# SCHEME AND SYLLABI

**FOR**

# THIRD TO EIGHTH SEMESTERS

**OF**

# BACHELOR OF TECHNOLOGY

**IN**

# CHEMICAL ENGINEERING

**FROM 2009 ADMISSION ONWARDS**

**CALICUT UNIVERSITY (P.O), THENHIPALAM**

# B.TECH. CHEMICAL ENGINEERING CURRICULAM

*2009 Admission onwards*

**3rd Semester**

| Code | Subject | Hours/week | | | Marks | | End-sem duration-hours | Credits |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P/D | Inte-rnal | End-sem | | |
| EN09 301 | Engineering Mathematics III | 3 | 1 | - | 30 | 70 | 3 | 4 |
| EN09 302 | Humanities and Communication Skills | 2 | 1 | - | 30 | 70 | 3 | 3 |
| CH09 303 | Chemical Process Principles | 3 | 2 | - | 30 | 70 | 3 | 5 |
| CH09 304 | Organic Chemistry | 3 | 1 | - | 30 | 70 | 3 | 4 |
| CH09 305 | Chemical Engineering Thermodynamics I | 3 | 1 | - | 30 | 70 | 3 | 4 |
| CH09 306 | Material Science & Engineering | 3 | 1 | - | 30 | 70 | 3 | 4 |
| CH09 307(P) | Chemistry Lab II | - | - | 3 | 50 | 50 | 3 | 2 |
| CH09 308(P) | Chemical Technology Lab | - | - | 3 | 50 | 50 | 3 | 2 |
| | **Total** | **17** | **7** | **6** | | | | **28** |

**4th Semester**

| Code | Subject | Hours/week | | | Marks | | End-sem duration-hours | Credits |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P/D | Inte-rnal | End-sem | | |
| EN09 401 A | Engineering Mathematics IV | 3 | 1 | - | 30 | 70 | 3 | 4 |
| EN09 402 | Environmental Science | 2 | 1 | - | 30 | 70 | 3 | 3 |
| CH09 403 | Fluid and Particle Mechanics | 3 | 2 | - | 30 | 70 | 3 | 5 |
| CH09 404 | Physical and Analytical Chemistry | 3 | 1 | - | 30 | 70 | 3 | 4 |
| CH09 405 | Chemical Engineering Thermodynamics II | 3 | 1 | - | 30 | 70 | 3 | 4 |
| CH09 406 | Particle Technology | 3 | 1 | - | 30 | 70 | 3 | 4 |
| CH09 407(P) | Environmental Engineering Lab | - | - | 3 | 50 | 50 | 3 | 2 |
| CH09 408(P) | Materials Technology and Engineering Lab | - | - | 3 | 50 | 50 | 3 | 2 |
| | **Total** | **17** | **7** | **6** | | | | **28** |

## 5th Semester

| Code | Subject | Hours/week | | | Marks | | End-sem duration-hours | Credits |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P/D | Inte-rnal | End-sem | | |
| CH09 501 | Chemical Reaction Engineering | 3 | 2 | - | 30 | 70 | 3 | 5 |
| CH09 502 | Petroleum Refinery Engineering & Petrochemicals | 3 | 1 | - | 30 | 70 | 3 | 4 |
| CH09 503 | Process Heat Transfer | 3 | 1 | - | 30 | 70 | 3 | 4 |
| CH09 504 | Mass Transfer Operations I | 3 | 1 | - | 30 | 70 | 3 | 4 |
| CH09 505 | Environmental Engineering | 3 | 1 | - | 30 | 70 | 3 | 4 |
| CH09 506 | Process Instrumentation | 2 | 1 | - | 30 | 70 | 3 | 3 |
| CH09 507(P) | Fluid & Particle Mechanics Lab | - | - | 3 | 50 | 50 | 3 | 2 |
| CH09 508(P) | Particle Technology Lab | - | - | 3 | 50 | 50 | 3 | 2 |
| | **Total** | **17** | **7** | **6** | | | | **28** |

## 6th Semester

| Code | Subject | Hours/week | | | Marks | | End-sem duration-hours | Credits |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P/D | Inte-rnal | End-sem | | |
| CH09 601 | Chemical Process Industries | 4 | 1 | - | 30 | 70 | 3 | 5 |
| CH09 602 | Process Dynamics & Control | 3 | 1 | - | 30 | 70 | 3 | 4 |
| CH09 603 | Mass Transfer Operations II | 3 | 1 | - | 30 | 70 | 3 | 4 |
| CH09 604 | Economics and Management of Chemical Industries | 3 | 1 | - | 30 | 70 | 3 | 4 |
| CH09 605 | Energy Engineering | 2 | 1 | - | 30 | 70 | 3 | 3 |
| CH09 Lxx | Elective I | 3 | 1 | - | 30 | 70 | 3 | 4 |
| CH09 607(P) | Heat Transfer Operations Lab | - | - | 3 | 50 | 50 | 3 | 2 |
| CH09 608(P) | Process Design Software Lab/ Mini Project | - | - | 3 | 50 | 50 | 3 | 2 |
| | **Total** | **18** | **6** | **6** | | | | **28** |

**Elective I**

CH09 L01 High Polymer Engineering

CH09 L02 Water Treatment Technology

CH09 L03 Essentials of Management

CH09 L04 Numerical Analysis

CH09 L05 Computational Fluid Dynamics

## 7th Semester

| Code | Subject | Hours/week | | | Marks | | End-sem duration-hours | Credits |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P/D | Inte-rnal | End-sem | | |
| CH09 701 | Chemical Engineering Design & Drawing I | 2 | 1 | 2 | 30 | 70 | 3 | 5 |
| CH09 702 | Transport Phenomena | 3 | 1 | - | 30 | 70 | 3 | 4 |
| CH09 703 | Safety Engineering in Process Plants | 2 | 1 | - | 30 | 70 | 3 | 3 |
| CH09 704 | Biochemical Engineering | 2 | 1 | - | 30 | 70 | 3 | 3 |
| CH09 Lxx | Elective II | 3 | 1 | - | 30 | 70 | 3 | 4 |
| CH09 Lxx | Elective III | 3 | 1 | - | 30 | 70 | 3 | 4 |
| CH09 707(P) | Mass Transfer Operations Lab | - | - | 3 | 50 | 50 | 3 | 2 |
| CH09 708(P) | Process Control and Reaction Engineering Lab | - | - | 3 | 50 | 50 | 3 | 2 |
| CH09 708(P) | Project | - | - | 1 | 100 | - | - | 1 |
| | **Total** | **15** | **6** | **9** | | | | **28** |

## 8th Semester

| Code | Subject | Hours/week | | | Marks | | End-sem duration-hours | Credits |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P/D | Inte-rnal | End-sem | | |
| CH09 801 | Chemical Engineering Design& Drawing II | 4 | 1 | - | 30 | 70 | 3 | 5 |
| CH09 802 | Optimization of Chemical Processes | 2 | 1 | - | 30 | 70 | 3 | 3 |
| CH09 Lxx | Elective IV | 3 | 1 | - | 30 | 70 | 3 | 4 |
| CH09 Lxx | Elective V | 3 | 1 | - | 30 | 70 | 3 | 4 |
| CH09 805 (P) | Seminar | - | - | 3 | 100 | - | - | 2 |
| CH09 806 (P) | Project | - | - | 11 | 100 | - | - | 7 |
| CH09 807 (P) | Viva-Voce | - | - | - | 100 | - | - | 3 |
| | **Total** | **12** | **4** | **14** | | | | **28** |

**Electives**

CH09 L06 Software Engineering
CH09 L07 Advances in Bioprocess Engineering
CH09 L08 Computer Aided Design
CH09 L09 Unconventional Separation Techniques
CH09 L10 Micro Electronics Processing
CH09 L11 Food Technology
CH09 L12 Process Modeling and Simulation

CH09 L13 Marketing Management
CH09 L14 Petroleum Exploration and Storage
CH09 L15 Composite Materials
CH09 L16 Catalysis- Theory and Practice
CH09 L17 Surface Coatings
CH09 L18 Ceramic Technology
CH09 L19 Rubber Technology
CH09 L20 Mathematical Methods in Chemical Engineering
CH09 L21 Solid Waste Management
CH09 L22 Nuclear Engineering
CH09 L23 Nanomaterial and Nanotechnology
CH09 L24 Industrial Pollution Control
CH09 L25 Project Engineering

**Global Electives**

PE09 L23 Total Quality Management
PE09 L24 Industrial Psychology
PE09 L25 Entrepreneurship
BT09 L23 Bio-nanotechnology
BT09 L24 Bio-ethics and Intellectual Property Rights
BT09 L25 Biomaterials
BM09 L23 Operation Research
EC09 L23 Data Structures and Algorithms
CE09 L23 Experimental Stress Analysis
CE09 L25 Finite Element Analysis
EE09 L22 Soft Computing Techniques
CS09 L24 Computer Based Numerical Methods
IC09 L24 Non-linear Dynamics and Chaos
IT09 L24 Management Information Systems
PT09 L24 Digital Photography

## For Laboratory

**Internal Continuous Assessment** *(Maximum Marks-50)*
60%-Laboratory practical and record
30%- Test/s
10%- Regularity in the class
**End Semester Examination** *(Maximum Marks-50)*
70% - Procedure, conducting experiment, results, tabulation, and inference
20% - Viva voce
10% - Fair record

## For Theory Subjects

**Internal Continuous Assessment** *(Maximum Marks-30)*
60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

**University Examination Pattern (for all Subjects except CH09 701 and CH09 801)**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**University question pattern (for CH09 701** *Chemical Engineering Design & Drawing I* and **CH09 801** *Chemical Engineering Design & Drawing II***)**

Part A - *Analytical/Problem solving questions* *1 x 20 marks=20 marks*

2 question of 20 marks from first module with choice to answer one.

Part B - *Analytical/Problem solving questions* *1 x 25 marks=25 marks*

2 question of 25 marks from second module with choice to answer one.

Part C - *Analytical/Problem solving questions* *1 x 25 marks=25 marks*

2 question of 25 marks from third module with choice to answer one.

*Maximum Total Marks: 70*

**Grading**

The university shall award the letter grade to students based on the marks secured by them in both internal assessment and end-semester examinations taken together in the subjects registered. Each letter grade indicates a qualitative assessment of the student's performance and is associated with a specified number of grade points. The grading system along with the grade points for each grade, applicable to passed candidates is shown below. All passed candidate will be allotted a grade S, A, B, C, D, or E according to the total marks scored by him/her.

| **Total marks scored by the passed candidate** | **Corresponding Grade allotted** | **Grade Points** |
|---|---|---|
| 86 - 100 | S | 10 |
| 76 - 85 | A | 8.5 |
| 66 - 75 | B | 7.5 |
| 56 - 65 | C | 6.5 |
| 46 - 55 | D | 5.5 |
| 40 - 45 | E | 4.5 |

If a candidate does not a pass a subject as per the conditions given in Section (9), he/she will be assigned an Unsatisfactory grade 'U' irrespective of his/her total marks. If a student does not pass a subject in two attempts, the maximum grade he/she can get is 'C' when he/she passes the subject in any subsequent examination, whatever be the marks scored by him/her. A student is considered to have completed a subject successfully and earned the credits if he/she secures a letter grade other than 'U' in that course. Letter grade 'U' has zero grade point and the candidate has to write the examination again to improve the grade. A student's performance is measured by the number of credits that he/she has earned and by the cumulative grade point average (CGPA) maintained by him/her.

**Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA)**

(a) A Semester Grade Point Average (SGPA) shall be computed for all the students for each semester, as follows:

$$\text{SGPA} = \frac{(C_1 G_1 + C_2 G_2 + C_3 G_3 + ..... + C_n G_n)}{(C_1 + C_2 + C_3 + .... + C_n)}$$

where, n is the number of subjects registered during the semester, Ci is the number of credits allotted to ith subject as per the scheme, and Gi is the grade points corresponding to the grade awarded to the student for the subject.

(b) A Cumulative Grade Point Average (CGPA) shall be computed for all the students at the end of each semester by taking into consideration their performance in the present and the past semesters as follows:

$$\text{CGPA} = \frac{(C_1 G_1 + C_2 G_2 + C_3 G_3 + ..... + C_m G_m)}{(C_1 + C_2 + C_3 + .... + C_m)}$$

where, m is the number of courses registered up to that semester, Ci is the number of credits allotted to ith subject as per the scheme, and Gi is the grade points corresponding to the grade awarded to the student for the subject. An up-to-date assessment of overall performance of a student is obtained by calculating CGPA. CGPA is weighted average of the grade points obtained in all the subjects registered by the students since he entered the B.Tech. course.

(c) Both the SGPA and CGPA shall be rounded off to the second place of decimal and recorded as such for ease of presentation. Whenever the CGPAs are to be used for the purpose of determining the merit ranking in a group of students, only the rounded off values shall be made use of.

# University of Calicut

**Scheme and Syllabus**

B.Tech.

# CHEMICAL ENGINEERING

III to VIII Semester

FROM 2009 ADMISSION ONWARDS

# B.TECH. CHEMICAL ENGINEERING SYLLABUS

## THIRD SEMESTER

**EN09 301 ENGINEERING MATHEMATICS III**

(Common for all branches)

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

**Objective**

- *This course provides a quick overview of the concepts and results in complex analysis that may be useful in engineering.*
- *Also it gives an introduction to linear algebra and Fourier transform which are wealths of ideas and results with wide area of application.*

**Module 1**: Functions of a Complex Variable (13 hours)

Functions of a Complex Variable – Limit – Continuity – Derivative of a Complex function – Analytic functions – Cauchy-Riemann Equations – Laplace equation – Harmonic Functions – Conformal Mapping – Examples: $Z^n$, sinz, cosz, sinhz, coshz, $(z+{}^1/_Z)$– Mobius Transformation.

**Module 2**: Functions of a Complex Variable (14 hours)

Definition of Line integral in the complex plane – Cauchy's integral theorem (Proof of existence of indefinite integral to be omitted) – Independence of path – Cauchy's integral formula – Derivatives of analytic functions (Proof not required) – Taylor series – Laurent series – Singularities and Zeros – Residues – Residue Integration method – Residues and Residue theorem – Evaluation of real integrals.

**Module 3**: Linear Algebra (13 hours) - Proofs not required

Vector spaces – Definition, Examples – Subspaces – Linear Span – Linear Independence – Linear Dependence – Basis – Dimension – Ordered Basis – Coordinate Vectors – Transition Matrix – Orthogonal and Orthonormal Sets – Orthogonal and Orthonormal Basis – Gram-Schmidt orthogonolisation process – Inner product spaces –Examples.

**Module 4**: Fourier Transforms (14 hours)

Fourier Integral theorem (Proof not required) – Fourier Sine and Cosine integral representations – Fourier Transforms – Fourier Sine and Cosine Transforms – Properties of Fourier Transforms.

**Text Books:**

**Module I:**

Erwin Kreysig, *Advanced Engineering Mathematics, 8e,* John Wiley and Sons, Inc.
Sections: 12.3, 12.4, 12.5, 12.6, 12.7, 12.9

**Module II:**

Erwin Kreysig, *Advanced Engineering Mathematics, 8e,* John Wiley and Sons, Inc.
Sections: 13.1, 13.2, 13.3, 13.4, 14.4, 15.1, 15.2, 15.3, 15.4

**Module III:**

Bernaed Kolman, David R Hill, *Introductory Linear Algebra, An Applied First Course,* Pearson Education.
Sections: 6.1, 6.2, 6.3, 6.4, 6.7, 6.8, Appendix.B.1

**Module IV:**
Wylie C.R and L.C. Barrett, *Advanced Engineering Mathematics*, McGraw Hill.Sections: 9.1, 9.3, 9.5

**References:**

1. H S Kasana, *Complex Variables, Theory and Applications,* 2e, Prentice Hall of India.
2. John M Howie, *Complex Analysis,* Springer International Edition.
3. Shahnaz bathul, *Text book of Engineering Mathematics, Special functions and Complex Variables,* Prentice Hall of India.
4. Gerald Dennis Mahan, *Applied mathematics*, Springer International Edition.
5. David Towers, *Guide to Linear Algebra*, MacMillan Mathematical Guides.
6. Howard Anton, Chris Rorres, *Elementary Linear Algebra, Applications Version, 9e*, John Wiley and Sons.
7. Anthony Croft, Robert Davison, Martin Hargreaves, *Engineering Mathematics*, 3e, Pearson Education.
8. H Parthasarathy, *Engineering Mathematics, A Project & Problem based approach,* Ane Books India.
9. B V Ramana, *Higher Engineering Mathematics,* McGrawHill.
10. Sarveswara Rao Koneru, *Engineering Mathematics*, Universities Press.
11. J K Sharma, *Business Mathematics, Theory and Applications,* Ane Books India.
12. John bird, *Higher Engineering Mathematics*, Elsevier, Newnes.
13. M Chandra Mohan, Vargheese Philip, *Engineering Mathematics-Vol. I, II, III & IV.*, Sanguine Technical Publishers.
14. N Bali, M Goyal, C Watkins, *Advanced Engineering Mathematics, A Computer Approach, 7e,* Infinity Science Press, Fire Wall Media.
15. V R Lakshmy Gorty, *Advanced Engineering Mathematics-Vol. I, II.*, Ane Books India.
16. Sastry S.S., *Advanced Engineering Mathematics-Vol. I and II.*, Prentice Hall of India.
17. Lary C Andrews, Bhimsen K Shivamoggi, *Integral Transforms for Engineers*, Prentice Hall of India.


**Internal Continuous Assessment** *(Maximum Marks-30)*
60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

**University Examination Pattern**
*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*
All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*
Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**EN09 302 HUMANITIES AND COMMUNICATION SKILLS**

(Common for all branches)

**Teaching scheme** **Credits:** 3

*2 hours lecture & 1 hour tutorial per week*

Objectives

- *To identify the most critical issues that confronted particular periods and locations in history*
- *To identify stages in the development of science and technology*
- *To understand the purpose and process of communication*
- *To produce documents reflecting different types of communication such as technical descriptions, proposals ,and reports*
- *To develop a positive attitude and self-confidence in the workplace and*
- *To develop appropriate social and business ethics.*

**Module 1 (14 hours)**

Humanities, Science and Technology: Importance of humanities to technology, education and society- Impact of science and technology on the development of modern civilization. Contributions of ancient civilization: Chinese, Indian, Egyptian and Greek. Cultural, Industrial, Transportation and Communication revolutions. Advances in modern India: Achievements in information, communication and space technologies.

**Module 2 (16 hours)**

Concept of communication: The speaker/writer and the listener/reader, medium of communication, barriers to communication, accuracy, brevity, clarity and appropriateness. Reading comprehension: Reading at various speeds, different kinds of text for different purposes, reading between lines. Listening comprehension: Comprehending material delivered at fast speed and spoken material, intelligent listening in interviews. Speaking: Achieving desired clarity and fluency, manipulating paralinguistic features of speaking, task oriented, interpersonal, informal and semi formal speaking, making a short classroom presentation. Group discussion: Use of persuasive strategies, being polite and firm, handling questions and taking in criticisms on self, turn-taking strategies and effective intervention, use of body language.

**Module 3 (16 hours)**

Written Communication : Note making and taking, summarizing, notes and memos, developing notes into text, organization of ideas, cohesion and coherence, paragraph writing, ordering information in space and time, description and argument, comparison and contrast, narrating events chronologically. Writing a rough draft, editing, proof reading, final draft and styling text. Technical report writing: Synopsis writing, formats for reports. Introductory report, Progress report, Incident report, Feasibility report, Marketing report, Field report and Laboratory test report. Project report: Reference work, General objective, specific objective, introduction, body, illustrations using graphs, tables, charts, diagrams and flow charts. Conclusion and references. Preparation of leaflets, brochure and C.V.

**Module 4 (14 hours)**

Human relations and Professional ethics: Art of dealing with people, empathy and sympathy, hearing and listening. Tension and stress, Methods to handle stress. Responsibilities and rights of engineers- collegiality and loyalty – Respect for authority – Confidentiality – conflicts of interest – Professional rights, Rights of information, Social responsibility. Senses of ethics – variety of moral issues – Moral dilemma – Moral autonomy – Attributes of an ethical personality – right action – self interest

**References:**


1. Meenakshi Raman and Sangeeta Sharma, *Technical Communication- Principles and Practice* Oxford University press, 2006
2. Jayashree Suresh and B S Raghavan, *Professional Ethics*, S Chand and Company Ltd, 2005
3. Subrayappa, *History of Science in India*, National Academy of Science, India
4. R C Bhatia, *Business Communication*, Ane Books Pvt. Ltd, 2009
5. Sunita Mishra and C Muralikrishna, *Communicatin Skils for Engineers*, Pearson Education, 2007.
6. Jovan van Emden and Lucinda Becker, *Effective Communication for Arts and Humanities Students*, Palgrave macmillam, 2009
7. W C Dampier, *History of Science*, Cambridge University Press
8. Vesilind, *Engineering, Ethics and the Environment*, Cambridge University Press
9. Larson E, *History of Inventions*, Thompson Press India Ltd.
10. Bernal J.D, *Science in History*, Penguin Books Ltd
11. Encyclopedia Britannica, *History of Science, History of Technology*


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 303 CHEMICAL PROCESS PRINCIPLES**

**Teaching scheme** **Credits:** 5

*3 hours lecture & 2 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of Chemical Engineering*

- *To develop understanding about material balance and energy balance for analysis of unit processes and unit operations*

**Module 1** (16 hours)

Introduction to chemical engineering, chemical process industries and role of chemical engineer, unit operations and unit processes, fundamental concepts, units and dimensions, conversion of units, dimensional analysis, conversion of empirical equations, mole concept and mole fraction, weight fraction and volume fraction, concentration of liquid solutions-molarity, molality, normality, ppm, density and specific gravity, specific gravity scales, use of mole concept in chemical reaction stiochiometry, concept of limiting and excess reactants, conversion and yield, ideal gases and gas mixtures, ideal gas law, Dalton and Amagat laws, real gas laws, Composition of gases on dry basis and on wet basis. average molecular weight and density of gases

**Module 2** (17 hours)

Material balances: typical flow sheet, batch, stagewise and continous operation, Material balance without chemical reactions, Basic material balance principles- Material balance in unit operations such as Evaporation, Crystallization, Drying, Absorption, Distillation etc. Material balance with chemical reaction; Bypass, Recycle and Purge Operations with and without reactions.

**Module 3** (16 hours)

Energy balances: Heat capacity, specific heat and enthalpy, Heat capacities of gases and gaseous mixtures, Effect of temperature on heat capacity of gas, Mean heat capacity of gas, Kopp's rule, Latent heats, Heat of fusion, Heat of vaporization, Trouton's rule, Kistyakowsky equation for non-polar liquids, Estimation of heat capacity, calculation of enthalpy changes wityh and without phase change, Estimation of latent heat of vaporization, heat balance calculations in processes without chemical reaction, heat of reaction, standard heats of formation, combustion and reaction, heat of solution and heat of mixing, Effect of temperature on heat of reaction, enthalpy change for mixtures, enthalpy-concentration charts and applications. Kirchoff's equation. Adiabatic and non-adiabatic reactions. Theoretical and actual flame temperatures.

**Module 4** (17 hours)

Vapor pressure: Vapor pressure of pure liquids, Effect of temperature on vapor pressure, Classius-Clayperon equation, Antoine equation, Reference substance vapor pressure plots, Vapor pressure of immiscible liquids. Ideal solutions and Raoult's law. Non-volatile solutes. Humidity: Humidity and saturation, Percentage saturation. Relative saturation or relative humidity, Enthalpy of humid air, and humid heat capacity, Dew point, Wet and dry bulb temperatures, Adiabatic vaporization and adiabatic saturation temperature, psychrometric charts, material and energy balance problems involving Vaporization and Condensation. fuels and combustion, heating value of fuels, proximate and ultimate analysis, orsat analysis of flue gases, percent excess air from flue gas analysis, heat loss calculation in combustion of fuels

**References:**


1. K.V.Narayanan & B.Lakshmikutty Stoichiometry and Process Calculations, Prentice Hall Of India
2. Hougen A, Watson K M, Ragatz R A, Chemical Process principles, John Wiley
3. David M Himmelblau, Basic principles and calculations in chemical engineering, Prentice Hall.
4. Richard M Felder & Ronald W. Rousseau Elementary Principles of Chemical Processes, Wiley India

5. B.I. Bhatt, and S.M. Vora, Stoichiometry (Third Ed), Tata McGraw Hill.
6. Williams E T, Johnson R C, Stoichiometry for chemical engineers, McGraw Hill.
7. Rao D P, Murthy D V S, Stoichiometry for chemical engineers, McMillan

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 304 ORGANIC CHEMISTRY**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of organic chemistry*
- *To develop understanding about concepts on organic reactions for analysis of unit processes*

**Module 1** (13 hours)

Electron displacements in organic molecules – inductive, electromeric, mesomeric and hyper conjugative effects – types of reagents, nucleophilic, electrophilic and free radicals – types of reactions, substitution, addition and rearrangements – Mechanism, Kinetic and stereochemistry of $SN_1$, $SN_2$, $E_1$ and $E_2$ reactions.

Oils – Fats – Soaps – Detergents – Stereo chemistry – Geometrical isomerism of maleic and fumaric acid – Optical ilsomerism of tartaric acid – Resolution – Recemisation – Asymetric Synthesis – Walden Inversion – Synthetic reagents – Synthesis and preparation of Grignard reagents – Organometallic compounds – Acetoacetic ester – Malonic ester – Keto-enol tautomerism – Preparation and use of antipyrene, veronal and luminal – Mechanism of Pinacol – Pinacolone rearrangement and Hofman's rearrangement.

**Module 2** (13 hours)

Proteins, nucleic acids – Aminoacids – Classification and biological importance – Synthesis of glycine and alanine by Gabriels method and Sorensen's method – Synthesis of Leucine (Strecker's method) and tryptophan by Azlactone method – Isolation of amino acids from natural sources – Properties and reactions of glycine and alamine – Action of heat on □,□ and amino acids – Sorensen's formal titration – Carbohydrates – Classification – Preparation and properties of glucose – Oxidation, reduction, acetylation, osazone formation – Conversion of an aldose to ketose and vice versa – Mutarotation – epimerization – anomers – Structure of

glucose – Pyranose and Furanose structure of D-glucose – Manufacture of fructose and sucrose – Preparation and properties of starch and cellulose.

