Teaching Scheme and Syllabi of B.E. (Chemical Engineering) [2018-2019]

First Year

1st SEMESTER

S. No.	Course code	Courses	L T P	Credits	Practical	Mid term	Ènd term	Total marks	Category
1.	BSC101	Mathematics ï I	3 1 -	4	-	50	50	100	BSC
2.	BSC102	Inorganic Chemistry	3 - 3	4	25	35	40	100	BSC
3.	ESC 101	Engineering Drawing	- - 6	3	75	-	-	75	ESC
4.	ESC 102	Computer Programming	2 - 3	3	25	25	25	75	ESC
5.	CHE 101	Introduction to Engineering & Technology	3 - -	3	-	35	40	75	CHE
6.	HSSC 101	Ethics and Self-Awareness	2 - -	2	-	25	25	50	HSSC
		Total	**13 1 12**	**19**	**125**	**170**	**180**	**475**	
Total Contact hours/week			**26**						

Note:

- **NSS/NCC/Sports proficiency/Community services/ Professional society activities/Technical activities related to the field of Engineering (1st to 3rd year, 2 credits to be earned in 7th semester)**
- **Discipline (1st to 4th year, 1 credit to be earned in 8th semester)**

L: Lectures/Week, T: Tutorials/Week, P: Practical Hours/Week

Note: Mid Term marks includes: Evaluation towards one best out of two minor tests (50% of Mid- term marks), Assignments (20% of the Mid- term marks), Class surprise tests /quizzes /presentations /term paper (20% of Mid- term marks) and class attendance (10% of Mid- term marks).

BSC: Basic engineering course

ESC: Engineering Sciences

CHE: Chemical Engineering Core Courses

CHO: Open Electives

HSSC : Humanities and Social Sciences Course

2nd SEMESTER

S. No.		Courses	L T P	Credits	Practical	Mid term	Ènd term	Total marks	Category
1.	BSC 103	Mathematics ï II	3 1 -	4	-	50	50	100	BSC
2.	BSC 104	Applied Physics (Condensed Matter)	2 1 2	4	25	35	40	100	BSC
3.	HSSC 102	Communication Skills (Advance)	1 - 2	2	25	10	15	50	HSSC
4.	ESC 103	Electrical & Electronics Engineering	3 1 3	5	25	50	50	125	ESC
5.	ESC 104	Engineering Mechanics	2 1 -	3	-	35	40	75	ESC
6.	ESC 105	Workshop Practices	- - 3	1	25	-	-	25	ESC
7.	ESC 106	Introduction to Environmental Science	3 - -	3	-	35	40	75	GSC
Total			**14 4 10**	**22**	**100**	**215**	**235**	**550**	
Total Contact hours/week			**28**						

Note:

- **NSS/NCC/Sports proficiency/Community services/ Professional society activities/ Technical activities related to the field of Engineering (1st to 3rd year, 2 credits to be earned in 7th semester)**

- **Discipline (1st to 4th year, 1 credit to be earned in 8th semester)**

L: Lectures/Week, T: Tutorials/Week, P: Practical Hours/Week

Note: Mid Term marks includes: Evaluation towards one best out of two minor tests (50% of Mid- term marks), Assignments (20% of the Mid- term marks), Class surprise tests /quizzes /presentations /term paper (20% of Mid- term marks) and class attendance (10% of Mid- term marks).

BSC: Basic engineering course

ESC: Engineering Sciences

CHE: Chemical Engineering Core Courses

CHO: Open Electives

HSSC : Humanities and Social Sciences Course

Third Semester

S No.	Course code	Subject	L	T	P	Credits	Practical	Mid term	End term	Total marks	Category
1	CHE 201	Physical Chemistry	3	1	3	5	25	50	50	125	CHE
2	CHE 202	Fluid Flow	3	1	3	5	25	50	50	125	CHE
3	CHE 203	Process Plant Material & Energy Balance	3	1	-	4	-	50	50	100	CHE
4	CHE 204	Engineering Materials	3	1	-	4	-	50	50	100	CHE
5	ESC 201	Strength of Materials	3	1	-	4	-	50	50	100	ESC
6	ESC 202	Process Equipment Design	-	-	3	1	25	-	-	25	ESC
		Total	**15**	**5**	**9**	**23**	**75**	**250**	**250**	**575**	
		Total contact hours/week	**29**								

Note:

- **NSS/NCC/Sports proficiency/Community services/ Professional society activities/Technical activities related to the field of Engineering (1st to 3rd year, 2 credits to be earned in 7th semester)**
- **Discipline (1st to 4th year, 1 credit to be earned in 8th semester)**
- **NSS/N Activi**
- **Discip**

Fourth Semester

S No.	Course code	Subject	L	T	P	Credits	Practical	Mid term	End term	Total marks	Category
1	BSC 201	Mathematics – III	3	1	-	4	-	50	50	100	BSC
2	CHE 205	Heat Transfer	3	1	3	5	25	50	50	125	CHE
3	CHE 206	Chemical Engineering Thermodynamics	3	1	-	4	-	50	50	100	CHE
4	CHE 207	Organic Chemistry	3	1	3	5	25	50	50	125	CHE
5	CHE 208	Mechanical Operations	3	1	3	5	25	50	50	125	CHE
6	CHE 209	Comprehensive Viva	-	-	-	1	-	-	25	25	CHE
		Total	**15**	**5**	**9**	**24**	**75**	**250**	**275**	**600**	
		Total contact hours/week	**29**								

Note:

- **NSS/NCC/Sports proficiency/Community services/ Professional society activities/Technical activities related to the field of Engineering (1st to 3rd year, 2 credits to be earned in 7th semester)**

- **Discipline (1st to 4th year, 1 credit to be earned in 8th semester)**

Fifth Semester

S No.	Course code	Subject	L	T	P	Credits	Practical	Mid term	End term	Total marks	Category
1	CHE 301	Numerical methods in Chemical Engineering	3	1	-	4	-	50	50	100	CHE
2	CHE 302	Energy Technology	3	1	-	4	-	50	50	100	CHE
3	CHE 303	Chemical Reaction Engineering-I	3	1	3	5	25	50	50	125	CHE
4	CHE 304	Mass Transfer-I	3	1	-	4	-	50	50	100	CHE
5	CHE 305	Chemical Technology (Inorganic)	3	1	3	5	25	50	50	125	CHE
6	CHE 306	Process Plant Design-I	-	-	3	1	25	-	-	25	CHE
7	CHE 307	Chemical Engineering Computation lab	-	-	3	1	25	-	-	25	CHE
		Total	**15**	**5**	**12**	**24**	**100**	**250**	**250**	**600**	
		Total contact hours/week	**32**								

Note:

- **Sports proficiency/Community services/ Professional society activities/Technical activities related to the field of Engineering (1st to 3rd year, 2 credits to be earned in 7th semester)**
- **Discipline (1st to 4th year, 1 credit to be earned in 8th semester)**

Sixth Semester

S No.	Course code	Subject	L	T	P	Credits	Practical	Mid term	End term	Total marks	Category
1	CHE 308	Chemical Reaction Engineering-II	3	1	-	4	-	50	50	100	CHE
2	CHE 309	Mass Transfer-II	3	1	3	5	25	50	50	125	CHE
3	CHE 310	Process Dynamics & Control	3	1	3	5	25	50	50	125	CHE
4	CHE 311	Chemical Technology (Organic)	3	1	3	5	25	50	50	125	CHE
5	CHD 301	Departmental Elective-I	3	1	3	5	25	50	50	125	CHD
		Total	**15**	**5**	**12**	**24**	**100**	**250**	**250**	**600**	
		Total contact hours/week	**32**								

Note:

- **Sports proficiency/Community services/ Professional society activities/Technical activities related to the field of Engineering (1st to 3rd year, 2 credits to be earned in 7th semester)**
- **Discipline (1st to 4th year, 1 credit to be earned in 8th semester)**

Seventh Semester

S No.	Course code	Subject	L	T	P	Credits	Practical	Mid term	End term	Total marks	Category
1	CHE 401	Transport Phenomena	3	-	-	3	-	35	40	75	CHE
2	CHE z402	Environmental Engineering	3	1	3	5	25	50	50	125	CHE
3	CHE 403	Process Modelling and Simulation	-	-	3	1	25	-	-	25	CHE
4	CHE 404	Industrial Training	-	-	-	1	-	25	-	25	CHE
5	CHE 405	Process Plant Design-II	-	-	3	1	25	-	-	25	CHE
6	CHE 406	Project work	-	-	2	-	-	-	-	-	CHE
7	CHO 401	Open Elective - I	3	-	-	3	-	35	40	75	CHO
8	CHD 401	Department Elective-II	3	1	-	4	-	50	50	100	CHD
		Total	12	2	11	18	75	195	180	450	
		Total contact hours/week	25								

Note:

- **Sports proficiency/Community services/ Professional society activities/Technical activities related to the field of Engineering (1st to 3rd year, 2 credits to be earned in 7th semester)**
- **Discipline (1st to 4th year, 1 credit to be earned in 8th semester)**

Eighth Semester

S No.	Course code	Subject	L	T	P	Credits	Practical	Mid term	End term	Total marks	Category
1	CHE 407	Process Instrumentation	3	1	-	4	-	50	50	100	CHE
2	CHE 408	Process Engineering Economics	3	1	-	4	-	50	50	100	CHE
3	CHE 406	Project work	-	-	2	2	-	-	'S' or 'X'*	-	CHE
4	CHE 409	Comprehensive viva	-	-	-	1	-	-	25	25	CHE
5	CHE 410	Literature Survey, Report Writing and Seminar	-	-	3	NC	-	-	-	-	CHE
6	CHO 402	Open Elective-II	3	-	-	3	-	35	40	75	CHO
7	CHO 403	Open Elective-III	3	-	-	3	-	35	40	75	CHO
8	CHD 402	Department Elective-III	3	1	-	4	-	50	50	100	CHD
		Total	15	3	5	21	-	220	255	475	
		Total contact hours/week	23								

***'S' (Satisfactory) or 'X' (Repeat)**

Note:

- **Discipline (1st to 4th year, 1 credit to be earned in 8th semester)**

S. No.	List of Departmental Electives
1	Petroleum Processing Engineering
2	Industrial Safety and Hazards
3	Plant Utilities
4	Petrochemical Technology
5	Biochemical Engineering

S.No.	List of Open Electives
1.	Fuel Cell Technology
2.	Nanotechnology
3.	Polymer Science and Engineering
4.	Operations Research
5.	Supply Chain and Logistic Management
6.	Project Management and Entrepreneurship

Note:

1. Mid term evaluation shall be as per the format already approved by the competent authority (as indicated in the scheme already approved for the first year)
2. Departmental electives (I, II and III) shall be offered amongst the list indicated above depending on the available resources.
3. Open electives (I, II and III) shall be offered amongst the list indicated above depending on the available resources.
4. List of electives (open and departmental) is subject to change and as approval of the competent authority from time to time.

SYLLABUS OF B.E. CHEMICAL ENGINEERING 2018-2019

FIRST YEAR

1st SEMESTER

Title	**MATHEMATICS-I**			**Credits**	04
Code	BSC 101	**Semester:-1st**		**L T P**	3 1 -
Max.Marks	**End term- 50**	**Mid term- 50**	**Practical --**	**Elective**	N
Pre requisites				**Contact Hours**	42

THEORY		**Time**	3 Hours
Objectives	To make the students 1. Understand the behaviour of infinite series and their use. 2. Learn the concepts related to functions of several variables and their applications. 3. Understand the concept of Vectors and its applications. 4. Learn the methods of evaluating multiple integrals and their applications to various problems. 5. Learn the methods to formulate and solve linear differential equations and apply them to solve engineering problems.		
Note for the Examiner	The semester question paper of the subject will be of 50 marks having 8 questions of equal marks. The paper will be divided into two parts having four questions each from Section A and Section B. The candidate is required to attempt total 5 questions selecting atleast two questions from each Section.		

