*

*20% - Regularity in the class*

**University Examination Pattern:**

*Examination duration: 3 hours* *Maximum Total Marks: 100*

*The question paper shall consist of 2 parts.*

*Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be at least two questions from each module and not more than three questions from any module.*

*Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.*

**Course Outcome:**

- *Upon successful completion of the course, the student shall be able to outline the impact of air, water and soil pollutants on humans as well as the environment. The student shall be able to design components and methods for measurement/monitoring, control/management of pollutants. Further the student shall be in a position to outline the legal aspects and legislations pertaining to pollution control*.

## 13.804 PROCESS INSTRUMENTATION (H)

**Teaching Scheme:** 3(L) - 1(T) - 0(P) **Credits**: 4

**Course Objective:**

*This course provides an introduction to the field of Instrumentation and covers process variables and the various instruments used to sense, measure, transmit and control these variables.*

### Module – I

Basic principles of measurements - Classification methods of measurements - Direct and indirect measurements, various elements in a measuring instrument - Sensing element, transducing element manipulating element and functioning element etc- Principles of working with a suitable example, static and dynamic characteristics of measuring instrument, accuracy, reproducibility, sensitivity, static error, dead zone, dynamic error, fidelity lag, speed of response etc. Sensing elements - various types of sensing elements, sensors for temperature, pressure and fluid flow, transducers, different types of transducers, their principles and working, transmission methods, indicating and recording means. Temperature measurements, temperature scales, basic principles and working of thermometers, mercury in glass thermometers, resistance thermometers, thermocouples, optical pyrometers, radiant pyrometers, ranges of different types of temperature measuring instruments, sources of errors and precautions to be taken in temperature measurements.

### Module – II

Pressure measurement - Principles of working of manometers, various types of manometers - Macleoad gauge, Kundsen gauge, Bourdon gauge, bellows, diaphragm, electrical pressure transducers peizo electric manometers, thermal conductivity gauges- ionization gauge high pressure measuring instrument, liquid level measurements - Sensitive measurements, conductivity meters, measurements of pH.

### Module – III

Flow measurements - Liquid and gas flow measurements, ways of measuring liquids and gas flow, direct volume measurements, quantity meters, gas meters, magnetic flow meters, heat input flow meters, elbow flow meters, impact meters, variable area meters, rotameters, cylinder and piston type - Liquid flow velocity, turbine meters, open channel flow measurements, wires notches, head meters, pitot tube, orifice meters ventury meters, theory and working flow measurements, electrical transducers, turbine type flow meters strain gauge flow meters, mass flow meter, measuring flow of dry materials.

**Module – IV**

Thermal analysis - Differential thermal analysis, thermo gravimetric, conductimetric analysis Chromatography and application. Measurement of density and specific gravity, humidity, viscosity and composition. Developments of P&I diagram for flow systems, level, PH control, temp control, Heat exchangers, Distillation column, reaction system etc, return on average investment, discounted cash flow, Net Present worth, Venture worth.

**References:**


1. Eckman D. P., Industrial instrumentation, Wiley Eastern
2. FRIBANCE, Industrial instrumentation fundamentals, T.M.H. Edition
3. Jain R. K., Mechanical and industrial measurements, Khanna Pub
4. Patranabis, Principles of industrial instrumentation , T.M.H
5. Beckwith and Buck, Measurement systems


**Internal Continuous Assessment** *(Maximum Marks-50)*

*50% - Tests (minimum 2)*

*30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project etc.*

*20% - Regularity in the class*

**University Examination Pattern:**

*Examination duration: 3 hours* *Maximum Total Marks: 100*

*The question paper shall consist of 2 parts.*

*Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be at least two questions from each module and not more than three questions from any module.*

*Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.*

**Course Outcome:**

*On successful completion of the course, the student will be able to:*

- *Analyse the characteristics of measuring instruments and identify the measuring variables and measurement techniques in the process industries*
- *Examine different instruments used in process industries for temperature, pressure, level, flow, concentration and pH measurements.*
- *Illustrate P&I diagrams used in process industries*
- *Outline the state-of-art measurement instrument for the different process variables in Industries.*

## 13.805.1 PROCESS PLANT SAFETY AND HAZARD ASSESSMENT (H) (ELECTIVE IV)

**Teaching Scheme:** 2(L) - 2(T) - 0(P) **Credits:** 4

**Course Objectives:**

- *To develop skills in the assessment of the severity of the consequences of incidents.*
- *To understand the key factors influencing the basis for process safety.*
- *To understand the typical sources of risk in a process plant by hazard identification and examination of case studies.*

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### Module – I

Importance & objectives of safety in chemical process plants. Fire and Explosion- Classification of fires, chemistry of fire. Flame- flammability principles, Ignition, rate of burning, heat transfer from flames. BLEVE and Runaway Reaction. Fire hazards - health- flammability - reactivity (stability). Air contaminants generally found in fires- toxic effects of fire gases.

Fire prevention – handling (storing flammable and combustible liquids, elimination of ignition sources). Fire detection - smoke detection, heat detectors, flame detectors. Fire suppression - different type of fire extinguishers and their handling, fixed automatic sprinklers, water deluge and portable fire extinguishers. Fire protection in plants and factories- fire walls, fire doors etc.

### Module – II

Origin of process hazards- laws, codes, standards. Chemical, mechanical, physical and health hazard of industrial substance, Hazard zone classification, hazard due to static electricity, safety in electrical systems, Chemical hazards- toxic chemicals, dust, gases, fumes, mists, vapours and smoke.

Hazards in storage and transport of Oil, natural gas, chlorine and ammonia, Material transportation rules- Hazard Chem. Code, Safety in the case of processes or operations involving explosives or flammable dust, gases, etc.

### Module – III

Risk management principles, Identification of hazards- different adopted methods for the identification of hazards, Hazard & Operability (HAZOP) studies, Hazard Analysis (HAZAN), Fault and Event Tree Analysis, Consequence Analysis.

Work permit system, First aid and treatment to victims, Personnel protection system, Housekeeping, Inherent safety design principles.

**Module – IV**

Emergency planning and disaster management- Onsite and Offsite emergency management plans. Safety Audit - Objective and Procedure for safety auditing. Safety organizations and movement- ILO, NSC, LPA. Safety management system- BS8800, OSHAS-18001 &18002.

Case Studies: Flixborough, Seveso, Bhopal, Chernobyl, ONGC offshore, HPCL Vizag and Jaipur IOC oil-storage depot incident.

**References:**


1. Wells G. L., *Safety in Process Plant Design*, George Godwin Ltd, London.
2. Crowl D. A. and J. F. Louvar, , *Chemical Process Safety, Fundamentals with Applications*, 2nd Ed, Prentice Hall, 2002
3. Kletz Trevor, *What Went Wrong, Case Histories of Process Plant Disasters*, 2nd Ed, Gulf Professional Publishing, 1998
4. *Encyclopedia of Occupational Health & Safety*, International labour Office, Geneva
5. Grialdi J. V., and R. H. Simonds, *Safety Management*, AITBS Publishers & Distributors, New Delhi
6. Buschmann, *Loss Prevention and Safety Promotion in the Process Industries*, Elsevier Scientific, New York
7. Raghavan K. V. and A. A. Khan, *Methodologies in Hazard Identification and Assessment Manual*, CLRI, December, 1990.
8. Marshal V.C, *Major Chemical Hazards*, Ellis Harwood Ltd., Chichester, UK, 1987.
9. Frank P. Leis, Loss Prevention in Process Industries Vol 1 &2, Butterworth, London, 1980.