**Module 3** (13 hours)

Aromatic Compounds – Concept of aromaticity – Huckel's rule – Mechanism of electrophilic substitution reactions on benzene – Nitration, sulfonation, halogenation, Fridel – Crafts raction – Directive influence of substitutents – Homologous of benzene – Aromatic nitro compounds – nitrobenzene – Preparation of nitrobenzene and its reduction under various conditions – Aromatic amino compounds – Aniline – Preparation and properties of aniline – Effect of substitutents on the basicity of aryl amines – Preparation and synthetic applications of benzene diazonium Chloride – Dyes and dyeing – Azo dyes – Congo red, Bismark brown – Triphenyl methane dyes – malachite green, rosaniline – Isolation of phenol from middle oil – Reactions of phenol – Acidic nature of phenol - Effect of substituents on acidity of phenol – Riemer – Tieman reaction – Kolb's reaction – Ledrer – Manasse reaction – Gattterman's aldehyde synthesis – Houben Hoesch reaction – Coupling reaction – Mechanism of coupling.

**Module 4** (13 hours )

Heterocyclic compounds – Isolation and reactions of furan, pyrrole, pyridine Terpenes – Isoprene rule – Polymerisation – Isolation, Structure and Synthesis of Citral – Alkaloids – Occurance, method of extraction and properties of nicotine- Synthesis and uses of DDT, Saccharin, aspirin, vanillin, coumarine, phenacetine and sulfanilamide – Introduction to enzymes – Classification – Mechanism of enzyme action – Introduction to vitamins – Classification and biological action.

**References:**


1. Finar, Organic Chemistry, Vol. I and II, ELBS
2. Morrison & Boyd, Organic Chemistry, Prentice-Hall of India
3. Bahl & Bahl, Advanced Organic Chemistry, S. Chand
4. Sony, P.L., Organic Chemistry, S. Chand
5. Lehninger, Biochemistry


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 305 CHEMICAL ENGINEERING THERMODYNAMICS I**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of thermodynamics for chemical engineers*

**Module 1** (12 hours)

Fundamental concepts and definitions - closed, open and isolated system - intensive and extensive properties - path and state functions - reversible and irreversible process - temperature - Zeroth law of thermodynamics - First law of thermodynamics - internal energy - enthalpy - heat capacity - first law for cyclic, non-flow and flow processes - applications - P-V-T behaviour of pure fluids - ideal gases and ideal gas processes - equations of state - vander Waals equation, Redlich-Kwong equation, Virial equation - principle of corresponding states - critical and pseudo critical properties - Compressibility charts.

**Module 2** (12 hours)

Heat effects in chemical reactions - standard heat of formation, combustion and reaction - effect of temperature on heat of reaction - temperature of reactions - adiabatic reaction temperature - Second law of thermodynamics - limitations of first law - general statements of second law - concept of entropy - calculation of entropy changes - Carnot's principle - absolute scale of temperature - Clausius inequality - entropy and irreversibility - statistical explanation of entropy - Third law of thermodynamics.

**Module 3** (13 hours)

Thermodynamic properties of pure fluids - Gibbs free energy, work function - Maxwell's equations - Clapeyron equation - entropy-heat capacity relationships - equations for entropy, internal energy and enthalpy in terms of measurable quantities - effect of temperature and pressure on U, H and S - relationship between $C_P$ and $C_V$ - effect of pressure and volume on heat capacities - Joule-Thomson coefficient - Gibbs - Helmholtz equation - method of Jacobians - thermodynamic diagrams - fugacity and activity of pure fluids - selection of standard state - determination of fugacity of pure gases and liquids - effect of temperature and pressure on fugacity and activity.

**Module 4** (15 hours)

Flow processes - total energy balance - mechanical energy balance - Bernoulli equation - flow in pipes and maximum velocity - flow through nozzles and ejectors - critical pressure ratio in nozzles - compressors - single-stage and multistage compression - refrigeration and liquefaction - COP - refrigeration cycles - Carnot, vapour compression, air compression and absorption refrigeration cycle - general properties of refrigerant - Joule-Thomson expansion and liquefaction processes - power cycles - steam-power plant cycles - internal combustion engine cycles - gas-turbine power plant cycle.

**References:**


1. Smith J. M. & Van Ness H.V., Introduction to Chemical Engineering Thermodynamics, McGraw Hill
2. Narayanan K. V., A Textbook of Chemical Engineering Thermodynamics, Prentice-Hall of India
3. Hougen A., Watson K.M. & Ragatz R.A., Chemical Process Principles Vol.2, Asia Pub.
4. Kyle B.G., Chemical and Process Thermodynamics, Prentice-Hall of India
5. Y.V.C. Rao, Chemical Engineering Thermodynamics, Universities Press


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 306 MATERIAL SCIENCE & ENGINEERING**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

**Objectives**

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

**Module 1** (13 hours)

Structure of atom-present concept of atom-Rutherford's and Bhor's model-Bonding in solids-Types of solids-crystalline and amorphous solids-crystal systems-Bravais lattices-miller indices-coordination number-crystal defects-determination of crystal structure-X-ray diffraction-electron diffraction methods-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 2** (13 hours)

Solid solutions-types of solid solutions-Hume Rothery rules-intermediate phases-mechanical mixtures-phase diagrams-eutectic systems-peritectic system,eutctoid and peritectoid systems-iorn - carbon diagram-T-T-T diagram-plastic deformation-recrystallisation-hot and cold working of metals,Heat treatments-elementary study of various metals and alloys like cast iron,carbon steel,alloy steels.

**Module 3** (13 hours)

Non-ferrous metals and alloys-aluminium and its alloys-copper and its alloys-Non ferrous metals and alloys used for high temperature services and nuclear application-organic polymers and its properties-ceramics-classification-comparison of ceramic and non-ceramic structures-properties and application of ceramics-composite materials-classification-general characteristics. Introduction to nanomaterials.

**Module 4** (13 hours)

Corrosion-different types, mechanism and factors influencing corrosion-corrosion prevention-inhibitors and their applications-oxidation-aging of rubber-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. Van Vlack, Elements of Material Science
2. Khanna O.P., A Text Book of Material Science & Metallurgy
3. Hajra Choudhary, Material Science & Processes
4. Chilton &Perry, Chemical Engineers Handbook
5. Nanocomposite science and technology, Pulikel M. Ajayan, Wiley-VCH 2005


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 307(P) CHEMISTRY LAB II**

**Teaching scheme** **Credits:** 2

*3 hours practical per week*

**Objectives**

- *To provide experience on analysis, estimation and preparation of few organic chemical.*
- *To acquaint the students with the handling and analyzing chemicals.*

Experiments in organic chemistry

1. Analysis of simple organic compounds (minimum 4 numbers)
2. Estimation of phenol
3. Estimation of aromatic primary amine
4. Preparation of Aspirin
5. Preparation of Benzanilide
6. Preparation of m-dinitrobenzene
7. Preparation of Benzoic acid
8. Preparation of Phthalimide
9. Preparation of Methyl Orange
10. Preparation of Parabenzoquinone

11. Preparation of Acetanilide
12. Preparation of Phenophthalein
13. Preparation of Methylene Blue
14. Preparation of Erichrome Black T
15. Preparation of nerolin

**References**

1. Srivastava T. N. & Kamboj P. C., Systematic Analytical Chemistry
2. Morrison & Boyd, Organic Chemistry, Prentice-Hall of India.
3. Bahl & Bahl, Advanced Organic Chemistry, S. Chand.

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

60%-Laboratory practical and record
30%- Test/s
10%- Regularity in the class

**End Semester Examination** *(Maximum Marks-50)*

70% - Procedure, conducting experiment, results, tabulation, and inference
20% - Viva voce
10% - Fair record

**CH09 308(P) CHEMICAL TECHNOLOGY LAB**

**Teaching scheme** **Credits:** 2

*3 hours practical per week*

**Objectives**

- To provide experience on preparation, analysis and testing of chemicals used for industrial raw materials and end uses.

1. Acid value of oils
2. Iodine value of oils
3. Saponification value of oils
4. Preparation and analysis of soap
5. Preparation of copper pigment
6. Preparation of chrome yellow pigment
7. Analysis of saw dust: Estimation of total cellulose
8. Determination of sucrose content in sugar
9. Analysis of lime, alum, activated carbon and coal
10. Determination of available chlorine in bleaching powder and hypochlorite
11. Determination of flash and fire point
12. Calibration of refractometer
13. Calorific value of gas using gas calorimeter
14. Redwood viscometer
15. Conductivity meter
16. Bomb Calorimeter

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

60%-Laboratory practical and record
30%- Test/s
10%- Regularity in the class

**End Semester Examination** *(Maximum Marks-50)*

70% - Procedure, conducting experiment, results, tabulation, and inference
20% - Viva voce
10% - Fair record

# FOURTH SEMESTER

**EN09 401 A ENGINEERING MATHEMATICS IV**
(Common for ME, CE, PE, CH, BT, PT, AM, and AN)
**Teaching scheme** **Credits:** 4
*3 hours lecture & 1 hour tutorial per week*
**Objective**

- *The use of probability models and statistical methods for analyzing data has become common practice in virtually all scientific disciplines.*
- *Two modules of this course attempt to provide a comprehensive introduction to those models and methods most likely to be encountered and used by students in their careers in engineering.*
- *A broad introduction to some important partial differential equations is also included to make the student get acquainted with the basics of PDE.*

**Module1: Probability Distributions (13 hours)**
Random variables – Mean and Variance of probability distributions – Binomial Distribution – Poisson Distribution – Poisson approximation to Binomial distribution – Hyper Geometric Distribution – Geometric Distribution – Probability densities – Normal Distribution – Uniform Distribution – Gamma Distribution.
**Module 2: Theory of Inference (14 hours)**
Population and Samples – Sampling Distribution – Sampling distribution of Mean ($\sigma$ known) – Sampling distribution of Mean ($\sigma$ unknown) – Sampling distribution of Variance – Interval Estimation – Confidence interval for Mean – Null Hypothesis and Tests of Hypotheses – Hypotheses concerning one mean – Hypotheses concerning two means – Estimation of Variances – Hypotheses concerning one variance – Hypotheses concerning two variances – Test of Goodness of fit.
**Module 3: Series Solutions of Differential Equations (14 hours)**
Power series method for solving ordinary differential equations – Legendre's equation – Legendre polynomials – Rodrigue's formula – Generating functions – Relation between Legendre polynomials – Orthogonality property of Legendre polynomials (Proof not required) – Frobenius method for solving ordinary differential equations – Bessel's equation – Bessel functions – Generating functions – Relation between Bessel functions – Orthogonality property of Bessel functions (Proof not required).
**Module 4: Partial Differential Equations (13 hours)**
Introduction – Formation of PDE – Complete Solution – Equations solvable by direct integration – Linear PDE of First order, Legrange's Equation: $Pp + Qq = R$ – Non-Linear PDE of First Order, $F(p,q) = 0$ , Clairaut's Form: $z = px + qv + F(p,q)$ , $F(z,p,q) = 0$ , $F_1(x,q) = F_2(y,q)$ – Classification of Linear PDE's – Derivation of one dimensional wave equation and one dimensional heat equation – Solution of these equation by the method of separation of variables – D'Alembert's solution of one dimensional wave equation.
**Text Books:**

1. Richard A Johnson, CB Gupta, *Miller and Freund's Probability and statistics for Engineers, 7e*, Pearson Education- Sections: 4.1, 4.2, 4.3, 4.4, 4.6, 4.8, 5.1, 5.2, 5.5, 5.7
2. Richard A Johnson, CB Gupta, *Miller and Freund's Probability and statistics for Engineers, 7e*, Pearson Education- Sections: 6.1, 6.2, 6.3, 6.4, 7.2, 7.4, 7.5, 7.8, 8.1, 8.2, 8.3, 9.5
3. Erwin Kreysig, *Advanced Engineering Mathematics, 8e,* John Wiley and Sons, Inc.- Sections: 4.1, 4.3, 4.4, 4.5

4. N Bali, M Goyal, C Watkins, *Advanced Engineering Mathematics, A Computer Approach, 7e,* Infinity Science Press, Fire Wall Media- Sections: 16.1, 16.2, 16.3, 16.4, 16.5, 16.6, 16.7, 16.8, 16.9
5. Erwin Kreysig, *Advanced Engineering Mathematics, 8e,* John Wiley and Sons, Inc. Sections: 11.2, 11.3, 11.4, 9.8 Ex.3, 11.5

**References:**


1. William Hines, Douglas Montgomery, avid Goldman, Connie Borror, *Probability and Statistics in Engineering,* 4e, John Wiley and Sons, Inc.
2. Sheldon M Ross, *Introduction to Probability and Statistics for Engineers and Scientists,* 3e, Elsevier, Academic Press.
3. Anthony Croft, Robert Davison, Martin Hargreaves, *Engineering Mathematics*, 3e, Pearson Education.
4. H Parthasarathy, *Engineering Mathematics, A Project & Problem based approach,* Ane Books India.
5. B V Ramana, *Higher Engineering Mathematics,* McGrawHill.
6. Sarveswara Rao Koneru, *Engineering Mathematics*, Universities Press.
7. J K Sharma, *Business Mathematics, Theory and Applications,* Ane Books India.
8. John bird, *Higher Engineering Mathematics*, Elsevier, Newnes.
9. M Chandra Mohan, Vargheese Philip, *Engineering Mathematics-Vol. I, II, III & IV.*, Sanguine Technical Publishers.
10. Wylie C.R and L.C. Barret, *Advanced Engineering Mathematics*, McGraw Hill.
11. V R Lakshmy Gorty, *Advanced Engineering Mathematics-Vol. I, II.*, Ane Books India.
12. Sastry S.S., *Advanced Engineering Mathematics-Vol. I and II*., Prentice Hall of India.
13. Michael D Greenberg, *Advanced Engineering Mathematics*, Pearson Education.


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**EN09 402 ENVIRONMENTAL SCIENCE**

(Common for all branches)

**Teaching scheme** **Credits:** 3

*2 hours lecture & 1 hour tutorial per week*

**Objectives**

- *To understand the problems of pollution, loss of forest, solid waste disposal, degradation of environment, loss of biodiversity and other environmental issues and create awareness among the students to address these issues and conserve the environment in a better way.*

**Module 1 (8 hours)**

The Multidisciplinary nature of environmental science, Definition-scope and importance-need for public awareness. Natural resources, Renewable and non-renewable resources: Natural resources and associated problems-forest resources: Use and over exploitation, deforestation, case studies. Timber extraction, mining, dams and their defects on forests and tribal people.-water resources: Use and over utilization of surface and ground water, floods , drought, conflicts over water, dams-benefits and problems.- Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.-Food resources: World food problems, changes caused by agriculture over grazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies.-Energy resources: Growing energy needs, renewable and non-renewable energy resources, use of alternate energy resources, Land resources: Land as a resource, land degradation, man induced land slides, soil erosion and desertification.

Module 2 (8 hours)

Ecosystems-Concept of an ecosystem-structure and function of an ecosystem – producers, consumers, decomposers-energy flow in the ecosystem-Ecological succession- Food chains, food webs and Ecological pyramids-Introduction, types, characteristics features, structure and function of the following ecosystem-Forest ecosystem- Grassland ecosystem –Desert ecosystem-Aquatic ecosystem(ponds, streams, lakes, rivers, oceans , estuaries), Biodiversity and its consideration. Introduction- Definition: genetic , species and ecosystem diversity-Biogeographical; classification of India –value of biodiversity: consumptive use, productive use, social ethical , aesthetic and option values Biodiversity at Global, national , and local level-India at mega –diversity nation- Hot spot of biodiversity-Threats to biodiversity: habitat loss, poaching of wild life, man , wild life conflicts –Endangered and endemic species of India-Conservation of biodiversity : In-situ and Ex-situ conservation of biodiversity.

Module 3 (10 hours)

Environmental pollution: Definition-Causes, effects and control measures of Air pollution-m Water pollution –soil pollution-Marine pollution-Noise pollution-Thermal pollution-Nuclear hazards-Solid waste management: Causes, effects and control measures of urban and industrial wastes-Role of an individual in prevention of pollution-pollution case studies-Disaster management: floods, earth quake, cyclone and landslides-Environmental impact assessment

**Module 4 (10 hours)**

Environment and sustainable development-Sustainable use of natural resources-Conversion of renewable energy resources into other forms-case studies-Problems related to energy and Energy auditing-Water conservation, rain water harvesting, water shed management-case studies-Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents

and holocaust-Waste land reclamation-Consumerism and waste products-Reduce, reuse and recycling of products-Value education.

**Text Books:**


1. Clark,R.S.Marine pollution,Clanderson Press Oxford.
2. Mhaskar A. K. Matter Hazrdous, Techno-science Publications.
3. Miller T. G. Jr., Environmental Science, Wadsworth Publishing Co.
4. Townsend C., Harper J, Michael Begon, Essential of Ecology, Blackwell Science
5. Trivedi R. K., Goel P. K., Introduction to Air Pollution, Techno-Science Publications.


**References:**


1. Raghavan Nambiar, Text book of Environmental Studies, Scitech Publishers(India) Pvt. Ltd
2. Bharucha Erach, Biodiversity of India, Mapin Publishing Pvt. Ltd., Ahmedabad
3. Cunningham, W.P., Cooper, T.H., Gorhani, E & Hepworth, M.T. 2001Environmental encyclopedia Jaico publ. House Mumbai
4. Down to Earth, Centre for Science and Environment
5. Hawkins, R.E. Encyclopedia of Indian Natural History, Bombay Natural History Society, Bombay
6. Mckinney, M.L. & School, R.M. 1996. Environmental Science system & Solutions, Web enhanced edition
7. Odum, E.P. 1971. Fundamentals of Ecology. W.B.Saunders Co. USA
8. Rao, M.N. & Datta, A.K 1987. Waste Water treatment. Oxford & IBH Publ. Co. Pvt. Ltd.
9. Survey of the Environment, The Hindu Magazine
10. Wagner.K.D. 1998. Environmental Management. W.B. Saunders Co. Philadelphia, USA


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

30% - Assignments (2 minimum) such as Report of field work, literature survey, seminars, etc.

10% - Regularity in the class

**Note:** Field work can be Visit to a local area to document environmental assets-river/forest/grass land/mountain or Visit to local polluted site-urban/rural/industrial/agricultural etc. or Study of common plants, insects, birds etc. or Study of simple ecosystems-pond, river, hill slopes etc. or mini project work on renewable energy and other natural resources , management of wastes etc.

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 403 FLUID AND PARTICLE MECHANICS**

**Teaching scheme** **Credits:** 5

*3 hours lecture & 2 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of fluid and particle mechanics*
- *To develop understanding about viscosity, fluid flow and machinery*

**MODULE 1 (16 Hour)**

Introduction to fluid mechanics-Definition of fluid-Physical properties of fluid-Variation of viscosity and density with temperature and pressure. Rheology of fluids-Classification of fluids-Fluid Statics and application-Pascals law-Hydrostatic equilibrium in gravity and centrifugal field-Barometric equation-Lapse rate-Principle of Manometer-Simple manometer and Inclined tube manometer-Principles of continious gravity and centrifugal decanter. Introduction to fluid flow phenomenon-Reynolds experiment-Reynolds number-Classification of flow-Turbulence-Different types-Reynolds stress-Flow in boundary layer-Boundary layer separation and wake formation-Boundary layer separation in straight tubes-Potential flow

**MODULE 2 (17 Hour)**

Basic equations of fluid flow-Continuity, Bernoullis and Momentum equation-Toricelli equation. Kinetic energy and Momentum correction factors-Correction for fluid friction and pump work for Bernoullis equation. Laminar flow of incompressible fluids in pipes and conduits.Shear stress and Velocity distribution-Maximum and average velocity-Hagen Poiseuille and Darcy wiesbach equation-Definition of Friction factor on Reynolds number in laminar flow. Turbulent flow of incompressible fluids in pipes and conduits-Universal velocity distribution equation-Friction factor and Reynolds number relation ship-Nikuradse and Karman equation-Blasius equation (derivation not required) Prantl one seventh power law-Friction factor chart-Frction from changes in velocity or direction-Sudden expansion and contraction-Fittings and valves. Flow through Non circular cross section-Equivalent length.

**MODULE 3 (16 Hour)**

Flow past immersed bodies-Drag, Drag coefficient for typical shapes. Stream lining, Stagnation point-Friction in flow through bed of solids-Ergun, Kozney Carman and Blake plummer equation. Motion of particle through fluids in gravity and centrifugal field. Terminal settling velocity in Stokes law. Intermediate law, and Newtons law range-Free and Hindered settling. Fluidization-Minimum fluidization velocity, Minimum porosity, Pressure drop calculation, Different type of fluidization. Slugging. Industrial application. Flow of Compressible fluids-Sonic velocity and Mach number-Basic equations for Compressible fluid flow-Isothermal and adiabatic-Stagnation properties.

**MODULE 4 (16 Hour)**

Flow rate equation for Venturi, Orifice, Mouth piece, Pitot tube, Rectangular, Triangular, Trapezoidal weir, Rotameter. Transportation of liquid through pipes-Economic pipe diameter-Pipes and tubes. Different types of fittings and Valves. General description, classification and application of Centrifugal, Reciprocating, Gear and Lobe pumps. Various losses-Characterestic curves-NPSH-Cavitation-Specific speed-Priming of Centrifugal pumps. Fans, Blower, Compressor-Different types-Compressor efficiency, Ejector-Principle and different type. Mixing and agitation.

**References:**


1. McCabe W.L. & Smith J.C., Unit Operations of Chemical Engg, McGraw Hill
2. Streeter V.L., Fluid Mechanics, McGraw Hill
3. Coulson J.M. & Richardson J.F., Chemical Engg. Vol. 1, Pergamon
4. Foust, Wenzel, Clump, Maus & Anderson, Principles of Unit Operation
5. Perry R.H., Chemical Engineers Handbook, McGraw Hill

6. Noel de Nerves, Fluid Mechanics for Chemical Engineers, McGraw Hill.
7. Rajput R.K., A textbook of Fluid Mechanics
8. Fluid Dynamics and Heat Transfer, Knudsen and Katz.

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CH09 404 PHYSICAL AND ANALYTICAL CHEMISTRY

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of physical and analytical chemistry*

**Module 1** (13 hours)

Adsorption – Physisorphtion and Chemisorption – Adsorption isotherms (Langmuir Isotherm only) catalysis – criteria of catalysis – Homogeneous catalysis (gases, liquids) – Mecanism of acid, base catalysis – Negative catalysis in gas reactions. Heterogeneous catalysis of gases – Function of the surface – Nonuniformity of surfaces – Nature of active centres – Catalytic activity of Oriented surface – Intermediate compound formation – Heterogeneous reactions in solutions – catalytic poisons – promoters – supported catalysis – Examples of catalysis (Hydrogenation, Cracking and reforming)

Colloids – Classification and preparation – Stability – electrical double layer - micelle formation – purification of colloids – ultrafiltraion – dialysis – properties of colloids (optical, electrical and kinetic) – ultramicroscope – protective colloids – Gold number – gels – Donnan membrane equilibrium – synerisis and thixotropy - Liesegang rings – colloidal electrolysis – ionic miscelles.

**Module 2** (13 hours)

Electroanalytical methods – potentiometric titrations – conductometric titrations – coulometry – amperometry – polarography – polarization and over voltage – half wave potential – diffusion current – anodic stripping voltametry – static drop mercury electrode – hanging drop mercury electrode – spectroanalytical methods – IR, UV and visible spectroscopy – atomic adsorption spectroscopy – atomic emission spectroscopy – mass spectrometry – instrumentation details and analysis.

**Module 3** (13 hours)

Principle and instrumentation of (Chromatography – absorption chromatography – partition chromatography – thin layer chromatography – paper chromatography – two dimension – solvent extraction – ion exchange chromatography – HPLC – gas chromatography – exclusion chromatography – electro chromatography – paired ion chromatography- chemical toxicity identification through chromatography – Thermogravimetric analysis – Thermobalance – DTG – DTA.

**Module 4** (13 hours)

Photochemistry – electromagnetic radiation – energy of radiation – light adsorption – laws of photochemistry – primary processes in photochemical reactions – Photochemical reactions in nature – Ozone depletion in stratosphere –Ozone formation in troposphere – fluorescence – phosphorescence. Photochemical versus thermal reactions – mechanism of photochemical reactions – Sonochemistry – cavitation – transient and stable – Sonoluminiscence – Sono Chemical Reactions - SCRs in Homogenous and Heterogeneous phases – synthesis of organometallics – oxidation and reduction reactions – Sonochemical equipments .

**References:**


1. Atkins & de Paula, Atkin's Physical Chemistry, 7th Edn., Oxford University Press
2. S. Glasston, A Textbook of Physical Chemistry, McMillan India
3. S. Usharani, Analytical Chemistry, McMillan India
4. Mason, Sonochemistry, Oxford University Press


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CH09 405 CHEMICAL ENGINEERING THERMODYNAMICS II

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

**Objectives**

- *To impart the detail concepts of thermodynamics*

**Module 1** (13 hours)

Properties of solutions - partial molar properties - definition - physical significance - determination - tangent-intercept method - chemical potential - definition - effect of temperature and pressure - fugacity in solution - ideal solution - Lewis-Randall rule - Raoult's law - Henry's law - activity and activity coefficients in solutions - effect of temperature and pressure on activity coefficients - Gibbs-Duhem equations - applications -

property changes on mixing - heat effects of mixing processes - enthalpy composition diagrams - excess properties - relation between excess Gibbs free energy and activity coefficient

**Module 2** (13 hours)
Phase equilibria - criterion of phase equilibria - criterion of stability - phase equilibrium in single - component systems - phase equilibria in multicomponent systems - phase rule for non-reacting systems - Duhem's theorem - vapour-liquid equilibrium - phase diagram for binary solutions - VLE in ideal solutions - non-ideal solutions - positive and negative deviation - azeotropes - VLE at low pressures - Wohl's equation - van Laar equation - Wilson equation - application of activity coefficient equations in equilibrium calculations - basic idea on NRTL, UNIQUAC and UNIFAC methods - calculation of activity coefficients using Gibbs - Duhem equations - consistency tests for equilibrium data - Redlich-Kister method - coexistence equation

**Module 3** (13 hours)
Applied phase equilibrium - vapour-liquid equilibrium at high pressures - vaporisation equilibrium constants - bubble point, dew point and flash calculations in multi component systems - computer programs for these calculations - vapour-liquid equilibrium in partially miscible and immiscible systems - phase diagrams - principles of steam distillation - phase equilibrium considerations in steam distillation - liquid-liquid equilibrium - binary and ternary equilibrium diagrams - use of triangular diagrams for ternary equilibrium - Different types of ternary systems and their representation on triangular coordinates. Thermodynamic analysis of processes - rate of entropy generation in steady flow processes - calculation of ideal work and lost work - thermodynamic analysis of steady state flow processes.