SECTION- A	**Hrs**
Infinite Series: Infinite series and convergence, alternating series, power series and convergence. Taylorôs and Maclaurinôs Series.	06
Multivariable Functions: Limit, Continuity and Partial Derivatives; Eulerôs Theorem for Homogeneous functions; Differentiability, Linearization and Differentials; Chain rule; Extreme values and Saddle Points; Lagrange multipliers; Taylorôs Formula.	08
Vectors: Gradient, Divergence, Curl, Statement of Greenôs, Gauss and Stokeôs Theorem and their simple applications.	06
SECTION- B	
Solid Geometry: Cylinders and Cones, Cylindrical and Spherical Polar Coordinates	04
Integral Calculus: Area between plane curves; Volumes of solids of revolution; Lengths of plane curves; Areas of surfaces of revolution. Double integrals in rectangular and Polar form, Triple integrals in Rectangular, Cylindrical and Spherical coordinates, Substitutions in Multiple Integrals.	08
Ordinary Differential Equations: First order exact differential equations, Integrating factor, Orthogonal trajectories, Second and Higher order Linear Differential Equations with constant coefficients, Differential Operators, Methods of Variation of Parameters and Undetermined Coefficients, Euler Cauchy Equation, Wronskian.	10

Text books:	1. G. B. Thomas, R. L. Finney: Calculus and Analytic Geometry, Ninth Edition, Pearson Education. **2.** E. Kreyszig: Advanced Engineering Mathematics, Eighth Edition, John Wiley.
Reference Books:	1. B. V. Ramana: Higher Engineering Mathematics, Tata McGraw Hill. 2. B. S. Grewal: Higher Engineering Mathematics, 41st Edition, Khanna Publishers, Delhi. 3. Differential Equations, Frank Ayers, TMH
Course Assessment	Assessment will consist of the following components 1. Mid-Term

Methods	a. One best of two minor tests (50% of Mid -term marks) b. Assignments (20% of Mid-term marks) c. Class Surprise Tests/ Quizzes/Presentations/Term paper (20% of Mid-term marks) d. Attendance. (10% of Mid-term marks) 2. End -Term
Course Outcomes	The students are able to 1. test the behaviour of infinite series. 2. analyze functions of several variables and their applications. 3. operate vectors and convert line integral to surface integral to volume integral. 4. evaluate multiple integrals and apply them to practical problems. 5. solve linear differential equations.

Title	**INORGANIC CHEMISTRY**			**Credits**	04
Code	BSC 102	**Semester:-**1st		**L T P**	3 - 3
Max. Marks	**End term- 40**	**Mid term- 35**	**Practical- 25**	**Elective**	N
Pre requisites				**Contact Hours**	42 (Theory) 14 (Practical Sessions)

THEORY	**Time**	3 Hours
Objectives	1. To introduce to the students the basics of quantum mechanics to derive the Schroedinger wave equation 2. To introduce the basic theories of bonding in simple ionic and covalent compounds as well as coordinate complexes and organometallic compounds and application of organometallics as catalysts 3. To make the students understand the crystal field theory and the splitting of d-orbitals for different geometries 4. To create an awareness regarding the toxic effects of heavy metals and also the role of metals like cobalt and iron in biological systems 5. To introduce the importance of inorganic polymers	
Note for the Examiner	The semester question paper of the subject will be of 40 marks having 8 questions of equal marks. The paper will be divided into two parts having four questions each from Section A and Section B. The candidate is required to attempt total 5 questions selecting atleast two questions from each Section.	

SECTION- A	**Hrs**
Quantum theory and atomic structure: Introduction to wave mechanics, the Schrodinger equation, as applied to hydrogen atom, the origin of quantum numbers and shapes of orbitals from the Schroedinger equation .	05
Chemical Bonding: Molecular orbital and valence bond theories of bond formation and application of molecular orbital theory to the formation of homonuclear and heteronuclear diatomic molecules.	07
Coordination Compounds: Part 1: Wernerôs theory, effective atomic number, bonding of transition metal complexes: valence bond theory, crystal field theory, crystal fieldsplitting in tetrahedral, octahedral and distorted octahedral (square planar) crystal fields.Thermodynamic aspects of coordination compounds (crystal field stabilization energies of octahedral and tetrahedral complexes, spectrochemical series).	08
SECTION- B	
Coordination Compounds: Part 2: Kinetic aspects of coordination compounds (substitution reactions in complexes with coordination number 4 and 6 and their mechanism - $\mathbf{SN^1}$, SN^2). Magnetic behaviour of complexes ï Para magnetism, diamagnetism, ferromagnetism and antiferromagnetism and measurement ofmagnetic susceptibility of complexes by Guoyôs method.	06
Organometallic Compounds: Nomenclature, types of ligands and bonding in organometallic compounds, use of	05

organometallics in industry.	
Inorganic polymers: Types of inorganic polymers, polyphosphazenes, polysiloxanes ï their structures and properties.	04
Role of Metals in Biological Systems: Bio-inorganic Chemistry of Iron ï Heme proteins & Non-Heme iron proteins;	04
Metal Toxicology : Toxic effects of heavy metals with special reference to Cd, Pb, Hg and As.	03

Recommended Books:	1. Sharpe, A. G. : Inorganic Chemistry, 3rd Edition, Longman Publishers ELBS, 1992. 2. Lee, J. D. : Concise: Inorganic Chemistry, 5th Edition, Chapman and Hall Publishers, 1996. 3. Cotton, F. A. & Wilkinson, G. : Advanced Inorganic Chemistry, 3rd Edition,Wiley Eastern Ltd., 1982. 4. Cotton, F. A. & Wilkinson, G. : Basic Inorganic Chemistry, Wiley EasternLtd., 1987. 12 5. Mark, J., West, R. & Allcock,H. : Inorganic Polymer, Prentice Hall, New Jersey Publishers, 1982. 6. Basola, F. & Pearson, R. G. : Inorganic Reaction Mechanism, 2nd Edition, Wiley Eastern Publishers, 1984. 7. Amdur, Doull & Klaasen (Eds.) : Casarett and Doulls Toxicology, Pergamon Press, New York, 1991. 8. William & Burson (Eds.) : Industrial Toxicology: Safety and Health applications in the work place, Van Nostrand ï Reinhold, New York, 1985.
Course Assessment Methods	Assessment will consist of the following components 1.Mid-Term a. One best of two minor tests (50% of Mid -term marks) b. Assignments (20% of Mid-term marks) c. Class Surprise Tests/ Quizzes/Presentations/Term paper (20% of Mid-term marks) d. Attendance. (10% of Mid-term marks) 2.End ï Term
Course Outcomes	Upon successful completion of this course, students will be able to: 1. Understand the basic concepts of quantum mechanics and derive the Schroedinger equation for the hydrogen atom and the origin of quantum numbers and shapes of orbitals from the Schroedinger equation. 2. Describe the fundamental principles of theories of bonding and molecular structure and construct M.O diagrams for simple homonuclear and heteronuclear diatomics 3. Understand the Structure of ionic solids and the concepts of lattice energy and solvation and their importance as well as crystal defects and applications of defect structures. 4. Explain the bonding in organometallic and Coordination Compounds,the concept of splitting of d-orbitals in a crystal field with the explanantion of magnetic and spectral properties as well as the Kinetic and thermodynamic aspects of ligand substitution reactions in coordination compounds 5. Recognise the importance of Metals in Biological System and Toxicity of heavy metals. 6. Understand the importance of inorganic polymers.
INORGANIC CHEMISTRY (PRACTICAL)	
Objectives	1. To introduce the different concepts for expressing concentration e.g molarity, molality and normality 2. To explain the volumetric and gravimetric methods for quantitative analyses and the importance of these methods 3. To explain the application of redox titrations 4. To introduce complexometric titrations

Practical session wise break-up	No. of sessions
I. Volumetric Analysis :	
(i) Redox Titrations :-Titrations involving	
a) $KMnO_4$ (Estimation of $C_2O_4^{-2}$)	02
b)$K_2Cr_2O_7$ (Estimation of Fe^{+2}/Fe^{+3})	02
c) Iodine [Iodometry & Iodimetry] (Standardisation with Sodium Thiosulphate,Estimation of Cu^{+2}, AsO_3^{-3} and Sb^{+3})	04
ii)Complexometric Titrations- Determination of Zn^{+2} by EDTA titration.	02
II Gravimetric Analysis a) Estimation of Ba^{+2}/SO_4^{-2} as $BaSO_4$ b) Estimation of Fe^{+2}/Fe^{+3} as Fe_2O_3	04

Text Book:	Vogelôs Qualitative Inorganic Analysis, 7th Ed. By G. Svehla, Pearson Education.
Course Assessment Methods	The expected outcomes would be assessed through performance reports, quizzes/ viva voce and end semester evaluation test.
Course Outcomes	The student will be capable to • apply the concept of normality and perform and apply redox titrations involving potassium dichromate and Iodine • Use Complexometric Titrations to determine Zn and Calcium ions by EDTA method. • Estimate Ba^{+2}/SO_4^{-2} as $BaSO_4$, and Fe^{+3} as Fe_2O_3 gravimetrically.

Title	**ENGINEERING DRAWING**			**Credits**	03
Code	ESC 101	**Semester:-1st**		**L T P**	- - 6
Max. Marks	**End term --**	**Mid term --**	**Practical-** 75	**Elective**	N
Pre requisites				**Contact Hours**	28 (Practical Sessions)

PRACTICAL

Objectives	Objectives of the Engineering Drawing course is 1. To introduce the students to visual science in the form of technical graphics. 2. To give general instructions related to Theory of Orthographic Projection of points, lines, planes and solids as per the BIS codes prevalent to drawing practices. 3. To upgrade the basic understanding and visualization of geometric objects and machine parts by introducing the students to section of solids, intersection and development of surfaces, isometric projection and orthographic projection of simple solids/blocks. 4. To introduce the students to Computer graphics to enhance understanding of the subject.

Practical session wise breakup	No. of Sessions
1. Introduction to engineering drawing, instruments, symbols and conventions in drawing practice.	02
2. Types of lines and BIS codes for lines, dimensioning	02
3. Introduction to methods of projections: Orthographic projection, Isometric projection	04
4. Projection of points, lines, planes and solids on principal and auxiliary planes.	08
5. Sectioning of solids, Intersection of solids	04
6. Development of surfaces	02
7. Drawing of threaded fasteners and assembly drawing	05
8. Introduction to CAD software.	01

Recommended Books:	1. P.S. Gill: Engineering Drawing 2. R.K. Dhawan : A textbook of engineering Drawing, S. Chand & Co. Ltd. New Delhi 2nd edition. 3. P.S.Gill: Machine Drawing 4. Sham Tickoo : Understanding AutoCAD 2006, Wiley Publication 5. James D. Bethune : AutoCAD, Pearson Publishers
Course Assessment Methods	The students will be assessed based upon the practical assignments and viva voce.
Course Outcomes	Student will be able to 1. understand the basics of engineering drawing. 2. visualize the different types of geometrical objects and the assembly drawing of machine parts.

Title	**COMPUTER PROGRAMMING**			**Credits**	03
Code	ESC 102	**Semester:-**1st		**L T P**	2 - 3
Max. Marks	**End term-** 25	**Mid term-** 25	**Practical-** 25	**Elective**	N
Pre requisites				**Contact Hours**	28 (Theory) 14 (Practical Sessions)

THEORY		**Time**	3 Hours
Objectives	1. To develop logical skills so that students should be able to solve basic computing problems. 2. To learn the syntax and usage of C++ programming constructs.		
Note for the Examiner	The semester question paper of the subject will be of 25 marks having 8 questions of equal marks. The paper will be divided into two parts having four questions each from Section A and Section B. The candidate is required to attempt total 5 questions selecting atleast two questions from each Section.		

SECTION- A	**Hrs**
Introduction To Programming: Basic introduction to computers, block diagram of computer.Evolution of languages: Machine languages, Assembly languages, High-level languages. Software requirements for programming: System softwares like operating system, compiler, linker, loader. Application programs like editor. Overview of Algorithm and Flowcharts.	03
Programming In C++ : Data types in C++, Formatted input-output for printing integer, floating point numbers, characters and strings.	01
Operators And Expression: Expressions in C++ and their evaluation. Precedence and associativity rules. Operators: arithmetic operators, relational operators, logical operators,miscellaneous operators.	02
Statements: Decision making structures: if, if-else, nested if and if-else, switch-Case. Loop control structures: for, while, do-while. Role of statements like break, continue, go to.	06
SECTION- B	
Arrays: Concept and use of arrays, declaration and usage of 1-dimensional arrays and 2-dimensional arrays.	
Functions: Advantage of modularizing C++ program into functions, function definition and function invocation. Methods of passing parameters to a function: call-by-value, call-by-reference; Passing arrays to functions, Recursion, Library functions.	04
Introduction To User-Defined Data Types: Structures- definition, declaration, use. Unions: definition, declaration, use, introduction to classes and Properties of object oriented programming **.**	04
Introduction to Numerical Methods And Spreadsheet Calculations:	04

Developing programs to solve engineering computation problems and working with spreadsheets.	
Text books:	1. Arora, SumitaòComputer Science with C++ò Dhanpat Rai & Co. 2. Balaguruswamy, ñObject Oriented Programming in C++ò, Tata McGraw Hill.
Reference Books:	1. Kamthane, ñObject Oriented Programming in ANSI and Turbo C++ò Pearson Education India 2. Lafore ,Robert ñObject Orients Programming in C++ò
Course Assessment Methods	Assessment will consist of the following components 1.Mid-Term a. One best of two minor tests (50% of Mid -term marks) b. Assignments (20% of Mid-term marks) c. Class Surprise Tests/ Quizzes/Presentations/Term paper (20% of Mid-term marks) d. Attendance. (10% of Mid-term marks) 2.End ï Term
Course Outcomes	1. The student will demonstrate proficiency in C++ programming language. 2. The student will be able to solve basic engineering computation problems using C++

COMPUTER PROGRAMMING (PRACTICAL)	
Objectives	1. To develop programs using C++ 2. To make the students design programs by using logic and become confident in handling numerical problems .