**Internal Continuous Assessment** *(Maximum Marks-50)*

*50% - Tests (minimum 2)*

*30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.*

*20% - Regularity in the class*

**University Examination Pattern:**

*Examination duration: 3 hours* *Maximum Total Marks: 100*

*The question paper shall consist of 2 parts.*

*Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be three questions each from Module I and Module II, and two questions each from Module III and Module IV.*

*Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.*

**Course Outcome:**

*Upon completion of the Course the student will able to:*

- *Identify the hazards of various chemicals and their limiting values.*
- *Explain inherent and design safety.*
- *Summarize rules and regulations regarding hazards.*
- *Compute various hazards assessment techniques like HAZOP etc.*

## 13.805.2 BIOINFORMATICS (H) (ELECTIVE IV)

**Teaching Scheme:** 2(L) - 2(T) - 0(P) **Credits**: 4

**Course Objective**:

*The course introduces an interdisciplinary field of science, bioinformatics combines computer science, statistics, mathematics, and engineering to analyze and interpret biological data.*

### Module – I

Biology for Bioinformatics :- Basic concepts - cells- Archaebacteria, Biomembranes, Nucleus, Organelles, Mitochondria, Chloroplasts, Viruses, Bacteriophage, Genetic contents of a cell - Viral Proteins - Amino acid, DNA and RNA - Forms of DNA.

Genetic Code :- Genome - Gene Expressions - Protein Synthesis - Transcription RNA - Processing- Capping- Splicing - Editing, Cell Signalling, DNA cloning Genomic library – cDNA library - Probes - Screening.

Bioinformatics basics: Computers in biology and medicine; Importance of Unix and Linux systems and its basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; Biological XML DTD’s; Pattern matching algorithm basics; Computational tools for DNA sequence analysis: GCG: The Wisconsin package of sequence analysis programs; Web-based interfaces for the GCG sequence analysis programs.

### Module – II

Databases and search tools: Biological back ground for sequence analysis; Identification of protein sequence from DNA sequence; Searching of databases similar sequence; The NCBI; Publicly available tools; Resources at EBI; Resources on the web; Database mining tools.

DNA sequence analysis: The gene bank sequence database; Submitting DNA sequence to the databases and database searching; Sequence alignment; Pair wise alignment techniques; Multiple sequence analysis; Multiple sequence alignment; Flexible sequence similarity searching with the FAST3 program package; Use of CLUSTAL W and CLUSTAL X for the multiple sequence alignment; Submitting DNA protein sequence to databases: Where and how to submit, SEQUIN, genome centres; Submitting aligned set of sequences, updates and internet resources.

### Module – III

**Protein Modeling: Introduction;** Force field methods; Energy, Buried and exposed residues; Side chains and neighbours; Fixed regions; Hydrogen bonds; Mapping properties onto surfaces; Fitting monomers; rms fit of conformers; Assigning secondary structures; Sequence alignment- methods, evaluation, scoring; Protein completion: backbone construction and side chain addition; Small peptide methodology; Software accessibility; Building peptides; Protein displays; Substructure manipulations, Annealing.

Peptidomimetics: Introduction, classification; Conformationally restricted peptides, design, pseudopeptides, peptidomimetics and transition state analogs; Biologically active template; Amino acid replacements; Peptidomimetics and rational drug design; CADD techniques in peptidomimetics; Development of non peptide peptidomimetics.

**Module – IV**

**Protein Structure Prediction**: Protein folding and model generation; Secondary structure prediction; Analyzing secondary structures; Protein loop searching; Loop generating methods; Loop analysis; Homology modeling: potential applications, description, methodology, homologous sequence identification; Align structures, align model sequence; Construction of variable and conserved regions; Threading techniques; Topology fingerprint approach for prediction; Evaluation of alternate models;

Structure prediction on a mystery sequence; Structure aided sequence techniques of structure prediction; Structural profiles, alignment algorithms, mutation tables, prediction, validation, sequence based methods of structure prediction, prediction using inverse folding, fold prediction; Significance analysis, scoring techniques, sequence-sequence scoring.

*The virtual library:* Searching MEDLINE, Pubmed, current content, science citation index and current awareness services, electronic journals, grants, and funding information.

**References:-**


1. David W. Mount, *Bioinformatics: Sequence and Genome Analysis,* 2nd Edition, CSHL Press, 2004.
2. Baxevanis A. and Ouellette F. B. F., *Bioinformatics: A Practical Guide to The Analysis of Genes and Proteins*, 2nd Edition, John Wiley, 2001.
3. Jonathan Pevsner, *Bioinformatics and Functional Genomics*, 1st Edition, Wiley, 2003.
4. Bourne P. E. and H. Weissig, *Structural Bioinformatics*, 2nd Edition, Wiley, 2008.
5. Branden C. and J. Tooze, *Introduction to Protein Structure*, 2nd Revised Edition Garland Publishing, 1998.


**Internal Continuous Assessment** *(Maximum Marks-50)*

*50% - Tests (minimum 2)*

*30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.*

*20% - Regularity in the class*

**University Examination Pattern:**

*Examination duration: 3 hours* *Maximum Total Marks: 100*

*The question paper shall consist of 2 parts.*

*Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be at least two questions from each module and not more than three questions from any module.*

*Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.*

**Course Outcome:**

*Upon completion of the Course the student will able to:*

- *understand fundamental concepts in bioinformatics*
- *understand how some of the basic methods for biological sequence analysis works*
- *appreciate the need for methods to be accurate and efficient*
- *implement some of the algorithms*

# 13.805.3 MATERIAL SCIENCE (H) (ELECTIVE IV)

**Teaching Scheme:** 2(L) - 2(T) - 0(P) **Credits**: 4

**Course Objective**:

- *To impart the basic concepts of material science*
- *To develop understanding about selection based on properties for various applications*

## Module – I

Atomic Structure - atomic bonding, atomic arrangements, coordination number. Crystal systems: crystal structure, non crystalline structure and crystal defects. Metallic phases and their properties: Single phase metals and alloys, binary equilibria involving solid solutions - eutectic and peritectic systems. Iron - carbon diagram, plastic deformations, recrystallization, cold and hot working of metals, control microstructure, heat treatments, failure of metals.

## Module – II

Properties of engineering materials-mechanical properties, isotropy and anisotropy, elasticity, plasticity, toughness, resilience, tensile strength, ductility, malleability, brittleness, hardness, fatigue, creep, wear resistance, Poisson's ratio, stress-strain relation, true stress and true strain-electrical and magnetic properties, resistivity, conductivity- ionic and electrical conductivity, semiconductors, superconductivity, insulators, ferroelectricity, piezoelectricity, magnetization, paramagnetism, ferromagnetism, and diamagnetism. Technological properties: castability, machinability, weldability, solderability, workability, formability.

## Module – III

Organic polymers and its properties. Ceramics- classification, comparison of ceramic and non-ceramic structures, properties and application of ceramics. Composite materials- Classification, reinforcement, fillers and additives, processing and application, characteristics of composite material, theory of composites. Introduction to nanomaterials.

## Module – IV

Corrosion-different types, mechanism and factors influencing corrosion-corrosion prevention-inhibitors and their applications, oxidation of metals and radiation damage, factors affecting the selection of materials for engineering purposes selection of suitable materials for construction in chemical industry.

**References:-**


1. Lawrence H. Van Vlack, *Elements of Material Science*, Addison Wesley.
2. Bhattacharya B. C., *Selection of Material and Fabrication for Chemical Process Equipments*, CEED, IIT Madras.
3. Raghavan V., *Material Science & Engineering- A first Course*, PHI Publications.
4. Khanna O. P., *A Text book of Material Science & Metallurgy*, Dhanpat Rai publications.
5. Gupta A. K. and R. C. Gupta., *Material Science*, S. Chand & Company Ltd.