**Module 4** (13 hours)
Chemical reaction equilibria - reaction stoichiometry - criteria of chemical equilibrium - equilibrium constant - standard free energy change - standard state - feasibility of reaction - effect of temperature on equilibrium constant - presentation of free energy data - evaluation of K - equilibrium conversion in gas-phase reactions - effect of pressure and other parameters on conversion - liquid-phase and heterogeneous reaction - reactions in solutions - pressures of decomposition in gas-solid reaction - simultaneous reactions - phase-rule for reacting systems

**References:**


1. Narayanan K. V., A Textbook of Chemical Engineering Thermodynamics, Prentice-Hall of India
2. Smith J. M. & Van Ness H.V., Introduction to Chemical Engineering Thermodynamics, McGraw Hill
3. Hougen A., Watson K.M. & Ragatz R.A., Chemical Process Principles Vol.2, Asia Pub.
4. Kyle B.G., Chemical and Process Thermodynamics, Prentice-Hall of India
5. Y.V.C. Rao, Chemical Engineering Thermodynamics, Universities Press


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 406 PARTICLE TECHNOLOGY**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1hour tutorial per week*

**Objectives**

- *To impart the basic concepts of mechanical operations*
- *To develop understanding about size analysis, size reduction and solid handling*

**Module 1** (13 hours)

Particle diameter and shape factor - particle size analysis - sieve analysis - particle size distribution - cumulative and differential methods of analysis - mean diameters - specific surface area and number of particles - sub-sieve analysis - pipette analysis - beaker decantation - photo sedimentation - sedimentation balance - ICI sedimentation - elutriation - microscopic counting - permeability and adsorption - screening - effectiveness and capacity of screens and factors affecting them - types of industrial screens

**Module 2** (13 hours)

Principles of free and hindered settling - equal settling particles - classifiers - types of classifiers - mechanical and non-mechanical, hydrocyclones, pneumatic classifiers - principles of mineral benefication methods - jigging - wilfley table - heavy media separation - magnetic and high-tension separation - types of equipment - froth flotation, principles, additives, and flotation cell arrangements and types of equipment - batch and continuous thickening - kynch theory - design of continuous thickener

**Module 3** (13 hours)

Filtration - theory of constant pressure and constant rate filtration - cake porosity and compressibility - filter aids - optimum filtration cycle - types of batch and continuous filters - washing of filter cakes - centrifugal methods of separation including centrifugal filtration - continuous centrifuge - gas cleaning methods - gravity settling - cyclone separation - electrostatic precipitation - scrubbing

**Module 4** (13 hours)

Laws of communition - mechanism and efficiency of size reduction - principles of important size reduction equipment - types and selection of equipment for all ranges - closed circuit and open circuit grinding - free crushing and choke feeding - wet and dry grinding - mixing of granular solids and pastes - degree of mixing - type and selection of equipment - storage and conveying of solids - silos, bins and hoppers - different types of conveyors - selection of conveyors

**References:**


1. McCabe W.L., Smith J.C. & Harriott P., Unit Operations in Chemical Engineering, McGraw Hill
2. Coulson J.M. & Richardson J.F., Chemical Engineering, Vol. II, ELBS, Pergamon Press
3. Foust A.S. et al, Principles of Unit Operations, John Wiley
4. Badger & Banchero, Introduction to Chemical Engineering, McGraw Hill

5. Perry R.H., Chemical Engineers Handbook, McGraw Hill
6. George Granger Brown, Unit Operations, Wiley

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 407(P) ENVIRONMENTAL ENGINEERING LAB**

**Teaching scheme** **Credits:** 2

*3 hours practical per week*

**Objectives**

- *To provide experience on analysis of water, waste water and air.*
- *To acquaint the students with the measurement using sophisticated instruments.*

1. Determination of hardness of water
2. Determination of dissolved oxygen in water
3. Determination of BOD of wastewater sample
4. Determination of COD of wastewater sample
5. Determination of total nitrogen and ammoniacal nitrogen
6. Determination of SS, TDS, and VSS of a wastewater sample
7. Analysis of oil & grease in wastewater sample
8. Determination of fluoride, silica, sodium, calcium, potassium, magnesium, sulphide, sulphate, phosphate, nitrate, iron and heavy metals
9. Flame photometer
10. Spectrophotometer
11. pH meter
12. Mercury Analyser
13. Atomic Absorption Spectrophotometer
14. Polarimeter
15. Sound level meter
16. Analysis of ambient air using high volume sampler
17. Stack analysis
18. Water analyser

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

60%-Laboratory practical and record

30%- Test/s

10%- Regularity in the class

**End Semester Examination** *(Maximum Marks-50)*
70% - Procedure, conducting experiment, results, tabulation, and inference
20% - Viva voce
10% - Fair record

**CH09 408(P) MATERIALS TECHNOLOGY AND ENGINEERING LAB**
**Teaching scheme** **Credits:** 2
*3 hours practical per week*
**Objectives**

- *To provide experience on preparation, testing, and analysis of materials.*

1. Viscosity measurement using Ostwald viscometer and Brookefield viscometer
2. Melt flow index
3. Measurement of environmental crack resistance of plastic materials
4. Measurement of abrasion resistance
5. Fabrication of FRP laminates and/or products
6. Measurement of softening point of plastic materials
7. Measurement of hardness of materials
8. Determination of the effect of a filler on a non-Newtonian fluid
9. Injection moulding
10. Specific gravity measurement
11. Heat deflection temperature measurement
12. Measurement of impact strength of plastic materials
13. Measurement of shore – D hardness
14. Measurement of resistance of materials
15. Study the fatigue behavior of materials using rotary fatigue testing machine
16. Measurement of the tensile properties of plastic materials
17. Preparation of phenol formaldehyde and urea formaldehyde
18. Preparation of PMMA, cupra-ammonium rayon and polystyrene

**Internal Continuous Assessment** *(Maximum Marks-50)*
60%-Laboratory practical and record
30%- Test/s
10%- Regularity in the class
**End Semester Examination** *(Maximum Marks-50)*
70% - Procedure, conducting experiment, results, tabulation, and inference
20% - Viva voce
10% - Fair record

# FIFTH SEMESTER

**CH09 501 CHEMICAL REACTION ENGINEERING**

**Teaching scheme** **Credits:** 5

*3 hours lecture & 2hour tutorial per week*

**Objectives**

- *To impart the basic concepts of chemical reaction engineering*
- *To develop understanding about reactor analysis and design*

**Module 1** (18 hours)

Overview of chemical reaction engineering. Classification of chemical reactions. Variables affecting the rate of reaction. Definition of reaction rate. Kinetics of homogeneous reaction. Concentration dependent term of rate equation. Searching for a mechanism. Temperature dependent term of rate equation. Temperature dependency from Arrhenius law, Collision theory and transition state theory. Interpretation of batch reactor data. Evaluation of rate equation by integral and differential analysis for constant volume and variable volume system

**Module 2** (15 hours)

Introduction to reactor design. Classification of reactors. Ideal reactors for a single reaction-Ideal batch reactor- Steady state mixed flow reactor-Steady state plug flow reactor. Design of single reactions-Size comparison of single reactors- Multiple reactor system. Recycle reactor. Auto catalytic reactions. Design of multiple reactions.

**Module 3** (15 hours)

Heat effects in reactor. Non isothermal reactor design. General graphical design procedure. Optimum temperture progression. Adiabatic and non adiabatic operations. Multiple steady state. Non ideality in reactors. Basics of non ideal flow. Residence time distribution studies-C,E & F curves and their relationships. Conversion in non ideal reactors. Micro mixing and macro mixing. Models for non ideal flow-dispersion model and tank in series model.

**Module 4** (18 hours)

Heterogeneous processes. Global rates of reaction. Catalysis. General characteristics of catalysis. Physical adsorption and chemisorption. Adsorption isotherms, Determination of surface area of a catalyst. Classification of catalyst, catalyst preparation. Catalyst deactivation (no kinetics). Gas – liquid reaction. Absorption combined with chemical reaction. Mass transfer coefficients and kinetic constants. Application of film penetration and surface renewal theories. Hatta number and enhancement factor for first order reaction.

**References:**


1. Levenspiel O., Chemical Reaction Engineering, John Wiley
2. Fogler H.S., Elements of Chemical Reaction Engineering, Prentice Hall of India
3. Smith J.M., Chemical Engineering Kinectics, McGraw Hill
4. Hill C.G., An Introduction to Chemical Engineering Kinetics & Reactor Design, John Wiley


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 502 PETROLEUM REFINERY ENGINEERING & PETROCHEMICALS**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1hour tutorial per week*

**Objectives**

- *To impart the basic concepts of petroleum processing and manufacture of petrochemicals*
- *To develop understanding about refining and post refining operations*

**MODULE 1** (13 Hour)

History and development of refining-Origin and formation of petroleum. Exploration, Drilling and Secondary recovery methods of crude. Storage and transportation of crude and products. Petroleum industry in India. Composition of crude-Evaluation of oil stock-ASTM, TBP, and Equilibrium flash vapourisation. Properties, test methods and uses of Refinery products such as L.P.G, Gasoline, Jet fuel, Kerosene, Diesel fuel, Lubricating oil, Waxes, Bitumen and Carbon black.

**MODULE 2** (13 Hour)

Petroleum processing-Dehydration and desalting of crude-Heating of crude-Distillation of crude-Arrangement of tower, Atmospheric and Vacuum distillation unit. Stabilzation of Gasoline-Treatment technique. Production and treatment of L,P.G.Treatment of Kerosene-Edeleanu process. Treatment of Lube- Sulphuric acid treatment, Clay treatment, Phenol extraction. Dewaxing methods.

**MODULE 3** (13 Hour)

Thermal Conversion process. Thermal cracking-Mechanism of cracking-Visbreaking-Coking. Catalytic conversion process-Catalytic cracking-Types of Catalyst-Types of reaction-Mechanism of Catalytic cracking. Catalytic reforming-Reforming reaction-Catalyst-Process description. Process description and application of Hydro cracking, Polymerization, Alkylation, Isomerisation. Hydrogenation to increase the quality of petroleum products.

**MODULE 4** (13 Hour)

Production of Acetylene, Ethylene and Propylene by steam cracking of Naphtha. Production of Aromatics in Refinery. Manufacture of Caprolactum from Benzene. Production of Phenol and Acetone from Benzene and propylene. Manufacture of Poly ethylene, P.V.C, Poly propylene, Poly styrene, Mono ethylene glycol, Methanol and Formaldehyde

**References:**

1.Baskara Rao B.K, Modern Petroleum Refinery Process, Oxford& IBM
2.Dr.Kochu Baby Manjooran S, Modern Petroleum Chemistry
3.Dr.Ram Prasad, Petroleum Refining Technology, Khanna Publishers
4.Nelson W.L, Petroleum Refinery Engineering, McGraw Hill

5.Gopala Rao M & Sitting M, Drydens Outline of Chemical Technology, Affiliated East West Press
6.Austin G.T, Shreves Chemical Process Industries, McGraw Hill

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CH09 503 PROCESS HEAT TRANSFER

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of heat transport*
- *To develop understanding about heat exchangers and evaporators*

**Module 1** (11 hours)

Modes of heat transfer - conduction and Fourier's law - thermal conductivity of solids, liquids and gases - convection and film concept of heat transfer coefficient - steady-state conduction through single resistance and composite resistances in series - critical thickness of insulation - transient heat conduction in infinite and semi-infinite solids.

**Module 2** (15 hours)

Forced convection heat transfer - factors influencing heat transfer coefficients - analogy between heat and momentum transfer - Reynold's, Prandtl and Colburn analogies - dimensional analysis - heat transfer to fluids in laminar and turbulent flow - empirical equations for heat transfer coefficient - natural convection and empirical correlations for different geometry - heat transfer to boiling liquids - regimes of boiling - mechanism of nucleate boiling - film condensation on vertical surfaces - Nusselt equation - dropwise condensation

**Module 3** (13 hours)

Radiation heat transfer - laws of radiation - radiation heat exchange between infinite plane gray bodies - view factor - radiation shields - radiation from flames and gases - combined radiation and convection - radiation errors in pyrometry - heat exchange equipment - classification and constructional details - double pipe, multipass, crossflow and extended surface heat exchangers - condensers, shell and tube and contact type - logarithmic mean temperature difference and LMTD correction factors - overall heat transfer coefficient - fouling factors - heat exchanger effectiveness - effectiveness - NTU approach

**Module 4** (13 hours)
Evaporation - equipment and classification - single effect and multiple effect evaporators - methods of feeding - performance criteria and factors affecting evaporator performance - calculation of heat transfer area - evaporator accessories - vapour recompression evaporators - scale formation and its effect

**References:**

1. McCabe W.L., Smith J.C. & Harriott P., Unit Operations in Chemical Engineering, McGraw Hill
2. Hollman J.P., Heat Transfer, McGraw Hill
3. Coulson J.M. & Richardson J.F., Chemical Engineering, Vol. I and II, ELBS, Pergamon Press
4. Welty J.R., Engineering Heat Transfer, John Wiley
5. Kern D.Q., Process Heat Transfer, McGraw Hill
6. Datta B.K., Heat Transfer: Principles and Applications, Prentice Hall India


**Internal Continuous Assessment** *(Maximum Marks-30)*
60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

**University Examination Pattern**
*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*
All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.
*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*
Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.
*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*
Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CH09 504 MASS TRANSFER OPERATIONS I

**Teaching scheme** **Credits:** 4
*3 hours lecture and 1 hour tutorial per week*

**Objectives**
- *To impart the basic concepts of mass transport*
- *To develop understanding about gas absorption, humidification, crystallization, adsorption and drying.*

**Module 1** (13 hours)
Molecular diffusion - mass fluxes $J_A$ and $N_A$ - fick's law - diffusivity and estimation - steady state diffusion of A through stagnant B and equimolar counter diffusion in binary gases, liquids and multicomponent gas mixtures. Mass transfer coefficients - film theory - f-type and k-type coefficients - dimensionless groups and dimensional analysis - analogy between mass,

heat and momentum transfer - application of empirical correlations to known geometry such as flat plates, wetted wall columns. Elementary treatment of theories of mass transfer: penetration and surface renewal theories - interphase mass transfer - equilibrium - diffusion between phases - two-film theory - local and overall k-type coefficients.

**Module 2** (13 hours)

Gas absorption, absorption equipment, multistage absorption, tray towers, tray types and general features of tray designs (qualitative treatment), continuous contact equipment, venturi scrubbers, packed columns, packing materials and characteristics, general constructional details of packed columns, flooding and loading, choice between plate and packed columns. Solubility of gases in liquid, choice of solvent, material balance in countercurrent and concurrent absorption and stripping, L/G ratio, multisatge operation, number of plates by graphical construction, Kremser equation, tray efficiency, design of packed columns, transfer unit and general graphical method, dilute solutions and simplified design methods

**Module 3** (13 hours)

Humidification and dehumidification, theory of wet-bulb temperature and adiabatic saturation temperature, Lewis relation, water cooling with air, types of cooling towers, enthalpy transfer unit, general design procedure, application of simplified methods of cooling tower design, spray chambers for air humidification, principles of gas dehumidification by countercurrent contact with water. Crystallization, principles of crystallization, purity, yield, energy requirements, super saturation, nucleation, rate of nucleation, growth of crystals, growth coefficients, crystallisation equipment, MSMPR crystallizer.

**Module 4** (13 hours)

Drying, equilibrium moisture content, batch drying, rate of drying, cross-circulation drying, mechanism of moisture movement, continuous drying, parallel and countercurrent, material and enthalpy balances, rough estimate of size of rotary dryer based on heat-transfer units for drying at high temperature, industrial dryers for batch and continuous drying. Adsorption, types of adsorption, nature of adsorbents, adsorption isotherm for single gases, vapours and dilute liquid solutions, Freundlich isotherm, contact filtration of liquids, single stage and multistage operation, unsteady state fixed-bed adsorbers, adsorption wave, rate of adsorption and breakthrough curve.

**References:**


1. Treybal R.E., Mass Transfer Operations, McGraw Hill
2. McCabe W.L., Smith J.C. & Harriott P., Unit Operations in Chemical Engineering, McGraw Hill
3. Seader J.D.& Henley E.J Separation Process Principles
4. Coulson J.M. & Richardson J.F., Chemical Engineering, Vol. I & II, ELBS, Pergamon Press
5. Rousseau R.W., Handbook of Separation Process Technology, John Wiley
6. Foust A.S. et al, Principles of Unit Operations, John Wiley
7. Welty J.R., Wilson R.E. & Wicks C.E., Fundamentals of Momentum Heat and Mass Transfer, John Wiley


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 505 ENVIROMENTAL ENGINEERING**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of environmental engineering*
- *To develop understanding about pollution and its treatment methodology.*

**Module 1** (13hours)

Introduction to environmental engineering - environmental legislation and regulation - Water treatment - precipitation processes - alum treatment and lime soda softening - municipal water conditioning - ion exchange processes - boiler feed water treatment - desalting -sources and classification of wastewater - physical, chemical and biological characteristics of wastewater - types of water pollutants and their effects - water quality standards - wastewater sampling and analysis - determination of organic matter - dissolved oxygen - biochemical oxygen demand - chemical oxygen demand - wastewater microbiology

**Module 2** (13hours)

Wastewater treatment methods - pretreatment - primary treatment - secondary treatment - tertiary treatment - screening, grit removal, oil removal and equalization - neutralization, coagulation, flocculation and sedimentation - clarifiers and clariflocculation - aerobic and anaerobic biological processes - activated sludge process - trickling filters - oxidation ditch - aeration lagoon - rotating biological contactors - aerobic fluidized bed bioreactors - anaerobic digestion process - anaerobic filter - anaerobic contact process - anaerobic fluidized bed bioreactors - up flow anaerobic sludge blanket (UASB) - disinfections - chlorinating and ozonation - sand filters - activated carbon adsorption - ion exchange - reverse osmosis- design of activated sludge and trickling filters.

**Module 3** (13hours)

Sludge treatment and disposal - sludge thickening - sludge conditioning - sludge dewatering - sludge digestion and composting - solid waste treatment - sources and classification - collection and disposal methods - open dumping - sanitary landfill - incineration - composting - recovery and recycling - sewage - characteristics - treatment and disposal - treatment of industrial waste - pulp and paper mill - textile mill - distillery - dairy - petroleum refinery - fertilizer industry. hazardous waste -types of hazardous waste - health effects - treatment methods

**Module 4** (13hours)

Air pollution - sources and classification of air pollution - effects of air pollution - global effects of air pollution - global warming and ozone depletion - air pollution meterology - atmospheric dispersion - air pollution from automobiles - sampling and analysis of air pollutants - air pollution control methods and equipment - settling chambers - cyclone separators - fabric filters - electrostatic precipitators - wet scrubbers - control of gaseous emission - absorption by liquid and adsorption by solids - noise pollution - effects of noise on people - noise control methods

**References**


1. Metcalf & Eddy, Wastewater Engg., Disposal & Reuse, McGraw Hill
2. Peavy H.S., Rose D.R.& Tchobanoglous G., Environmental Engineering, McGraw Hill
3. Rao M.N. & Rao H., Air Pollution, Tata McGraw Hill
4. Sincero A.P. & Sincero G.A., Environmental Engineering-A Design Approach, Prentice Hall of India
5. Rao C.S., Environmental Pollution Control Engineering, New age International Pub.
6. Mahajans S.P., Pollution Control in Process Industries, Tata McGraw Hill
7. Babbitt H.E., Sewage & Sewage Treatment, John Willey
8. Perkins H.C., Air Pollution, McGraw Hill
9. Chemtech I, Chem. Eng. Curriculum Dev. Centre, IIT-Madras
10. Austin G.T. (Ed.), Shreve's Chemical Process Industries, McGraw Hill
11. Gopal Rao M. & Sittig M. (Eds.), Dryden's Outlines of Chemical Technology, Affiliated East West Press


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 506 PROCESS INSTRUMENTATION**

**Teaching scheme** **Credits:** 3

*2 hours lecture & 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of instrumentation*

**Module 1** (10 hours)

Introduction-definition of instrumentation-concept of an instrument-functional elements and functions of an instrument –classification of instruments . Performance characteristics of an

instrument like static and dynamic type. Temperature measurement- electrical ,non-electrical, contact and non-contact methods, thermometers of three types like liquid-filled, vapour-pressure and gas-filled type, bimetallic thermometers, resistance thermometers, thermocouple type-thermoelectric principles like Seebeck effect, Peltier effect & Thomson effect and the laws of thermoelectricity-thermocouple output measurement. Radiation methods-radiation and optical pyrometry. Thermistors-resistance characteristics and their application in temperature measurement.

**Module 2** (10 hours)

Pressure measurement- manometers of U-tube type, well type and inclined type. Prandtl and air type micromanometers. Barometer method for atmospheric pressure measurement. Low pressure measurement by kenetometer, McLeod gage, thermal conductivity gauge, Pressure measurement using bourdon tube, flat and corrugated diaphragms, and capsules. Measurement of pressure in corrosive fluids using liquid seal and diaphragm seal. Transducers of electrical and mechanical type. Density measurement using constant volume hydrometer and, air pressure balance method, gas density detector and gas specific gravity measuring system.

**Module 3** (10 hours)

Flow measurement using head type flowmeters based on differential pressure measurement-orifice meter, venturimeter, flow nozzle and pitot tube. Open channel meters like weirs, flumes. Electromagnetic flowmeters. Variable area meters like rotameter and cone and float type. Mechanical flowmeters of positive displacement type like rotating disk and turbine type & anemometers. Level measurement-direct type and indirect type. Differential pressure method for pressurized vessels. Solid level detectors.

**Module 4** (10 hours)

Moisture content and humidity definition, moisture content determination by thermal drying. Instruments for measuring humidity like hygrometer, psychrometer, dew point apparatus. pH measurement using calomel electrode. Composition analysis using spectroscopic methods like absorption ,emission and mass spectrometers. Analysis of solids by X-ray diffraction. Gas analysis by thermal conductivity, polarography & chromatography.

**References:**

1. Jain R.K., Mechanical and Industrial Measurements, Khanna
2. Eckman D.P., Industrial Instrumentation, Wiley Eastern

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 507(P) FLUID & PARTICLE MECHANICS LAB**

**Teaching scheme** **Credits:** 2

*3 hours practical per week*

**Objectives**

- *To provide experience on various basic fluid and particle mechanics experiments*

1. Losses in pipe fittings, expansion and contractions
2. Determination of equivalent lengths of piping layouts
3. Free settling - (Stoke's Law)
4. Packed bed - (pressure drop characteristics)
5. Fluidisation - (liquid-solid)
6. Centrifugal pump - (characteristic curves)
7. Rotary pump - (study of features)
8. Orifice plate and venturimeter - (hydraulic equation)
9. Orifices and mouthpieces - (flow coefficients)
10. Flow under varying head - (Equation of discharge)
11. Weirs and notches - (hydraulic equation)
12. Rotameter – (calibration)

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

60%-Laboratory practical and record
30%- Test/s
10%- Regularity in the class

**End Semester Examination** *(Maximum Marks-50)*

70% - Procedure, conducting experiment, results, tabulation, and inference
20% - Viva voce
10% - Fair record

**CH09 508(P) PARTICLE TECHNOLOGY LAB**

**Teaching scheme** **Credits:** 2

*3 hours practical per week*

**Objectives**

- *To provide experience on analysis of size and size reduction.*
- *To acquaint the students with the separations based on size.*

1. Ball mill - verification of the laws of crushing
2. Ball mill - determination of the critical speed
3. Sieve analysis - determination of particle size - size distribution, mean diameter, specific surface area and number of particles per unit mass
4. Determination of the effectiveness of the screen
5. Pipette analysis
6. Beaker decantation
7. Sedimentation
8. Leaf filter- specific cake resistance and compressibility factor
9. Plate & frame filter press
10. Froth floatation
11. Elutriator
12. Mineral jig
13. Super centrifuge
14. Wilfley table

15. Continuous thickener
16. Rotary drum filter
17. Jaw crusher and hammer mill
18. Cyclone separator
19. Study of equipments

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

60%-Laboratory practical and record
30%- Test/s
10%- Regularity in the class

**End Semester Examination** *(Maximum Marks-50)*

70% - Procedure, conducting experiment, results, tabulation, and inference
20% - Viva voce
10% - Fair record

# SIXTH SEMESTER

**CH09 601 CHEMICAL PROCESS INDUSTRIES**

**Teaching scheme** **Credits:** 5

*3 hours lecture & 2 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of chemical technology*
- *To develop understanding about unit process and unit operations in various industries.*

**Module 1** (16 hours)

Fuel gases: natural gas, coke oven gas, producer gas, water gas, LPG. Industrial gases: carbon dioxide, hydrogen, nitrogen, oxygen. Sulphur and sulphuric acid: manufacturing of sulphur and sulphuric acid. phosphorus and phosophoric acid: wet process phosphoric acid, electric furnace phosphorus and phosphoric acid, single super phosphate and triple super phosphate. Chlor-alkali industries: salt, soda ash, baking soda, caustic soda, chlorine, hydrochloric acid.

**Module 2** (16 hours)

Nitrogen industries: ammonia, nitric acid, urea, fertilizer industries, ammonium sulphate, ammonium nitrate, nitrolime, MAP, DAP and nitrophosphates, mixed and complex fertilizers, carbon chemicals, carbon black, activated carbon, synthetic graphite, calcium carbide. Surface coating industries: pigments, paints, varnishes, lacquers, industrial coatings. Cement: portland cement, constituents, types, raw materials and manufacturing processes.

**Module 3** (16 hours)

Glass: classes of glass, raw materials, methods of manufacture. Ceramics and refractories (general study). Pesticides: DDT, Nicotine, Parathrins, Heptachlor, Endosulfan. Natural products industries: soaps and detergents, glycerine, pulp and paper, wood chemicals, Coal chemicals.

**Module 4** (16 hours)

General study of food processing, food byproduts, leather, gelatin, adhesives, vegetable oils, animal fats and oils, waxes, sugar, starches and related products, industrial alcohol by fermentation, absolute alcohol, beers, wines and liquors. Pharmaceuticals, biotechnology.

**References**:


1. Austin G.T. (Ed.), Shreve's Chemical Process Industries, McGraw Hill
2. Gopal Rao M. & Sittig M. (Eds.), Dryden's Outlines of Chemical Technology, Affiliated East West Press
3. G. N. Pandey, A textbook of Chemical Technology, Vol. I, Vikas Publishing House.