Practical Session Wise Break Up	**No. of Sessions**
1. Programs based on input & output in C++	02
2. Programs using Decision Statements if-else, CASE	02
3. Programs using while statements, do- while and for Loops	03
4. Array based programs	02
5. Developing user defined Functions with and without recursion	02
6. How to create and access user defined data types	01
7. Implementation of engineering computation programs and using spreadsheet calculations.	02

Course Assessment Methods	The students will be assessed based upon the practical assignments and viva voce
Course Outcomes	1. The students will be able to demonstrate proficiency in C++ 2. The student will become confident in solving any computation problem using his programming skills.

Title	**INTRODUCTION TO ENGINEERING & TECHNOLOGY**			**Credits**	03
Code	CHE 101	**Semester:-**1st		**L T P**	3 - -
Max. Marks	**End term-** 40	**Mid term-** 35	**Practical --**	**Elective**	N
Pre requisites				**Contact Hours**	42

THEORY	**Time**	3 Hours
Objectives	1. To provide a comprehensive overview of the engineering profession and practice. 2. To develop systematic problem solving skills and enhance confidence in the students through varied numerical problems. 3. To prepare the students to formulate and solve material balances on chemical process systems.	
Note for the Examiner	The semester question paper of the subject will be of 40 marks having 8 questions of equal marks. The paper will be divided into two parts having four questions each from Section A and Section B. The candidate is required to attempt total 5 questions selecting atleast two questions from each Section.	

SECTION- A	**Hrs**
Definition of Engineering: Brief history of engineering. Various engineering fields of specialisation: Chemical	02

engineering, environmental engineering, Bio engineering, petrochemical engineering, food engineering, mechanical engineering, electrical engineering, civil engineering, computer engineering. Functions of engineering. Career opportunities for engineers. Issues of professional responsibility and ethics for an engineer.	
Systematic analysis of chemical processes: Unit operations and unit processes, material and energy balances, thermodynamics, chemical reaction engineering, process instrumentation, process control and economics.	02
Introduction to Engineering Calculations: Units and dimensions, conversion of units, systems of units, conventions in methods of analysis and measurement, numerical calculation and estimation, dimensional homogeneity and dimensionless quantities, process data representation and analysis, Conversions involving process variables like pressure, temperature, density/specific gravity, mass, volume, flow rate and chemical composition. Chemical equation and stoichiometry.	12
SECTION- B	
P-V-T relations for gas and gas mixtures, calculations using ideal gas law, Use of compressibility charts and equations of state (Van der Waalsô) to predict real gas properties from experimental data.	06
Liquid and liquid mixtures: Vapour pressures (cox chart, Duhrings lines, Clausius Clapeyron equation), saturation, vapour-liquid equilibrium calculations using Raoultôs law and Henryôs law, partial saturation and humidity, material balances involving condensation and vaporization.	10
Introduction to material balances without chemical reactions, material balance on multipleï unit processes, Recycle, Bypass and Purge calculations.	10

Text books:	1. Wright, P.H.; ñIntroduction to Engineeringò, 3rd Edition, John Wiley & Sons (2002). 2. Felder, R. M. and Rousseau, R.W.; ñElementary Principles of Chemical Processesò, 2nd Edition, John Wiley & Sons (2009). **3.** Himmelbleau, D. M.; ñBasic Principles and Calculations of Chemical Engg.ò 7th Edition, Prentice Hall (2007).
Reference Books:	1. Littlejohn, C. E. and Meenagham, C. M.; ñIntroduction to Chemical Engineeringò, 1st Edition, McGraw Hill 2. Anderson, L. B., ñIntroduction to Chemical Engineeringò, 1st Edition, McGraw Hill. 3. Shaheen, E. I.; ñBasic Practices of Chemical Engineeringò, Houghton Miftlin Company, Boston(1975)
Course Assessment Methods	Assessment will consist of the following components 1.Mid-Term a. One best of two minor tests (50% of Mid -term marks) b. Assignments (20% of Mid-term marks) c. Class Surprise Tests/ Quizzes/Presentations/Term paper (20% of Mid-term marks) d. Attendance. (10% of Mid-term marks) 2.End ï Term
Course Outcomes	1. The student will recognise his/her role as an engineer in the society and the associated responsibility lying ahead. The budding engineers will have a better understanding of professional ethics and importance of team work in achieving the professional goals. 2. The course will enable the students to analyze the local and global impact of engineering solutions and applications on individuals, organizations and hence its impact on society. 3. It will enable the students to identify, formulate and solve chemical engineering problems using law of conservation of mass and engineering sciences. 4. Students will be capable of representing and analysing the experimental process data that would be helpful in solving engineering problems.

Title	**ETHICS AND SELF AWARENESS**			**Credits**	02
Code	HSSC 101	**Semester:-** 1st		**L T P**	2 - -
Max.Marks	**End term- 25**	**Mid term- 25**	**Practical --**	**Elective**	N
Pre requisites				**Contact Hours**	28

THEORY	**Time**	3 Hours

Objectives	1. To provide basic knowledge about ethics, values, norms and standards and their importance in life. 2. To improve the personality of students by their self-assessment. 3. To imbibe positive thinking in students, thereby enhancing the quality of life of students and henceforth the nation as a whole.
Note for the Examiner	The semester question paper of the subject will be of 25 marks having 8 questions of equal marks. The paper will be divided into two parts having four questions each from Section A and Section B. The candidate is required to attempt total 5 questions selecting atleast two questions from each Section.

SECTION- A	**Hrs**
Introduction to Ethics : Concept of Ethics ï Nature, Scope, Sources, Types, Functions and Factors influencing Ethics, Approaches to Ethics ï Psychological, Philosophical and Social, Broader Ethical Issues in Society.	06
Values, Norms, Standards and Morality: Concept and Role, Relation with Ethics, Psycho-Social Theories of Moral Development ï Kohlberg and Carol Gilligan.	04
Ethics and Business: Concept of Business Ethics ï Nature, Objectives and Factors influencing Business Ethics, 3 Cös of Business Ethics, Ethics in Business Activities, Ethical Dilemmas in Business, Managing Ethics.	05
SECTION- B	
Self-Awareness: Concept of Self Awareness ï Need, Elements, Self Assessment ï SWOT Analysis, Self Concepts ï Self-Knowledge, Assertiveness and Self-Confidence, Self-Esteem .	04
Self-Development: Concept of Self-Development, Social Intelligence, Emotional Intelligence, Managing Time and Stress, Positive Human Qualities (Self-Efficacy, Empathy, Gratitude, Compassion, Forgiveness and Motivation), Personality Development Models ï Johari Window, Transactional Analysis, Myers Briggs Type Indicator, Self-Awareness and Self-Development Exercises.	09

Recommended books:	1. Murthy, C.S.V., ñBusiness Ethics ï Text and Casesò, Himalaya Publishing House 2. Hartman, Laura P. and Chatterjee, Abha, ñBusiness Ethicsò, Tata McGraw Hill 3. Rao, A.B., ñBusiness Ethics and Professional Valuesò, Excel Books 4. Velasquez, Manuel G., ñBusiness Ethics ï Concepts and Casesò, Prentice Hall 5. Corey, G., Schneider, Corey M., and Callanan, P., ñIssues and Ethics in the Helping Professionsò, Brooks/Cole 6. Hall, Calvin S., Lindzey, Dardner and Cambell, John B., ñTheories of Personalityò, Hamilton Printing Company 7. Leary, M.R., ñThe Curse of Self: Self-awareness, Egotism and the Quality of Human Lifeò, Oxford University Press.
Course Assessment Methods	Assessment will consist of the following components 1.Mid-Term a. One best of two minor tests (50% of Mid -term marks) b. Assignments (20% of Mid-term marks) c. Class Surprise Tests/ Quizzes/Presentations/Term paper (20% of Mid-term marks) d. Attendance. (10% of Mid-term marks)

	2.End ï Term
Course Outcomes	1. The students will become a better human being by being able to distinguish between right and wrong in both personal and professional front. 2. The students will be able to realize the importance of ethics , moral values, duties and self awareness . 3. The students will be able to identify their strengths, weaknesses, opportunities & threats and work enthusiastically to transform weaknesses into strengths and threats into opportunities

2nd SEMESTER

Title	**MATHEMATICS-II**			**Credits**	4
Code	BSC 103	**Semester:- 2nd**		**L T P**	3 1 -
Max marks	**End term- 50**	**Mid term- 50**	**Practical --**	**Elective**	N
Pre-requisites	Mathematics-I (101)			**Contact hours**	42
Theory				**Time**	3 hours

Objectives	To students shall • Learn to expand various functions in terms of Fourier series. • Learn the methods to formulate and solve partial differential equations. • Be taught to apply the method of separation of variables to solve partial differential equations of engineering interest. • Learn to find Laplace transforms and inverse transforms and apply these to solve differential equations. • Understand the concept of Complex functions and their applications to various problems.
Note for examiner	**The semester question paper of the subject will be of 50 marks having 8 questions of equal marks. The paper will be divided into two parts having four questions each from Section A and Section B. The candidate is required to attempt total 5 questions selecting atleast two questions from each Section.**

SECTION A	**Hrs**
Fourier Series Eulerôs Formulae, Dirchieletôs Conditions for Expansion, Change of interval, Odd and Even Functions, Expansion of Odd and Even Periodic Functions, Introduction to Harmonic Analysis.	8
Partial Differential Equations (Pde's) Formation and classification of partial differential equations, first order linear equations, standard forms of non linear equations, Charpitôs method, homogeneous linear equations with constant coefficients.	7
Engineering Applications Of Pde's Method of separation of variables , Solution of partial differential equations of engineering interest by the method of separation of variables.	5
SECTION B	**Hrs**
Laplace Transforms Definition, Transforms of Elementary functions, Properties of Transforms, Inverse Transforms, Transforms of Derivatives, Unit Step Function, Diracôs Delta Function & Unit Impulse function. Periodic Functions, Application of Transform to the solution of ordinary Differential equations	12
Calculus Of Complex Functions Functions of complex variables, analytic functions, Cauchy-Riemann equations, Cauchyôs theorem, Cauchyôs integral formula, introduction to Taylerôs series and Laurentôs series, Residues, Residue theorem and its simple applications.	10

Text Books	1. G. B. Thomas, R. L. Finney: Calculus and Analytic Geometry, Ninth Edition, Pearson Education. 2. E. Kreyszig: Advanced Engineering Mathematics, Eighth Edition, John Wiley.
Reference Books	1. B. V. Ramana: Higher Engineering Mathematics, Tata McGraw Hill. 2. B. S. Grewal: Higher Engineering Mathematics, 41st Edition, Khanna Publishers, Delhi. 3. Differential Equations, Frank Ayers, TMH
Course Assessment Methods	Assessment will consist of the following components 1.Mid-Term e. One best of two minor tests (50% of Mid -term marks) f. Assignments (20% of Mid-term marks)

	g. Class Surprise Tests/ Quizzes/Presentations/Term paper (20% of Mid-term marks) h. Attendance. (10% of Mid-term marks) 2.End ï Term
Course Outcomes	The students are able to: • expand functions in terms of Fourier series. • formulate and solve partial differential equations. • solve partial differential equations of engineering interest. • find Lapalace transforms, inverse transforms and apply these to solve various differential equations. • evaluate complex integrals and apply these to various problems.

Title	**Applied Physics (Condensed Matter)**			**Credits**	4
Code	BSC 104	**Semester:- 2nd**		**L T P**	2 1 2
Max marks	**End term- 40**	**Mid term- 35**	**Practical- 25**	**Elective**	N
Pre-requisites				**Contact hours**	28 (Theory) 14 (Practical Sessions)

Theory	**Time**	3 hours
Objectives	To make the students understand • the importance of the structural properties of materials and engineering their properties. • the engineering of semiconducting, magnetic and nano-materials and utilize the concept studied for developing various applications.	
Note for examiner	**The semester question paper of the subject will be of 40 marks having 8 questions of equal marks. The paper will be divided into two parts having four questions each from Section A and Section B. The candidate is required to attempt total 5 questions selecting atleast two questions from each Section.**	

SECTION A	**Hrs**
Crystal structure: Space lattices and their symmetries, crystal structures (cubic and hexagonal cells), assignment of coordinates, directions and planes in crystals, linear, planer and space densities in crystals, close packed morphology (Hexagonal and cubic close packing), single and polycrystalline structures, interstitial spaces (trigonal, tetrahedral and octahedral voids, crystal Structure analysis, X-ray diffraction and Braggôs law, crystal defects, Point, line, surface and volume imperfections	10
Theory of Metals: Free electron theory, electrical properties, thermal properties, motion in magnetic field (cyclotron resonance), Zone theory. Band theory of solids, Kronig-Penney Model (qualitative), conductors, insulators and semiconductors	6
Dielectric Materials: Review of basic formulas, dielectric constant and polarizability, sources of polarizability, classical treatment of dipolar, ionic and electronic polarizability, piezoelectricity, ferroelectrcity.	5
SECTION B	**Hrs**
Magnetic Materials: Review of basic formulas, magnetic susceptibility, classification of materials, Langevin diamagnetism, paramagnetism (only classical treatment), magnetism in metals, ferromagnetism in insulators, anti-ferromagnetism and ferrimagnetism, ferromagnetism in metals, ferromagnetic domains, hysteresis	8
Superconductivity: Zero resistance, occurrence of superconductivity, Meissner effect, critical field, thermodynamics of superconducting transitions, electrodynamics of superconductors, qualitative idea of BCS theory.	4
Semiconductors: p-type and n-type semiconductors, statistics of electrons and holes, Hall effect (for single as well as both type of charge carriers)	4
Nanotechnology: Introduction, Synthesis of Nanoparticles: Mechanical Method, Sputtering, Chemical Vapour Deposition, Sol-gel Technique, Applications of Nanotechnology	5

Text Books	1. Introduction to Solid State Physics: Charles Kittle 8th Ed. 2. Elements of X-ray Diffraction, B.D. Cullity
Reference	a. Material science and Engineering ï An Introduction by William D Callister, Jr, Sixth Edition, John Wiley and Sons.