**Internal Continuous Assessment** *(Maximum Marks-50)*

*50% - Tests (minimum 2)*

*30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.*

*20% - Regularity in the class*

**University Examination Pattern:**

*Examination duration: 3 hours* *Maximum Total Marks: 100*

*The question paper shall consist of 2 parts.*

*Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be at least two questions from each module and not more than three questions from any module.*

*Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.*

**Course Outcome:**

*Upon completion of the Course the student will able to:*

- *Apply concepts in Materials Science to solve engineering problems.*
- *Explain contemporary issues relevant to Materials Science and Engineering.*
- *Select suitable materials for design and construction.*
- *Summarize the skills and techniques necessary for modern materials engineering practice.*

## 13.805.4 DRUGS AND PHARMACEUTICAL TECHNOLOGY (H) (ELECTIVE IV)

**Teaching Scheme:** 2(L) - 2(T) - 0(P) **Credits**: 4

**Course Objective**:

*This course is aimed at introducing the various aspects of drugs and pharmaceutical technology covering their use, metabolism and manufacturing methods and principles. The course further lays down the various applications of drugs and pharmaceuticals.*

**Module – I**

**Introduction:** Development of Drug and Pharmaceutical Industry – Therapeutic agents, their use and economics; Regulatory aspects.

**Drug Metabolism and Pharmacokinetics:** Drug metabolism: physico-chemical principles, radio activity pharma kinetic action of drugs on human bodies.

**Module – II**

**Important Unit Processes and their Applications:** Bulk drug manufacturers, Type of reactions in bulk drug manufacture and processes. Special requirements for bulk drug manufacture.

**Module – III**

**Manufacturing Principles:** Compressed table, wet granulation-dry granulation or slugging direct compression-tablet presses, coating of tablets, capsules, sustained action dosage forms parental solution oral liquids-injections-ointment-topical applications, Preservation, analytical methods and test for various drug and pharmaceuticals, packing-packing techniques, quality management, GMP.

**Module – IV**

**Pharmaceutical Products and their Control:** Therapeutic categories such as vitamins, laxatives, analgesics, non-steroidal contraceptives, Antibiotics, biologicals, hormones.

**References:-**

1. Leon Lachman et al., *Theory and Practice of Industrial Pharmacy*, 3 Edition, Lea and Febiger, 1986
2. *Remington's Pharmaceutical Science*, Mark Publishing and Co.

**Internal Continuous Assessment** *(Maximum Marks-50)*

*50% - Tests (minimum 2)*

*30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.*

*20% - Regularity in the class*

**University Examination Pattern:**

*Examination duration: 3 hours* *Maximum Total Marks: 100*

*The question paper shall consist of 2 parts.*

*Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be at least two questions from each module and not more than three questions from any module.*

*Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.*

**Course Outcome:**

*Upon successful completion of the course, the student shall be able to give an overview of drug metabolism. The student shall be able to explain the manufacturing principles of various drugs and pharmaceuticals. The student shall be able to list out the applications of drugs and pharmaceuticals and categorize them accordingly.*

## 13.805.5 APPLIED STATICS FOR CHEMICAL ENGINEERS (H) (ELECTIVE IV)

**Teaching Scheme:** 2(L) - 2(T) - 0(P) **Credits**: 4

**Course Objective**:

*This course provides an introduction to descriptive statistics, inferential statistics, linear regression and correlation.*

**Module – I**

Graphical data analysis. Review of probability, random variables and their properties. The normal and binomial distributions, the central limit theorem. Applications to statistical quality control. Theory of statistical inference including confidence intervals and hypothesis testing with applications to one and two sample problems based on the t- and F- test

**Module – II**

Simple and multiple linear regression including data transformations to normality. Residual Analysis. Nonlinear regression: Parameter estimation, confidence intervals, profile t-plot, profile tracers, parameter transformation, forecasts and calibration.

**Module – III**

Analysis of variance and design of Experiments: Multiple Groups, One-Way ANOVA , Random Effects, Ring Trials , Two and More Factors , Response Surface Methods , Second-Order Response Surfaces ,Experimental Designs, Robust Designs.

**Module – IV**

Multivariate Analysis of Spectra: Multivariate Statistics -Basics, Principal Component Analysis (PCA) , Linear Mixing Models, Factor Analysis , Regression with Many Predictors. Introduction to factorial designs.

**References:-**

1. Ang H. S. and Tang W. H., *Probability Concepts in Engineering Planning and Design.*
2. Little R. E., *Probability and Statistics for Engineers.*
3. Rice R. G. and D. D. Duong, *Applied Mathematics and Modeling for Chemical Engineers.*
4. Mitin V. V., D.A. Romanov and M.P. Polis, *Modern Advanced Mathematics for Engineers.*
5. Amundson N. R., *Mathematical Methods in Chemical Engineering.*
6. George E. P. Box, W. G. Hunter, and J. S. Hunter, *Statistics for Experimenters: An Introduction to Design, Data Analysis and Model Building.*
7. Douglas C. Montgomery, E. A. Peck, and G. G. Vining, *Introduction to Linear Regression Analysis.*

8. Norman R. Draper and Harry Smith*, Applied Regression Analysis.*
9. Douglas C. Montgomery and G. C. Runger*, Applied Statistics and Probability for Engineers.*

**Internal Continuous Assessment** *(Maximum Marks-50)*

*50% - Tests (minimum 2)*

*30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.*

*20% - Regularity in the class*

**University Examination Pattern:**

*Examination duration: 3 hours Maximum Total Marks: 100*

*The question paper shall consist of 2 parts.*

*Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be at least two questions from each module and not more than three questions from any module.*

*Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.*

**Course Outcome:**

*At the end of the course, the students will be able to:*

- *Construct graphical displays of science/engineering data and interpret the role of such displays in data analysis.*
- *Apply basic statistical inference techniques, including confidence intervals, hypothesis testing and analysis of variance, to science/engineering problems.*
- *Employ appropriate regression models to determine statistical relationships.*

## 13.805.6 MULTICOMPONENT DISTILLATION (H) (ELECTIVE IV)

**Teaching Scheme:** 2(L) - 2(T) - 0(P) **Credits**: 4

**Course Objective**:

*To introduce multicomponent distillation concepts such as key components, non-key components, distributing components (sandwiches components), and optimum feed stage; General procedure for stage-by-stage analysis of multicomponent distillation; Use of various shortcut methods (Fenske, Underwood and Gilliland) and to apply these techniques to develop approximate column designs.*

### Module – I

Fundamental principles of distillation - equilibrium relationships, component material balances, total material and energy balance. Separation of multicomponent mixtures by use of one equilibrium stage, Multiple-stage separation of binary mixtures, separation of multicomponent mixtures at total reflux. Thermodynamic relationships for multicomponent mixtures – fundamental principles of thermodynamics needed in the calculation of vapour-liquid equilibria and enthalpies of multicomponent mixtures, equations of state and their use in the prediction of K values and enthalpies.

### Module – II

Selection of Operating Pressure: Determination of operating pressure for the various industrial distillation columns, criteria for vacuum distillation, Pros & Cons of vacuum distillation. Dew point and bubble point for multicomponent hydrocarbon mixtures, Design of multicomponent distillation Column using short cut methods: Fenske-Underwood-Gilliland's method, Plate-to-plate calculations, Introduction to rigorous solution procedures: Lewis-Metheson method, Theile-Geddes method, Equation tearing procedures using tridiagonal matrix algorithm.

### Module – III

Azeotropic and Extractive Distillation: Concept and working principle, industrial examples, determination of number of theoretical stages for azeotropic and extractive distillation, advantage and disadvantage over each other.

Tower Diameter and Pressure Drop: Criteria of selection between tray tower and packed tower, among various type of packings, among various types of trays, determination of tower diameter and pressure drop.