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 602 PROCESS DYNAMICS & CONTROL**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1hour tutorial per week*

**Objectives**

- *To impart the basic concepts of controls for chemical process*

**Module 1** (13 hours)

Introduction to process dynamics and control - definition of terms - laplace transform - transform of simple functions - derivatives and integral - properties of laplace transforms - final value theorem - initial value theorem - transition of transforms and functions - examples - inversion by partial fraction - solution of differential equations - qualitative nature of solutions - linear open loop systems - first order systems - mercury thermometer, liquid level and mixing processes - response of these to different types of forcing functions - systems in series - interacting and non-interacting types and generalization of results

**Module 2** (13 hours)

Linear open loop systems - second order systems - mercury thermometer in a well and manometer - impulse and step response of under damped, critically damped and over damped system, their derivation - closed loop system - servo and regulator problems - block diagram development - block diagram reduction - controllers - types, basic principles and transfer functions - the flapper nozzle assembly - pneumatic & electronic controllers - PID, PI and PD (derivation excluded) - supervisory control and data acquisition (SCADA) - distributed control system (DCS)

**Module 3** (13 hours)

Transient response of simple control systems - step response and offset - introduction to stability of linear systems - Routh-Hurwitz criterion for stability - root locus technique - plotting the root locus diagram - transportation lag and its effect on root locus diagram

**Module 4** (13 hours)

Introduction to frequency response - substitution rule - bode diagram for first order systems - first order systems in series - second order systems - bode stability criterion, gain margin and phase margin - controller tuning- Ziegler-Nichols method - reaction curve method - comparison of closed loop responses for different controller settings. Basic principles of advanced control systems: Cascade control, ratio control and Fuzzy logic.

**References:**


1. Coughanewr D.P., Process System Analysis & Control, McGraw Hill
2. Harriot P., Process Control, Tata McGraw Hill
3. Stephanopoulose G., Chemical Process Control, An Introduction to Theory & Practice, Prentice Hall
4. Ceaglske N.H., Automatic Process Control for Chemical Engineers
5. Eckman D.P., Principles of Industrial Process Control
6. Tsai T.H., Lane J.W. & Lom C.S., Modern Control Techniques for the Processing Industries, Marwel Dekker
7. Albert C.L. & Coggen D.A., Fundamentals of Industrial Control, ISA

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 603 MASS TRANSFER OPERATIONS II**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of mass transfer in distillation, extraction, leaching and membrane operations*
- *To develop understanding about design and analysis of distillation, extraction, leaching and membrane operation units.*

**Module 1** (13 hours)

Distillation - boiling-point diagram and equilibrium curves - application of Raoult's law - relative volatility - flash distillation - differential distillation - steam distillation - fractionation - plate columns for distillation - condensers - reboilers - principles of rectification - material and energy balance - reflux ratio and its importance - Ponchon-Savarit method - enthalpy-composition diagrams - difference points and L/G ratio - number of plates - feed plate location - minimum reflux conditions

**Module 2** (13 hours)

Design of fractionation columns by McCabe-Thiele method - basic assumptions - number of plates - feed quality and feed line - feed plate location - total reflux -minimum reflux - optimum reflux - cold reflux - open steam - intermediate streams - rectification of partially miscible mixtures - comparison of McCabe-Thiele and Ponchon-Savarit methods - plate efficiency - relation between Murphree and overall efficiency - rectification in packed columns - height of packed towers - azeotropic and extractive distillation (qualitative treatment only)

**Module 3** (13 hours)

Extraction - applications - ternary equilibria on triangular coordinate system - mixer rule - distribution curve - selectivity - choice of solvent - single-stage and multistage operations - calculations for immiscible systems and partially miscible systems - extraction with reflux - construction and working of mixer - settler cascades, sieve-tray columns, and baffle towers for extraction - continuous contact extraction - design for insoluble liquids - simplification for

dilute solutions - packed columns versus spray columns for extraction - construction and working of agitated towers, pulse columns and centrifugal extractors

**Module 4** (13 hours)

Leaching - factors affecting rate of leaching - stage efficiency - practical equilibrium - constant underflow - variable underflow - single stage and multistage leaching - shank's system - working principles of leaching equipment - thickeners, classifiers and moving bed leaching equipment. Membrane separation processes – classification – types of membranes : flat, spiral wound, hollow fibre - dialysis – pervaporation - reverse osmosis – effects of operating variables, concentration polarization – ultrafiltration.

**References:**


1. Treybal R.E., Mass Transfer Operations, McGraw Hill
2. McCabe W.L., Smith J.C. & Harriott P., Unit Operations in Chemical Engineering, McGraw Hill
3. Seader J.D.& Henley E.J Separation Process Principles Wiley India
4. Coulson J.M. & Richardson J.F., Chemical Engineering, Vol. II, ELBS, Pergamon
5. Foust A.S. et al, Principles of Unit Operations, John Wiley
6. Geankoplis C.J., Transport Processes and Unit Operations, Prentice Hall India


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CH09 604 ECONOMICS AND MANAGEMENT OF CHEMICAL INDUSTRIES

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of economics and management*

**Module 1** (13 hours)

Equivalence and cost comparison - time value of money and equivalence - equations used in economic analysis - compound interest and continuous interest as una cost - Hoskold's formula - capitalized cost - cost comparison with equal and unequal duration of service life - depreciation and taxes - nature of depreciation - methods of determining depreciation - straight line - sinking fund - declining balances - double declining balance - sum of years digits and units of production methods - present worth after taxes - cost comparison after taxes

**Module 2** (13 hours)

Cost estimation - equipments for process plants - cost indices - construction cost indices - material cost indices - labour cost indices - William's sixteenth factor - location index - types of cost estimates - order of magnitude estimate - study estimate - preliminary estimate - definitive estimate - detailed estimate - techniques of cost estimates - conference techniques - comparison techniques graphic relationship - tabular relationship - unit rate techniques - lang factor method - hand factor method - Chilton method - miller method - Peter's and Timmerhaus ratio factor method - check list of items for capital cost estimates, product cost estimates, direct production cost, administration expenses - check list of items for total product cost estimates - elements of complete costs - start up costs

**Module 3** (13 hours)

Profitability analysis - mathematical methods for profitability evaluation - payout time - payout time with interest - return on average investment - DCF rate of return - net present value - net present value index - incremental analysis - break even analysis - variable cost and fixed cost - economic production chart for 100% capacity and dumping - non-linear economic production chart

**Module 4** (13 hours)

Inflation - cost comparison under inflation - una burden - allowance for inflation - displacement vs replacement - one year more of existent - more than one year of the existent - principles of accounting - accounting definition - trial balance - balance sheet - profit and loss accounts - financial ratios related to balance sheet and profit and loss account - financial institutions - feasibility analysis report of a venture - canons of ethics of engineers

**References:**


1. Jelen F.C., Cost and Optimisation Engineering, McGraw Hill
2. Davies G.S., Process Engineering Economics, Chem. Eng. Ed. Dev. Centre, IIT Madras
3. Peters & Timmerhaus, Plant Design & Economics for Chemical Engineering, McGraw Hill
4. Schweyer, Process Engineering Economics, McGraw Hill
5. Tyler, Chemical Engineering Cost Estimation
6. Aries & Newton, Chemical Engineering & Cost Estimation
7. Happel, Chemical Process Economics, Marcel Decker
8. Vilbrant & Dryden, Chemical Engineering Plant Design, Tata McGraw Hill


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 605 ENERGY ENGINEERING**

**Teaching scheme** **Credits:** 3

*2 hours lecture & 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of energy engineering*
- *To develop understanding about energy harnessing methodology for sustainable development.*

**Module 1** (10 hours)

Energy, units of energy, conversion factors, general classification of energy, world energy resources and energy consumption, Indian energy resources and energy consumption, energy crisis, energy alternatives, electrical energy from conventional energy resources, internal combustion engines, steam turbines, gas turbines, hydroturbines (thermodynamic cycles not included), nuclear reactors, thermal, hydel and nuclear power plants (process outlines only), efficiency, merits and demerits of the above power plants, combined cycle power plants, fluidized bed combustion, small hydropower.

**Module 2** (10 hours)

Solar energy, solar thermal systems, flat plate collectors, focusing collectors, solar water heating, solar cooing, solar distillation, solar refrigeration, solar dryers, solar pond, solar thermal power generation, solar photovoltaic systems, solar cells, solar photovoltaic power generation, solar energy application in India, energy plantations, wind energy, types of windmills, types of wind rotors, Darrieus rotor and Gravian rotar, wind electric power generation, wind power in India, economics of wind farm, ocean wave energy conversion, ocean thermal energy conversion, tidal energy conversion, geothermal energy.

**Module 3** (10 hours)

Biomass energy resources, thermochemical and biochemical methods of biomass conversion, combustion, gasification, pyrolysis, biogas production, ethanol, fuel cells, alkaline fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, solid polymer electrolyte fuel cell, magneto hydro dynamics, open cycle and closed cycle systems, magneto hydro dynamic power generation, energy storage routes like thermal energy storage, chemical, mechanical storage, electrical storage.

**Module 4** (10 hours)

Energy conservation in chemical process plants, energy audit energy saving in heat exchangers, distillation columns, dryers, ovens and furnaces and boilers, steam economy in chemical plants, energy conservation in petroleum, fertilizer and steel industry, cogeneration, pinch technology, recycling for energy saving, electrical energy conservation in chemical process plants, environmental aspects of energy use.

**References:**


1. Goldmberg J., Johansson, Reddy A.K.N. & Williams R.H., Energy for a Sustainable World, John Wiley
2. Bansal N.K., Kleeman M. & Meliss M., Renewable Energy Sources & Conversion Tech., Tata McGraw Hill
3. Sukhatme S.P., Solar Energy, Tata McGraw Hill
4. Mittal K.M., Non-Conventional Energy Systems, Wheeler Pub.
5. Venkataswarlu D., Chemical Technology, I, S. Chand
6. Pandey G.N., A Text Book on Energy System and Engineering, Vikas Pub.
7. Rao S. & Parulekar B.B., Energy Technology, Khanna Pub.
8. Rai G.D., Non-Conventional Energy Sources, Khanna Pub.

9. Nagpal G.R., Power Plant Engineering, Khanna Pub.

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

ELECTIVE I

**CH09 L01 HIGH POLYMER ENGINEERING**

**Teaching scheme** **Credits:** 4

*3 hours lecture and 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of polymer technology*
- *To develop understanding about polymer as an engineering material*

**No Pre-requisites**

**Module 1** (12 hours)

Kinetics of Polymerisation – addition polymerization – free radical polymerization – anionic and cationic polymerization – derivation of copolymer equation – different types of copolymers – branched and crosslinked polymers and characteristic features. Methods of polymerization – bulk, solution, suspension and emulsion polymerization. Analysis of plastic materials – melting point test- solubility test – copperwire test – specific gravity test – identification of plastic materials.

**Module 2** (16 hours)

Thermoplastics – ABS – acetal – acrylic – cellulose acetate – cellulose propionate – fluoropolymers (CTFE,PTFE,PVF,FEP) – nylons – polycarbonate – thermoplastic polyester – PVC – PE – PP – PS – polyphenelene oxide – polysulfones – polyurethanes. Thermosetting plastics – diallyl phathalate – (DAP) – epoxy – phenol formaldehyde – urea formaldehyde – melamine formaldehyde – polyesters – silicones – (manufacturing details not included)

Properties of polymers – rheology- viscous flow – apparent viscosity – viscosity and molecular weight – Weisenberg effect- rubber like elasticity – thermodynamics of rubber like elasticity – stress strain behaviour of elastomers – viscoelasticity – models – Maxwell element – voigt element –burger model- stress relaxation and creep – measurement of rheological properties – melt flow index (MFI) – capillary rheometers – Viscous heating , Viscous flow,

**Module 3** (12 hours)

Molecular weight of polymers – weight average ,number average – sedimentation and viscosity averagemolecular weights – practical significance of molecular weights – size of polymer molecules – Experimental methods for molecular weight determination – end group analysis, cryoscopy,ebulliometry, membrane osmometry,light scattering method – viscometry (Oswald viscometer and Ubbelohde suspended level viscometer) Intrinsic viscosity – Mark Howink equation – polymer fractionation – fractional precipitation technique –extraction technique – gradient elution technique and gel permeation chromatographic technique – molecular weight distribution curve – factors affecting polymer properties – crystallinity – orientation treatment – solubility of polymers – glass transition temperature – polymer degradation – effect of reinforcement on the properties.

**Module 4** (12 hours)

Processing methods - effect of additives used – plasticizers – colourants – heat stabilizers - antioxidants – ultraviolet absorbers – antistatic agents – flame retardants – blowing agents – lubricants and fillers – brief description of compounding methods. Moulding techniques for plastics – injection moulding – compression moulding – transfer moulding – calendaring – blow moulding – extrusion – thermoforming – vacuum moulding – reaction injection moulding – Wet, dry and melt spinning methods for fibres – compounding methods for elastomers and natural rubber – vulcanization of rubber – general study of elastomer processing methods.

**References:**


1. Billmeyer F.W., Text book of Polymer Science, John Wiley.
2. Gowariker V.R.,Polymer Science, New Age.
3. Shah V.H., Handbook of Plastic Testing Technology
4. Rodrigues F., Principles of Polymer Systems, Tata Mc Graw Hill
5. Premamoy Ghosh., Polymer Science and Technology, Tata Mc Graw Hill.


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CH09 L02 WATER TREATMENT TECHNOLOGY

**Teaching scheme** **Credits:** 4

*3 hours lecture and 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of water treatment technology*

**No Pre-requisites**

**Module 1** (13hours)

Water resources- Rainfall and runoff, ground water and surface waters. Quantity of water- Domestic water needs, Industrial demand, Institutional demand and Fire fighting demand. Quality of water- Impurities in water and their importance, water borne diseases. Water Analysis-Physical, Chemical and Biological analysis.

**Module 2** (13hours)

Treatment technologies-Coagulation, flocculation and sedimentation. Usual coagulants, the jar test, flash mixers, flocculators, clarifiers and clariflocculators. Filtration- classification of filters, slow sand filters, rapid sand filters and pressure sand filters. Disinfection of water-chlorination, ozonation and ultra-violet rays.

**Module 3** (13hours)

Carbon adsorption, Desalination, Ion exchange and membrane processes. Turbidity removal, taste and odour control, iron and manganese removal and fluoride removal. Removal of hardness, removal of dissolved salts and nutrients. Dewatering and disposal of waste from water treatment plants.

**Module 4** (13hours)

Water quality standards for drinking water, mineral water, boiler feed water and swimming pools. Water recycling and reuse, rain water harvesting. Water pollution control and water management.

**References:**

1. Mark.J.Hammer & Mark.J.Hammer Jr., Water and Wastewater Technology, Prentice Hall of India. Ltd.
2. W.Wesley Eckenfelder,Jr, Principles of water quality management, CBI Publishing Company,Inc.
3. Areadio P Sincen & Gregoria A Sincen, Environmental Engineering A Design Approach, Prentce Hall of India Ltd.
4. Ragwala, Water supply and sanitary Engineering, Charator Publishing House,Anand,India
5. Mackenzie L Davis & David A Cornwell, Introduction to Environmental Engineering, Mc Graw Hill.
6. Duggal, K.N.,Elements of Public Health Engineering, S.Chand & Co.,New Delhi.

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 L03 ESSENTIALS OF MANAGEMENT**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of management*

**No Pre-requisites**

**Module 1** (13 hours)

Definitions of management - evolution of management thought - classical theories of management - human relations approach - quantitative school - systems approach - contingency approach - functions or process of management - managerial roles - levels of management - management skills - areas of management

**Module 2** (13 hours)

Planning - costs of planning - strategic planning - operational planning - the basic steps in planning - management by objective (MBO) - decision making - steps in decision making process - decision making styles - quantitative decision making aids - decision trees

**Module 3** (13 hours)

Organizing - job design - organizational relationships - delegation - decentralization - organizational culture - time management - leadership - managerial grid - theory X and theory Y - behavioural approach to leadership - path - goal model of leadership - motivational techniques - communication - formal channels of communication - barrier to effective communication

**Module 4** (13 hours)

Controlling - the basic control process - financial control methods- budgetory control methods - types of auditing - introduction to total quality management (TQM) - quality - costs of quality - the deming philosophy - designing for quality - conformance to design - quality certification - introduction to business process reengineering (BPR) - management information systems (MIS)

**References:**


1. Lewis P.S., Goodman S.H. & Fandt P.M., Management - Challenges In The 21st Century, West Pub.
2. Stoner J.A.F., Management, Prentice Hall of India
3. Koontz H., O'Donnell C. & Weihrich H., Essentials of Management, Tata McGraw Hill
4. Drummond H., The TQM Movement, What Total Quality Management is Really All About, UBS Pub.
5. Johansson H., McHugh P., Pendlebury A.J. & Wheeler W.A., Business Process Reengineering-Breakpoint Strategies for Market Dominance, John Wiley


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 L04 NUMERICAL ANALYSIS**

**Teaching scheme** **Credits:** 4

3 hours lecture & 1hour tutorial per week

**Objectives**

- *To impart the basic concepts of numerical analysis*
- *To develop understanding about numerical solutions for engineering problems.*

**No Pre-requisites**

**Module 1**: Errors in numerical calculations (13 hours)

Sources of errors, significant digits and numerical instability - numerical solution of polynomial and transcendental equations - bisection method - method of false position - Newton-Raphson method - fixed-point iteration - rate of convergence of these methods - iteration based on second degree equation - the Muller's method - Chebyshev method - Graeffe's root squaring method for polynomial equations - Bairstow's method for quadratic factors in the case of polynomial equations

**Module 2**: Solutions of system of linear algebraic equations (13 hours)

Direct methods - gauss and gauss - Jordan methods - Crout's reduction method - error analysis - iterative methods - Jacobi's iteration - Gauss-seidel iteration - the relaxation method - convergence analysis - solution of system of nonlinear equations by Newton-Raphson method - power method for the determination of Eigen values - convergence of power method

**Module 3**: Polynomial interpolation (13 hours)

Lagrange's interpolation polynomial - divided differences Newton's divided difference interpolation polynomial - error of interpolation - finite difference operators - Gregory – Newton forward and backward interpolations - Stirling's interpolation formula - interpolation with a cubic spline - numerical differentiation - differential formulas in the case of equally spaced points - numerical integration - trapezoidal and Simpson's rules - gaussian integration - errors of integration formulas

**Module 4**: Numerical solution of ordinary differential equations (13 hours)

The Taylor series method - Euler and modified Euler methods - Runge–Kutta methods ($2^{nd}$ order and $4^{th}$ order only) - multistep methods - Milne's predictor - corrector formulas - Adam-Bashforth & Adam-Moulton formulas - solution of boundary value problems in ordinary differential equations - finite difference methods for solving two dimensional Laplace's equation for a rectangular region - finite difference method of solving heat equation and wave equation with given initial and boundary conditions

**References:**


1. Froberg C.E., Introduction to Numerical Analysis, Addison Wesley
2. Gerald C.F., Applied Numerical Analysis, Addison Wesley
3. Hildebrand F.B., Introduction to Numerical Analysis, T.M.H.
4. James M.L., Smith C.M. & Wolford J.C., Applied Numerical Methods for Digital Computation, Harper & Row
5. Mathew J.H., Numerical Methods for Mathematics, Science and Engineering, P.H.I

6. Ajay K. Ray, Mathematical Methods in Chemical & Environmental Engineering, Thomson-Learning

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 L05 COMPUTATIONAL FLUID DYNAMICS**

**Teaching scheme** **Credits:** 4

*3 hours lecture and 1 hour practicals per week*

**Objectives**

- *To impart the basic concepts of computational fluid dynamics*

**No Pre-requisites**

**Module 1** (10 hours)

Introduction of the governing equations of fluid mechanics - Conservation equations for mass, momentum, energy and chemical species- Derivation of the governing equations - turbulence closure and mass transfer models — Dimensionless form – simplified equations-

**Module 2** (10 hours)

Introduction to compressible flow – Euler equations- conservative/non-conservative forms - computational fluid dynamic techniques.Matrices and linear equations – Gauss elimination methods – Tri Diagonal matrix algorithm, iterative method.

**Module 3** (14 hours)

Introduction of finite difference method - Discretaisation – linearisation of the governing equations –linear wave equation, Burgers equation, convection-diffusion equation, First and second order numerical methods such as upwind, Lax-Frederichs, Lax_Wendroff, MacCormack, etc. Examples and applications of fluid flow, heat transfer, non Newtonian flow – Implicit and explicit schemes – Stability and CFL condition – Two dimensional problem – Finite difference method for the momentum equations, boundary conditions for the velocity – The equations for the pressure, boundary conditions for pressure.

**Module 4** (18 hours)

The numerical procedure for solving Navier-Stokes equation – Mixed variational form – Galerkin and FE approximations – the algebraic problem – stability, the LBB condition- mass conservation.

(Computer lab practical class) Computer programs for solving -Navier-Stokes equations – Practical exposure to different CFD packages for solving Navier-Stokes equation, Euler equation, etc.

**References:**


1. D. A. Anderson, J.C. Tanneheil, R.H. Fletcher, Computational Fluid Mechanics and Heat Transfer, Hemisphere, New York, 1984
2. R. Peyret, T. D. Taylor, Computational Methods for Fluid Flow, Springer Verlag, 1983
3. G.D. Smith, Numerical Solution of Partial Differential Equations: Finite Difference Methods, Clarendon Press, Oxford
4. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, McGraw Hill, Washington, 1980
5. R. B. Bird, R. C. Armstrong, O. Hassagar, Dynamics of Polymeric Liquids, John Wiley, New York, 1987


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CH09 607(P) HEAT TRANSFER OPERATIONS LAB

**Teaching scheme** **Credits:** 2

*3 hours practical per week*

**Objectives**

- *To provide experience on testing, and analysis of heat transfer in various approaches.*

Laboratory experiments and study of equipment based on the course CH09 503 PROCESS HEAT TRANSFER such as

1. Thickness of insulation
2. Radiation constant and emissivity of solids
3. Thermal conductivity of materials
4. Transient conduction
5. Stefan-Boltzman constant
6. Heat transfer in double-pipe exchanger - parallel and counter current flow
7. Heat transfer in shell and tube exchanger
8. Condensation on vertical and horizontal surfaces

9. Heat transfer by natural and forced convection
10. Heat exchange in jacketed kettles
11. Heat transfer in agitated vessels
12. Open pan evaporation
13. Single and multiple effect evaporation

**Internal Continuous Assessment** *(Maximum Marks-50)*
60%-Laboratory practical and record
30%- Test/s
10%- Regularity in the class
**End Semester Examination** *(Maximum Marks-50)*
70% - Procedure, conducting experiment, results, tabulation, and inference
20% - Viva voce
10% - Fair record

**CH09 608(P) MINI PROJECT / PROCESS DESIGN SOFTWARE LAB**
**Teaching scheme** **Credits:** 2
*3 hours practical per week*
**Objectives**

- *To provide experience on chemical engineering research.*
- *For enabling the students to gain experience in organisation and implementation of a small project and thus acquire the necessary confidence to carry out main project in the final year.*

**MINI PROJECT**: The student jointly or individually is required to prepare a project report based on experimental or theoretical work, literature review, computer application to chemical engineering problems or any other work such as fabrication or setting up of an experimental set-up, preparation of feasibility report etc. under the supervision of a guide - the project report is to be submitted by the end of the semester and the work will be assessed based on the report and the presentation of the work. The assessment of all the mini projects should be done by a committee consisting of three or four faculty members - the students will present their project work before the committee - the relative grading and group average marks for the various projects will be fixed by the committee - the guides will award the marks for the individual students in the project maintaining the group average - each group will submit the project report to the department through the guide - the head of the department will certify the copies and keep one copy in the departmental library.
**Internal Continuous Assessment** *(50 marks)*
40% - Design and development
30% - Final result and Demonstration
20% - Report
10% - Regularity in the class
**End Semester Examination** *(Maximum Marks-50)*
20% - Demonstration of mini project
50% - Practical test connected with mini project
20% - Viva voce
10% - Fair record

**Objectives**

- *To provide experience on chemical engineering research.*
- *For enabling the students to gain experience in software*

**PROCESS DESIGN SOFTWARE LAB**: Use of Aspen plus, chemcad, Matlab, Hysis, CFD

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

60%-Laboratory practical and record
30%- Test/s
10%- Regularity in the class

**End Semester Examination** *(Maximum Marks-50)*

70% - Procedure, conducting experiment, results, tabulation, and inference
20% - Viva voce
10% - Fair record

# SEVENTH SEMESTER

**CH09 701 CHEMICAL ENGINEERING DESIGN& DRAWING I**

**Teaching scheme** **Credits:** 5

*2 hours lecture, 1hour tutorial & 2 hours drawing per week*

**Objectives**

- *To impart the basic concepts of chemical engineering drawing, mechanical design and process design of evaporators*
- *To develop understanding about P&ID, I&C drawing, pressure vessel design, storage tank design and heat exchangers*

**Module 1** (18 hrs)

Introduction to chemical engineering drawing – P&ID symbols and drawings – I&C drawing of heat exchangers, distillation columns and stirred tank jacketed reactors.

Introduction to pressure vessels: stress variation. Mechanical design of pressure vessels and jacketed vessels.

**Module 2** (24 hrs)

Mechanical design of process equipment: tall columns, column supports & accessories, etc. Mechanical design of non standard flange. Design of storage tanks for Volatile and Non-volatile liquids.

**Module 3** (24 hrs)

Process design and detailed drawing of shell & tube heat exchangers and double pipe heat exchanger for single phase streams. Process design of condensers: Tubular horizontal & Tubular vertical for condensation of single vapours.

**References:**


1. B.C Bhattacharya, Introduction to Chemical Equipment Design, CBS Publishers & Distributors, New Delhi.
1. M.V Joshi & Mahajan V.V., Process Equipment Design, 3rd Edn, Mac-Milan & Co. India.
2. D.Q.Kern, Process Heat Transfer, Tata Mc-GRAWHILL.
3. J.M.Coulson & J.F.Richardson, Chemical Engineering, Vol.6, 3rd Edn, Butterworth-Heinemann, (Indian print)
4. E. Ludwig, Applied Process Design for Chemical & Petrochemical Plants, Vol I, II, II, Gulf Publication, London.
5. IS Codes.
6. Perry. R.H & Green.D.W., Chemical Engineers Handbook, 7th Edn, Mc- Grawhill.
7. Bhatt N.D., Machine Drawing, Charator Book Stall
8. Badger & Bancharo, Introduction to Chemical Engineering, McGraw Hill
9. Rase & Barrow, Project Engineering of Process Plants, John Wiley
10. McCabe W.L., Smith J.C., & Harriot P., Unit Operations In Chemical Engineering, McGraw Hill.
11. Treybal R. E., Mass Transfer Operations, McGraw Hill
12. Harriot P., Process Control, Tata McGraw Hill
13. I.S.A. code (P&ID)


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

Part A - *Analytical/Problem solving questions with drawing* *1 x 20 marks=20 marks*

2 question of 20 marks from first module with choice to answer one.