Books	b. Material science and Engineering ï A First Course by V.Raghvan Fourth Edition, EasternEconomy Edition c. Solid State Physics (New Age Publishers) ï S.O. Pillai d. Introduction to Solids (Tata McGraw Hill, Third Edition) - Leonid V Azaroff
Course Assessment Methods	Assessment will consist of the following components 1.Mid-Term a. One best of two minor tests (50% of Mid -term marks) b. Assignments (20% of Mid-term marks) c. Class Surprise Tests/ Quizzes/Presentations/Term paper (20% of Mid-term marks) d. Attendance. (10% of Mid-term marks) 2.End ï Term
Course Outcomes	Students are able to - analyze the crystal structure of materials along with the knowledge of XRD technique. - understand the electrical, thermal and dielectric properties of materials. - understand magnetic properties of materials with the knowledge of superconductor and semiconductors and are in a position to synthesize and understand the engineering of nano-materials.

Applied Physics (Condensed Matter) Practical	
Objectives	To make student understand the theories technically by performing and developing the respective experiments.

Practical session wise break-up	**No. of sessions**
To find the energy band gap of the given semiconductor by four probe method.	**4***
To study the Hall Effect of a given semiconductor	**2**
To determine the dielectric constant of the given materials.	**2**
To study the B-H curve of the ferromagnetic materials.	**2**
To determine the value of e/m for electron by long solenoid (helical) method.	**2**
To study the variation of magnetic field with distance along the axis of a circular coil carrying current by plotting a graph	**2**

Text Books	1. Practical Physics by CL Arora, S Chand & Co. 2. Engineering physics by S.K. Srivastva
Reference Books	A text book of practical physics by William & Watson
Course Assessment Methods	One *project out of 6 carries 40% marks, 20% for respective viva and 20% for external exams and 10% for attendance.
Course outcomes	The student will gain • Proficiency in technical aspects of performing the experiments. • Proficiency in designing scientific projects

Title	**Communication Skills (Advance)**			**Credits**	2
Code	HSSC 102	**Semester:- 2nd**		**L T P**	1 - 2
Max. marks	**End term- 15**	**Mid term- 10**	**Practical- 25**	**Elective**	N
Pre-requisites				**Contact hours**	14 (Theory) 14 (Practical Sessions)

Theory		**Time**	3 hours
Objectives	1. To inculcate effective communication skills in students for better performance in professional as well as personal life 2. To improve personality of students with advanced techniques in verbal, non verbal and para verbal communication.		
Note for examiner	**The semester question paper of the subject will be of 15 marks having 8 questions of equal marks. The paper will be divided into two parts having four questions each from Section A and Section B. The candidate is required to attempt total 5 questions selecting atleast two questions from each Section.**		

SECTION A	**Hrs**
Advanced Communication Skills Scope, Significance, Process of Communication in an Organization, Types and Levels, Communication Networks, Technical Communication, Tools of Effective Communication, Barriers of Communication.	2
Speaking Skills Interpersonal Communication, Presentation Skills, Voice Modulation, Persuasion, Negotiation and Linguistic Programming, Public Speaking, Group Discussions, Interviews and Case Studies, Conducting Meetings and Conferences	3
Personality Development Body Language and importance of Non Verbal communication, Social and Professional etiquettes.	2
SECTION B	**Hrs**
Communication and Media Social and Political Context of Communication, Recent Developments in Media	1
Advanced Techniques in Speaking Skills Importance of Listening/Responding to native and global accents, Telephonic Interviews and Video Conferencing	2
Advanced Techniques in Technical Writing Job Application, CV Writing, Business Letters, Memos, Minutes, Reports and Report Writing Strategies, E-mail Etiquette, Blog Writing, Instruction Manuals and Technical Proposals	4

Text Books	1. Ashraf, M. Rizvi, ñEffective Technical Communicationò, McGraw Hill 2. Bovee, Courtland L. and John, V. Thill, ñBusiness Communication Todayò, Pearson Education
Reference Books	1. Sharma, R.C. and Mohan, K., ñBusiness Correspondence and Report Writingò, Tata McGraw Hill 2. Raman, Minakshi and Sharma, S., ñTechnical Communication: Principles and Practiceò, Oxford University Press 3. Scott, Bill, ñCommunication for Professional Engineersò, Thomas Teleford Ltd. 4. McMurrey, David A. and Joanne, Buckley, ñHandbook for Technical Writingò, Cengage Learning 5. Harve, L., Locke, W. and Morey, A., ñEnhancing Employability and Recognizing Diversityò, Universities UK and CSU 6. Lock, R., ñStudent Activities for taking charge of your Career Direction and Job Searchò, Cole Publishing Pease, A., ñBody Languageò, Sheldon Press
Course Assessment Methods	Assessment will consist of the following components 1.Mid-Term a. One best of two minor tests (50% of Mid -term marks) b. Assignments (20% of Mid-term marks)

	c. Class Surprise Tests/ Quizzes/Presentations/Term paper (20% of Mid-term marks) d. Attendance. (10% of Mid-term marks) 2.End ï Term
Course Outcomes	1. Gain proficiency in English language as medium for communication in both professional and personal life 2. Increase in employment prospective of students by developing technical aspects of communication. 3. Personality development of students by thorough knowledge of effective and enhanced communication skills
Communication Skills (Advance) Practical	
Objectives	1.To develop better pronunciation and communication skills. 2.To be able to face interviews and participate in conferences or any personal or professionals discussions with confidence. 3.To develop technical writing skills. 4.To be able to articulate ones voice and overcome stage fright.

Practical session wise break-up	**No. of sessions**
Organizational Communication Verbal and Non-Verbal Communication at different levels of organization, Role Play, Interaction with Bosses and Co-employees	**2**
Speaking Techniques Preparation of Interviews, Participation in Group Discussions and Case Studies, Making and Presenting Power Point Lectures.	**4**
Advanced Speaking Techniques Conducting Meetings and Conferences, Exposure to different Accents, Listening and responding in the global scenario, Telephonic Interviews/Conversations, Video Conferencing	**4**
Technical Writing Writing Letters, Memos, Minutes, Notes, CV, Job Applications, Reports and e-mails, Preparing Instruction Manuals and Technical Proposals	**4**

Course outcomes	1. English Speaking skills of students will be enhanced. 2. Students will become self confident in handling both professional and personal meetings/discussions. 3. Students will be able to demonstrate improved technical writing skills. **4.** Overall personality of students as well as their communication skills will be developed.

Title	**Electrical and Electronics Engineering**			**Credits**	5
Code	ESC 103	**Semester:- 2nd**		**L T P**	3 1 3
Max. marks	**End term- 50**	**Mid term- 50**	**Practical- 25**	**Elective**	N
Pre-requisites				**Contact hours**	42 (Theory) 14 (Practical Sessions)
THEORY				**Time**	3 hours
Objectives	• To provide students about basic knowledge of A.C and D.C circuits, theorems, laws. • Introduce to the students about difference between single phase and three phase system. • To teach the students basic principle of operation of transformers and other electrical machines. • To make them aware of the difference between analog and digital system and study diodes, rectifiers, digital circuits.				
Note for examiner	**The semester question paper of the subject will be of 50 marks having 8 questions of equal marks. The paper will be divided into two parts having four questions each from Section A and Section B. The candidate is required to attempt total 5 questions selecting atleast two questions from each Section.**				
SECTION A					**Hrs**

DC Circuits and Single Phase A.C. Fundamentals General introduction to Electrical Engineering, Kirchoffôs Laws ,Mesh and Node analysis, Superposition theorem , Thevenin Theorem, Norton Theorem, Maximum power transfer theorem. Generation of alternating voltages and currents, Equations for AC quantities, cycle, time period, frequency, amplitude, calculation of R.M.S values, Average values for different waveforms, solution and phasor diagram of single phase AC circuit with sinusoidal source of excitation, series and parallel combination of R-L-C circuits.	10
Three Phase AC Fundamentals Disadvantages of single phase system, star and delta connection in three phase circuits, relation between line and phasor quantities, power in three phase system, solution of three phase balanced circuits, power and power factor measurement by two wattmeter method.	4
Electrical Machines **B**asic principle and construction of transformers, E.M.F equation, approximate equivalent circuit, phasor diagram, losses, efficiency and condition for maximum efficiency, open circuit and short circuit test on single phase transformers. Operating principle and construction of three phase induction motors, Operating principle and construction of DC Machines, types of DC Machine & E.M.F equations	10
SECTION B	**Hrs**
Semiconductor Diodes and Transistors General introduction to Electronics.Concept of stiff Voltage and Current Source. PN Junction, Depletion layer, Barrier Potential, Forward and Reverse Bias, Breakdown voltage, V-I characteristics, Half wave and full wave rectifiers, Zener diode. Introduction to junction transistors, Transistor amplifying action, CB, CE, CC-configuration characteristics.	8
Digital Electronics Binary and Hexadecimal number system, conversion of numbers from one system to other, OR, Relations: Commutative, Associative and Distributive Laws. Concept of flip-flops, RS,JK flip flops, shift register.	10

Text Books	1. Edward Hughes: Electrical and Electronic Technology, Pearson Education Publication, Asia, 2003. 2. Nagsarkar, T.K. and Sukhija M.S.: Basic Electrical Engg., Oxford University Press, 2004. 3. Bhargava: Basic electronics and Linear circuits, Tata McGraw Hill.
Reference Books	1. Nagrath, I.J. and Kothari, D.P.: Basic Electrical Engg., TMH, New Delhi. 2. Malvino: Digital Principles and Applications, Tata McGraw Hill
Course Assessment Methods	Assessment will consist of the following components 1.Mid-Term a. One best of two minor tests (50% of Mid -term marks) b. Assignments (20% of Mid-term marks) c. Class Surprise Tests/ Quizzes/Presentations/Term paper (20% of Mid-term marks) d. Attendance. (10% of Mid-term marks) 2.End ï Term
Course Outcomes	1. The student will understand how various loads are connected in circuits and difference between single and three phase system. 2. The students will know the principles and working of different types of electrical machines used in industry 3. The students will have the basic knowledge of digitalization and conversion of physical quantity to digital quantity.
Electrical and Electronics Engineering Practical	
Objectives	Students will be able • to design electric circuits. • To use voltmeter ,ammeter and wattmeter • Perform open circuit test and short circuit test on a single phase transformer and draw equivalent circuit • To identify diode characteristics and transistor characteristics and perform experiments related to rectifiers(half-wave and full-wave) • To verify various logical gates and networking theorems through experiments.

Practical session wise break-up (min eight experiments to be done)	**No. of sessions**
1.Overview of the equipments, instruments and procedure to be used, safety precautions and report writing.	**1**
2.To study resonance in R-L-C series and parallel circuit.	**1**
3.Measurement of power and power factor by three voltmeter method.	**1**
4. Measurement of power and power factor by three ammeter method.	**1**
5.To measure power and power factor using a single wattmeter in a single phase circuit.	**1**
6.Measurement of power and power factor of three phase balanced load by two wattmeter method.	**1**
7.To perform open circuit test and short circuit test on a single phase transformer and draw equivalent circuit.	**1**
8.To obtain magnetization characteristics of DC Machine	**1**
9.Study the forward and reverse biased diode characteristics.	**1**
10. Study the CB, CE, CC transistor characteristics.	**1**
11. To obtain the waveforms of half wave rectifier circuit on CRO.	**1**
12. To obtain the waveforms of full wave rectifier circuit on CRO.	**1**
13. Verification of basic and universal gates.	**1**
14. To verify the thevenin theorem, nortan theorem, Maximum power transfer theorem	**1**

Course Outcomes	Students will • have hands on knowledge about the design, purpose and working of R-L-C and parallel circuits • become confident in taking accurate readings of voltmeter, ammeter and wattmeter • have in depth knowledge about transformers, transistors , diodes and rectifiers and will be able to understand their applications in industry. • have knowledge about networking theorems and their utility in industry.