### Module – IV

Multicomponent Batch Distillation: Design of multicomponent batch distillation with and without rectification.

Energy Saving in Distillation: By Heat integration, advanced process control, thermally coupled distillation column, use of heat pumps.

**References:-**


1. Charles D. Holland, *Fundamentals of Multicomponent Distillation*, McGraw-Hill.
2. Treybal, *Mass Transfer Operations*, McGraw-Hill Publication.
3. Schweitzer, *Separation Techniques for Chemical Engineers*, McGraw Hill Publications.
4. McCabe W. L., J. C. Smith and P. Harriot, Unit Operations in Chemical Engineering, McGraw Hill.


**Internal Continuous Assessment** *(Maximum Marks-50)*

*50% - Tests (minimum 2)*

*30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.*

*20% - Regularity in the class*

**University Examination Pattern:**

*Examination duration: 3 hours* *Maximum Total Marks: 100*

*The question paper shall consist of 2 parts.*

*Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be at least two questions from each module and not more than three questions from any module.*

*Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.*

**Course Outcome:**

*At the end of the course, the student will be able to handle multicomponent and complex mixtures VLE and use it in process design of distillation column and any phase change equipment.*

## 13.805.7 NEW SEPARATION PROCESSES (H) (ELECTIVE IV)

**Teaching Scheme:** 2(L) - 2(T) - 0(P) **Credits**: 4

**Course Objective**:

*To impart the knowledge about Novel separation processes viz. membrane processes, adsorption and desorption that had been used in process industries in last few decades in increasing order.*

### Module – I

Limitations of common separation techniques like sedimentation, screening, filtration, evaporation, distillation, absorption, liquid-liquid and solid liquid extraction. Thermal Separation: Thermal Diffusion: Basic Rate Law, Theory of Thermal Diffusion Phenomena for gas and liquid mixtures, Equipments, design and Applications. Zone Melting: Equilibrium diagrams, Controlling factors, Apparatus and Applications.

### Module – II

Concepts and definitions in adsorption: adsorbent types; their preparation and properties; different types of adsorption isotherms and their importance; adsorption types; basic mathematical modeling with suitable initial and boundary conditions for different cases such as thermal swing, pressure swing, and moving bed adsorption.

Introduction to membrane processes. Types of membranes, Membrane processes and their applications, Porous sand solid membranes, Osmosis, Micro – Filtration, Ultrafiltration, Nanofiltration, Reverse Osmosis, Piezodialysis, Electrodialysis, Dialysis, Membranes for gas separation, Pervaporation. Applications to these processes.

### Module – III

Liquid membranes: Supported and unsupported liquid membranes, Applications and mathematical modeling. Characterization of porous membranes, Characterization of ionic membranes, Characterization of non – ionic membranes. Polarization phenomena and fouling concentration polarization, Characteristic flux behavior in pressure driven membrane operation, Various models, Temperature polarization, Membrane fouling, Methods to reduce fouling. Modules and process design: plate and frame, Spiral wound, Tubular, Capillary, Hollow fiber modules and their comparison, System design.

## Module – IV

Foam Separation: Surface Adsorption, Nature of foams, Apparatus, Applications, and controlling factors. Parametric pumping: thermal parametric pumping, batch, continuous pumping, multicomponent separation, pH-parametric pumping, heatless parametric pumping. Ionic Separation: Controlling factors, Applications, Equipments for Electrophoresis, Dielectrophoresis, Electro Dialysis and Ion - Exchange, Commercial processes. Adductive Crystallization: Molecular addition compounds, Clathrate compounds and Adducts, Equipments, Applications, Economics and Commercial processes. Adsorptive chromatographic separations processes, hybrid separation technologies-membrane chromatography and electrochromatography. Extractive separation, aqueous two-phase extraction, supercritical extraction.

**References:-**


1. Schoen H. M., *New Chemical Engineering Separation Techniques*, Inter Science Publications, New York, 1972.
2. Wankat P.C., *Rate Controlled Separations* , Elsevier, 1990
3. Asenjo JM, *Separation Processes in Biotechnology*, 1993, Marcel Dekker Inc
4. Marcel Mulder, *Basic Principles of Membrane Technology*, Kluwer Academic Publishers, 1997
5. King J., *Separation Process,* McGraw Hill.
6. Kaup E. C., *Design Factors in Reverse Osmosis*, Chemical Engineering, 1973.
7. Arden T. V., *Water Purification by ION Exchange,* Butterworth, London, 1968.
8. Sirkar K. and H. O. Winston, *Membrane Hand Book*, Van Nostrand Reinhold, New
9. Ruthven D. M., *Principles of Adsorption and Adsorption Processes*, John Wiley & Sons, 1984.
10. Belter P. A. and E. Cussler, *Bioseparations*, Wiley, 1985.
11. McCabe W. L. and J. C.-Smith, *Unit Operation of Chemical Engineer*, Tata McGraw Hill.


**Internal Continuous Assessment** *(Maximum Marks-50)*

*50% - Tests (minimum 2)*

*30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.*

*20% - Regularity in the class*

**University Examination Pattern:**

*Examination duration: 3 hours* *Maximum Total Marks: 100*

*The question paper shall consist of 2 parts.*

*Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be at least two questions from each module and not more than three questions from any module.*

*Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.*

**Course Outcome:**

*At the end of the course, the student will be able to*

- *Understand the governing mechanism and driving force of various advanced separation processes*
- *Perform process and design calculations*
- *Understand the importance of modern separations in terms of economics and commercial development.*

## 13.806.1 PROCESS UTILITIES AND PIPELINE DESIGN (H) (ELECTIVE V)

**Teaching Scheme:** 2(L) - 2(T) - 0(P) **Credits:** 4

**Course Objectives:**

- *To describe the different equipments used to run the process plant with different utilities.*
- *To acquire the knowledge for selection of different utilities.*
- *To understand basic calculation involved in steam generation, psychometric operation and refrigeration.*
- *To gain a comprehensive knowledge of elements those are essential for the design, operation, and maintenance of pipelines.*

**Module – I**

Importance of process utilities in chemical industries and plants. Introduction to the use of various utilities. Water as a utility in process industries, treatment and cooling. Storage and distribution of water, recycle and conservation of water, cooling tower, spray pond. Compressors and vacuum pumps – performance characteristics of compressors and vacuum pumps, Boosters, Air receivers, piping network, Air leaks, Lubrication. Oil and moisture removal. Refrigeration systems and their characteristics. Production of cryogenic temperatures.

**Module – II**

Characteristics of Air-water systems. Humidification and Dehumidification equipment. Exhaust, Ventilation. Steam generation and its application in chemical process plants, properties of steam, distribution and utilization, design of efficient steam heating systems, steam economy, condensate utilization, steam traps- their characteristics, selection and application, waste heat utilization. Boilers and power generation equipments, Steam engines and turbines. Electric power distribution in process plantsetc.

**Module – III**

Introduction to piping engineering: Fluid flow, types of fluids and examples, classification of pipes and tubes - IS & BS codes for pipes used in chemical process industries and utilities, pipe connections and fittings- Rail fittings, welded and flanged fittings, pipe system layout, tube fastening and attachment, non ferrous tube fittings, ducts and elbows. Pipe anchors and supports. Flow control in pipes - Types of valves, control valves, safety valves, constructional features, criteria for selection. Selection of material for piping, desirable properties of piping materials, materials for various temperature and pressure conditions, materials for corrosion resistance. Gaskets - Functions and properties, types of gaskets and their selection.

## Module – IV

Critical thickness of insulation, estimating thickness of insulation, optimum thickness of insulation. Friction factor and pressure drop for flow- Newtonian and non-Newtonian fluids, pipe sizing, economic velocity, sudden expansion and contraction effects, pipe surface roughness effects.