Part B - *Analytical/Problem solving questions* *1 x 25 marks=25 marks*

2 question of 25 marks from second module with choice to answer one.

Part C - *Analytical/Problem solving questions with drawing* *1 x 25 marks=25 marks*

2 question of 25 marks from third module with choice to answer one.

*Maximum Total Marks: 70*

**CH09 702 TRANSPORT PHENOMENA**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1hour tutorial per week*

**Objectives**

- *To impart the basic concepts of transport phenomena*
- *To develop understanding about momentum transport, heat transport and mass transport*

**Module 1** (10 hours)

Prediction of transport coefficients - viscosity, thermal conductivity, diffusivity - effect of temperature, pressure and composition on transport coefficients - kinetic theories of viscosity, thermal conductivity and diffusivity of gases - relationship among viscosity, thermal conductivity and diffusivity in gases - prediction of transport coefficients of liquids

**Module 2** (14 hours)

Shell momentum balance - boundary conditions - application of shell balance to simple flow systems - falling film - flow through tube - flow through annulus - flow of immiscible liquids in layers - creeping flow around solid sphere - general transport equations for momentum - derivation of continuity equation and equation of motion in rectangular coordinates - Navier-Stoke's equation and Euler equation - transport equations in curvilinear coordinates (no derivation) - application of transport equations to steady flow problems - flow through tube - tangential annular flow - rotating liquid - cone and plate viscometer

**Module 3** (14 hours)

Shell energy balance - boundary conditions - application of shell balance to heat conduction problems - conduction with electric, nuclear and viscous heat sources - fixed bed flow reactor - cooling fin - heat transfer by forced and free convection - equations of energy in rectangular coordinates - energy equations in curvilinear coordinates (no derivation) - application to steady-state heat transfer problems - tangential flow in annulus with viscous heat generation - flow of nonisothermal film - transpiration cooling - free convection from vertical plate

**Module 4** (14 hours)

Shell mass balance - boundary conditions - diffusion through stagnant gas - diffusion with heterogeneous and homogeneous chemical reaction - diffusion into falling film - diffusion and chemical reaction in porous catalyst - equation of continuity for binary mixtures in rectangular coordinates - equation of continuity in curvilinear coordinates and multicomponent equations of change (no derivation) - application to combined heat and mass transfer, thermal diffusion and pressure diffusion

**Note:** For the University examinations, students are permitted to take tables of equations of continuity, motion and energy inside the examination hall.

**References:**

1. Bird R.B., Stewart W.E. & Lightfoot E.N., Transport Phenomena, John Wiley
2. Welty J.R., Wicks C.E. & Wilson R.E., Fundamentals of Momentum, Heat & Mass Transfer, John Wiley

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CH09 703 SAFETY ENGINEERING IN PROCESS PLANTS

**Teaching scheme** **Credits:** 3

*2 hours lecture & 1hour tutorial per week*

**Objectives**

- *To impart the basic concepts of industrial safety.*
- *To develop understanding about safety practices in industries and emergency procedures.*

**Module 1** (10 hours)

Introduction to safety: Concept and importance of industrial safety. Fundamental safety tenets. Safety in the site selection and lay out. Location and design parameters for chimney, flares, rupture discs, location of boiler houses, storage of hazardous chemicals etc. Safety in operations and processes. Work permit system. Confined space safety practices.

**Module 2** (10 hours)

Chemical hazards classification, hazards due to fire, explosion, toxic chemicals and radiation. Reduction of Process hazards by plant condition monitoring. Electrical exposures. Guarding live electrical elements. Electrical wiring, switches and fuses. Grounding. Ground Fault Interrupter. Classification of atmospheric contaminants. TLV Contamination reduction or removal methods. Handling and storage of Hazardous chemicals. Pressurized lines and containers (LPG, Compressed air, gases or fluids). Extreme temperatures – hot and cold.

**Module 3** (10 hours)

System Safety Analysis: Systems approach to safety utilizing techniques such as plant Inspections, safety Audits, Job- safety Analysis, Hazard Survey and analysis, HAZOP, Fault tree analysis, failure mode and effect analysis, Event tree analysis etc. Case studies on these techniques applied in process industries.

**Module 4** (10 hours)

Emergency Preparedness: Fire and Explosion. Fire hazards. Fire pyramid. Types of fires. Types of fire extinguishers and its handling. Types of built in extinguishing systems. Fixed fire protection systems. Fire fighting techniques. BLEVE and Runaway Reaction. Emergency procedures. Types of alarm systems. Study of fire protection systems and emergency procedure of a leading chemical industry (preferably refinery/petrochemical)

**References:**


1. Wells, G. L., Safety in process plant design, George Godwin Ltd, London
2. Encyclopedia of Occupational Health & Safety, International labour Office, Geneva
3. Grialdi, J. V., and Simonds, R.H., Safety Management, AITBS Publishers & Distributors, New Delhi
4. Slote, L., Handbook of occupational safety & Health, John Wiley & Sons, New York.
5. Kumar, A., Chemical Process Synthetics and Engineering Design, Tata McGraw Hill, New Delhi
6. Buschmann, Loss Prevention and Safety Promotion in the Process Industries, Elsevier Scientific, New York
7. K.V. Raghavan and A.A.Khan : Methodologies in Hazard Identification and Assessment Manual by CLRI, December 1990.
8. V.C Marshal : Major Chemical Hazards – Ellis Harwood Ltd., Chichester, U.K. 1987.
9. Frank P. Leis: Loss Prevention in Process Industries Vol 1 &2: Butterworth – London 1980.
10. Wills, G.L, "Safety in Process.
11. Crowl, D.A. and Louvar, J.F., "Chemical Process Safety: Fundamentals with Applications", Prentice Hall, Inc.
12. Safety in Chemical Process Industries: 0. P. Kharbanda


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CH09 704 BIOCHEMICAL ENGINEERING

**Teaching scheme** **Credits:** 3

*2 hours lecture & 1hour tutorial per week*

**Objectives**

- *To impart the basic concepts of biochemical engineering*
- *To develop understanding about biochemistry and bioprocesses*

**Module 1** (10 hours)

Introduction to biochemical engineering – Comparison of chemical and biochemical processes, industrially important microbial strains used for different bio products, Chemicals of life –Carbohydrates, proteins, lipids, Fats and water soluble vitamins, nucleic acids, their classification and functions, Biology of microbes – Protist kingdom, classification and structure of different cells,Introduction to biochemical engineering – Bioprocess Development: An Interdisciplinary Challenge, Steps in Bioprocess Development: A Typical New Product from Recombinant DNA. A Quantitative Approach.

**Module 2** (10 hours)

Sterilization - Media and air, methods. Stoichiometry of Growth and Product Formation, Fermentation Energy-Balance, Mixing in Fermenters, Role of Shear in Stirred Fermenters, Role of Diffusion in Bioprocessing, Oxygen Uptake in Cell Cultures. Oxygen Transfer in Fermenters, Cell Disruption

**Module 3** (10 hours)

Introduction to enzymes – Classification, kinetics of enzyme catalyzed reactions, factors affecting E.S complex, derivation of Michaelis Menten equation for single substrate, determination of M.M parameters, enzyme inhibition – types, immobilization of enzymes, methods, immobilized enzyme kinetics, applications of immobilized enzymes, Kinetics of cell growth – Growth phases, yield coefficient, Monod growth kinetics, Effect of Culture Conditions on Cell Kinetics. Kinetics of Cell Death. Heterogeneous Reactions in Bioprocessing, ideal bioreactors – batch –mixed flow and plug flow reactors, their analyses

**Module 4** (10 hours)

Down stream processing – Special reference to membrane separation and chromatographic techniques, important industrial bio products – ethanol – penicillin – citric acid – acetic acid, effluent treatment, production of biogas. Paper chromatography and thin layer chromatography techniques for the separation of sugars and amino acids.

**References:**


1. Bailey & Ollis, Biochemical Engineering Fundamentals, McGraw Hill
2. M.L.Shuler and F.Kargi, Bioprocess Engineering, Prentice-Hall of India
3. Pauline Doran, Bioprocess Engineering Principles, Elsevier
4. Perry R.H. & Chilton H.C. (Eds.), Chemical Engineers Handbook, McGraw Hill


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 Lxx ELECTIVE II**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

Any one from Ch09 L06 to CH09 L025 or Global Electives listed at last with maximum one global elective for one semester

**CH09 Lxx ELECTIVE III**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

Any one from Ch09 L06 to CH09 L025 or Global Electives listed at last with maximum one global elective for one semester

**CH09 707(P) MASS TRANSFER OPERATIONS LAB**

**Teaching scheme** **Credits:** 2

*3 hours practical per week*

**Objectives**

- *To provide experience analysis of mass transfer operations.*

The experiments based on the courses CH09-504 MASS TRANSFER OPERATIONS I and CH09-604 MASS TRANSFER OPERATIONS II such as

1. Determination of diffusivity
2. Determination of mass transfer coefficient in surface evaporation
3. Simple distillation
4. Steam distillation
5. Simple leaching
6. Cross-current leaching
7. Counter current leaching
8. Ternary liquid equilibrium
9. Adsorption isotherm
10. Atmospheric batch drying
11. Wetted wall columns
12. Fractionation columns
13. Packed absorption columns
14. Height equivalent of theoretical plate
15. Experiments on liquid-liquid extraction
16. Continuous drying

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

60%-Laboratory practical and record
30%- Test/s
10%- Regularity in the class

**End Semester Examination** *(Maximum Marks-50)*

70% - Procedure, conducting experiment, results, tabulation, and inference
20% - Viva voce
10% - Fair record

**CH09 708(P) PROCESS CONTROL AND REACTION ENGINEERING LAB**

**Teaching scheme** **Credits:** 2

*3 hours practical per week*

**Objectives**

- *To provide experience on analysis of process control and reaction engineering.*

1. Calibration of thermocouple
2. Dynamics of thermocouple
3. Dynamics of thermometer
4. Dynamics of thermometer with thermo well
5. Dynamics of liquid level system - single tank
6. Dynamics of liquid level system - non-interacting tanks in series
7. Dynamics of liquid level system - interacting tanks in series
8. Control of level process systems
9. Dynamics of mixing process
10. Dynamics of manometer
11. Control of temperature process system
12. Comparative study of P, PI and PID controllers for temperature process system
13. Study of Electro-pneumatic converter
14. Control valve characteristics
15. Determination of activation energy
16. Kinetics of hydrolysis of methyl acetate
17. Kinetics of hydrolysis of ethyl acetate
18. Performance study of plug flow reactor
19. Performance study of CSTR
20. RTD studies

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

60%-Laboratory practical and record
30%- Test/s
10%- Regularity in the class

**End Semester Examination** *(Maximum Marks-50)*

70% - Procedure, conducting experiment, results, tabulation, and inference
20% - Viva voce
10% - Fair record

**CH09 708(P) PROJECT**

**Teaching scheme** **Credits:** 1

*1 hours per week*

**Objectives:**

- *To judge the capacity of the students in converting the theoretical knowledge into practical systems/investigative analysis.*

Project work is for duration of two semesters and is expected to be completed in the eighth semester. Each student group consisting of not more than five members is expected to design and develop a complete system or make an investigative analysis of a technical problem in the relevant area. The objective of the project is to test the ability of the student to coordinate the entire knowledge of chemical engineering and to judge his/her originality and capacity in the design of a plant/process/system - the students are required to prepare a project report on a complete process showing the selection of alternatives, preparation of flow-sheet, material

and energy balances, detailed design calculations of the major items of equipment including mechanical design and drawing, capital cost and product cost estimation and profitability, break even analysis, selection of plant location and lay-out - the project has to be completed in the VII and VIII semester - the progress of the work in the VII semester will be assessed and evaluated based on the preliminary report submitted towards the end of the semester and a presentation before a project evaluation committee consisting of three or four faculty members- the complete project report is not expected at the end of the seventh semester - however a three-four page typed report based on the work done should be submitted by the students to the assessing committee - the project guides will award the marks for the individual students in a project group maintaining the group average assigned by the project evaluation committee.

Each project group should submit project synopsis within three weeks from start of seventh semester. Project evaluation committee shall study the feasibility of each project work before giving consent. Literature survey is to be completed in the seventh semester.

Students should execute the project work using the facilities of the institute. However, external projects can be taken up in reputed industries, if that work solves a technical problem of the external firm. Prior sanction should be obtained from the head of department before taking up external project work and there must be an internal guide for such projects.

Each student has to submit an interim report of the project at the end of the $7^{th}$ semester. Members of the group will present the project details and progress of the project before the committee at the end of the $7^{th}$ semester.

50% of the marks is to be awarded by the guide and 50% by the evaluation committee.

**Internal Continuous Assessment**

20% - Technical relevance of the project
40% - Literature survey and data collection
20% - Progress of the project and presentation
10% - Report
10% - Regularity in the class

# EIGHTH SEMESTER

**CH09 801 CHEMICAL ENGINEERING DESIGN & DRAWING II**

**Teaching scheme** **Credits:** 5

*2 hours lecture, 1hour tutorial & 2 hours drawing per week*

**Objectives**

- *To impart the basic concepts of process design of evaporators, distillation, absorption and stripping columns, extraction columns, dryers and cooling towers.*

**Module 1** (20 hrs)

Process design and detailed drawing of: Evaporators- Standard short tube, Standard long tube and forced circulation evaporators. Multiple effect evaporators. Process design of Cooling Towers.

**Module 2** (23 hrs)

Process design of steady state isothermal binary component distillation columns. Detailed drawing of distillation column and its accessories. Process design of steady state isothermal absorption and stripping column.

**Module 3** (22 hrs)

Process design and drawing of: tray and packed Extraction columns; Rotary Dryers and tray dryers.

**References:**


1. B.C Bhattacharya, Introduction to Chemical Equipment Design, CBS Publishers & Distributors, New Delhi.
2. M.V Joshi & Mahajan V.V., Process Equipment Design, 3rd Edn, Mac-Milan & Co. India.
3. R.E.Treybal, Mass Transfer Operations, McGraw hill.
4. J.M.Coulson & J.F.Richardson, Chemical Engineering, Vol.6, 3rd Edn, Butterworth-Heinemann, (Indian print)
5. E. Ludwig, Applied Process Design for Chemical & Petrochemical Plants, Vol I, II, II, Gulf Publication, London.
6. IS Codes.
7. Perry. R.H & Green.D.W., Chemical Engineers Handbook, 7th Edn, McGraw hill.
8. D.Q.Kern, Process Heat Transfer, Tata Mc-GRAWHILL.
9. Badger & Bancharo, Introduction to Chemical Engineering, McGraw Hill
10. Rase & Barrow, Project Engineering of Process Plants, John Wiley
11. McCabe W.L., Smith J.C., & Harriot P., Unit Operations In Chemical Engineering, McGraw Hill.
12. Treybal R. E., Mass Transfer Operations, McGraw Hill


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

Part A - *Analytical/Problem solving questionswith drawing* *1 x 20 marks=20 marks*

2 question of 20 marks from first module with choice to answer one.

Part B - *Analytical/Problem solving questionswith drawing* *1 x 25 marks=25 marks*
2 question of 25 marks from second module with choice to answer one.
Part C - *Analytical/Problem solving questionswith drawing* *1 x 25 marks=25 marks*
2 question of 25 marks from third module with choice to answer one.

*Maximum Total Marks: 70*

**CH09 802 OPTIMISATION OF CHEMICAL PROCESSES**

**Teaching scheme** **Credits:** 3

2 hours lecture & 1 hour tutorial per week

**Objectives**

- *To impart the basic concepts of optimization*

**Module 1** (10 hours)

Nature and organisation of optimisation problems - scope and hierarchy of optimisation - typical applications of optimisation - essential features of optimisation problems - objective function - investment costs and operating costs in objective function - optimising profitability - constraints - internal and external constraints - formulation of optimisation problems - typical examples - nature of functions and their representation - continuous functions - discrete functions - unimodal functions - convex and concave functions - necessary and sufficient conditions for optimum of unconstrained functions

**Module 2** (10 hours)

Numerical methods for unconstrained functions - one dimensional search - gradient-free search with fixed step size - gradient search with acceleration - Newton's method - Quasi-Newton method - dichotomous search -fibonacci search - golden-section method - quadratic interpolation - numerical methods for unconstrained multivariable optimisation - univariate search - simplex method - Powell's method - method of steepest descent - Fletcher-Reeves conjugate - gradient method - Newton's method

**Module 3** (10 hours)

Linear programming - basic concepts in linear programming - graphical interpretation - simplex method - apparent difficulties in the simplex method - two-phase simplex method - nonlinear programming with constraints - equality constraints - method of direct substitution - lagrange multiplier method - use of lagrange multipliers for inequality constraints - kuhn-tucker conditions

**Module 4** (10 hours)

Zoutendijk's method - Rosen's gradient projection method - some typical applications (numerical solution not expected) - optimising recovery of waste heat - optimisation of evaporator design - optimum diameter for pipe for transportation of fluid - optimisation of liquid - liquid extraction process - optimal design and operation of staged distillation columns - optimum residence time for isothermal batch reactor - linear programming to optimise reactor operations

**Reference books:**


1. Edgar T.F. & Himmelblau D.M., Optimization of Chemical Processes, McGraw Hill
2. Beveridge G.S.G. & Schechter R.S., Optimiszation: Theory & Practice, McGraw Hill
3. Rao S.S., Optimization: Theory and Applications, Wiley Eastern
4. Beightler C.S., Phillips D.T. & Wilde D.J., Foundations of Optimization, Prentice Hall of India

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 Lxx ELECTIVE IV**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

Any one from Ch09 L06 to CH09 L025 or Global Electives listed at last with maximum one global elective for one semester

**CH09 Lxx ELECTIVE V**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

Any one from Ch09 L06 to CH09 L025 or Global Electives listed at last with maximum one global elective for one semester

**CH09 805(P) SEMINAR**

**Teaching scheme** **Credits:** 3

*3 hours per week*

**Objective:**

- *To assess the ability of the student to study and present a seminar on a topic of current relevance in chemical engineering or allied areas.*

It enables the students to gain knowledge in any of the technically relevant current topics and acquire the confidence in presenting the topic. The student will undertake a detailed study on the chosen topic under the supervision of a faculty member, by referring papers published in reputed journals and conferences. Each student has to submit a seminar report, based on these papers; the report must not be reproduction of any original paper.

The student shall give at least one seminar for about thirty minutes during the seventh semester before a committee consisting of three or four staff members of the department. The committee assesses the presentation of the seminars and award the marks to the students. Each student should be asked to submit at least two copies of a write up of his seminar talk – one copy should be returned to the student after duly certifying it by the chairman of the assessing committee and the other kept in the departmental library.

**Internal Continuous Assessment**

20% - Relevance of the topic and literature survey

50% - Presentation and discussion
20% - Report
10% - Regularity in the class and Participation in the seminar

**CH09 806(P) PROJECT**
**Teaching scheme** **Credits:** 11
11 hours per week

This project work is the continuation of the project initiated in seventh semester. The performance of the students in the project work shall be assessed on a continuous basis by the project evaluation committee through progress seminars and demonstrations conducted during the semester. Each project group should maintain a log book of activities of the project. It should have entries related to the work done, problems faced, solution evolved etc.
Extension and completion of the project work assigned in VII semester - the project report is to be submitted towards the end of the semester. In addition, the student has to make a presentation of his work and appear for a viva-voce before the project evaluation committee constituted for assessing the work. The assessment committee as constituted in the seventh semester, will assess the various projects, fix the relative grading and group average marks - the guides will award the marks for the individual students in a project maintaining the group average - each group will submit the copies of the completed project report signed by the guide to the department - the head of the department will certify the copies and return them to the students - one copy will be kept in the departmental library
There shall be at least an Interim Evaluation and a final evaluation of the project in the $8^{th}$ semester. Each project group has to submit an interim report in the prescribed format for the interim evaluation. Each project group should complete the project work in the $8^{th}$ semester. Each student is expected to prepare a report in the prescribed format, based on the project work. Members of the group will present the relevance, design, implementation, and results of the project before the project evaluation committee comprising of the guide, and three/four faculty members specialised in chemical engineering.
50% of the marks is to be awarded by the guide and 50% by the evaluation committee.
**Internal Continuous Assessment**
40% - Design and development/Simulation and analysis
30% - Presentation & demonstration of results
20% - Report
10% - Regularity in the class

**CH09 807(P) VIVA-VOCE**
**Credits:** 4
**Objective**

- *To examine the knowledge acquired by the student during the B.Tech. course, through an oral examination*

The students shall prepare for the oral examination based on the theory and laboratory subjects studied in the B.Tech. Course, mini project, seminar, and project. There is only university examination for viva-voce. University will appoint two external examiners and an internal examiner for viva-voce. These examiners shall be senior faculty members having minimum five years teaching experience at engineering degree level. For final viva-voce, candidates should produce certified reports of mini project, seminar, and project (two interim reports and main report). If he/she has

undergone industrial training/industrial visit/educational tour or presented a paper in any conference, the certified report/technical paper shall also be brought for the viva-voce.

**Assessment in Viva-voce**

40% - Subjects
30% - Project and Mini Project
20% - Seminar
10% - Industrial training/industrial visit/educational tour or Paper presented at National-level
Maximum marks: 100

ELECTIVES

**CH09 L06 ADVANCES IN BIOCHEMICAL ENGINEERING**

**Teaching scheme** **Credits:** 4

*3 hours lecture and 1 hour tutorial per week*

**Objectives**

- *To impart the detailed concepts of biochemical engineering*

**No Pre-requisites**

**Module 1** (13 hours)

Definition and introduction of biochemical engineering. Microbiology – general idea on structure of cells(prokaryotes and eukaryotes) and cell theory. Classification of micro-organisms(protist kingdom)and their morphological characteristics eg. bacteria,blue –green algae, actinomycetes, fungi(mold, yeasts), protozoa(primitive animals) and algae(primitive plants). Biochemistry-study of structure, properties and functions of important cell chemicals like lipids( fatty acids, fats, vitamins, steroids, phospholipids) and carbohydrates, proteins and nucleic acids. Molecular genetics-concept and definition- process of gene expression, DNA replication and mutation, recombinant DNA technology, prospects of genetic engineering.

**Module 2** (13 hours)

Enzyme classification. Comparison of enzymes with synthetic catalysts. Kinetics of enzyme-catalysed reactions-Michealis-Menten equation for single substrate reaction-concept of substrate and substrate-enzyme complex. Evaluation of kinetic parameters in M-M equation. Substrate inhibition and activation. Feedback inhibition. Competitive and non-competitive inhibition. Enzyme activation and inhibition(.no derivation). Study of parameters affecting enzymatic activity like pH,temperature and mechanical forces.Production and purification of enzymes.(methods).Immobilization of enzymes(physical and chemical methods). Applications of enzymes as catalysts. Industrial, medical and analytical applications of immobilized enzymes.(general idea) Bioenergetics-Energy through EMP pathway and TCA cycle on glucose molecule. Importance of NAD and ATP.

**Module 3** (13 hours)

Cell growth stoichiometry . Batch cultivation of cells –growth cycle phases like lag, exponential growth, maximum stationary phase, and death phase. Medium formulation, yield factors, Monod growth kinetics. Transport phenomena in bioprocess systems-gas-liquid mass transfer, metabolic oxygen utilization,oxygen transfer rate determination, overall coefficientsand power requirements in sparged and agitated vessels. Heat transfer in biochemical reactions. Bioreactor instrumentation- physical and chemical sensors, gas analysis, online and offline sensors.

**Module 4** (13 hours)

Design and analysis of biological reactors_ Ideal reactors and non-ideal reactors, sterilization reactors, multiphase reactors- packed type, bubble column, fluidized bed, fixed bed (general

description). Fermentation technology- design and operation of typical aseptic aerobic fermentation process. Different configurations for fermentors. Product recovery operations- filtration, centrifugation, extraction, sorption, precipitation, chromatography and membrane processes. Bio-chemical industry- flow diagrams and descriptions for production of fine chemicals like enzymes, proteins, antibodies, steroids. Flow diagrams and descriptions for manufacture of beer, wine, fuel alcohol, ethanol, organic acids, amino-acids, and single cell proteins.

**References:**


1. Bailey & Ollis, Biochemical Engineering Fundamentals, McGraw Hill
2. Perry R.H. & Chilton H.C. (Eds.), Chemical Engineers Handbook, McGraw Hill
3. 'Biochemical Engineering' by A.Aiba, E.Humphrey and N.R.Milli
4. 'Bioprocess Engineering - Basic Concepts' by M.L.Shuler and F.Kargi
5. 'Biochemical Engineering' by J.M.Lee
6. 'Biochemical Engineering' by H.W.Blanch and D.S.Clark


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CH09 L07 COMPUTER AIDED DESIGN

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of computer aided design*

**No Pre-requisites**

**Module 1** (13 hours)

Introduction to computer aided design - use of computers for physical property evaluation - thermodynamic properties of gases and binary mixtures - methods of calculating vapour-liquid equilibrium data for ideal and non- ideal mixture - bubble point and dew point - flash calculations

**Module 2** (13 hours)

Design of pressure vessels - vessels under internal pressure - heads and closures - compensation requirements for openings and flanges - vessels under external pressure - tall vessels - development of CAD modules for design of pressure vessels

**Module 3** (13 hours)

Computer aided design of heat exchanger systems - double pipe and shell and tube heat exchanger design - computer aided design of evaporators - design of single effect evaporator and multiple effect evaporator systems

**Module 4** (13 hours)

Computer aided design of packed bed absorbers and strippers - computer aided mechanical design of bubble - cap distillation column

**Reference books:**


1. Bhattacharya B.C & Narayanan C.M., Computer Aided Design of Chemical Process Equipment, New Central Book Agency
2. Perry R.H. & Chilton C.E., Chemical Engineers Handbook, McGraw Hill
3. Joshi M.V, Process Equipment Design, McMillan
4. Coulson J.M. & Richardson J.F., Chemical Engg. Vol. V1, Pergamon
5. Kern D.Q., Process Heat Transfer, McGraw Hill
6. Ludwig E.E., Applied Process Design for Chemical and Petrochemical Plants, Vols. I, II & III, Gulf Pub.
7. Fraas A.P. & Ozisik M.N., Heat Exchanger Design, John Wiley


**Internal Work Assessment**

60% - Test papers (minimum 2)
30% - Assignments / Term project/any other mode decided by the teacher.
10% - Other measures like Regularity and Participation in Class.