Title	**ENGINEERING MECHANICS**			**Credits**	3
Code	ESC 104	**Semester:- 2nd**		**L T P**	2 1 -
Max. marks	**End term- 40**	**Mid term- 35**	**Practical --**	**Elective**	N
Pre-requisites				**Contact hours**	28
THEORY				**Time**	3 hours
Objectives	1. To make the students understand the fundamentals of engineering mechanics i.e. force systems, centre of gravity, moment of inertia and types of structures. 2. To learn kinetics of particles and kinematics of rigid bodies, friction and vibration.				
Note for examiner	**The semester question paper of the subject will be of 40 marks having 8 questions of equal marks. The paper will be divided into two parts having four questions each from Section A and Section B. The candidate is required to attempt total 5 questions selecting atleast two questions from each Section.**				

SECTION A	**Hrs**
Force System Introduction, force, principle of transmissibility of a force, resultant of a force system, resolution of a force, moment of force , Varigon's theorem, couple, resolution of force, properties of couple and their application to engineering problems, Free body diagram, Equilibrium.	4
Structure: Plane truss, perfect and imperfect truss, assumption in the truss analysis, analysis of perfect plane trusses by the method of joints and method of section	3
Friction: Static and kinetic friction, laws of dry friction, co-efficient of friction, angle of friction, angle of repose, cone of friction, friction of journal-bearing, friction in screws, derivation of equation	3

$T_1/T_2 = \mu_c$ A and its application.	
Centroid and Moment of Inertia: Centre of gravity, centre of mass, centroid of line , area and volume, mass moment of inertia and area moment of inertia, polar moment of inertia, radius of gyration, parallel axis theorem, Perpendicular Axis Theorem, Pappus theorems.	3
SECTION B	**Hrs**
Kinetics of Particles: Introduction to dynamics, rectilinear motion, plane curvilinear motion-rectangular co-ordinates, normal and tangential coordinates. Equation of motion, work energy equation, impulse and momentum, conservation of momentum, impact of bodies, co-efficient of restitution, loss of energy during impact.	4
Kinematics of Rigid Bodies: Concept of rigid body, types of rigid body motion, Plane, absolute and rectilinear motion, equation of motion in straight line, Equation of motion due to gravity, rigid body angular motion, relative velocity, relative acceleration (Coriolisô component excluded).	4
Kinetics of Rigid Bodies: Equation of motion, translatory motion, DôAlembertôs principle, circular motion about fixed axis , work energy relation for rotation , concept of virtual work.	3
Vibration: Classification of vibrations, degree of freedom, free vibrations, forced vibrations, Effect of damping, simple pendulum, torsion pendulum. Spring mass system-its damped (linear dash pot) and undamped free vibrations, Energy method.	4

Recommended Books	Meriam, J. L. & Kraige, L. G.	:	Statics, 3rd Edition, John Wiley & Sons.
	Meriam, J. L. & Kraige, L. G.	:	Dynamics, 3rd Edition, John Wiley & Sons.
	Dr DS Bedi	:	Engineering Mechanics, Khana Book Publishing Co. (P)Ltd

Course Assessment Methods	Assessment will consist of the following components 1.Mid-Term a. One best of two minor tests (50% of Mid -term marks) b. Assignments (20% of Mid-term marks) c. Class Surprise Tests/ Quizzes/Presentations/Term paper (20% of Mid-term marks) d. Attendance. (10% of Mid-term marks) 2.End ï Term
Course Outcomes	Students will be able to • Describe force system, construct force body diagrams and calculate the rections necessary to ensure static equilibrium. • Describe trusses and define friction, its types and laws of friction. • Determine centre of gravity and moment of inertia. • Describe and examine kinematics of rigid bodies, equations of motion and vibrations .

Title	**WORKSHOP PRACTICES**			**Credits**	1
Code	ESC 105	**Semester:- 2nd**		**L T P**	- - 3
Max. marks	**End term --**	**Mid term - -**	**Practical -** 25	**Elective**	N
Pre-requisites				**Contact hours**	28 (Practical Sessions)

PRACTICAL	
Objectives	• To make the students understand the need and importance of different manufacturing techniques. • To introduce the different tools and equipments used in mechanical workshops and develop the skill to use the same.

Practical session wise breakup	No. of Sessions
Carpentry Shop: Description and use of carpenter's tools, Wood and timber, defects found in wood, seasoning of wood. Different types of timber in common use, making of lap joint, Bridle joint, dovetail joint and Mitre joint.	3
Electric Tools: Exercise of wiring in link clip and casting and causing wiring of lights with switches in parallels, series and with 2 ways switches, Connecting energy meter, main switch and distribution board, testing a wiring installation for insulation resistance, Relevant Indian Electricity Rules.	4
Machine Shop: Classification of fabrication processes, machine tools and materials, introduction to working of lathe, shapper, milling and drilling machines, power hacksaw, shearing machine and grinding wheel. Simple turning, threading, drilling board and knurling operations on a lathe.	4
Welding**:** Introduction to electric arc welding, gas welding and their use in making different types of joints e.g. lap joint, butt joint and T joint.	3
Reccomended Books	1. Raghuwanshi, B.S. : A course in Workshop technology, Vol 1 & II, Dhanpat Rai & Sons , New Delhi. 2. Swarn Singh: Workshop Technology.
Course Outcomes	Students will be able to • understand the theory of different manufacturing techniques and tools . • do practices by hand

Title	**Introduction to Environmental Science**			**Credits**	3
Code	ESC 106	**Semester:- 2nd**		**L T P**	3 - -
Max. marks	**End term- 40**	**Mid term- 35**	**Practical --**	**Elective**	N
Pre-requisites				**Contact hours**	42
THEORY				**Time**	3 hours
Objectives	• To recognize major concepts of environmental sciences and demonstrate in depth understanding of the environment. • To make the students to understand the need and importance of protection of environment. • To spread awareness regarding environmental issues and their impact on society				
Note for examiner	**The semester question paper of the subject will be of 40 marks having 8 questions of equal marks. The paper will be divided into two parts having four questions each from Section A and Section B. The candidate is required to attempt total 5 questions selecting atleast two questions from each Section.**				

SECTION A	**Hrs**
Introduction Man and environment, environmental pollution, Ecosystem-structure and function of ecosystem, types of ecosystem, Introduction to biodiversity, International concern over environmental problems	8
Air pollution Sources of air pollution, types of air pollutants, air quality, effects of air pollution, greenhouse effect, ozone layer depletion, smog and photochemical smog, acid rain-theory and effects.	8
Water pollution Different types of water pollutants, effects of water pollution, pollution of receiving bodies, analysis of water pollution.	5
SECTION B	**Hrs**
Soil pollution Components of soil, soil pollution, detrimental effects of pesticides and metal ions	4
Noise pollution Classification ofnoise pollution, effectsof noise pollution and control measures	2

Nuclear hazards, radiation pollution, solid waste- Introduction and case studies	3
Social issues and the environment, concept of sustainable development, rain water harvesting, watershed management, wasteland reclamation	6
Population and economic growth	2
Environmental ethics, laws relating to environment	4
Text Books	1. J.G. Henry and G.W. Heinke ,ñEnvironmental Science and Engineeringò, 2nd edition, , PHI Publisher, 2011. 2. A. Bhaskar ,òEnvironmental Studiesò , Pearson Publisher, 2011. 3. C.N. Sawyer, P.L. McCarty, G.F. Parkin, ñChemistry for EnvironmentalEngineeringò Tata McGraw Hill, New Delhi, 2000.
Reference Books	1. Edition Richard T. Wright and Bernard J. Nebel ñEnvironmental Science:Toward a Sustainable Futureò, Eighth edition, Prentice Hall. 2. Samir K Banerji, ñEnvironmental Chemistryò 2nd Edition, PHI Publisher, 2005 3. A K De,ñEnvironmental Chemistryò, 6th edition, New Age International, New Delhi, 2006.
Course Assessment Methods	Assessment will consist of the following components 1.Mid-Term a. One best of two minor tests (50% of Mid -term marks) b. Assignments (20% of Mid-term marks) c. Class Surprise Tests/ Quizzes/Presentations/Term paper (20% of Mid-term marks) d. Attendance. (10% of Mid-term marks) 2.End ï Term
Course Outcomes	The students are able to: 1. To identify environmental problems relating to the living organisms. 2. To analyse various risks associated with environmental problems and their remedial measures 3. To develop a sense of community responsibility by becoming aware of scientific issues in larger social context.

THIRD SEMESTER

Title	**PHYSICAL CHEMISTRY**			**Credits**	05
Code	CHE 201	**Semester:-**3rd		**L T P**	3 1 3
Max.Marks	**End term- 50**	**Mid term- 50**	**Practical -25**	**Elective**	N
Pre requisites				**Contact Hours**	42 14 (Practical Sessions)
THEORY				**Time**	3 Hours
Note for the Examiner	The semester question paper of the subject will be of 50 marks having 8 questions of equal marks. The paper will be divided into two parts having four questions each from Section A and Section B. The candidate is required to attempt total 5 questions selecting atleast two questions from each Section.				

SECTION- A

Solutions: Ideal and non-ideal solutions, Raoults's law, change of free energy, enthalpy, and entropy on mixing of liquids, distillation of binary solutions. Partially miscible liquids such as Phenol- water, triethylamine- water, and Nicotine- water systems. Henry's law, Nernst distribution law, Colligative properties of dilute solutions. Abnormal molar mass, degree of dissociation and association of solutes.

Chemical Kinetics: Rate equation of reactions of various orders, rate mechanism, kinetics of complex reactions. Concept of energy barrier and energy of activation. Theories of reaction rates, measurement of extent of reaction, zero order reactions. Rates of flow systems. Lindemann theory of unimolecular reactions.

Surface Phenomena: Adsorption of gases by solids. Types of adsorption, adsorption isotherms, Langmuir's adsorption equation, B.E.T. equation for determination of surface area of adsorbents, applications of adsorption, catalysis, kinetics of surface reactions. Introduction to micelles, emulsions and gels.

SECTION- B

Photochemistry: Laws of photochemistry, principles of photochemical excitation, quantum efficiency, Kinetics of photochemical reactions

Electrochemistry: Conductance of electrolytic solutions, transference number and its determination, Kohlrausch's law of independent migration of ions, Interionic attraction theory, activity and activity coefficients of strong electrolytes, ionic equilibria. Ionizaton of water, ionization constants of weak acids and weak bases, hydrolysis, pH, commonion effect, solubility product and salt effect.

Electrochemical Cells: Reversible and irreversible cells, e.m.f. and its measurement, cell reactions and e.m.f., thermodynamics of electrode potentials, half- cell potential and its determination, Nernst equation, concentration cells, liquid junction potential, determination of activity co-efficient from cell potential data, potentiometric titrations.

***Books recommended*:**

1. Maron, Samuel H. Prutton, Carl F. : Principles of Physical Chemistry, Oxford & IBH Publishing Co. Pvt. Ltd, New Delhi.
2. Glasstone, Samuel : Textbook of Physical Chemistry, MacMillan and Co. Ltd. London
3. Barrow, M. Gorden : Physical Chemistry, McGraw Hill, N.Y.
4. Rose, J. : Dynamics of Physical Chemistry, Lond Pitman

5. Puri, B.R., Sharma, L.R. and Pathania, Madan, S. : Principles of Physical Chemistry, S. Nagin &Co Jalandhar.
6. Negi, A.S. and Anand, S.C. : A Text Book of Physical Chemistry, Wiley Eastern Ltd. New Delhi.
7. Laidler, Keith J. : Chemical Kinetics, Tata McGraw-Hill Co. Ltd., New Delhi.
8. Moore, W.J. : Basic Physical Chemistry, Prentice-Hall of India, New Delhi.
9. Atkin, P.W. : A Text Book of Physical Chemistry, Oxford University Press.

Paper Title : PHYSICAL CHEMISTRY LAB.(Practical)

Paper Code CHE 201 Max. Marks 25 Credits : 1

1. Surface tension of liquids using Stalagmometer and calculation of Parachor values.
2. Distribution of Iodine between water and carbon tetrachloride.
3. Kinetics of the hydrolysis of methyl acetate in the presence of hydrochloric acid.
4. Adsorption of acetic acid on activated charcoal.
5. Viscosity of liquids and composition of a binary solution.
6. Conductometry
   - Variation of equivalent conductance and specific conductance on dilution.
   - Dissociation constant of acetic acid.
   - Solubility of sparingly soluble salts.
   - Conductometric titrations of HCl vs NaOH and acetic acid vs. NaOH.
7. Potentiometric titration of HCl vs NaOH and acetic acid vs NaOH and determination of dissociation constant of acetic acid.
8. Colorimetry
   - Verification of Lambert-Beer Law.
   - Determination of concentration of solution of $KMnO_4/K_2Cr_2O_7$.
   - Determination of composition of Fe-Salicylic Acid Complex by Job's Method.