Pipe line networks and their analysis for flow in branches, restriction orifice sizing. Pressure drop calculations for non-Newtonian fluids. Pipes of circular and non-circular cross section – velocity distribution, average velocity and volumetric rate of flow. Flow through curved pipes (Variable cross sections). Effect of pipe fittings on pressure losses.

Two phase flow, types of two phase flow, two phase flow as encountered in piping for steam, pressure drop, vibrations in two phase flow.

**References:**

1. Bhasin S. D., *Project Engineering of Process Plants*, Chemical Engineering Education Development Centre, I.I.T., Madras, 1979.
2. Davidson P. J. and T. F. West, *Services for the Chemical Industry*, Pergamon Press, Oxford, 1968.
3. Chemical Engineering Development Centre, *Process Utilities*, I.I.T., Madras, 1986.
4. Cremer H. W. and S. B. Watkins, *Chemical Engineering Practice*, Vol.10, Butterworths, London, 1960.
5. Raze H. F. and M. H. Barrow, *Project Engineering of Process Plants*, John Wiley, New York, 1957
6. Mcquiston F. C and J. Parker, *Heating, Ventilating & Air conditioning – Analysis and Design*, John Wiley, New York, 3rd Edition, 1988.
7. Coulson J. M. and J. F. Richardson, *Chemical Engineering,* Vol I , VI Edition, Butterworth Heinemann, British Library, Publications, Oxford, 1999.
8. Govier G. W. and K. Aziz, *The flow of Complex Mixtures in Pipe*, Krieger Publication, Florida, 1982.

**Internal Continuous Assessment** *(Maximum Marks-50)*

*50% - Tests (minimum 2)*

*30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.*

*20% - Regularity in the class*

**University Examination Pattern:**

*Examination duration: 3 hours* *Maximum Total Marks: 100*

*The question paper shall consist of 2 parts.*

*Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be three questions each from Module I and Module II, and two questions each from Module III and Module IV.*

*Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.*

**Course Outcome:**

*Upon completion of the Course the student will able to:*

- *Identify and describe the major types of utility systems employed in industries and the major tasks involved in their operations.*
- *Identify the rating of instruments for process auxiliaries and utilities in process industry.*
- *Perform mathematical calculations involved in steam generation, psychometric and refrigeration operations.*
- *Gain a comprehensive knowledge of elements those are essential for the design, operation, and maintenance of pipelines.*
- *Select appropriate pipes, fittings and other accessories used for the construction of pipelines.*

## 13.806.2 DESIGN OF BIOLOGICAL WASTE TREATMENT SYSTEMS (H) (ELECTIVE V)

**Teaching Scheme:** 2(L) - 2(T) - 0(P) **Credits**: 4

**Course Objective**:

*This course is aimed at creating an understanding of the factors affecting biological growth and growth kinetics in aerobic and anaerobic systems for waste treatment. The course further explains the design aspects of various systems and components in the biological wastewater treatment systems.*

### Module – I

**Principles**: Objectives of biological treatment – significance – aerobic and anaerobic treatment kinetics of biological growth – Factors affecting growth – attached and suspended growth Determination of Kinetic coefficients for organics removal – Biodegradability assessment -selection of process- reactors-batch-continuous type-kinetics.

### Module – II

**Design of Aerobic Treatment Systems**: Design of sewage treatment plant units –Activated Sludge process and variations, Sequencing Batch reactors, Membrane Biological Reactors-Trickling Filters-Bio Tower RBC-Moving Bed Reactors-fluidized bed reactors, aerated lagoons, waste stabilization ponds – nutrient removal systems – natural treatment systems, constructed wet land – Disinfectant – disposal options – reclamation and reuse – Flow charts, layout, hydraulic profile, recent trends.

### Module – III

**Anaerobic Treatment of Wastewater**: Attached and suspended growth, Design of units – UASB, up flow filters, Fluidized beds septic tank and disposal – Nutrient removal systems – Flow chart Layout and Hydraulic profile – Recent trends.

**Sludge Treatment and Disposal**: Design of sludge management facilities, sludge thickening, sludge digestion, biogas generation, sludge dewatering (mechanical and gravity) Layout PID hydraulics profile – upgrading existing plants – ultimate residue disposal – recent advances.

### Module – IV

**Construction Operations and Maintenance Aspects**: Construction and Operational Maintenance problems – Trouble shooting – Planning, Organising and Controlling of plant operations – capacity building, Case studies – sewage treatment plants – sludge management facilities.

**References:**

1. Arceivala S. J., *Wastewater Treatment for Pollution Control*, TMH, New Delhi, Second Edition, 2000.

2. *Manual on Sewerage and Sewage Treatment* CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1999.
3. Metcalf and Eddy, INC, *Wastewater Engineering – Treatment and Reuse*, Fourth Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2003.
4. Qasim S. R., *Wastewater Treatment Plant, Planning, Design & Operation*, Technomic Publications, New York, 1994.

**Internal Continuous Assessment** *(Maximum Marks-50)*

*50% - Tests (minimum 2)*

*30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.*

*20% - Regularity in the class*

**University Examination Pattern:**

*Examination duration: 3 hours* *Maximum Total Marks: 100*

*The question paper shall consist of 2 parts.*

*Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be at least two questions from each module and not more than three questions from any module.*

*Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.*

**Course Outcome:**

*Upon successful completion of the course, the student shall be able to understand the kinetics of aerobic and anaerobic waste degradation. The student shall be able design systems for aerobic and anaerobic treatment of wastewater as well as sludge treatment and disposal systems.*

# 13.806.3 BIOMATERIALS (H) (ELECTIVE V)

**Teaching Scheme:** 2(L) - 2(T) - 0(P) **Credits**: 4

**Course Objective**:

*In this course, the students will be introduced to the basic concepts o f biomaterials, biodegradable polymers and biocomposites and characterisation of biomaterials.*

## Module – I

Definition of biomaterials- Common biomaterials; Proteins, Carbohydrates and specialized polymers. Structure of Collagen and Fibroin- Production of these proteins by conventional cloning methods. Carbohydrates: Modified carbohydrates acting as lubricants for biomedical applications; Polydextrose from bacteria; Carbohydrates modified from enzymes; artificial wood. Biopolymers: Synthesis from simple biological monomers- Dextrans; Rubber like materials produced by bacteria and fungi- Polyhydroxybutyrate (PHB), Polycaprolactone (PCL); Production of Biopol(copolymer of PHB and PHV).

## Module – II

Biodegradable polymers. Industrial biopolymers: Production of polyphenol resins. Evaluation of properties of biopolymers - Tensile strength (elasticity and breaking strength); Hydration, visco- elastic properties; viscosity

Bioceramics and Biocomposites: Classification of bio-ceramic materials for medical applications. Alumina and zirconia in surgical implants, bioactive glasses and their clinical applications, phosphate glass ceramics. Dense and porous hydroxyl apatite calcium phosphate ceramics, coatings and resorbable ceramics. Carbon as an implant. CMC and PMC composites. Characterization of bio-ceramics. Types of composites and their advantages. Reinforcement: Glass, boron, carbon, organic and ceramic fibers, their structure, properties and processing. Matrix materials: Polymers, metal and ceramic matrices, their structure, properties and processing.

## Module – III

Wettability and interface bonding ; Polymer matrix composites: Lamina, laminate composites. Properties of Biocomposites- Mechanical properties, thermal properties and load transfer. Macromechanics: Elastic behavior, fracture behavior, fatigue behavior, creep behavior of composites. Tribological and electrical behavior of composites. Degradation of composites due to various environmental conditions, corrosion resistance of composites. Designing with composites; Biological application of composites.