Total Marks = 30

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 L08 SOFTWARE ENGINEERING**

**Teaching scheme** **Credits:** 4

*3 hours lecture and 1 hour practical per week*

**Objectives**

- *To impart the basic concepts of software engineering*

**No Pre-requisites**

**Module 1** (13 hours)

Introduction: FAQ's about Software Engineering - Professional and Ethical responsibility, System Modeling, System Engineering process. Software products: System software, Application software, Software product attributes, Software Engineering Approach, The need for an engineering approach, phased development process. Software process: Software development process life cycle models, Waterfall model, Spiral model, Incremental development, Rapid application development, Iteration model. Software Prototyping: Prototyping techniques, Throw-away prototyping, Evolutionary prototyping. System Models: Context models, Behavior model, Data models. Computer Aided Software Engineering: CASE tools, Advantages of using CASE tools, Components of a CASE tool, Function oriented CASE tools – (e.g. Designer 2000/6i), Object oriented CASE tools – (e.g. Rational Rose)

**Module 2** (13 hours)

Software Requirement Analysis and Specification: Software requirements, functional and non-functional requirements, user requirements, system requirements, Requirement definition, Software requirement specification (SRS), Components of an SRS, Specification languages, Requirement validation, Requirement reviews. Software Design: Software design techniques, Top-down design technique, Bottom-up design techniques, Data flow oriented design, Object oriented design, User Interface design, Design Principles and Issues – Modularity, Abstraction, Encapsulation, Re-usability, Support maintainability.

**Module 3** (13 hours)

Software Coding and Verification: Structured programming, Programming style, internal documentation, Code Inspections, Code reviews. Software Testing: Testing process, Test plans, Test cases and test criteria, Test case execution and analysis, Test results specification, Testing strategies, Top-down integration, Bottom-up integration, Testing techniques, Black-box testing, White-box testing, Alpha testing, Beta testing, object oriented testing. Software Evolution: Legacy systems, Software change, Software maintenance, Architectural evolution, Software re-engineering, Data re-engineering. Overview of Critical systems: Availability, Reliability, Safety, Security.

**Module 4** (13 hours)

Software Project Management: Project planning, Scheduling, Risk management. Managing People: Group working, closing and keeping people. Quality Management: Quality Assurance and standards, Quality planning, Quality control, Software measurement and metrics. Process Improvement: Process and product quality, Process analysis and modeling, Process measurement, Process CMM. Configuration Management: Planning, Change management, Version and Release management, System building

**References:**

1. Ian Sommerville, Software Engineering, Pearson Education Asia
2. Pressman R.S., Software Engineering, McGraw Hill
3. Mall R., Fundamentals of Software Engineering, Prentice Hall of India
4. Behferooz A. & Hudson F.J., Software Engineering Fundamentals, Oxford University Press
5. Jalote P., An Integrated Approach to Software Engineering, Narosa

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CH09 L09 UNCONVENTIONAL SEPARATION TECHNIQUES

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1hour tutorial per week*

**Objectives**

- *To impart the basic concepts of unconventional separation techniques*
- *To develop understanding about membrane processes, chromatography, super critical fluid extraction, etc*

**No Pre-requisites**

**Module 1** (13 hours)

Membrane separation processes - fundamentals, mechanism and equilibrium relationships - types and structure of membranes - membrane permeation of liquids and gases - effects of concentration, pressure and temperature - dialysis - mechanism - basic idea on dialyser design - industrial application - reverse osmosis - definitions and theory - design considerations - applications - evaporation - ultra filtration

**Module 2** (13 hours)

Diffusional separation processes - gaseous diffusion - mechanism - process description - design considerations - basic principles of thermal diffusion and pressure diffusion - fundamentals of mass diffusion - desalting by freezing - molecular sieves - super critical extraction - SCE solvents - phase behaviour - industrial applications

**Module 3** (13 hours)

Chromatographic and allied fixed bed separation processes - theory and principle of operation - concentration profile and effluent curves - major applications - foam and bubble fractionation processes - foam-column theory - limiting equations - foam drainage and overflow - adductive crystallization and zone melting - ultra and zonal centrifugation

**Module 4** (13 hours)

Separation by action in a field - theory of electrical separation - electrophoresis - electrophoretic mobility - modes of operation - membrane electrophoresis - continuous flow electrophoresis - electro dialysis - ion-selective membranes - design aspects - operating parameters - applications

**References:**


1. Shoen K.M. (Ed.), New Chemical Engineering Separation Techniques, Inter Science
2. Loeb S., Industrial Membrane Separation Processes
3. Perry J.H. & Chilton C.E. (Eds.), Chemical Engineer's Handbook, McGraw Hill

4. McCabe W.L., Smith J.C. & Harriott P., Unit Operations in Chemical Engineering, McGraw Hill
5. Rousseau R.W., Handbook of Separation Process Technology, John Wiley
6. McHugh M.A. & Krukonis V.J., Super Critical Fluid Extraction - Principles & Practice, Butterworths Pub.
7. Seader J.D.& Henley E.J Separation Process Principles

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CH09 L10 MICRO ELECTRONICS PROCESSING

**Teaching scheme** **Credits:** 4

*3 hours lecture and 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of microelectronics processing*

**No Pre-requisites**

**Module 1** (12 hours)

Integrated circuits –Semiconductors and charge carriers –basic relationships and conductivity – basic units of integrated circuits- broad view of microelectronics processing. Silicon refining and other raw materials – metallurgical grade and electronic grade silicon – metal organic compounds.

**Module 2** (12 Hours)

Bulk crystal growth: crystal structures and defects – crystal growth and impurity distribution – oxygen precipitation. Chemical rate processes in the fabrication of ICs: growth processes of films of crystalline structure – heterogeneous reactions and deposition kinetics.

**Module 3** (14 Hours)

Chemical vapour deposition reactors – regimes of fluid flow – intrinsic kinetics and transport effects – reactor design – isothermal, nonisothermal and molecular flow reactors. Incorporation and transportation of dopants – dopant incorporation – radiation damage and annealing – dopant redistribution and auto doping

**Module 4** (14 Hours)

Lithography – illumination and pattern transfer – resists and resist development – yield and ultimate limits. Physical and physico chemical rate processes: evaporation and physical

vapour deposition – plasma – physical sputtering – plasma deposition and gas-solid reaction – plasma etching – physical vapour deposition apparatuses – plasma reactors

**References:**


1. Lee H.H., Microelectronics Processing, McGraw Hill
2. Dennis W. Hess, Klavs F. Jensen, Microelectronics processing: chemical engineering aspects, American Chemical Society, 1989
3. Roy A. Colclaser, Microelectronics: processing and device design, Wiley


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CH09 L11 FOOD TECHNOLOGY

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of food processing*

**No Pre-requisites**

**Module 1** (13 hours)

Introduction - general aspects of food industry - world food needs and Indian situation - constituents of food - quality and nutritive aspects - food additives - standards - deteriorative factors and their control - preliminary processing methods - conversion and preservation operations

**Module 2** (13 hours)

Preservation by heat and cold - dehydration - concentration - frying - irradiation - micro wave heating - sterilization and pasteurisation - fermentation and pickling - packing methods

**Module 3** (13 hours)

Production and utilization of food products - cereal grains - pulses - vegetables - spices - fats and oils - bakery, confectionery and chocolate products

**Module 4** (13 hours)

Soft and alcoholic beverages - dairy products, meat, poultry and fish products - treatment and disposal of food processing wastes

**Reference books:**


1. Heid J.L. & Joslyn M. A., Fundamentals of Food Processing Operations, AVI Pub.
2. Potter N.N., Food Science, AVI Pub.

3. Waston E.L., Elements of Food Engineering, Van Nostrand-Reinhold
4. Ronsivalli L.J., Elementary Food Science, Van Nostrand-Reinhold
5. Considine D.M., Considine G.D. & Considine P.E., Foods & Food Production Encyclopedia, Van Nostrand-Reinhold
6. Hall C.W., Farall A.W. & Rippen A.L., Encyclopedia of Food Engineering, Van Nostrand- Reinhold
7. Goldberg I., Biotechnology & Food Ingredients, Van Nostrand-Reinhold

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CH09 L12 PROCESS MODELING AND SIMULATION

**Teaching scheme** **Credits:** 4

3 hours lecture & 1 hour tutorial per week

**Objectives**

- *To impart the basic concepts of simulation and modeling of chemical processes*

**No Pre-requisites**

**Module 1** (13 hours)

Basic modelling principles - uses of mathematical modelling - classification of modelling techniques - fundamental laws - energy equations - continuity equation - equations of motion - transport equations - equations of state - equilibrium states and chemical kinetics - examples

**Module 2** (13 hours)

Mathematical models for chemical engineering systems - continuous flow tanks - enclosed vessel - mixing vessel - mixing with reaction - reversible reaction - steam jacketed vessel - boiling of single component liquid - open and closed vessel - continuous boiling - multicomponent boiling system - batch distillation

**Module 3** (13 hours)

Gas flow system - hydraulic transients between two reservoirs - reaction kinetics - general modelling scheme - liquid phase CSTR - batch reactor - ideal binary distillation column - distributed systems - jacketed tubular reactor - laminar flow in a pipe - counter current heat exchanger

**Module 4** (13 hours)
Digital simulation - numerical integration - Euler and fourth order Runge Kutta methods - simulation of gravity flow tank - CSTR in series - non isothermal CSTR - binary distillation column - batch reactor

**Reference books:**


1. Luyben W.L., Process Modeling Simulation and Control for Chemical Engineers, McGraw Hill
2. Franks R.G.E., Mathematical Modeling in Chemical Engineering, John Wiley
3. John Ingham et.al., Chemical Engineering Dynamics- Modeling with PC Simulation, VCH Publishers
4. Biquette W.B., Process Dynamics - Modeling Analysis and Simulation, Prentice Hall


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CH09 L13 MARKETING MANAGEMENT

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of marketing*
- *To develop understanding about market analysis and sales promotion*

**No Pre-requisites**

**Module 1** (13 hours)
Critical role of management in organization and society - global economy - concept of marketing - company orientation towards marketplace - customer, values and satisfaction - corporate strategic planning - business strategic planning - marketing information systems - marketing intelligence systems - marketing research systems - analysing marketing environment - demographic - economic - natural - technological - political - cultural - consumer market and buyer behaviour - major factors influencing buyer behaviour - buying decision process - business market and business buying - analysing industries and competitors

**Module 2** (13 hours)
Measuring and forecasting market demand - estimating current demand and future demand - market segments and selecting target market - differentiating and positioning market offer - developing, testing and launching new products
**Module 3** (13 hours)
Product life cycle - introduction stage - growth stage - maturity stage - decline stage - designing marketing strategies for market leaders - challengers - followers - strategies for global market place - managing product lines, brands and packaging - pricing strategies and programs - marketing channels, retailing, wholesaling and physical distribution systems
**Module 4** (13 hours)
Direct marketing, sales promotion and public relations programs - managing the sales force - organizing and implementing marketing programs - evaluating and controlling marketing programs
**Reference books:**

1. Kotler P., Marketing Management - Analysis, Planning, Implementation &Control, Prentice Hall of India
2. Candiff & Still, Basic Marketing, Prentice Hall of India
3. Khanna O.P., Industrial Engineering & Management, Dhanpatrai

**Internal Continuous Assessment** *(Maximum Marks-30)*
60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class
**University Examination Pattern**
*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*
All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.
*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*
Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.
*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*
Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CH09 L14 PETROLEUM EXPLORATION AND STORAGE

**Teaching scheme** **Credits:** 4
*3 hours lecture & 1hour tutorial per week*
**Objectives**
- *To impart the basic concepts of petroleum drilling and exploration*

**No Pre-requisites**

**Module 1** (13 Hours)
Petroleum geology and its scope, Origin of petroleum (emphasis on both techniques and geochemistry), oil and gas traps. Physical and chemical characteristics of crude oil, source rock and maturation. Migration of oil-mechanism pattern and barriers, Reservoir rocks and cap rocks, Entrapment of oil-types and mechanism. Reservoir Rock Properties: Porosity, permeability, Effective and relative permeability, wettability, capillary pressure

characteristics. Application of remote sensing in petroleum resource development, Basin and exploration strategies. The model approach to exploration strategy, Basin mapping methods, Depositional systems such as marine, non-marine, coastal, shelf, carbonate evaporates, Basin evolution, Sedimentation and plate techtonics, Basin evaluation, factors governing hydrocarbon potential.

**Module 2** (13 Hours)

Instruments used, principles and working, magnetometers, Seismograms, Radiation counters and gravimeters. Effective strategies for integrated geophysical exploration from a system view point. Interpretation of electrical, electromagnetic, magneto telluric , gravity and seismic data. Types of hydrocarbon groups present in petroleum & their structures, sulfur, nitrogen, oxygen and metal –organic compound in petroleum. Estimation of reservoir is and determination criteria for commercial exploration. Methods for offshore and onshore petroleum recovery methods primary, secondary, and tertiary.

**Module 3** (13 Hours)

Methods of petroleum prospecting and exploration such as geophysical, seismic, etc. drilling equipments such as rigs, platforms etc and techniques for offshore and onshore operation. Surface operation for separation of oil and gas, well head operation including separation of oil from associated gas. Separation of natural gas from casing head gas. Transportation of crude oil and gas. Flow of fluids through porous media: Darcy's law, single and multiphase flow. Reservoir flow through porous media, drive mechanism, Introduction to enhanced oil recovery methods. Petroleum Exploitation – Well testing and completion, Production potential and well performances. Material balance, Artificial lift, Improved recovery methods.

**Module 4** (13 Hours)

Drilling: Introduction to on-shore and offshore drilling operations, drilling accessories rig components, drilling fluid circulation system. Types of wells – Exploration, appraisal and development, deviated hole, horizontal and multilateral wells. Well design and casing policy. Types and structure of drilling rigs and Rig components. Drilling tubulars and bits, Offshore rigs-for shallow and deep waters, Borehole profile and environment. Drilling methods, predrill operations in onland and offshore environments, planning and execution of drilling operations. Types of drilling fluids, properties and functions, Fluid influx studies and identification by Gas chromatography, Drilling fluid circulation loop. Types of oil well cements, slurry designing and cementation. Production: Production equipment, Introduction to work over and well stimulation method. Two phase oil and gas separation equipment, Types, their description, vessel internal sizing. Theory of separation., Three phase oil- Gas and water separators- type of separators their description, various control and vessel internals. LACT Units. Storage and handling of Petroleum fluids: Different types of tanks for storage of oil and LPG

**References:**


1. Sabins, R. F., Remote Sensing, Principles & Interpretation.
2. Lillsend T. M. & Kiefer R. W., Remote Sensing and Image Interpretation.
3. Berger B D, Anderson K E, "Modern Petroleum" Pennwell books
4. Bradley H B, "Petroleum Engineering Handbook", SPE
5. Cole F W, Reservoir Engineering manual
6. Carl Gatlin , "Petroleum Engineering Drilling and Well Completions" Prentice Hall .
7. Mc Cray and Cole , " Oil Well Drilling Technology" Oklahoma Press
8. D. S. Parasnis, Principles of Applied Geophysics, Chapman
9. R. K. Jain, Engineering Metrology

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 L15 COMPOSITE MATERIALS**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1hour tutorial per week*

**Objectives**

- *To impart the basic concepts of composite materials*

**No Pre-requisites**

**MODULE 1** (13 hours)

Introduction to composite materials-definitions and basic concepts-natural and man made composites-classification based on structure-phase composition and layered composition types of composite materials-plastics matrix composites-rubber matrix composites-metal matrix composites-ceramic and other brittle matrix composites characteristic features and advantages of composites materials- reinforcement and matrix materials and their properties-glass, carbon, Kevlar, boron, asbestos, steel, natural fibers and whiskers-reinforcement fibers-different types and forms used in FRP-surface treatment for fibers-size and coupling agents-commonly used fibers and additives in FRP and their effects-various types of resins used – polyester resins-epoxy and phenol formaldehyde resins.

**MODULE 2** ( 13hours)

Manufacturing of advanced composites: Polymer matrix composites: Preparation of Moulding compounds and prepregs – hand lay up method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding- vaccum bag moulding centrifugal casting-pultrusion-machinery, operation, advantages and disadvantages - Fibre Reinforced Thermoplastics(FRTP) preparation-brief description of coating process-melt compounding process and dry blending process-injection moulding, rotational moulding and cold forming of reinforced thermoplastics.

**MODULE 3** (13 hours)

Theory of reinforcement –basic criterion to be adopted in the selection of matrix and reinforcement-mechanics of composite materials-micromechanics and macro mechanics-mechanism of load transfer-minimum and critical fibre content-critical fibre length-law of mixture rule-unidirectional and fibrous composites-effects of fibre orientation on stiffness

and strength-bidirectional and random fibre composites-concepts of unit cell-stress analysis of unit cells-toughness of fibrous composites, microscopic stress-strain curves.

**MODULE 4** (13 hours)

Testing of composites materials and products for quality control- Brief outlines of testing of glass fibre, testing of resins-testing of products. General design considerations-design values-factor of safety-working stress approach – service ability design-warning of danger-design process-shape design & se4lection of materials and processing methods-application of composite of materials in various fields-chemical industries- electrical and electronic industries- aerospace, marine, and transport applications- application in buildings.

**References**


1. Handbook of composites- G.Lubin, Von Nostrand, New York, 1982.
2. Mohr.J.G.et al, SPI handbook of Technology and Engineering of reinforced Plastics/Composites, Von Nostrand, New York.
3. Katz.H.S. & J.V. Milewski, Handbook of Fillers and Reinforcement for plastics- Von Nostrand, New York.
4. Polymer Engineering Composites. Ed.M.O.W. Richardson, Applied Science Publishers, London.
5. Composite Materials – K.K.Chawla
6. An Introduction to Composite Materials, D. Hull, Cambridge University Press, Cambridge.


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CH09 L16 CATALYSIS- THEORY AND PRACTICE

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1hour tutorial per week*

**Objectives**

- *To impart the basic concepts of catalysis*
- *To develop understanding about catalyst selection for various unit processes*

**No Pre-requisites**

**Module 1** (13 hours)

Heterogeneous processes. Global rates of reaction. Catalysis. General characteristics of catalysis. Physical adsorption and chemisorption. Adsorption isotherms, Determination of

surface area of a catalyst. Classification of catalyst, catalyst preparation. Catalyst deactivation. Langmuir- Himshelwood and Eley – Rideal model. Rate equation when surface reaction, adsorption and desorption control. External Diffusion effects on heterogeneous catalytic reaction. Modeling diffusion without reaction.

**Module 2** (13 hours)

External resistance to mass transfer. Mass transfer limited reaction in packed beds. Diffusion and reaction in porous catalyst pellets. Effective diffusivity and effective thermal conductivity. Internal effectiveness factor. Thiele modules. Mass transfer and reaction in a packed bed reactor. Gas- solid non catalytic reaction –shrinking core model – Diffusion through ash layer, chemical reaction and gas film controls.

**Module 3** (13 hours)

Limitation of shrinking core model. Determination of the rate controlling step. Design of gas solid particle reaction. Gas – liquid reaction. Absorption combined with chemical reaction. Mass transfer coefficients and kinetic constants. Application of film penetration and surface renewal theories. Hatta number and enhancement factor for first order reaction. Tower reactor design.

**Module 4** (13 hours)

Phenomena of Fluidization, liquid like behavior of fluidized beds, advantages and disadvantages of fluidized beds, different types of fluidized beds and applications of fluidization technique in process industries.Heat and Mass Transfer in Fluidized Beds : Variables affecting heat transfer rate, heat transfer at the wall of containing vessel, heat transfer to immersed tubes. Models proposed by (i) Wicke- Fetting, (ii) Mickley and Fair Banks and (iii) Levenspiel and Walton. Heat transfer in fixed and fluidized beds. Definition and evaluation of mass transfer coefficient.

**References:**


1. Smith J.M., Chemical Engineering Kinetics, McGraw Hill
2. Fogler H.S., Elements of Chemical Reaction Engineering, Prentice Hall of India
3. Levenspiel O., Chemical Reaction Engineering, John Wiley
4. Hill C.G., An Introduction to Chemical Engineering Kinetics & Reactor Design, John Wiley
5. B. Viswanathan, S. Sivasanker, A. V. Ramaswamy, Catalysis: Principles and Applications, Academic Press
6. R. A. Van Santen, Piet W. N. M. Van Leeuwen, Jacob A. Moulijn, Bruce A. Averill, Catalysis: An Integrated Approach, Elsevier
7. Diazo Kunii, and Octave Levenspiel, Fluidization Engineering, Butterworth-Heinemann
8. Max Leva, Fluidization, McGraw-Hill


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 L17 SURFACE COATINGS**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1hour tutorial per week*

**Objectives**

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

**No Pre-requisites**

**Module 1** (13 hours)

Film formation-Film forming compositions- properties- types of polymerization in film forming compounds - drying oils - composition -manufacturing procedure.

**Module 2** (13hours)

Resins - types - natural resins and its extraction - alkyd resin- manufacturing -compositions - properties - various synthetic resins -chemical constitution - manufacturing procedures - diluents - thinners - plasticizers - driers -additives -anti settling agents in surface coating

**Module 3** (13 hours)

Pigments - properties - types - white pigments - properties - manufacturing procedures - red pigments, green, blue and black pigments - properties and manufacturing procedure

**Module 4** (13 hours)

Formulation of exterior coating – interior, decorative, industrial, special purpose, marine, bituminous and powder coatings – manufacture of various paints

**References:**


1. Payne H.F.,Organic Coating Technology, Vol.I&II, John Wiley
2. Oil&Colour Chemicals Association,Australia,Surface Coatings,Vol.I&II, Chapman & Hall
3. Wood.H.R.& Morrel.R.S.,The Chemistry and Technology of Drying Oils, Eruest Benn Ltd.
4. Noel Heaton; " Outlines of Paint Technology ", Charles Griffin and Co., Ltd., W.C.2. 1976.
5. Turner, G.P.A.; " Introduction to Paint Chemistry and Principles of Paint Technology ",Oxford & IBH Pub.Co. 1980.


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*Analytical/Problem solving questions* *4 x 5 marks=20 marks*

*PART B:*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 L18 CERAMIC TECHNOLOGY**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1hour tutorial per week*

**Objectives**

- *To impart the basic concepts of ceramics technology*

**No Pre-requisites**

**Module 1** (13 hours)

Synthesis and fabrication of advanced and future materials with emphasis on ceramic, semi-conducting and super-conducting materials with superior structural, optical and electrical properties. Comparison of properties of such advanced materials, with conventional materials such as metal ad polymers.

**Module 2** (13 hours)

Techniques for preparation of ultra-pure, ultra fine powders; of oxides, nitrides, carbides, etc., with very well defined characteristics and superior properties.

**Module 3** (13 hours)

Processing techniques: such as Sintering, hot pressing, hot isostatic pressing, tape-casting, sol-gel processing for the formation of monolithic ceramics composites (Ceramic, Ceramic Metal, as well as metal matrix). SiO2, Glasses from above powders. Synthesis and processing of mixed ceramic oxides with high temperature super conducting properties.

**Module 4** (13 hours)

Processing techniques based on reaction methods: such as chemical vapour deposition (CVD), vapour phase epitaxy, plasma-enhanced chemical vapour deposition (PECVD), Chemical vapour infilteration (CVI), self-propagating high temperature synthesis (SHS) for the preparation of monolithic ceramics, composites, coating, thin films, whiskers and fibres and semi conducting materials such as SI and gallium arsenide.

**References:**


1. Kingery, W.D., Introduction to Ceramics, John Wiley & sons, New York, 1965.
2. Chawla, K.K., Ceramic Matrix Composites, 2nd Edn., Kluwer Academic Publishers, Boston, 2003.
3. Vanvlack,L.H, Elements of Material Science and Engineering, 6th Edn., Adddison Wesley, 1989.
4. Brian S, Mittchell, An Introduction to Materials engineering and Science: for Chemical and Materials Engineers, Wiley Interscience, New York, 2004


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 L19 RUBBER TECHNOLOGY**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1hour tutorial per week*

**Objectives**

- *To impart the basic concepts of rubber processing and testing*
- *To develop understanding about rubber products and its constituents.*

**No Pre-requisites**

**Module 1** (13 hours)

Introduction: Definition and fundamental characteristics of latex; Comparison between latex and polymer solutions; Comparison between product manufacture from latex and solid rubbers; Handling of latex; Important latex products including their classification. Natural rubber latex: Important aspects of rubber cultivation; Tapping and collection of latex, Composition and properties of fresh latex; Preservation of latex; Methods of concentration of latex; Details of latex centrifuging and creaming; Specifications and quality control of concentrated latex; Storage of latex; Choice of latex type. Synthetic rubber latices: Basic principles of emulsion, polymerization; Comparison of synthetic and natural rubber latices; Agglomeration and concentration of synthetic latices: SBR, NBR, CR, Vinyl Acetate and Vinyl Pyridine latices; Characterisation of synthetic latices; Salient features of compounding; Applications of synthetic latices. Prevulcanised latex: Principles of prevulcanisation: Methods of Prevulcanisation; Properties of prevulcanised latex; Advantages of prevulcanisation; Use of prevulcanised latex in different products.

**Module 2** (13 hours)

Latex compounding ingredients: Vulcanising agents; accelerators; Antioxidants; Fillers and pigments; Surface active agents including wetting agents, dispersing agents, stabilizers, emulsifiers, foam promoters etc.; Viscosity modifiers and protective colloids; miscellaneous ingredients including mineral oils, tackifiers, antifoaming agents etc. Preparation of compounding ingredients: General principles; Preparation of solutions; Preparation of dispersions; Equipment for preparing dispersions such as ball and pebble mills, colloid mills, ultrasonic mills etc.; Preparation of emulsions; Representation of latex formulations. Latex dipping: Outline of the dipping process; Design of latex compounds for dipping; Different dipping processes such as straight, wet- coagulant, dry- coagulant, heat sensitized dipping and electrodeposition; Production of articles by dipping including details of formers, dipping tanks, sequence of operations and after-treatments; Defects in dipped goods. Latex gloves: Introduction to the glove industry; Different types of latex gloves; Details of production of examination, surgical and household gloves; Machinery used for automatic production of

gloves; Protein removal from NR latex gloves; After-treatments for gloves; Manufacture of gloves from NBR latex; Testing and quality control of gloves; Defects and remedies; Packing.