***Books Recommended*:**

1. Lavitt, B.P. : Findlay's Practical Physical Chemistry, Longman Group Ltd.

Title	**FLUID FLOW**			**Credits**	05
Code	CHE 202	**Semester:-**3rd		**L T P**	3 1 3
Max.Marks	**End term- 50**	**Mid term- 50**	**Practical -25**	**Elective**	N
Pre requisites				**Contact Hours**	42 14 (Practical Sessions)
THEORY				**Time**	3 Hours
Note for the Examiner	The semester question paper of the subject will be of 50 marks having 8 questions of equal marks. The paper will be divided into two parts having four questions each from Section A and Section B. The candidate is required to attempt total 5 questions selecting atleast two questions from each Section.				

SECTION- A

Fluid Statics: Normal forces in fluids, Pressure Measurements, Forces on Submerged bodies, Buoyancy and Stability.

Fluid Properties: Newtonian and non-Newtonian Fluids, Nature of Turbulence, Eddy Viscosity, Flow in Boundary Layers, Basic Equation of Fluid Flow, Bernoulli's Equation, Navier stokes equation.

Flow of Incompressible Fluids: Laminar and Turbulent flow in pipes, Velocity Distribution in Pipes, Frictional Losses in Pipes and Fittings, Fanning equation, Estimation of economic pipe diameter. Derivation of HAGEN-POISEULLI and f=16/Re equations.

SECTION- B
Dimensional analysis and its Applications to Fluid Flow. *Flow of compressible fluids*: Compressible flow and flow through nozzles. *Flow Measurements*: Pilot tube, Orifice, Venturi, Rotameter and Notches, wet gas metre etc. *Fluid Machinery*: Classification and Performance of Pumps, Turbines, Compressors, and Blowers,Selection and Specification, Net positive Suction Head.

***Books Recommended*:**

1. Mc Cabe, W.L. and Smith, J.C. : Unit Operation of Chemical Engineering, McGraw Hill.
2. Fox, R.W. and McDonald, A.T. : Introduction of Fluid Mechanics (SI Version) 4th ed. John Wiley and Sons, 1996.
3. Coulson, J.M. and Richardson, J.F. : Chemical Engineering, Vol. I, Pergamon
4. Foust, A.S., Wensel, L.A., Clump, C.W., Maus, L. and Anderson, L. : Principles of Unit Operations, John Wiley.
5. Badger, W.L. and Banchero, J.T. : Introduction to Chemical Engineering, Tata McGraw Hill Pub. Co. Ltd., 1997.
6. Chattopadhya, P. : Unit Operations of Chemical Engineering, Vol. I, Khanna Publishers, Delhi, 1997.

Paper Title: FLUID Flow (Practical)

Paper Code CHE 202 **Max. Marks 25** **Credits: 2**

1. General study of pipe fittings, valves and other equipments in the unit operations laboratory.
2. Pressure drop for flow through pipelines, valves & fittings.
3. Characteristics of pumps.
4. Flow measurement by the use of orifice meter, venturimeter, rotameter & pitot tube.
5. Flow over weirs and notches.
6. Flow measurement of compressible fluids.

Title	**PROCESS PLANT MATERIAL AND ENERGY BALANCE**			**Credits**	04
Code	CHE 203	**Semester:-**3rd		**L T P**	3 1 -
Max.Marks	**End term- 50**	**Mid term- 50**	**Practical --**	**Elective**	N
Pre requisites				**Contact Hours**	42
THEORY				**Time**	3 Hours
	1.				
Note for the Examiner	The semester question paper of the subject will be of 50 marks having 8 questions of equal marks. The paper will be divided into two parts having four questions each from Section A and Section B. The candidate is required to attempt total 5 questions selecting atleast two questions from each Section.				

SECTION- A
Review: Stoichiometric and composition relationship gas laws; Gaseous mixtures, vapor pressure, humidity, etc. Material Balances for Non-reaction systems including balances involving recycle and by-pass streams. Material Balances for Reacting systems including balances involving recycle and purge streams.
SECTION- B
Combustion Calculations. Energy balances on nonreactive and reactive systems

***Books Recommended*:**

1. Bhatt, V. I. & Vora, S. M. : Stiochiometry, 3rd Edition, Tata McGraw Hill, 1984.
2. Himmelbleau, D. M. : Basic Principles and Calculations in Chemical Engineering, 6th Edition, Prentice Hall, 1977.
3. Felder, R. M. & Rousseau R.W. : Elementary Principles of Chemical Processes, 3rd Edition, John Wiley and Sons, 1986.
4. Reklaithis, G. V. : Introduction of Material and Energy balances, John Wiley, 1983.
5. Lubyben, L.W. & Winzel, L. A. : Chemical Process Analysis, 2nd Edition, Prentice Hall, 1988.

Title	**ENGINEERING MATERIALS**			**Credits**	04
Code	CHE 204	**Semester:-** 3rd		**L T P**	3 1 -
Max. Marks	**End term- 50**	**Mid term- 50**	**Practical- -**	**Elective**	N
Pre requisites				**Contact Hours**	42 (Theory)
THEORY				**Time**	3 Hours
Note for the Examiner	The semester question paper of the subject will be of 40 marks having 8 questions of equal marks. The paper will be divided into two parts having four questions each from Section A and Section B. The candidate is required to attempt total 5 questions selecting atleast two questions from each Section.				

SECTION- A

Atomic Structure: Review of bonding in solids, structure –property-processing Relationships

Crystal Structure : Space lattice,crystal systems, Miller indices, effect of radius ratio on co-ordination, structures of common metallic, polymeric, ceramic, amorphous and partly crystalline materials.

Imperfections in atomic arrangement: various defects in atomic arrangement, diffusion phenomenon in solids, Fick's first and second law of diffusion, solid solution, slip systems, various methods of strengthening materials, Schmid's law.

SECTION- B

Phase Diagrams and phase transformation: binary phase diagrams – Fe-Fe_3C, Cu-Ni, Pb-Sn. microstructure development, TTT diagrams, heat treatment processes-hot and cold working, hardening and softening processes.

Materials: Standards and specifications, unified alloy numbering system, ferrous metals and alloys, non-ferrous metals and alloys; overview of ceramic, polymeric and composite materials; Mechanical tests: standard test procedures for mechanical property determination-strength, toughness, fracture toughness, hardness, deformation, fatigue, creep etc.

Corrosion: Types and mechanism of corrosion, factors influencing corrosion, combating corrosion,selection of materials of construction for handling different chemicals

***Books Recommended*:**

1. Askelland, Donald R. : The Science & Engineering of Materials, PWSKENT.
2. Shackleford, J.F. : Introduction to Material Science for Engineers, Mc Millan.
3. Van-Vlack, L.H. : Elements of Material Science & Engineering, Addison Wesley
4. Raghavan, V. : Material Science & Engineering, Prentice Hall of India
5. Callister Jr. William D. : Materials Science and Engineering- An Introduction, Wiley

Title	STRENGTH OF MATERIALS			Credits	04
Code	ESC 201	Semester:-3rd		L T P	3 1 -
Max. Marks	End term- 50	Mid term- 50	Practical- -	Elective	N
Pre requisites				Contact Hours	42 (Theory)

THEORY	Time	3 Hours
Note for the Examiner	The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.	

SECTION- A

Stresses and Strains: *Concept of simple stress and simple strain,* mechanical properties of solids, *t*ypes of load, Tensile stress , compressive stress, shear stress, complementary shear stress, thermal stresses, tensile test , stress strain curve , Hooke's law, modulus of elasticity, modulus of rigidity, Principle of St. Venant strain, factor of safety, compound bars, , Compound Stresses and Compound Strains in two-dimensional stress system , Stresses on oblique plane due to pure shear, principle planes and principle stresses, maximum shear stress, Mohr's circle of stress, Poisson's ratio, volumetric strain, elastic constants and relations between them.

Shearing Force and Bending Moments in Beams: Shearing force, bending moment, types of beams, types of load on beams, types of supports, sign- conventions for shearing force and bending moment, point of inflection , relations between bending moment and shearing force shearing force and bending moment diagrams for beam under different loads. Concentrated loads, uniformly distributed loads, numerical problems.

Bending Stresses and Shearing Stresses in Beams: Pure bending, graphical determination of moments of inertia, bending stress, composite beams, reinforced concrete beams, General eccentric loading, combined direct and bending stresses, eccentric longitudinal loads , Shear stress distribution in rectangular section and circular section, numerical problems.

Deflection of Beam: Introduction, Macauly's integration method, simply supported beam with load at mid span and beam with eccentric load, moment area method, deflection due to shear, numerical problems.

SECTION-B

Torsion of Shafts: Torsion of thin circular shaft, composite shaft, combined bending and torsion. equivalent torque, equivalent bending moment, numerical problems.

Struts and Columns: Definition of strut and column, Euler's Column theory and assumptions made, Strut with both ends pinned, strut with one end fixed and one end free, strut with both ends free, Slenderness ratio, limitations of Euler theory, Rankine's Empirical formula, strut with eccentric loading, numerical problems.

Stresses and Strains in Thin Shells: Thin cylinder under internal pressure, thin spherical shell under internal pressure, volumetric strain, modifications for built-up shells, numerical problems.

Stresses and Strains in Springs: Types of Springs, stresses in Close coiled helical springs, open coiled helical springs, leaf springs, springs in parallel and in series, numerical problems.

Strain Energy and Theories of Elastic Failure: Strain energy and resilience, Strain energy in tension and compression due to suddenly applied load and impact loads, strain energy due to shear, strain energy due to bending, strain energy due to torsion, theories of elastic failure and their graphical representation, numerical problems.

Books Recommended:

1. Ryder, G. H. : Strength of Materials, 3rd Edition S.I. Units Macmillan, 1969.
2. Bedi, D. S. : Strength of Materials, 6th Edition Khana Book Publishing Co. (P)Ltd.
3. Timoshenko, S. : Strength of Materials Part-I, 3rd Edition, Cbs Publishers, 1986.
4. Singal & Sharma : Strength of Materials , Modern Publisher.

Title	**PROCESS EQUIPMENT DESIGN**			**Credits**	01
Code	ESC-202	**Semester:-**3rd		**L T P**	- - 3
Max. Marks	**End term- -**	**Mid term- -**	**Practical- 25**	**Elective**	N
Pre requisites				**Contact Hours**	14 (Practical Sessions)

PRACTICAL

LIST OF PRACTICALS

1. Study of factors influencing the design of vessels; classification of pressure vessels,applications, method of fabrications, fundamental principles and equations.
2. Study of pressure vessel codes specifications and standards; Review of code and its development, ASME codes, API-ASME code, Section VIII of ASME codes
3. General design considerations for pressure vessels; Design pressure, design temperature, materials, design stress (nominal design strength), corrosion allowance, design loads, minimum practical wall thickness.
4. Design of thin-walled vessels under internal pressure; Cylinders and spherical shells, heads and closures, design of flat ends, design of domes ends, conical sections and end closures.
5. Design of vessels subject to external pressure; Cylindrical shells, design of stiffening rings, vessels heads.
6. Design of vessels subject to combined loading: Weight loads, wind loads (tall vessels), torque.
7. Design of welded joints and Bolted flanged joints.
8. Design of Foundation and supports.

***Books Recommended*:**

1. Battacharyya, B.C. : Introduction to Chemical Equipment Design Mechanical aspects, Chemical Engineering Education Development Centre.
2. Brownell and Young : Process Equipment Design , Willey Publication
3. Joshi, M.V. : Process Equipment Design, Macmillan India.