## Module – IV

Characterization of biomaterials – definition, importance and application; Principles and general methods of compositional and structural characterization, techniques of X-ray, electron and neutron diffraction, EDAX, Thermal methods - DTA, TGA, DSC, DMA, temperature dependent rheology. Microscopy - optical, electron (TEM, SEM), Atomic force microscopy, optical profilometer and confocal laser scanning microscopy, Spectroscopy – UV-visible, fluorescence and phosphorescence IR, Raman and NMR spectroscopy, ESCA and Auger spectroscopy.

**References:-**


1. Ratledge C. and B. Kristiansen*, Basic Biotechnol*ogy, Cambridge University Press, 2nd Edition, 2001
2. Doi Y., *Microbial Polyesters*, VCH Weinheim, 1990
3. Sujata V. Bhat, *Biomaterial*, Springer, 2002.
4. Buddy D. Ratner, Fredrick J. Schoen, Allan S. Hoffman and Jack E. Lemons, *Biomaterials Science: An Introduction to Materials in Medicine*, Academic Press, 2004.
5. Jonathan Black, *Biological Performance of Materials*, Taylor and Francis, 2006.
6. Sharma C. P and Szycher M, Blood Compatible Materials and Devices, Technomic Publishing Co. Ltd., 1991.
7. Piskin E. and A. S. Hoffmann, *Polymeric Biomaterials*, Martinus Nijhoff Publishers, 1986
8. Park J B, *Biomaterials - Science and Engineering*, Plenum Press, 1984.
9. Larry L. Hench and June Wilson, *An Introduction to Bioceramics*, World Scientific Publishing Company;1 Edition 1993
10. Sharon Brown, Ian Clarke and Paul Williams, *Bioceramics*, Trans Tech Publications, 2002.
11. Kokubo T.*, Bioceramics and Their Clinical Applications*, CRC, 2008.
12. Joon Park, *Bioceramics: Properties, Characterization and Applications*, Springer, 2008.
13. Amar K. Mohanty, Manjusri Misra and Lawrence T. Drzal, *Natural Fibers, Biopolyme and Biocomposites*, CRC; 1st Edition 2005.


**Internal Continuous Assessment** *(Maximum Marks-50)*

*50% - Tests (minimum 2)*

*30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.*

*20% - Regularity in the class*

**University Examination Pattern:**

*Examination duration: 3 hours* *Maximum Total Marks: 100*

*The question paper shall consist of 2 parts.*

*Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be at least two questions from each module and not more than three questions from any module.*

*Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.*

**Course Outcome:**

*Upon completion of the Course the students will be able to understand the various classes of biomaterials in use and their application in different fields. Further they will be able to understand material bulk and surface properties and standard characterization tools.*

## 13.806.4 SURFACE COATINGS (H) (ELECTIVE V)

**Teaching Scheme:** 2(L) - 2(T) - 0(P) **Credits**: 4

**Course Objective**:

- *To impart basic concepts of surface coating*
- *To develop understanding about coating and its constituents.*

### Module – I

An overview of surface coatings: Different types of surface coatings and their uses - General properties of different surface coatings. Pre-treatment of surfaces - Types of surface contamination –Surface cleaning Advantages and disadvantages of solvent cleaning and alkaline water-based cleaning - Precautions necessary in operating a solvent degreaser - Methods of pretreatment for most common metals - Safe pre-treatments for high-strength steels, aluminium alloys, stainless steels and similar high-alloy steels.

### Module – II

History and development of paint industry, function and classification. Raw material for industry, drying oils, natural and synthetic resins, pigments and extenders. Auxiliaries like driers, plasticizers, softeners, dispersing and flatting agents varnishes and lacquers, formulation and manufacturing of paints, machinery used in paint manufactures, methods of application, applications of industrial and architectural finishes. Common defect in paints and varnishes.

Electrochemical processes:- Processes of dissociation and ionisation - Influence of changes in electrolyte temperature, metal concentration and agitation on reactions taking place in the cathode film - Process of the crystal build-up on the cathode surface to produce deposits and its effect on stress and ductility - Faraday's Laws in relation to anode and cathode efficiency Effect of variations in cathode efficiency on metal distribution - Influence of deposition potential on the ability to electroplate into recesses and hollows.

### Module – III

Effect of pretreatment on adhesion and porosity – Porosity of coatings - Pitting in coatings - Coating hardness and its effect on wear resistance – Electrodeposition – Anodizing – Phosphating – Chromating- Oxidation – CVD Environmental impact of coatings and the requirements of legislation.

Non-electrolytic coating processes: Hot Dipping Processes - Zinc galvanising - Hot dip tinning - Hot dip aluminium Cladding of metals with metals, with plastics - Vitreous enamelling - Vacuum metallisation by: Evaporation, Sputtering, Ion plating - Physical Vapour Deposition (PVD)

**Module – IV**

Organic coating:- Properties and uses of primers, primer-surfacers, primer-fillers, undercoats, topcoats coating - Diffusion Coating Processes - thermal spraying of materials (Hot and Cold), lacquers and varnishes - Convertible and non-convertible polymer systems - properties and uses of solvent-containing paints, emulsions, water-based paints , powder coatings - Conversion coatings - Chemistry of the phosphating of steel - Conversion coatings for aluminium and its alloys - Paint spraying coatings - types of spray painting techniques - Dipping and flow coating – electrocoating - Common tests for paint films - Common film defects and Remedies.

**References:-**


1. Lambourne R. and T. A. Strivens, *Paint and Surface Coatings*, Theory and Practice, 1999, Woodhead Publishing
2. West J. M., *Electrodeposition and Corrosion processes*, Van Nostrand Reinhold Publisher, 1970.
3. Wolf Riedel., *Electroless Coatings* ASM International, Ohio, 1991.
4. Sunderland E. and Nylen Paul, *Modern Surface Coatings A textbook of the Chemistry and Technology of Paints, Varnishes and Lacquers*, John Wiley & Sons, 1965.
5. Fancutt F. and J. C. Hudson, *Protective Painting of Structural Steel*. Chapman and Hall Ltd.
6. Boxall J. and J. A. Von Fraunhofer., *Paint Formulation, Principle and Practice*.


**Internal Continuous Assessment** *(Maximum Marks-50)*

*50% - Tests (minimum 2)*

*30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.*

*20% - Regularity in the class*

**University Examination Pattern:**

*Examination duration: 3 hours* *Maximum Total Marks: 100*

*The question paper shall consist of 2 parts.*

*Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be at least two questions from each module and not more than three questions from any module.*

*Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.*

**Course Outcome:**

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

- *Describe the basic concepts of surface coatings*
- *Discuss about coatings and its constituents.*

## 13.806.5 WATER AND WASTE WATER ENGINEERING (H) (ELECTIVE V)

**Teaching Scheme:** 2(L) - 2(T) - 0(P) **Credits**: 4

**Course Objective**:

*This course is aimed at imparting an understanding of the significance of wastewater treatment and various methods adopted for wastewater treatment. The course further covers the water quality parameters and characterization methods and gives due emphasis on the concept and significance of sustainable methods in water treatment.*

**Module – I**

Introduction to Water Supply and Wastewater- Water Quality Parameters and Standards- Characteristics of water: physical, chemical and biological parameters, standard methods of water analyses, biodegradable waste and agricultural runoff in streams, population forecasting, prediction of water demand and wastewater generation, water and wastewater quality.

**Module – II**

Water and wastewater treatment plants and systems: physical, chemical and biological systems, primary, secondary and tertiary treatment- Design considerations for sedimentation, coagulation, flocculation, filtration, adsorption, ammonia removal, aeration, anaerobic and aerobic digestion, activated sludge and trickling filter, ion exchange, lagoons, disinfection, natural treatment systems, sludge treatment and disposal.