**Module 3** (13 hours)

Latex condoms: Introduction to the condom industry; Different types of latex condoms; Details of production of condoms; Machinery for condom manufacture; Protein removal by leaching; After-treatments; Testing and quality control; defects and remedies; Packing. Miscellaneous dipped goods: Folley catheters; Urinary condoms; Balloons; Industrial gloves; Electricians gloves; Football bladders; Feeding bottle nipples and soothers, Latex foam: Introduction to latex foam manufacture; Dunlop and Talalay Processes; Details of the Dunlop process; Compounding; Batchwise and continuous foaming; ; Machinery; Details of processes including frothing, refining, foam stabilization, moulding and gelling; Vulcanization, washing, dewatering and drying; Testing and quality control; Defects and remedies; Foam backing of carpets.

**Module 4** (13 hours)

Fibre foam: Introduction to fibre foam products; Predominance of coir foam; Different processes in coir foam production such as curling of coir fibre, latex compounding, spreading of fibre and spraying of latex compound, drying and vulcanisation, pressing, finishing ; Quality control; Defects and remedies, Fibres other than coir.
Latex thread: Introduction to elastic thread manufacture; Types of elastic thread; Latex thread by extrusion; Compounding of latex; Maturation of latex; Manual and automatic production; Machinery and equipment; Different stages in production; Extrusion, Coagulation, Washing, Drying and vulcanization, Band formation, Dusting, Spooling, Testing and quality control; Defects and remedies. Latex adhesives: Introduction to latex based adhesives; General principles of formulation such as choice of polymer, adhesion promoters, plasticizers, curatives, fillers, thickeners etc; Paper and leather adhesives based on NR, SBR and PVA; Rubber-textile bonding adhesives; Evaluation of adhesives; Latex treatment of tyre chords. Miscellaneous latex applications: Moulded and cast latex products; Latex based surface coatings; Latex in paper; latex-cement compositions; Latex modified bitumen; Soil stabilization and seepage control with latex; Flowers and other ornamental products from latex.

**References:**


1. Morton, Maurice Morton, Rubber Technology
2. James E. Mark, Burak Erman, Frederick Roland Eirich. Science and technology of rubber
3. Claude M. Blow, Rubber technology and manufacture
4. Alexander S. Craig , Rubber Technology: A Basic Course
5. Maurice Morton, Introduction to rubber technology


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 L20 MATHEMATICAL METHODS IN CHEMICAL ENGINEERING**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1hour tutorial per week*

**Objectives**

- *To impart the basic concepts of mathematical methods in chemical engineering*

**No Pre-requisites**

**Module 1** (13 hours)

Mathematical formulation of the physical problems - application of the law of conservation of mass, salt accumulation in stirred tank, starting equilibrium still, solvent extraction in two stages, diffusion with chemical reaction, application of the law of conservation of energy, radial heat transfer through cylindrical conductors, heating a closed kettle, flow of heat from a fin.

**Module 2** (13 hours)

Analytical (explicit) solution of ordinary differential equations encountered in chemical engineering problems - first order differential equations, method of separation of variables, equations solved by integration factors, certain examples involving mass and energy balances and reaction kinetics, second order differential equations, non-linear equations, linear equations, simultaneous diffusions and chemical reaction in a tubular reactor, continuous hydrolysis of tallow in a spray column. Formulation of partial differential equations, unsteady state heat conduction in one dimension, mass transfer with axial symmetry, continuity equations, boundary conditions, function specified, derivative specified and mixed conditions, iterative solution of algebraic equations - Jacobi's method, Gauss- Siedal method and successive order – relaxation (S.O.R) method.

**Module 3** (13 hours)

The difference operator, properties of the difference operator, difference tables and other difference operators, linear finite difference equations, the complimentary solution of the particular solution, simultaneous linear differential equations, non-linear finite difference equations, analytical solution. Solution of the following type of problems by finite difference method - calculation of the number of plates required for absorption column, calculation of the number of theoretical plates required for distillation column, number of steps required for a counter-current extraction and leaching operations.

**Module 4** (13 hours)

Application of statistical methods - propagation of errors of experimental data, parameter estimation of algebraic equations encountered in heat and mass transfer, kinetics and thermodynamics by: the method of averages, linear least squares and weighted lineJenson, V.J. and Jeffereys, G.V., Mathematical Methods in Chemical Engineering, Academic Press, London and New York, 1977.

Mickley, H.S., Thomas. K. Sherwood and Road, C.E., Applied Mathematics in Chemical Engineering, Tata McGraw-Hill Publications, 1957.ar least square methods, design of experiments: factorial, fractional factorial methods.

**References:**


1. Jenson, V.J. and Jeffereys, G.V., Mathematical Methods in Chemical Engineering, Academic Press, London and New York, 1977.
2. Mickley, H.S., Thomas. K. Sherwood and Road, C.E., Applied Mathematics in Chemical Engineering, Tata McGraw-Hill Publications, 1957.
3. S. Pushpavanam, Mathematical Methods in Chemical Engineering, PHI


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CH09 L21 SOLID WASTE MANAGEMENT

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of solid waste management*
- *To develop understanding about recovery, reuse and disposal of solid waste.*

**No Pre-requisites**

**Module 1** (12 hours)

Solid wastes-Sources, nature and characteristics - types of solid waste, Residential, Commercial ,Hazardous wastes, and Industrial wastes, Properties of Solid wastes, Waste generation, Sampling and analysis, Characteristics of solid wastes - Energy content, Chemical content, Estimation of chemical composition of of a solid waste sample, Changing nature of solid wastes and its impact on solid waste management, Generation rates - Estimation of solid waste quantities - Factors affecting generation rates

**Module 2** (11 hours)

Collection of solid waste, On-site storage methods-containers, their type, size and location, Collection systems-Vehicles, Types of collection system –HCS,SCS , Determination of vehicle and labor requirements, Collection routing, route balancing and transfer stations, Transfer methods Processing methods.

**Module 3** (9 hours)

Recovery and reuse of materials and energy, Disposal methods such as sanitary landfill – methods, leachate in landfills – control of leachate movement , Gas movement – control , Design and operation of landfills, Landfarming, Deep well injection,etc.

**Module 4** (13 hours)
Composting, Factors affecting composting, Aerobic composting and anaerobic Digestion, Design principles. Incineration, Municipal incinerators, Grates, Furnances, Design principles, Pyrolysis of solid waste. Recovery, Recycle and Reuse-Material and Energy recovery operations. Overview of solid waste management practices in India. Industrial and Hazardous solid waste management, Integrated Waste Management (IWM), Basics of Data base Management System (DBMS), Geographic Information System (GIS) and Remote Sensing data in planning and management of MSW

**References:**


1. Environmental Engineering - Howard S.Peavy, Donald R.Rowe, George Tchobanoglous
2. Environmental Engineering - Gerard Kiely
3. Solid waste Engineering - P.Aarne Vesilind, William Worrell, Reinhart
4. Handbook of Solid Waste Management and Waste Minimization Technologies, Nicholas P. Cheremisinoff
5. Handbook of Solid Waste Management, Frank Kreith, George Tchobanoglous
6. Solid Waste Management, Luis F. Diaz, George M. Savage, Linda L. Eggerth, Larry Rosenberg


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CH09 L22 NUCLEAR ENGINEERING

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of nuclear fusion and fission as energy source*
- *To develop understanding about feed processing and fuel recovery for nuclear reactors*

**No Pre-requisites**

**Module 1** (13 Hours)
Nuclear fission and fusion, types and classification of nuclear reactors, nuclear fuels, other reactor materials, fuel processing flow sheet, chemical processes for nuclear power industries, separation of reactor products, nuclides, radioactivity, decay chains, neutron reactions, fission

process, growth and decay of fission products in a reactor with neutron burnout and continuous processing. Make up of reactor, reactor fuel process flow sheet, irradiation schemes, neutron balance, feed requirements and fuel burn up for completely mixed fuels with no recycle.

**Module 2** (13 Hours)

Fundamentals of the Atom, Binding Energy and Nuclear Instability, Alpha Decay, Beta Decay, Gamma Decay, Activity and Exponential Decay, Radiological Dating, Radiation Interactions: Heavy Charged Particles, Radiation Interactions: Light Charged Particles, Radiation Interactions: Neutrons, Neutron Sources, Radiation Detection

**Module 3** (13 Hours)

Introduction to nuclear power systems, Thermal-hydraulics: Thermal parameters: definitions and uses. Sources and distribution of thermal loads in nuclear power reactors. Conservation equations and their applications to nuclear power systems: power conversion cycles, containment analysis. Thermal analysis of nuclear fuel, Single-phase flow and heat transfer. Two-phase flow and heat transfer, Structural mechanics: Fundamentals of structural mechanics, Applications to nuclear systems.

**Module 4** (13 Hours)

Feed requirements and fuel burn up for completely mixed fuels-plutonium recycle feed requirements and fuel burn up and reactivity changes for unmixed fuel, flow sheets for uranium 235,238 fuel cycle, single region thorium breeder. Production of uranium feed materials. Solvent extraction of metals. Properties of irradiated fuels. Uses of stable isotopes and methods of isotope separation. Principles of isotope. separation. separation of isotopes of light and heavy elements.

References:


1. Vanson benedict and Thomas H Pigford “Nuclear chemical Engineering ”Mcgraw hill
2. Turner, J. E. Atoms, Radiation, and Radiation Protection. 2nd ed. New York, NY: J. Wiley, 1995
3. Williamson, M. Essentials of Ultrasound.
4. Selman, J. The Fundamentals of X-Ray and Radium Physics.
5. Knief, R. A. Nuclear Engineering: Theory and Technology of Commercial Nuclear Power. New York, NY: Taylor & Francis Inc., May, 1992. ISBN: 9781560320890. (General nuclear engineering)
6. Bird, R. B., W. E. Stewart, and E. N. Lightfoot. Transport Phenomena. New York, NY: John Wiley and Sons, 1960.
7. Incropera, F. P., and D. P. DeWitt. Fundamentals of Heat and Mass Transfer. New York, NY: John Wiley and Sons, 1990.
8. Collier, J. G., and J. R. Thome. Convective Boiling and Condensation. 3rd ed. Oxford, UK: Oxford Science Publications, June 1, 1996.
9. Tong, L. S., and J. Weisman. Thermal Analysis of Pressurized Water Reactors. 1st ed., 1970; 2nd ed., 1979; 3rd ed., 1996
10. Lahey, R. T., Jr., and F. J. Moody. The Thermal-Hydraulics of a Boiling Water Nuclear Reactor. 2nd ed. La Grange Park, IL: American Nuclear Society, 1993.
11. Todreas, N. E., and M. S. Kazimi. Nuclear Systems II: Elements of Thermal Hydraulic Design. New York, NY: Francis and Taylor, 1990.


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 L23 NANOMATERIAL AND NANOTECHNOLOGY**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of nanotechnology*
- *To develop understanding about application of nanomaterials.*

**No Pre-requisites**

**Module 1** (13 Hours)

Introduction to nanotechnology, nanoscale, electromagnetic spectrum, top down and bottom up approach, particle size, chemistry and physics of nanomaterials, electronic phenomenon in nanostructures, optical absorption in solids, quantum effects.

**Module 2** (13 Hours)

Nanomaterials, preparation of nanomaterials like gold, silver, different types of nano-oxides, $Al_2O_3$, $TiO_2$, ZnO etc. Sol-gel methods, chemical vapour deposition, ball milling etc. Carbon nanotubes, preparation properties and applications like field emission displays. Different types of characterization techniques like SEM, AFM, TEM & STM.

**Module 3** (13 Hours)

Nanocomposites, nanofillers, high performance materials, polymer nanocomposites, nanoclays, nanowires, nanotubes, nanoclusters etc. Smart materials, self assembly of materials, safety issues with nanoscale powders.

**Module 4** (13 Hours)

Nanomanipulation, Micro and nanofabrication techniques, Photolithography, E-beam, FIB etc. Nanolithography., softlithography, photoresist materials. Introduction to MEMS, NEMS and nanoelectronics. Introduction to bionanotechnology and nanomedicines.

**References:**


1. Nanocomposite science and technology, Pulikel M. Ajayan, Wiley-VCH 2005
2. Nanolithography and patterning techniques in microelectronics, David G. Bucknall, Wood head publishing 2005
3. Transport in Nanostructures, D.K. Ferry and S.M. Goodmick, Cambridge university press 1997.
4. Optical properties of solids, F. Wooten, Academic press 1972
5. Micro and Nanofabrication, Zheng Cui, Springer 2005

6. Nanostructured materials, Jackie Y. Ying, Academic press 2001
7. Nanotechnology and nanoelectronics, W.R, Fahrner, Springer 2005
8. Nanoengineering of structural, functional and smart materials, Mark J. Schulz, Taylor & Francis 2006.
9. Hand book of Nanoscience, Engineering, and Technology, William A. Goddard, CRC press 2003.
10. Nanoelectronics and Information Technology, Rainer Waser, Wiley-VCH 2003.
11. The MEMS Handbook Frank Kreith, CRC press 2002.

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CH09 L24 INDUSTRIAL POLLUTION CONTROL

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of industrial pollution control*
- *To develop understanding about water, air, light pollution control*

**No Pre-requisites**

**Module 1** (13hours)

Classification of industrial wastewater - types of pollutants and their effects - monitoring and analysis methods - water pollution laws and standards - industrial wastewater treatment - processes and equipment

**Module 2** (13hours)

Water pollution control in industries - pulp and paper, textile processing, tannery wastes, dairy wastes, cannery wastes, brewery, distillery, meet packing, food processing wastes, pharmaceutical wastes, chlor-alkali industries, fertilizer industry, petrochemical industry, rubber processing industry, starch industries, metal industries, nuclear power plant wastes, thermal power plant wastes.

**Module 3** (13hours)

Air pollution control in industries: source and classification of industrial air pollutants - monitoring equipment and method of analysis - damages to health, vegetation and materials - air pollution laws and standards - treatment method in specific industries - thermal power

plants - cement - fertilizers - petroleum refineries - iron and steel - chlor-alkali - pulp and paper

**Module 4** (13hours)

Industrial odour control - sources and solutions - odour control by adsorption and wet scrubbing - industrial noise control methods - sludge treatment and disposal - industrial hazardous waste management, waste minimization. Environmental Impact Assessment and risk assessment-Environmental Audit and Environmental management system- Concept of common effluent treatment plants.

**References**:


1. Nelson & Nemerow, Industrial Water pollution-Origin, Characteristics and treatment, Addison, Wesley Publishing Co.
2. Gerard Kiely,Environmental Engineering, McGraw Hill
3. Rao M.N. & Rao H,Air Pollution, Tata McGraw Hill
4. Sincero A.P.& Sincero G.A., Environmental Engineering, A Design Approach, Prentice Hall of India
5. Rao C.S., Environmental Pollution Control Engineering, New Age Int. Pub.
6. Mahajan S.P., Pollution Control in Process Industries, Tata McGraw Hill
7. Babbitt H.E, Sewage & Sewage Treatment, John Wiley
8. Abbasi S.A, & Ramasami E, Biotechnical Methods of Pollution Control, Universities Press(India) Ltd.


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

**CH09 L25 PROJECT ENGINEERING**

**Teaching scheme** **Credits:** 4

*3 hours lecture & 1 hour tutorial per week*

**Objectives**

- *To impart the basic concepts of project management*

**No Pre-requisites**

**Module 1** (13 hours)

Scope of project engineering - the role of project engineer - R & D - TEFR - plant location and site selection - preliminary data for construction projects - process engineering - flow diagrams - plot plans - engineering design and drafting

**Module 2** (13 hours)

Planning and scheduling of projects - bar chart and network techniques - procurement operations - office procedures - contracts and contractors - project financing - statutory sanctions

**Module 3** (13 hours)

Details of engineering design and equipment selection I - design calculations excluded - vessels - heat exchangers - process pumps - compressors and vacuum pumps - motors and turbines - other process equipment

**Module 4** (13 hours)

Details of engineering design and equipment selection II - design calculations excluded - piping design - thermal insulation and buildings - safety in plant design - plant constructions, start up and commissioning

**References**:


1. Rase & Barrow, Project Engineering of Process Plants, John Wiley
2. Peter S. Max & Timmerhaus, Plant design and economics for chemical engineers.
3. Mc Graw Hill (2002).
4. Srinath L. S., "PERT AND CPM." affiliated east press pvt. Ltd., new york (1973)
5. Perry J. H.,"Chemical engineering handbook" 7TH ed. Mc Graw Hill ( 1997).
6. JELLEN F. C., "Cost and optimization in engineering". Mc Graw Hill (1983).
7. Frederick B. Plummer, Project Engineering, BH
8. Ernest E. Ludwig, Applied project engineering and management, Gulf Pub. Co., (1988)


**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)

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

10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

# GLOBAL ELECTIVES

**PE09 L23 TOTAL QUALITY MANAGEMENT**

**PE09 L24 INDUSTRIAL PSYCHOLOGY**

**PE09 L25 ENTREPRENEURSHIP**

**BT09 L23 BIO-NANOTECHNOLOGY**

**BT09 L24 BIO-ETHICS AND INTELLECTUAL PROPERTY RIGHTS**

**BT09 L25 BIOMATERIALS**

**BM09 L23 OPERATION RESEARCH**

**EC09 L23 DATA STRUCTURES AND ALGORITHMS**

**CE09 L23 EXPERIMENTAL STRESS ANALYSIS**

**CE09 L25 FINITE ELEMENT METHODS**

**EE09 L22 SOFT COMPUTING TECHNIQUES**

**CS09 L24 COMPUTER BASED NUMERICAL METHODS**

**IC09 L24 NON-LINEAR DYNAMICS AND CHAOS**

**IT09 L24 MANAGEMENT INFORMATION SYSTEMS**

**PT09 L24 DIGITAL PHOTOGRAPHY**

## PE09 L23: TOTAL QUALITY MANAGEMENT

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

**Objectives**

- *To impart knowledge on the concept of quality tools for analysing quality statistical tools in quality acceptance sampling life tests*

**Module I (14 hours)**
Definition of quality-internal and external customers- vision statement – mission statements – objectives – goals – targets- evolution of TQM – Defining TQM – stages in TQ M implementation-TQM models

Module II (14 hours)
SWOT analysis-strategic planning-customer focus-quality function deployment-customer satisfaction measurement-seven new management tools-Deming wheel-zero defect concept-bench marking-six sigma concepts-failure mode and effect analysis-poke yoke

Module III (13 hours)
Five S for quality assurance-quality circle philosophy-failure rate analysis-mean failure rate-mean time to failure (MTTF)-Mean time between failure (MTBF)-hazard models-system reliability-availability- maintenance

**Module IV (13 hours)**
Quality and cost-characteristics of quality cost-micro analysis of quality cost-measurement of quality-TQM road map- ISO 9000 series certification-ISO 9001:2000 certification-ISO 14000 certification-QS 9000 auditing-Quality auditing- quality awards

**Text Books**

1. L Suganthi, Anand A Samuel, *Total Quality Management*, PHI
2. Lt.Gen. Lal H, *Total Quality Management*, Wiley Eastern Limited

**Reference Books**

1. Greg Bounds, *Beyond Total Quality Management*, McGraw Hill Publishers
2. Menon H G, *TQM in New Product Manufacturing*, McGraw Hill Publishers

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

University Examination Pattern

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*
All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*
Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*
Two questions from each module with choice to answer one question.

## PE09 L24: INDUSTRIAL PSYCHOLOGY

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

**Objectives**

- *To give awareness on the Human and Industrial Psychology*

**Module I (14 hours)**
Introduction- psychology as a science- area of applications – study of individual- individual differences- study of behaviour- stimulus- response behaviour- heredity and environment- human mind- cognition- character- thinking- attention- memory- emotion- traits- attitude- personality

Module II (14 hours)
Organizational behaviour- definition –development- fundamental concept- nature of people- nature of organization – an organizational behaviour system- models- autocratic model- hybrid model- understanding a social-system social culture- managing communication- downward, upward and other forms of communication

Module III 13 hours)
Motivation- motivation driver- human needs- behavior modification- goal setting- expectancy model- comparison models- interpreting motivational models- leadership- path goal model- style – contingency approach

**Module IV (13 hours)**
Special topics in industrial psychology- managing group in organization- group and inter group dynamics- managing change and organizational development- nature planned change- resistance- characteristic of OD-OD process

**Text Books**
1. Davis K. & Newstrom J.W., *Human Behaviour at work*, Mcgraw Hill International

**Reference Books**
1. Schermerhorn J.R.Jr., Hunt J.G &Osborn R.N., *Managing Organizational Behaviour*, John Wiley
2. Luthans, *Organizational Behaviour*, McGraw Hill, International
3. Morgan C.t.,King R.A.,John Rweisz &John Schoples, *Introduction to Psychology*,

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

University Examination Pattern

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

## PE09 L25: ENTREPRENEURSHIP

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

**Objectives**

- *To give an idea on entrepreneurial perspectives*

**Module I (14 hours)**
Entrepreneurial perspectives- understanding of entrepreneurship process- entrepreneurial decision process- entrepreneurship and economic development- characteristics of entrepreneur- entrepreneurial competencies- managerial functions for enterprise.

**Module II (14 hours)**
Process of business opportunity identification and evaluation- industrial policy- environment-market survey and market assessment- project report preparation-study of feasibility and viability of a project-assessment of risk in the industry

**Module III (13 hours)**
Process and strategies for starting venture- stages of small business growth- entrepreneurship in international environment- entrepreneurship- achievement motivation- time management creativity and innovation structure of the enterprise- planning, implementation and growth

**Module IV (13 hours)**
Technology acquisition for small units- formalities to be completed for setting up a small scale unit- forms of organizations for small scale units-financing of project and working capital-venture capital and other equity assistance available- break even analysis and economic ratios technology transfer and business incubation

**Text Books**

1. Harold Koontz & Heinz Weihrich, *Essentials of Management*, McGraw hill International
2 Hirich R.D. &Peters Irwin M.P., *Entrepreneurship*, McGraw Hill
3. Rao T.V., Deshpande M.V., Prayag Mehta &Manohar S. Nadakarni, *Developing Entrepreneurship a Hand Book*, Learning systems
4. Donald Kurado & Hodgelts R.M., *Entrepreneurship A contemporary Approach*, The Dryden Press
5. Dr. Patel V.G., *Seven Business Crisis*, Tata McGraw hill
Timmons J.A., *New venture Creation- Entrepreneurship for 21st century*, McGraw Hill International
6. Patel J.B., Noid S.S., *A manual on Business Oppurnity Identification*, selections, EDII
7. Rao C.R., *Finance for small scale Industries*
8. Pandey G.W., *A complete Guide to successful Entrepreneurship*, Vikas Publishing

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

## BT 09 L23 BIONANOTECHNOLOGY

**Teaching Scheme :**

3hours lecture and 1 hour tutorial per week Credits :4

**Objectives**

- To impart basic ideas on nanoparticles
- To impart knowledge on the use of nanotechnology in biotechnology

Prerequisite : No prerequisite

**Module – I**

Introduction to Nanobiotechnology and Nanomedicine, Visualization and Manipulation on Nanoscale. Atomic Force Microscopy, Magnetic Resonance Force Microscopy, Scanning Probe Microscopy, Nanoscale Scanning Electron Microscopy, Optical Imaging with a Silver Superlens.

**Module – II**

QuantumDots, Gold Nanoparticles, Lipoparticies, Assembly of Nanoparticles into Micelles, Biomedical Applications of Self-Assembly of Nanoparticles, Paramagnetic and Superparamagnetic Nanoparticles, Fluorescent Nanoparticles.

**Module – III**

Bacterial Structure Relevant to Nanobiotechnology, Cubosomes, Dendrimers, DNA-Nanoparticle Conjugates, DNA Octahedron, Fullerenes, Nanoshells, Carbonnnn Nanotubes, Nanopores, Nano structured Sillicon.

**Module – IV**

Molecular Motors, Nano particles for Molecular Diagnostics, Nano biosensors, Nanopharmaceuticals, Nanoparticle – Based Drug Delivery, Nanostructures for Tissue Engineering/Regenerative. Medicine, Ethical Safety, and Regulatory issues of Nanomedicine.

**References**

1. Nanobiotechnology: Bioinspired Devices and Materials of the Future: Oded Shoseyov and llan Levy.
2. Nanomaterials and Nanosystems for Biomedical Applications: M.Reza Mozafari.
3. The Handbook of Nanomedicine, Kewal K.Jain
4. Bio Nanotechnology, Elisabeth S.Pappazoglou, Aravind Parthasarathy
5. Biomedical Nanostructures, Kenneth E.Goonsalves, Craig R.Halberstadt, Cate T. Laurecin, Lakshmi S.Nair.

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*

All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*

Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*

Two questions from each module with choice to answer one question.

## BT 09 L24 BIOTECHICS & INTELLECTUAL PROPERTY RIGHTS

**Teaching Scheme :**
3 hours lecture and 1 hour tutorial per week Credits : 4

**Objectives :**

- To impart knowledge on bioethics and intellectual property rights
- To study the various ethical issues in biotechnology

Prerequisite : No prerequisite

**Module – I**

Biotechnology and Bioethics. what is Ethical Biotechnology? (Rights, Confidentiality, Animal Rights, Environmental Ethics, Decision Making) – Ethical Aspects of Designer Babies, genetic screening and prenatal testing – issues of ethics in biomedicine. Transgenic plants. The debates of GM foods. Terminator technology, Ethical, issues of the Human Genome Project. Ethical issues in pharmaceutical drug research. Orphan drugs.

**Module – II**

Intellectual Property Rights – Development and need for IPR in knowledge based industries. Various types of intellectual Property Rights with examples (Trademarks, copyrights, Industrial Designs, Patents, Geographical Indicators etc) – Objectives of the patent system – Basic Principles and General Requirements of Patents (Novelty, Utility Non obviousness. Etc) and tenets of patent law – Product and process Patents)

**Module – III**

The patenting process in India – Exercising and Enforcing of intellectual Property Rights. Rights of IPR owner Brief overview of Patent filing in India. Criteria for Patent infringement – Various Amendments to Patent Law in India. Comparison of Patent Law in India and the US.