FOURTH SEMESTER

Title	**MATHEMATICS-III**			**Credits**	4
Code	BSC 201			**L T P**	3 1 -
Max marks	**End term- 50**	**Mid term- 50**	**Practical --**		
Pre-requisites	Mathematics-I (101) & Mathematics-II (103)			**Contact hours**	42
Theory				**Time**	3 hours

Objectives	The students shall • Learn to find Rank of a matrix & find matrix inverse using Cayley-Hamilton theorem. • Learn to solve difference equations with constant coefficients. • Learn to find Z-transforms and inverse Z-transforms and apply these to solve difference equations. • Be taught to apply the series solution method to solve Bessel and Legendre differential equations. • Learn various Probability distributions, test of significance and goodness of fit.
Note for examiner	**The semester question paper of the subject will be of 50 marks having 8 questions of equal marks. The paper will be divided into two parts having four questions each from Section A and Section B. The candidate is required to attempt total 5 questions selecting atleast two questions from each Section.**

SECTION A	**Hrs**
Matrices: Rank of a matrix, Elementary transformations, Eigen-values, Eigen-vectors, Cayley-Hamilton Theorem and its application to find inverse of a matrix.	5
Difference equations: Solution of difference equations with constant coefficients, Complementary function and Particular solution.	5
Z-Transforms: Introduction, Some standard Z-transforms, Linearity property, Damping rule, Some standard results, Shifting rules, Initial and Final value theorems, Convolution theorem, Evaluation of inverse transforms, Applications in the solution of difference equations.	12
SECTION B	**Hrs**
Series solution of differential equations: Solution of differential equations in series with reference to Bessel and Legendre equations, elementary properties of Bessel and Legendre functions.	10
Statistics: Binomial distribution, Poisson distribution and Normal distribution, Test of significance for large samples, Comparison of large samples, Means of two large samples, Studentôs t-distribution, chi^2-test, Goodness of fit.	10

Text Books	2. G. B. Thomas, R. L. Finney: Calculus and Analytic Geometry, Ninth Edition, Pearson Education. 3. E. Kreyszig: Advanced Engineering Mathematics, Eighth Edition, John Wiley.
Reference Books	4. B. V. Ramana: Higher Engineering Mathematics, Tata McGraw Hill. 5. B. S. Grewal: Higher Engineering Mathematics, 41st Edition, Khanna Publishers, Delhi.
Course Assessment Methods	Assessment will consist of the following components 1.Mid-Term i. One best of two minor tests (50% of Mid -term marks) j. Assignments (20% of Mid-term marks) k. Class Surprise Tests/ Quizzes/Presentations/Term paper (20% of Mid-term marks) l. Attendance. (10% of Mid-term marks) 2.End ï Term
Course	The students are able to:

Outcomes	• find Rank of a matrix & find matrix inverse using Cayley-Hamilton theorem. • solve difference equations with constant coefficients. • find Z-transforms and inverse Z-transforms and apply these to solve difference equations. • apply the series solution method to solve Bessel and Legendre differential equations. • apply various probability distributions, test of significance and goodness of fit.

Title	**HEAT TRANSFER**			**Credits**	05
Code	CHE 205	**Semester:-**4th		**L T P**	3 1 3
Max. Marks	**End term- 50**	**Mid term- 50**	**Practical- 25**	**Elective**	N
Pre requisites				**Contact Hours**	42 (Theory) 14 (Practical Sessions)
THEORY				**Time**	3 Hours
Note for the Examiner	The semester question paper of the subject will be of 40 marks having 8 questions of equal marks. The paper will be divided into two parts having four questions each from Section A and Section B. The candidate is required to attempt total 5 questions selecting atleast two questions from each Section.				

SECTION- A

Conduction: Steady state conduction in one dimensional system, general conduction equation, effect of variable thermal conductivity, steady state conduction involving internal heat generation, lagging on pipes, the critical thickness of insulation on pipes, extended surfaces of uniform thickness and fin effectiveness, fin efficiency.

Convection: Free and forced convection, concept of heat transfer co-efficient, dimensionless numbers in free and forced convection, Dimensional analysis, Determination of Heat transfer coefficient using heat and momentum transfer analogies, experimental determination of heat transfer coefficient and common working correlations.

Radiation Heat Transfer: Black Body radiation, and grey body radiation, physical mechanism, radiation properties and shape factor, heat exchange between non-black bodies, radiation shields pyrometry and effect of radiation on temperature measurement

SECTION- B

Condensation and Boiling: Condensation heat transfer phenomenon, film condensation on vertical plates and cylinders as well as on horizontal cylinders. Effects of non-condensable gases and vapor velocity on condensation, pool boiling, forced convection boiling, working correlations for pool boiling.

Evaporation: Types of Evaporators, single and multiple effects, single and multiple effects calculations, evaporator capacity, economy, effect of liquid head and boiling point elevation, methods of feeding.

Heat Exchangers: Various types of heat exchangers, overall heat transfer coefficients, heat exchanger mean temperature differences, heat exchanger effectiveness and the number of transfer units.

***Books Recommended*:**

1. Mc Cabe, W.L., Smith, J.C. : Unit Operations of Chemical Engineering McGraw Hill.
2. Holman, J.P. : Heat Transfer, McGraw Hill Book Co.
3. Mc Adams, W.H. : Heat Transmission, McGraw Hill Book Co.
4. Chapmann, A.J. : Heat Transfer, Mc Millan Publishing Co.
5. Kern, D.Q. : Process heat Transfer, McGraw Hill Book Co.

6. Kreith, F. : Principles of Heat Transfer, Harper & Row Pub., London.
7. Geankoplis, C.J. : Transport Processes and Unit Operations, Prentice Hall of India Pvt. Ltd., 3rd Edition, 1999.

Paper Title : HEAT TRANSFER (Practical)

Paper Code CHE 204 Max. Marks 25 Credits : 1

1. Determination of heat transfer coefficient for different types of heat transfer equipment. Wilson plots.
2. Unsteady state heat transfer in jacketed vessels. (Open pan evaporator)
3. Correlation of instantaneous heat transfer coefficients with time study deposition of scale on a heating surface.
4. Determination of heat losses for insulated pipes
5. Study of double pipe heat exchanger and to determine overall heat transfer coefficient
6. Study the performance characteristics of a 1,2 - shell and tube heat exchanger
7. Study and **operation** of long tube, forced circulation and multiple effect evaporators.
8. Duhring plot for solutions involving nonvolatile solutes

Title	**CHEMICAL ENGINEERING THERMODYNAMICS**			**Credits**	04
Code	CHE 205	**Semester:-**4th		**L T P**	3 1 -
Max. Marks	**End term- 50**	**Mid term- 50**	**Practical-**	**Elective**	N
Pre requisites				**Contact Hours**	42 (Theory)
THEORY			**Time**		3 Hours
Note for the Examiner	The semester question paper of the subject will be of 40 marks having 8 questions of equal marks. The paper will be divided into two parts having four questions each from Section A and Section B. The candidate is required to attempt total 5 questions selecting atleast two questions from each Section.				

SECTION- A

Brief review of the terms: state functions, types of systems, internal energy, heat and work and reversible and irreversible processes. First Law of Thermodynamics and its Engineering Applications i.e. constant volume processes, constant pressure processes, isothermal and adiabatic processes, pumps, turbines, compressors, nozzles, heat exchangers, pitot tube, venturimeter and orifice meter. Throttling Processes, Joule-Thomson Coefficient, liquefication of gases, thermochemistry includes a brief review of heat capacities and their measurement, standard heat of reaction, standard heat of formation, standard heat of combustion, flame temperature, H-x diagrams, heat of solution, partial, molar enthalpies, enthalpy for phase change etc. Equation of state for real gases and their mixtures. Principle of corresponding states and generalized compressibility factor.

Review of Second law of thermodynamics, entropy concept, Entropy and lost work calculations. Microscopic interpretation of entropy. Third Law of thermodynamics and its applications. Free energy functions and their significance in phase and chemical equilibria, Clapeyron's equation and some important correlations for estimating vapor pressures. Estimation of thermodynamic properties by using graphs and tables.

SECTION- B

Phase Equilibria:

Partial molar properties, partial molar Gibbs free energy, Chemical potential and its dependence on temperature and pressure Ideal solutions (Lewis-Randel Rule).

Fugacity and its calculations. Dependence of fugacity of temperatures and pressure

Solution behaviour of real liquids and solids. Activity and activity coefficients. Variation of activity co-efficient with temperature and composition. Activity coefficients of electrolytes standard states. Properties of mixing. Excess Properties, Gibbs-Duhem equation and its application to vapour-liquid equilibria.

Chemical Equilibria:

Equilibrium constant in terms of measurable properties variations of equilibrium constant with temperature and pressure. Adiabatic reactions, Gibbs phase rule, equilibria in heterogeneous reactions.

***Books Recommended*:**

1. Smith, J.M., Van Ness, H.C. and Abbott, M.M. : Introduction to Chemical Engineering Thermodynamics, 7th Edition, McGraw Hill Professional, 2005
2. Elliott, J.R and Lira, C.T. : Introductory Chemical Engineering Thermodynamic, Prentice Hall PTR., 1999.
3. Rao, Y.V.C. : Chemical Engg. Thermodynamics, Orient Blackswan, 1997.
4. Dodge, B.F. : Chemical Engg. Thermodynamics, McGraw Hill, 1944, Original from the University of Michigan, 2007.
5. Narayanan, K.V. : A Textbook of Chemical Engineering Thermodynamics, PHI Learning Pvt. Ltd., 2004.

Title	**ORGANIC CHEMISTRY**			**Credits**	05
Code	CHE 207	**Semester:-**4th		**L T P**	3 1 3
Max. Marks	**End term- 50**	**Mid term- 50**	**Practical- 25**	**Elective**	N
Pre requisites				**Contact Hours**	42 (Theory) 14 (Practical Sessions)

THEORY		**Time**	3 Hours
	1.		
Note for the Examiner	The semester question paper of the subject will be of 40 marks having 8 questions of equal marks. The paper will be divided into two parts having four questions each from Section A and Section B. The candidate is required to attempt total 5 questions selecting atleast two questions from each Section.		

SECTION- A

Classification of organic compounds: IUPAC nomenclature, Structural isomerism, Cis-trans isomerism. Shapes and Molecular orbital structures of compounds containing C, N and O. Conformations of alkanes. Organic reagents and reaction intermediates structures of dienes, pyridine, pyrrole, aromatic compounds. Optical isomerism, Chirality and optical activity; Enantiomers, Diastereomers, Meso-and Racemic compounds, Resolution of racemic mixture. Asymmetric synthesis, Walden Inversion, Configuration (D and L nomenclature), Absolute con figuration (R and S nomenclature)

Chemistry of hydrocarbons: House synthesis, halogenation of alkanes, free radical mechanism, orientation, reactivity and selectivity. Cracking effect of structure on physical properties of compounds. Alkenes, catalytic hydrogenation, dehydration of alcohols, dehydrohalogenation, Saytzeff rule, electrophillic addition reactions, peroxide effect, mechanism of allylic substitution, acidity of 1-alkynes, conjugated dienes, 1,2-and 1,4-additions, free radical and ionic mechanisms of addition polymerisation reactions, ring-opening reactions of cyclopropane and cyclobutane, chemistry of benzene and alkylbenzenes, aromatic electrophillic substitution reactions, Friedel-Crafts reactions

SECTION- B

Delocalisation: Concept of aromaticity, stability of cycloalkanes, resonance concept, inductive and mesomeric effects, directive effects, activating and deactivating groups. Hydrogen-bonding.

Chemistry of functional groups: Alkyl and aryl halides, nucleophilic substitution, synthetic utility

of Grignard reagents and alkyllithiums, mechanism of Grignard reactions of alcohols, benzylalcohol, acidity of phenols epoxy compounds, Anisole nucleophilic addition, benzaldehyde, acetophene, benzophenone, aldol condensation, acidity of acids, alkyl and aryl amines.
Synthetic utility of diazonium salts, basicity of amines, multistep synthesis.

Books Recommended:

1. Bahl, B. S. & Bahl, Arun : Text-book of Organic Chemistry, 16th Edition, S. Chand and Company Ltd., New Delhi.
2. Solomons, T. W. G. : Fundamentals of Organic Chemistry, John Wiley and Sons, Inc., New York, 1994.
3. Morrison & Boyd : Organic Chemistry, Pearson education, 6th edition, 2007.
4. F.A.Carey: Organic Chemistry, Tata McGraw Hill, 7th edition, 2008.
5. Mukherji & Singh: Reaction mechanism in organic chemistry, Macmillan India Ltd.,

Paper Title : ORGANIC CHEMISTRY (Practical)

Paper Code CHE 206 **Max. Marks 25** **Credits : 1**

1. Lab – Safety
2. Preparation of Benzamide & Aspirin-Purification, determination of melting point and percentage yield.
3. Identification of unknown organic compounds – Hydrocarbons, Phenols, Aldehydes, Ketones, Carboxylic acids, Amides and Amines.

Title	**MECHANICAL OPERATIONS**			**Credits**	05
Code	CHE 208	**Semester:-4th**		**L T P**	3 1 3
Max. Marks	**End term- 50**	**Mid term- 50**	**Practical- 25**	**Elective**	N
Pre requisites				**Contact Hours**	42 (Theory) 14 (Practical Sessions)
THEORY				**Time**	3 Hours
Note for the Examiner	The semester question paper of the subject will be of 40 marks having 8 questions of equal marks. The paper will be divided into two parts having four questions each from Section A and Section B. The candidate is required to attempt total 5 questions selecting atleast two questions from each Section.				

SECTION- A

Size Reduction: Crushers and Grinders: jaw crusher, crushing rolls, Gyratory Crusher Tumbling/revolving mills, hammer Mill and Fluid energy mill. Closed and open circuits grinding. Power requirements. Laws of crushing.

Mechanical Separation: Screening: Stationery screens, Grizzlies, Trommel and Vibrating screens. International Standard Screens & Indian Standard Screens. Screening Analysis-differential and cumulative.