**Module – III**

Industrial wastewater treatment – Overview of major industries (dairy, distillery, sugar, textile, tannery, pulp & paper, metal finishing, petroleum refining, pharmaceutical and fertilizer; thermal power), their water requirements, and the typical quantities and characteristics of wastewaters generated. Environmental consequences of wastewater discharge and the regulatory requirements for treatment and disposal treatment levels and available technologies. Theory and design of waste stabilization ponds and oxidation ditches.

**Module – IV**

Concept of sustainable waste water treatment. Management, administration, legal and financial aspects of water and wastewater treatment plants. Operational problems encountered in treatment plants: typical problems arising in various units, trouble shooting. Operation and maintenance of plant operations. Training of operating personnel.

**References:-**

1. Metcalf and Eddy, *Wastewater Engineering – Treatment and Reuse*, Revised by G.Tchobanoglous, F. L. Burton, and H. D. Stensel, 4/e, Tata McGraw-Hill, 2003.

2. Casey T. J., *Unit Processes in Water and Wastewater Engineering*. Wiley Interscience, 1997.
3. Eckenfelder W.W., *Industrial Water Pollution Control*, Mc-Graw Hill, 1999
4. Weber W. J. and F. A. DiGiano, *Process Dynamics in Environmental Systems*. Wiley Interscience.
5. McCarty P., and Rittmann, B., *Environmental Biotechnology: Principles and Applications*,McGraw Hill, 2000.

**Internal Continuous Assessment** *(Maximum Marks-50)*

*50% - Tests (minimum 2)*

*30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.*

*20% - Regularity in the class*

**University Examination Pattern:**

*Examination duration: 3 hours* *Maximum Total Marks: 100*

*The question paper shall consist of 2 parts.*

*Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be at least two questions from each module and not more than three questions from any module.*

*Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.*

**Course Outcome:**

*Upon successful completion of the course the student shall be able to familiarize the water quality parameters and standards as well water characterization methods. The student shall be able to explain the design aspects of components and systems for wastewater treatment. The student shall further be able to explain the nature and treatment methods for wastewater from specific industries.*

## 13.806.6 COMPUTATIONAL FLUID DYNAMICS (H) (ELECTIVE V)

**Teaching Scheme:** 2(L) - 2(T) - 0(P) **Credits**: 4

**Course Objective**:

*The course introduces the student to widely used techniques in the numerical solution of fluid equations, issues that arise in the solution of such equations, and modern trends in CFD.*

### Module – I

Introduction to Computational Fluid Dynamics (CFD). History of development of CFD. Philosophy of CFD, CFD as a research and design tool. Experimental, analytical and computational approaches to prediction of fluid flow and heat transfer processes. Review of derivation of governing equations of transport processes. Classification of the differential equation models. Navier–Stokes and Euler equations. Turbulent flow: Time–averaged equations of turbulent flow, Turbulence–kinetic energy equations, k-? model, Mixing length model, the Physical meaning of these equations and forms suitable for CFD methods.

### Module – II

Discretization methods – Taylor series, variational formulation, weighted residuals, Concepts of finite control volume and infinitesimal fluid elements. Finite difference and finite element methods. Properties of discretization schemes conservativeness boundedness, transportiveness, Grid generation- structured, unstructured and adaptive grid generation.

### Module – III

Steady state one- dimensional conduction, grid spacing, interface conductivity, Nonlinearity, source-term linearization, boundary conditions. Steady one-dimensional convection – diffusion, Discretization equations in one, two and three dimensions. The upwind scheme, exponential scheme, hybrid scheme, power law scheme. Higher order schemes.

### Module – IV

Un-steady state one-dimensional conduction. Crank Nicholson scheme, Fully implicit schemes,Fully implicit discretization equation, CFD methods for solving unsteady flow equations, Implementation of inlet, outlet and wall boundary conditions, Constant pressure boundary condition, Two and three dimensional situations, Beam warming algorithm, MacCormack's scheme, upwind scheme. Discretization of transient convection-diffusion equation, Overrelaxation and underrelaxation. Customizing commercial CFD solvers.
Construction of geometry and discretization using Gambit-Fluent's manuals : Commercial CFD Solver packages. Components of CFD packages.

**References:-**


1. Anderson J. D., *Computational Fluid Dynamics: The Basics with Application,* McGraw Hill Co. Inc
2. Anderson D. A., Tannechil J. C. and Pletcher R. H., *Computational Fluid Mechanics and Heat Transfer*, Hemisphere Publishing Corp.
3. ANIL W. DATE, *Introduction to Computational Fluid Dynamics*, Cambridge University Press, 2005
4. Suhas V. Patangar, *Numerical Heat Transfer and Fluid Flow*, Hemisphere Publishing Corp., 1980
5. Shaw C. T., *Using Computational Fluid Dynamics*, Prentice Hall, 1992.
6. Joel H. Ferziger and Milovan Peric, *Computational Methods for Fluid Dynamics*, Springer Verlag, 3rd edition, 2001.
7. Chung T. J., *Computational Fluid Dynamics*, Cambridge University Press


**Internal Continuous Assessment** *(Maximum Marks-50)*

*50% - Tests (minimum 2)*

*30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.*

*20% - Regularity in the class*

**University Examination Pattern:**

*Examination duration: 3 hours* *Maximum Total Marks: 100*

*The question paper shall consist of 2 parts.*

*Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be at least two questions from each module and not more than three questions from any module.*

*Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.*

**Course Outcome:**

*At the end of the course, the student will be able to get numerical solution of fluid equations, issues that arise in the solution of such equations, and modern trends in CFD.*

## 13.806.7 SOLID WASTE MANAGEMENT (H) (ELECTIVE V)

**Teaching Scheme:** 2(L) - 2(T) - 0(P) **Credits**: 4

**Course Objective**:

*The course is aimed at imparting the fundamental concepts of solid waste management including segregation, collection, storage and disposal while emphasizing on the concept of reduce, recycle and reuse. This course is further aimed at explaining the various solid waste processing methods including handling of hazardous wastes. Lastly the course gives an overview of the legal aspects and governmental policies pertaining to solid waste handling.*

### Module – I

**Introduction:** Solid wastes- definition, types, sources, characteristics, and impact on environmental health. Waste generation rates. Waste Management Practices: Municipal, Hazardous, and Industrial Concepts of waste reduction, recycling and reuse. Collection, segregation and transport of solid wastes Handling and segregation of wastes at source. Collection and storage of municipal solid wastes; analysis of Collection systems.

### Module – II

**Solid waste processing technologies**: Mechanical and thermal volume reduction. Biological and chemical techniques for energy and other resource recovery: composting. vermicomposting, fermentation. Incineration of solid wastes. Pyrolysis. Disposal in landfills: site selection design, and operation of sanitary landfills; secure landfills and landfill bioreactors; leachate and landfill gas management; landfill closure and post-closure environmental monitoring; landfill remediation.

### Module – III

**Hazardous wastes**: definition, sources and characteristics: handling, collection, labelling, storage and transport. Hazardous waste treatment technologies. Physical, chemical and thermal treatment of hazardous waste: solidification, chemical fixation and encapsulation, incineration. Hazardous waste landfills: site selection, design and operation.

**Biomedical, plastic and e-waste**: waste categorization, generation, collection, transport, treatment and disposal.

### Module – IV

**Legislation on solid waste handling:** Elements of integrated waste management: Waste Minimization Technologies, Environmental and health impact of solid waste management activities - Legislations on management and handling of municipal solid wastes, biomedical wastes, and other hazardous wastes. Public participation and the role of NGOs.