**International Conventions and treaties**: TRIPS. Evolution and present status. WIPO and its functioning. CBD Treaty. Paris and Berne Conventions Enforcement and Dispute Settlement in WTO – Patent Cooperation Treaty IPR and WTO regime.

**Module – IV**

Biotechnological inventions and patent law – patentable subjects and protection in biotechnology. The patentability of microorganisms – Diamond vs Chakrabarty Case – Bioprospecting & Biopiracy (Case studies of Neem / Turmeric / Arogyapacha of Kani Tribals in Kerala/Rosy Periwinkle of Madagascar)-Traditional knowledge Systems (TKS) – Options for protection of Traditional knowledge Systems. Need for Sui Generics Systems. TKS and the National and International Arena. Biodiversity and Farmers rights – IPR and Plant Genetic Resources – Plant Breeder Rights .UPOV Treaty.

**Text Books**

1. Ethical Issues in Biotechnology. Edited by Richard Sherlock and John D.Morrey. 2002 Publishers Lanham, Md: Rowman and Littlefield.
2. J.Rehm and G.Reed, Biotechnology, Second Edition, Multi Volume Treatise, Volume 12 Legal Economic and Ethical Dimensions, VCHPublishers.
3. Prabuddha Ganguli Intellectual Property Rights-Unleashing the Knowledge Economy. Tata Mc.Graw Hill Publishing Company Limited, New Delhi.
4. Beier, F.K, Crespi,R.S and Straus, T.Biotechnology and Patent protection – Oxford and IBH Publishing Co.New Delhi.
5. Sasson A, Biotechnologies and Development, UNESCO Publications.
6. Jeffrey M.Gimble, Academia to Biotechnology, Elsevier, Academic Press.

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*
All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*
Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*
Two questions from each module with choice to answer one question.

## BT 09 L25 BIO MATERIALS

**Teaching Scheme :**
3 hours lecture and 1 hour tutorial per week Credits :4

- To study the structure and characteristics of biomaterials of synthetic and natural origin
- To give an idea on the effective uses of these biomaterials

Prerequisite : No prerequisite

**Module1**

Structure of solid. Review of basic concepts. Biomaterials,: Definition, classification. Polymers, metals, alloys, ceramics and composites, physical, chemical and mechanical aspects of bulk and surface properties of metallic ,polymer and ceramic biomateriuals (in vivo and in vitro ) Corrosion studies. Structure property relation. Characterisation of biomaterials. Bulk analysis-XRD,FTIR,SEM,TGA etc. Surface aaaaanalysis-XPS,SIMS,AES,STM etc.

**Module II**
Hard tissue replacement implant: orthopaedic implants ( hip, knee), dental implants, adhesives and sealants.Soft tissue replacement implant. Skin implant, burn (wound ) , dressings/ synthetic skin, dialysis membranes, scaffolds, vascular implants, heart valve implants . Artifiifial kidneys and livers. sutures, biomaterials for gene delivery. Hydrogel as stimuli- sensitive biomaterials, ophthalmologic implants, biomaterials for drug delivery

**Module III**
Blood and tissue compatibility of biomaterials and their in vitro and in vivo assessment. Tissue response to biomaterials. Importance of interfacial tissue reaction ( eg. Ceramic bone tissue reaction ). Qualification of implant ( in vivo and in vitro ) Blood materials interaction. Mineralization and cncrustation, , microbial- biofilm formation, badterial adhesion toxicology, degradation of biomaterials in biological environments. toxicity of biomaterials, acute and chronic toxicity studies. Implant associated infection

**Module IV**
Biopolymers, definition, plant and animal biopolymers- polynucleotide, polyamides,polysaccharides,polyisoprene, lignin, polyphosphate and poly hydroxyl alkanoates.Application and chemical synthesis of super absorbent polmers,polyethylene glycol,polypropylene glycol, poly tetra methylene glycol, polyglycerine. Bioplastics and environment, commercial bioplastics. Natural fibers like silk, wool, flax, jute, linen, cotton, sisal, bamboo. Biocomposite- properties and applications

**Text books/ references**
1 Ratner, Hoffman,Schoen Biomaterial science- an introduction to materials in medicine Academic press
2 Park .J.B. Biomaterials- science and engineering, Plenum press
3 Sharma C.P., Szycher.M Blood compatible materials and devices Technomic publishing company
4 R.M. Johnson, R.M. Mwaikambo, Tucker Biopolymers Rapra technology

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*
All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*
Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*
Two questions from each module with choice to answer one question.

## BM09 L23: OPERATION RESEARCH

**Teaching scheme** **Credits:** 4

3 hours lecture and 1 hour tutorial per week

**Objectives**

*Objective of this introductory course on operations research is to give the students the essential tools of operations research. This will enable them to model and make scientifically based decisions in economic and production environments*

**Module 1 (13 hours)**

Introduction to operation research: OR model, solving the OR model, simulation models, art of modeling, phases of OR study.

Linear programming: Formulation (Identification of decision variables, constructing objective functions and constraints, assumption), Graphical LP solution,

**Module II (14 hours)**

Simplex Method: Standard LP form, basic solution,, the M-method, the two-phase method, degeneracy, alternative optimal solution, unbounded solution, infeasible solution.

Sensitivity analysis and dual problem : Definition of the dual problem, the relationship between the optimal primal and dual solution, economic interpretation of duality, the dual Simplex method, primal-dual computations, sensitivity analysis

**Module III (13 hours)**

Transportation Model: Definition of the transportation model, determination of a starting solution, the transportation algorithm, definition of the assignment problem, the Hungarian method.

Network models : Network definition, minimal spanning tree algorithm, shortest route problem, shortest route algorithm, maximal flow model, enumeration of cuts, maximal flow algorithm, CPM, PERT

**Module IV (14 hours)**

Queuing systems: Elements of a queuing model, role of exponential distribution, birth and death models, steady state measures of performance, single server models

Game theory: Formulation of two person zero sum games, solution of simple games, mixed strategy games(using graphical method and Lp), saddle point condition.

**Text Books**

1. H. Taha, *Operations Research: an introduction*, 8th Edition, 2007.
2. F. Hillier, *Introduction to Operations Research*, 7th. Ed. December, 2000. McGraw-Hill.
3. W. Winston, *Operations Research: Applications and Algorithms*, Duxbury Press, 2003.

**Reference Book**

Hilier and Liebermann, *Introduction to Operations Research*, McGraw-Hill, 2001

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*
All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*
Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*
Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## EC09 L023: DATA STRUCTURE & ALGORITHMS

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

Objectives

- *To give ideas of basic data structures*
- *To impart knowledge about algorithm specification*

**Module I (14hours)**
Study of basic data structures – Arrays- Structures-Sparse matrix – Stacks – Queues- Circular queues- Priority queues - Dqueues. Evaluation of expressions – Polynomial representation using arrays.

**Module II (14 hours)**
Linked Lists - Linked stacks and queues - Doubly linked lists - Polynomial representation using linked lists, Strings – Data representation – Pattern matching.

**Module III (15 hours)**
Trees - Binary Trees – Tree Traversal – Inorder - Preorder and Postorder, Graphs – Depth first and breadth first search. Sorting methods: Selection sort, Bubble sort, Insertion sort, Merge sort, Quick sort, Heap sort, Radix sort, External sorting methods (basic idea only).

**Module IV (11 hours)**
Principles of programming – System Life Cycle - Algorithm Specification-Recursive Algorithms- Documentation- Performance Analysis and Measurements- Time and Space complexity-Complexity calculation of simple algorithms.

**Text Books**

1. Classic Data Structures: Samanta, PHI
2. Data Structures and program design in C: Robert Kruse, Pearson Education Asia
3. An introduction to Data Structures with applications: Trembley & Sorenson, McGraw Hill

**Reference Books**

1. Fundamentals of Data Structures in C++: Horowitz, Sahni & Mehta, Galgottia Pub.
2. Data Structures using C & C++: Langsam, Augenstein & Tanenbaum
3. Fundamental Algorithms: Knuth.
4. Algorithms + Data Structures & Programs: N.Wirth, PHI
5. Data structures in Java: Thomas Standish, Pearson Education Asia

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

One of the assignments shall be simulation using any of the tools

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*
All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*
Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*
Two questions from each module with choice to answer one question.

*Maximum Total Marks: 70*

## CE09 L23 EXPERIMENTAL STRESS ANALYSIS*

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

**Objective**
To make students aware of various measurement techniques and experimental planning and procedures adopted in laboratory

**Module I (14 hours)**
Strain gauges - definition of gauge length - sensitivity and range - characteristics of an ideal strain gauge - different types of mechanical strain gauges, optical strain gauge - acoustic strain gauge - pneumatic strain gauge - merits and demerits - electrical strain gauges - inductance, capacitance and piezo electric gauges - bonded and unbonded resistance gauges and their application in stress analysis - fixing techniques and measurement of strains - rosettes - determination of principal stress - construction of stress, strain circles - analytical solution

**Module II (13 hours)**
Photo elasticity - basics of optics, stress optic law - plane and circularly polarized light and their use in photos elasticity - polariscopes - diffusion type - lens type polariscopes - isoclinics and isochromatics

**Module III (14 hours)**
Model materials - calibration methods for finding material fringe values - model fringe values - examples of beam flexure and diametrically loaded circular plates.

Non Destructive Testing Methods – Ultrasonic Methods – Hardness methods – Rebound Hammer – Detection of embedded reinforcement.
Computer based data acquisition systems.

**Module IV (13 hours)**
Model analysis - direct and indirect models - laws of structural similitude - choice of scales - limitation of model studies - buckingham pi-theorem - dimensional analysis - model materials - Begg's deformater and its use - simple design of direct and indirect models

**Text Books**

1. Dally, J. W. and Raliey W.F., Experimental Stress Analysis, McGraw Hill.
2. Srinath L.S., Experimental Stress Analysis, Tata McGraw Hill
3. Roy, T.K., Experimental Analysis of stress and strain

**Reference Books**

1. Dove and Adams, Experimental Stress Analysis and Motion measurement, Prentice Hall
2. Hetenyi M., Hand book of Experimental Stress Analysis, John Wiley
3. Bently JP – Principles of Measurement Systems, Longman, 1983
4. Nakra & Chowdhary – Instrumentation Measurement & Analysis – Tata McGraw Hill, 1995

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*
All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*
Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*
Two questions from each module with choice to answer one question.

## CE09 L25 FINITE ELEMENT METHODS*

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

**Objective:**
To make the back ground, basic concepts and basic formulation of finite element method clear to the students

**Module I (14 hours)**
**Introduction to Finite Element Methods:** Physical problems, mathematical models and finite element solutions – Mathematical model of Discrete systems – elements and assemblage - matrix formulation – Equations of equilibrium - element assembly and solution for unknowns –Gauss elimination method, $LDL^{-T}$ Method - Basic equations of elasticity – stress–strain and strain-displacement relations - theory of stress and deformation - stress-strain-temperature relations
**Review of direct stiffness method:** Descretization – element and structure stiffness matrices DOF relationship- assembly of global stiffness matrix and load vector - solution of equations for unknowns - displacement boundary conditions - computation of stress - support reactions.

**Module II (13 hours)**
**Continuous systems:** Practical Examples –mathematical models- differential formulation – limitations – Variational formulation – Total potential energy - principle of stationary potential energy - problems having many d.o.f - potential energy of an elastic body - the Rayleigh-Ritz method - piecewise polynomial field - finite element form of Rayleigh-Ritz method - finite element formulations derived from a functional - interpolation - shape functions for $C^0$ and $C^1$ elements - Lagrangian interpolation functions for two and three dimensional elements

**Module III (13 hours)**
**Displacement based elements for structural mechanics:** formulas for element stiffness matrix and load vector - overview of element stiffness matrices - consistent element nodal vector - equilibrium and compatibility in the solution - convergence requirements - patch test - stress calculation - other formulation methods
**Straight sided triangles and tetrahedral:** natural coordinates for lines - triangles and tetrahedral - interpolation fields for plane triangles - linear and quadratic triangle - quadratic tetrahedron
**Module IV (14 hours)**
**The isoparametric formulation:** introduction - an isoparametric bar element - plane bilinear element - summary of gauss quadrature - quadratic plane elements - direct construction of shape functions for transition elements - triangular isoparametric elements - consistent element nodal loads - validity of isoparametric elements - appropriate order of quadrature - element and mesh instabilities - remarks on stress computation
**Coordinate transformation:** transformation of vectors - transformation of stress, strain and material properties - transformation of stiffness matrices - transformation of flexibility to stiffness - inclined support - joining dissimilar elements to one another- rigid links - rigid elements

**Text books:**

1. Bathe K.J., Finite Element Procedures in Engineering Analysis, Prentice Hall of India
2. Cook R.D., Malkus D.S. & Plesha M.F., Concepts & Applications of Finite Element Analysis, John Wiley
3. Reddy, J.N., An Introduction to the Finite Element Method, McGraw Hill, 2006.

**Reference books:**

1. Desai C.S., Elementary Finite Element Method, Prentice Hall of India
2. Chandrupatla T.R. & Belegundu A.D., Introduction to Finite Elements in Engineering, Prentice Hall of India
3. Cook, R.D., Finite Element Modelling for Structural Analysis, John Wiley and sons.
4. Gallaghar R.H., Finite Element Analysis: Fundamentals, Prentice Hall Inc.
5. Rajasekaran S., Finite Element Analysis in Engineering Design, Wheeler Pub.
6. Krishnamoorthy C. S., Finite Element Analysis - Theory and Programming, Tata McGraw Hill
7. Zienkiewics O.C. & Taylor R.L., The Finite Element Method, Vol I & II, McGraw Hill
8. Segrelind., The Finite Element Method.

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*
All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*
Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*
Two questions from each module with choice to answer one question.

## EE09 L 22 SOFT COMPUTING TECHNIQUES

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

**Objectives**

- *To acquaint the students with the important soft computing methodologies- neural networks, fuzzy logic, genetic algorithms and genetic programming*

**Module I (12 Hours)**
Artificial Intelligent systems – Neural Networks, Fuzzy Logic and Evolutionary Programming concepts. Artificial Neural Networks – Biological neural networks – Model of an artificial neuron- Comparison between biological neuron and artificial neuron– Basic models of artificial neural network –Learning methods – - Activation function and terminologies of ANN- - Mc Culloch Pitts Neuron – Linear Separability – Hebb network – Perceptron Networks , Adaline, Madaline.

**Module II (14 Hours)**
Back propagation Networks : Architecture - Multi layer perceptron –Back propagation learning – Input layer, Hidden Layer , Output Layer computations, Calculation of error, Training of ANN, Back propagation Algorithm, Momentum and Learning rate, Selection of various parameters in BP networks- Radial Basis Function Networks [T. B. 1].
Variations in standard BP algorithms – Decremental iteration procedure, Adaptive BP, GA based BP, Quick prop training, Augmented BP networks, Sequential learning Approach for single hidden layer Neural networks.

**Module III (14 Hours)**
Fuzzy sets and crisp sets-Fuzzy sets –Fuzzy set operations-Fuzzy relations- Membership functions – Features of the membership functions-Fuzzification- Methods of membership value assignments-Defuzzification- Defuzzification methods-Fuzzy Rule Base and approximate reasoning- Truth values and tables in fuzzy logic, Fuzzy propositions, Formation of rules, Decomposition of rules, Aggregation of fuzzy rules- Fuzzy Inference Systems- Construction and Working Principle of FIS- Methods of FIS- Mamdani FIS and Sugeno FIS- Fuzzy Logic Control Systems- Architecture and Operation of FLC System- FLC System Models- Application of FLC Systems.

**Module IV (14 Hours)**
Genetic Algorithms- Basic Concepts- Creation of off- springs- Working Principle- Encoding- Fitness function- Reproduction- Roulette- Wheel Selection, Boltzmann Selection- Tournament selection- Rank Selection- Steady- State Selection- Elitism- Generation gap and steady state replacement- Inheritance operators- Cross Over- Inversion and deletion- Mutation Operator- Bit- wise operators- Generational Cycle- Convergence of Genetic Algorithm- Differences and Similarities between GA and other traditional methods- Applications.

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**Text Books**

1. S. N. Sivanandam, S. N. Deepa, *Principles of Soft Computing,* Wiley India Pvt. Ltd.[Module I& III]
2. R.Rajasekharan and G.A. Vijayalakshmi Pai, *Neural Networks, Fuzzy Logic and Genetic Algorithms- Synthesis and Applications,* Prentice Hall of India. [ Module II, & IV]

**Reference Books**

1. Fakhreddine O.Karray, Clarence De Silva, Intelligent Systems Design, Theory, Tools and Application, Pearson Education
2. S. Haykins, Neural Networks – A Comprehensive Foundation , Prentice Hall 2002.
3. L. Fausett, Fundamentals of Neural Networks, Prentice Hall 1994.
4. T.Ross, Fuzzy Logic with Engineering Applications, Tata McGrawHill, New Delhi 1995.
5. D.E. Goldberg, Genetic Algorithms in search, Optimization and Machine Learning, Addison Wesley MA, 1989.
6. John Yen, Reza Lengari, *Fuzzy Logic- Intelligence, Control and Information,*Pearson Education

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

**Note:** *One of the assignments may be simulation of systems using any technical software*

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*
All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*
Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*
Two questions from each module with choice to answer one question.

## CS09 L24 : COMPUTER BASED NUMERICALMMETHODS

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

### Objectives

- *To impart the basic concepts of mathematical modelling of problems in science and engineering and to know procedures for solving different kinds of problems.*
- *To understand the various numerical techniques which provide solutions to non linear equations, partial differential equations etc that describe the mathematical models of problems.*

**Module I (13 hours)**
Errors in numerical computation - mathematical preliminaries - errors and their analysis - machine computations - computer software. Algebraic and Transcendental Equations - bisection method - iteration method - method of false position - rate of convergence - method for complex root - Muller's method - quotient difference method - Newton-Raphson method.

**Module II (13 hours)**
Interpolation – introduction - errors in polynomial interpolation - finite differences - decision of errors - Newton's formula for interpolation. Gauss, Sterling, Bessel's, Everett's Formula - interpolation by unevenly spaced points - Lagrange interpolation formula - divided difference - Newton's general interpolation formula.

**Module III (13 hours)**
Numerical Integration and Differentiation – introduction - numerical differentiation - numerical integration - trapezoidal rule - Simpson 1/3 rule - Simpson 3/8 rule - Boole's and Weddle's rules - Euler-Maclariaun formula - Gaussian formula - numerical evaluation of singular integrals.

**Module IV (13 hours)**
Statistical Computations - frequency Chart - method of least square curve fitting procedures - fitting a straight line - curve fitting by sum of exponential - data fitting with cubic splines - approximation of functions. Regression Analysis - linear and nonlinear regression - multiple regression - statistical quality control methods.

**Text Books**

1. E. Balagurusamy, *Numerical Methods*, Tata McGraw-Hill Pub.Co.Ltd, New Delhi, 1999.
2. C.F. Gerald and P.O. Wheatley, *Applied Numerical Analysis, 6th Ed.*, Pearson Education Asia, New Delhi, 2002.

**Reference Books**

1. P. Kandasamy, K. Thilagavathy and K. Gunavathy, *Numerical Methods*, S.Chand Co. Ltd., New Delhi, 2003.
2. R.L. Burden and T.D. Faires, *Numerical Analysis, 7th Ed.*, Thomson Asia Pvt. Ltd., Singapore, 2002.
3. Shastri, *Introductory methods of numerical analysis*, Prentice Hall International.
4. V. Rajaraman, *Introduction to Numerical Methods*, Tata McGraw Hill.

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*
All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*
Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*
Two questions from each module with choice to answer one question.

## IC09 L24 NONLINEAR DYNAMICS AND CHAOS

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

**Objectives:**
To enable the students to get an exposure to non linear dynamics and chaos.

**Prerequisites:** Familiarity with nonlinear control systems is desirable.

**Module I (14hours)**
**Introduction to Dynamical systems:** Discrete time systems- Continuous time systems- Autonomous and non-autonomous systems phase space and flows- Attracting sets- Concepts of stability.

**Equilibrium solutions:** Fixed points and stability of continuous- Time systems- Classification and stability of equilibrium solutions- Fixed points of maps and their stability- Local and global bifurcation of continuous system- Static and dynamic bifurcation- Bifurcation of maps.

**Module II (13 hours)**
**Periodic solutions:** Periodic solutions of continuous- Time dynamical systems- Autonomous and non-autonomous systems- Limit cycle- Floquet theory- Poincare' maps- Bifurcation- Symmetry breaking- Cyclic fold- Period doubling- Transcritical and Hopf bifurcation.

**Quasiperiodic solutions:** Poincare' maps- Circle map- Construction of quasiperiodic solutions.

**Module III (14hours)**
**Chaotic solutions of maps:** Dynamic of logistic equations- Bifurcation diagram of one dimensional maps- Feigenbaum number- Henon map.

**Chaotic solutions of continuous systems:** Duffing's equation- Rossler equations- Period doubling and intermittency mechanisms.

**Experimental methods in chaotic vibrations:** Experimental system to measure the Poincare' map of chaotic physical system.

**Module IV (13 hours)**
**Fractals and dynamical systems:** Fractal dimension- Capacity dimension- Correlation dimension and Information dimension- Fractal dimension of strange attractors.

**Tools to identify and analyze motions**: Time history- State- Space and pseudostate space- Embedding dimension and time delay- Fourier Spectra, Poincare' section and maps- Iyapunov exponents.

**Text Books**

1. Nayfeh A.H. & Balachandran B, *Applied Non-linear Dynamics*, John Wiley.
2. Thomson J.M.T. & Steward H.V, *Non-linear Dynamics and Chaos*, John Wiley.
3. Moon F.C., *Chaotic and Fractal Dynamics*, John Wiley.

**References**

1. Wiggins S. *Introduction to Applied Non-linear Dynamical Systems and Chaos*, Springar Verlag.
2. Baker G.L. & Gollub J.P. *Chaotic Dynamics*, Cambridge Press.
3. Peitgens, Jurgens & Saupe, *Chaos and Fractal*, Springar Verlag.
4. Scheinerman E.R., *Invitation to Dynamical Systems*, Prentice Hall.

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*
All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*
Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*
Two questions from each module with choice to answer one question.

## IT09 L24: MANAGEMENT INFORMATION SYSTEMS

**Teaching scheme** **Credits:** 4

3 hours lecture and 1 hour tutorial per week

**Objectives**

- *This course will introduce the methods and the influence of the information systems in management milieu and use MIS as an effective tool in management and decision making*.

**Module - I: (12 hours)**

Information systems - functions of management - levels of management - framework for information systems - systems approach - systems concepts - systems and their environment - effects of system approach in information systems design - using systems approach in problem solving - strategic uses of information technology

**Module - II: (10 hours)**

An overview of computer hardware and software components - file and database management systems - introduction to network components - topologies and types - remote access - the reasons for managers to implement networks - distributed systems - the internet and office communications

**Module - III: (14 hours)**

Application of information systems to functional - tactical and strategic areas of management, decision support systems and expert systems

**Module - IV: (16 hours)**

Information systems planning - critical success factor - business system planning - ends/means analysis - organizing the information systems plan - systems analysis and design - alternative application development approaches - organization of data processing - security and ethical issues of information systems

**Text Books**

1. Robert Schultheis & Mary Sumner, *Management Information Systems-The Manager's View*, Tata McGraw Hill.

**Reference Books**

1. Laudon K.C. & Laudon J.P, *Management Information Systems - Organization and Technology*, Prentice Hall of India
2. Sadagopan S, *Management Information Systems*, Prentice Hall of India
3. Basandra S.K, *Management Information Systems*, Wheeler Publishing.
4. Alter S, *Information Systems: A Management Perspective*, Addison Wesley.
5. Effy Oz, *Management Information Systems,* Thomson, Vikas Publishing House.

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*
All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*
Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*
Two questions from each module with choice to answer one question.

## PT09 L24 DIGITAL PHOTOGRAPHY

**Teaching scheme** **Credit:** 4

3Hours lecture and 1 Hr tutorial per week

**Objectives:** *To impart the basic concepts of photography &camera controls.*
*Gives an understanding of photographic processing methods & Digital Imaging.*

**Module I (13hours)**

**Imaging Systems:** The production of images. Photographic & Digital Imaging. General characteristics of reproduction systems. Imaging chains. Reproduction of tone and color. Image quality expectations. Fundamentals of light & vision. **Photographic light sources**: characteristics. Light outputs- units, illumination law, Reflectors & luminaries-constancy of output – efficiency-operation & maintenance. Types of lamps, flash bulb. Types of camera, special purpose cameras, Automatic camera, Digital cameras-principle, features & function.

**Module II (13hours)**

**Camera features:** Shutter system, Iris diaphragm, View finders- types & function. Flash synchronization. Focusing systems. Autos focus systems. Exposure metering systems. Battery power. Data Imprinting. **Camera movements:** Transitional & Rotational. Lens covering power. Control of image sharpness. Limits to lens tilt .Control of image shape.

**Module III (13hours)**

**Sensitive materials & Image Sensors:** Latent image formation. Image formation by charge coupled devices. Production of light sensitive materials and sensors. Coating the photographic emulsion. CCD. Size and formats of photographic & electronic sensors and media. Film coating. **Spectral sensitivity of photographic materials:** Types, Response to short wave radiation & visible radiation. Spectral sensitization. Determination of color sensitivity. Spectral sensitivity of digital camera. Principle of color photography. Reproduction of color.

**Module IV (13hours)**

**Photographic processing:** Developers & development, Replenishment. Techniques of development, fixing, washing, drying. **Hard copy output media:** Photographic papers, types of silver halide emulsion, Color photographic papers- processing & development techniques. Digital output.

**Text Book:**

1. Ralph E Jacobson, Sidney F ray , Geoffreyy A Attridge, Norman R Axford.*The manual of photography Photography & digital imaging*: 9th ed,

**ReferenceBooks:**

1. Barbara London, John Upton, KenKobre, Betsy Brill ,*Photography 7 th ed* ,Prentice Hall.
2. George H Wallace, Chuck Gloman *Digital Photography Solutions*,

**Internal Continuous Assessment** *(Maximum Marks-30)*

60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

**University Examination Pattern**

*PART A: Short answer questions (one/two sentences)* *5 x 2 marks=10 marks*
All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

*PART B: Analytical/Problem solving questions* *4 x 5 marks=20 marks*
Candidates have to answer four questions out of six. There should be at least one question from each module and not more than two questions from any module.

*PART C: Descriptive/Analytical/Problem solving questions* *4 x 10 marks=40 marks*
Two questions from each module with choice to answer one question.