**References:-**


1. Kreith F. and G. Tchobanoglous, *Handbook of Solid Waste Management,*2nd edition.
2. LaGrega M. D., P. L Buckingham, J. C. Evans*, Hazardous Waste Management*, McGraw-Hill, 2000.
3. Tchobanglais G., H. Theisen and S. A. Vigil, *Integrated Solid Waste Management: Engineering Principles and Management Issues*, McGraw Hill. 1993
4. Shah K. L., *Basics of Solid and Hazardous Waste Management Techniques*, Prentice Hall. 1999
5. Tedder D. W. and F. G. Pohland (editors), *Emerging Technologies in Hazardous Waste Management*, American Chemical Society. 1990
6. Conway R. A. and Ross R. D., *Handbook of Industrial Waste Disposal*, Van-Nostrand Reinhold. 1980
7. Side G. W., *Hazardous Materials and Hazardous Waste Management*, Wiley.


**Internal Continuous Assessment** *(Maximum Marks-50)*

*50% - Tests (minimum 2)*

*30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.*

*20% - Regularity in the class*

**University Examination Pattern:**

*Examination duration: 3 hours* *Maximum Total Marks: 100*

*The question paper shall consist of 2 parts.*

*Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be at least two questions from each module and not more than three questions from any module.*

*Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.*

**Course Outcome:**

*Upon successful completion of the course, the students shall become familiar with the basics of solid waste management involving segregation, collection, storage and disposal as well as the concept of reduce, recycle and reuse. The student shall be able to explain the methods and stages involved in solid waste management right from collection to disposal. The students will be able to give an overview of the various legal aspects in solid waste management.*

## 13.806.8 COMPOSITE TECHNOLOGY (H) (ELECTIVE V)

**Teaching Scheme:** 2(L) - 2(T) - 0(P) **Credits**: 4

**Course Objective**:

*The objective of this course is to introduce students to the concepts of modern composite materials and its technology.*

**Module – I**

Introduction to composites: General Introduction and Concept of Composite materials, Basic definitions, need and types. Classification- based on Matrix Material: Organic matrix composites Polymer matrix composites (PMC), Carbon matrix Composites or Carbon-Carbon Composites, Metal matrix composites (MMC), Ceramic matrix composites (CMC); Classification based on reinforcements: Fiber Reinforced Composites, Fiber Reinforced Polymer (FRP) Composites, Laminar Composites and Particulate composites. Comparison of composites with metals, applications of various types of composites, advantageous and limitations of composites.

**Module – II**

Polymer matrix composites: Polymer matrix resins – Thermosetting resins, thermoplastic resins, Reinforcement fibres – Rovings Woven fabrics, Non woven random mats, various types of fibres. PMC processes - Hand layup processes, Spray up processes, Compression moulding, reinforced reaction injection moulding, Resin transfer moulding. Pultrusion – Filament winding – Injection moulding. Fibre reinforced plastics (FRP), Glass fibre reinforced plastics (GRP).

**Module – III**

Metal matrix composites:- Characteristics of MMC, Various types of Metal matrix composites. Alloy vs MMC, Advantages of MMC, Limitations of MMC, Metal Matrix, Reinforcements –particles – fibres. Effect of reinforcement - Volume fraction – Rule of mixtures. Processing of MMC – Powder metallurgy process - diffusion bonding – stir casting – squeeze casting.

**Module – IV**

Ceramic matrix composites:- Engineering ceramic materials – properties, advantages, limitations, Monolithic ceramics. Need for CMC Ceramic matrix - Various types of Ceramic Matrix composites- oxide ceramics, non oxide ceramics, aluminium oxide, silicon nitride, reinforcements – particles, fibres, whiskers. Sintering - Hot pressing, Cold isostatic pressing (CIPing), Hot isostatic pressing (HIPing). Advances in composites: - Carbon /carbon composites, advantages of carbon matrix, limitations of carbon matrix. Carbon fibre, chemical vapour deposition of carbon on carbon fibre perform. Solgel technique. Composites for aerospace applications.

**References:-**


1. Mathews F. L. and R. D. Rawlings, *Composite Materials: Engineering and Science*, Chapman and Hall, London, England, 1st edition, 1994.
2. Chawla K. K., *Composite Materials*, Springer – Verlag, 1987.
3. Clyne T. W. and P. J. Withers, *Introduction to Metal Matrix Composites*, Cambridge University Press, 1993.
4. Strong A. B., *Fundamentals of Composite Manufacturing*, SME, 1989.
5. Sharma S. C., *Composite Materials*, Narosa Publications, 2000.
6. *Short Term Course on Advances in Composite Materials*, Composite Technology Centre, Department of Metallurgy, IIT- Madras, December 2001.


**Internal Continuous Assessment** *(Maximum Marks-50)*

*50% - Tests (minimum 2)*

*30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.*

*20% - Regularity in the class*

**University Examination Pattern:**

*Examination duration: 3 hours* *Maximum Total Marks: 100*

*The question paper shall consist of 2 parts.*

*Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be at least two questions from each module and not more than three questions from any module.*

*Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.*

**Course Outcome:**

*Upon successful completion of this course, the student will be able to:*

- *identify and explain the types of composite materials and their characteristic features*
- *understand the differences in the strengthening mechanism of composite and its corresponding effect on performance and application;*
- *understand and explain the methods employed in composite fabrication*

## 13.807 PROJECT AND VIVA- VOCE (H)

**Teaching Scheme:** 0(L) - 0(T) - 5(P) **Credits**: 5

**Course Objective :**

*The objectives of this course are to:*

- *introduce students to independent project research*
- *provide students with opportunities to develop basic skills invloved in collecting, analysing and presenting necessary data required for independent project research.*

Every student will be required to submit a project report in a typed form, on a topic selected by the student, but specifically approved by the faculty member, who will guide the student or on a topic to be assigned by one or more faculty members.

The project work on the topic will consists of either investigational work or computer simulation or design problem or experimental set up of some development work or prototype equipment.

Every student will be orally examined in the topic incorporated in the project and in the related area of specialization.

The student will be required to submit three copies of his/her typed copy of the project report to the department office for record (One copy each for the department library, participating faculty and students own copy)

**Internal Continuous Assessment** *(Maximum Marks-200)*

**Guide's share: 100 Marks**

*The guide has to award a maximum of 80 marks based on the performance of the student during the course of execution of the work associated with the project. A maximum of 20 marks shall be awarded to the students having more than 90 % attendance at the centre where project work is carried out. Proportionate deductions may be made as is done in the case of internal evaluation for theory subjects.*

**Evaluation Committee's share: 100 Marks**

*An evaluation committee consisting of the project coordinator, the guide and one faculty of the department has to evaluate the student based on oral evaluations on the basis of the project work during the different stages of the work (minimum two).*

***University* Examination Pattern:**

*Viva-Voce* *Maximum Total Marks: 100*

*Distribution of marks for Viva Voce examination is as follows:*

**General Subject Viva**: **50 Marks**

*A comprehensive viva should be conducted by both the external and internal examiners, to evaluate the student based on the various courses taken up during the period of his/her undergraduate programme.*

**Viva based on the project**: **50 Marks**

*The knowledge of the student in the work done for the project has to be evaluated by both the external and internal examiners in the viva-voce examination conducted with questions exclusively based on the project work and evaluated out of a maximum of 50 marks.*

**Course Outcome:**

*On successful completion of the course students will be able to:*

- *Demonstrate a sound technical knowledge of their selected project topic.*
- *Undertake problem identification, formulation and solution.*
- *Design engineering solutions to complex problems utilising a systems approach.*
- *Conduct an engineering project*
- *Communicate with engineers and the community at large in written an oral forms.*
- *Demonstrate the knowledge, skills and attitudes of a professional engineer.*