- Motion of particle through a fluid: Stoke's Newton's law. Free and hindered setting.
- Setting tank and double cone classifiers
- Batch and continuous thickeners

Settling chamber, cyclone, filter bag and electrostatic precipitators.

SECTION- B

Filtration: Plate and frame filter press, continuous rotary vacuum filter, filter aids, theory of filtration for non-compressible cakes.

Centrifugation: Tubular bowl centrifuge, disk centrifuge and batch basket centrifuge.
Fluidization: Conditions for fluidization: Aggregate and particulate fluidization. Ergun's and Carman-Kozeny equations.
Mixing and Agitation: Basic ideas and characteristics of mixing equipment power consumptions scale-up.
Conveying: Mechanical and pneumatic conveying systems, storage & handling of materials.

***Books Recommended*:**

1. Mc Cabe, Warren L., Smith, Juluain C. and Harroit, Peter : Unit Operations of Chemical Engineering, 5th Edition, Mc Graw Hill Int. ed (Chemical Engineering Series) Mc Graw Hill Book Company, New York, 1993.
2. Foust, Alan S., Wenseli, Leonard A., Clump, Curtis W., mans, Louis and Anersen, L. Bryce : Principles of Unit Operations, Wiley International Edition, John Wiley & Sons Inc., New York.
3. Coulson, J.M. and Richardson, J.F. : Unit Operations (Volume 2 of Chemical Engineering) New York: Mc Graw – Hill Book Co;, Inc.
4. Gupta, Santosh K. : Momentum Transfer Operations, Tata McGraw-Hill, New Delhi.
5. Badger, Walter L. and Banchero, Julius T. : Introduction to Chemical Engineering, Mc Graw-Hill, Kogakusha Ltd., New Delhi.
6. Brown, C.G. : Unit Operations, John Wiley & Sons, Inc., New York.
7. Chattopadhyay, P. : Unit Operations of Chemical Engineering, Vol. I, Khanna Publishers, New Delhi.

Paper Title : MECHANICal OPERATIONS (Practical)
Paper Code CHE 207 Max. Marks 25 Credits: 01

1. Pressure drop and two phase flow characteristics in packed and fluidized beds.
2. Measurement of drag force.
3. Batch settling of slurries.
4. Constant pressure filtration.
5. Mixing, crushing, grinding, screening and particle size analysis (Anderson Pipette)

Title	**COMPREHENSIVE VIVA**			**Credits**	01
Code	CHE 209	**Semester:-4th**		**L T P**	- - -
Max. Marks	**End term--25**	**Mid term- -**	**Practical-**	**Elective**	N
Pre requisites				**Contact Hours**	
SECTION- A					
The viva-voce examinations will be comprehensive and covering all subjects taught during first to fourth semesters.					

Fifth Semester

Title	**NUMERICAL METHODS IN CHEMICAL ENGINEERING**			**Credits**	4
Code	CHE 301		**Semester:-**5th	**L T P**	3 1 -
Max.Marks	**End term 50**	**Mid term 50**	**Practical :**	**Elective**	N
Pre requisites	-			**Contact Hours**	42

THEORY

Note for the Examiner	**Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.**

SECTION- A

Errors in Numerical Calculations, Solution of Algebratic and Transcendental Equations: The Bisection Method, The method of False Position, The Iteration Method, Newton-Raphson Method.

Interpolation: Finite Differences, Differences of a Polynomial, Newton's Formulae for Interpolation, Central Difference Interpolation Formulae, Interpolation with Unevenly Spaced Points, Divided Differences and their Properties, Inverse Interpolation, Curve Fitting, Least-Squares Curve Fitting Procedures, Weighted Least Squares Approximation.

Numerical Differentiation and Integration: Trapezoidal Rule, Simpson's 1/3 –Rule, Simpson's 3/8-Rule, Weddle's Rules and Romberg Integration.

SECTION- B

Solution of Linear Systems, Gaussian Elimination Method, Gauss-Jordan Method, Jacobi Iteration Method, Gauss-Seidel Iteration Method.

Numerical Solution of Ordinary Differential Equation: Taylor's Series Expansion Method, Picard's Method, Euler's Method, Runga-Kutta Methods, Predictor-Corrector Methods, Simultaneous and Higher Order Equations.

Numerical Solution of Partial Differential Equations: Finite-Difference Approximation to Laplace's Equation, Parabolic Equations and Hyperbolic Equations

Recommended Books

1. Hildebrand, F.B. : Introduction to Numerical Analysis.
2. Scarborough, J.B. : Numerical Mathematical Analysis, Oxford and ISH Pub. Co.
3. Chopra, S.C., & Canale, R.P. : Numerical Methods for Engineers.
4. Sastry, S. S. : Introductory Methods of Numerical Analysis, 4th Edition, Prentice Hall.

Title	ENERGY TECHNOLOGY			Credits	4
Code	CHE 302	Semester:-5th		L T P	3 1 -
Max.Marks	End term 50	Mid term 50	Practical	Elective	N
Pre requisites	-			Contact Hours	42

THEORY

Note for the Examiner	**Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.**

SECTION- A

Fuels: Types of conventional fuels, their merits and demerits. Non-conventional/renewable energy sources, their importance for sustainable development and environmental protection.

Solid Fuels: Origin of coal, proximate and ultimate analysis of coal, coal preparation and washing methods, safe storage of coal. Low and High temperature carbonization, products of carbonization, By product coke ovens. Synthetics fuels from coal ï Bergius process and Fischer Tropsch process.

Liquid fuels: Origin of petroleum, refining and distillation of crude oil, uses of petroleum products.

Gaseous fuels: Natural gas, manufacture of water gas and producer gas, gas cleaning methods.

SECTION- B

Principles of combustion: Combustion calculations, waste heat utilization.

Furnaces: Classification of furnaces, draught, furnace atmosphere, Portland cement continuous rotary kiln, blast furnace, glass melting furnace

Alternate sources of energy:

- Introduction to solar radiation and evaluation of radiation incident on a solar collector.
- Applications of solar thermal energy such as solar water heater, solar cooker, solar concentrators and solar thermal power generation.
- Types of solar photovoltaic systems and applications.
- Photosynthesis and biomass conversion systems.
- Wind Energy: Nature of wind and wind turbine performance.

Other renewable energy sources such as geothermal, tidal, ocean and wave.

Recommended Books

1. Gupta, O.P. : Elements of Fuels, Furnaces & Refractions, 5th Edition, Khanna Publishe 2007.
2. Rao, S. and Parulekar, B.B. : Energy Technology ï Non-conventional, Renewable & Conventional, Edition, Khanna Publishers, 2007.
3. Dayal, M. : Renewable Energy ï Environment and Development, Konark Publish Pvt. Ltd., 1989.
4. Sukhatme, S.P. : Solar Energy ï Principles of Thermal Collection and Storage, 2nd Edition, T McGraw ï Hill Publishing Company Ltd., 2006.
5. Sharma, S.P. and Mohan, C. : Fuels and Combustion, Tata Mc-Graw Hill Publishing Company Lt 1984.

Title	CHEMICAL REACTION ENGINEERING–I			Credits	5
Code	CHE 303		Semester:-5th	L T P	3 1 3
Max.Marks	End term 50	Mid term 50	Practical : 25	Elective	N
Pre requisites	-			Contact Hours	42 (Theory) 14 (Practical Sessions)

THEORY

Note for the Examiner	Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

SECTION- A

Introduction and a brief review of the kinetics of homogeneous reactions.
Interpretation of rate data from constant volume and constant pressure systems.
Single Ideal reactors.
Design for single reactions.

SECTION- B

Design for multiple reactions.
Thermal characteristics of reactors: temperature and pressure effects.
Non-ideality in reactors and its effects on chemical conversion. One parameter models to represent the behaviour of chemical reactors.

Practical

1. Kinetic studies in a batch reactor.
2. Kinetic studies in a plug flow reactor.
3. Kinetic studies in a CSTR.
4. Kinetic studies in a semi batch reactor.
5. RTD studies in CSTR.
6. Dispersion number for packed bed reactor.
7. Adiabatic batch reactor.

Recommended Books

1. Levenspiel, O. : Chemical Reaction Engineering, 3rd Edition, John Wiley and So 2004.
2. Smith, J.M. : Chemical Engineering, Kinetics, 3rd Edition, and McGraw Hill, 198
4. Dinbigh, K. and Turner, K.G. : Chemical Reactor Theory – An Introduction, CambridgeUniv. Pres
5. Scott Fogler, H. : Elements of Chemical Reaction Engineering, 4th Edition, Prenti Hall, 2007.

Title	MASS TRANSFER – I			Credits	4
Code	CHE 304		Semester:-5th	L T P	3 1 -
Max.Marks	End term 50	Mid term 50	Practical 0	Elective	N
Pre requisites	-			Contact Hours	42

THEORY

Note for the Examiner	Note for the Paper setter: The question paper should be divided into Section A

	and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

SECTION- A

Mass transfer operations, classification of mass transfer operations, choice of separation methods, methods of conducting mass transfer operations, design principles.

Introduction to mass transfer and diffusion, molecular diffusion in gases and liquids, diffusion coefficients for gases and liquids, diffusion in solids, types of solid diffusion.

Mass transfer coefficients, types of mass transfer coefficients, mass transfer coefficients in laminar flow, theories of mass transfer.

Interphase mass transfer, concept of overall mass transfer coefficient.

SECTION- B

Working principle, construction and industrial applications of various gas liquid contacting equipments like sparged vessels, mechanically agitated vessels, tray towers, packed towers, spray chambers, venturi scrubbers.

Humidification operations, psychometric chart, adiabatic saturation temperatures, wet bulb temperature, adiabatic operations, types of cooling towers.

Principle of drying, batch drying, drying curve, constructional details and working of different dryers

Recommended Books

1. Treybal, Robert E. : Mass Transfer Operations, 3rd Edition. McGraw-Hill, 1981.
2. Sherwood, T.K., Pifford, Robert L. and Wilke, Charles R. : Mass Transfer, McGraw-Hill.
3. Sharma, K.R. : Principles of Mass Transfer, Prentice Hall of India Pvt. Ltd., 2007.
4. McCabe, Warren L., Smith Juliam C. and Harriott, Peter : Unit Operations of Chemical Engg., 7th Edition, McGraw-Hill, 2005.
5. Coulson & Richardson : Chemical Engineering, Vol.I (6th Edition, 2009) and Vol. II. (5th Edition, 2006).

Title	**CHEMICAL TECHNOLOGY (INORGANIC)**			**Credits**	5
Code	CHE 305		**Semester:-**5th	**L T P**	3 1 3
Max.Marks	**End term 50**	**Mid term 50**	**Practical-25**	**Elective**	N
Pre requisites	**-**			**Contact Hours**	42 (Theory) 14 (Practical Sessions)

THEORY

Note for the Examiner	**Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.**

SECTION- A

Chlor-Alkali Industry: Voltage efficiency, Current efficiency, Current density, Decomposition efficiency, Manufacture of soda ash by Solvay and Modified Solvay process, Manufacture of caustic soda.

Sulphuric Acid: Introduction, Manufacture of sulphuric acid by Chamber and Contact process, Material of construction, Storage and handling.

Cement & Glass: Cement-Types of cement, Constituents of cement, Manufacture of Portland cement.

Glass-Introduction, Types of glass, Raw materials, Manufacture of glass.
Ceramics: Introduction, Properties of ceramics, Classification of refractories, Important steps involved in the manufacture of refractories

SECTION- B

Industrial gases: Manufacture and uses of carbon dioxide, oxygen and nitrogen, acetylene.
Paints: Introduction, Classification of paints, Manufacture of paints, Requirement of a good Paint.
Fertilizers: Nitrogeneous fertilizers- Manufacture of Ammonia, Nitric acid, Urea, CAN, Ammonium Sulphate. Phosphatic fertilizers- superphosphate and triple superphosphate. Potassic fertilizers- Potassium Chloride and Potassium Sulphate, Safety aspects.

Practical

1. Fertilizers (i) Determination of N-P-K Values
   (ii) Determination of micronutrients
2. Cement: Loss of ignition, silica, insolubles, estimation of Mg, Ca, Fe.
3. Water

Recommended Books

1. Shreev, R.N. & Brink, J.A. : Chemical Process Industries, 5th Edition, McGraw Hill, 1987.
2. Austine, G.T. : Shreeves Chemicals Process Industries, 5th Edition, Mc Graw Hill, 1984.
3. Dryden, C.E., Rao M.G. & Silting, M. : Outlines of Chemical Technology, 3rd Edition, Affiliated East West Press Pvt. Ltd., N. Delhi, 2008.
4. Pandey, G.N. : Chemical Technology, Volume-I, Lion Press, Kanpur.

Title	**PROCESS PLANT DESIGN –I**			**Credits**	1
Code	CHE 306	**Semester:-**5th		**L T P**	- - 3
Max.Marks	**End term**	**Mid term**	**Practical:25**	**Elective**	N
Pre requisites	**-**			**Contact Hours**	14 Practical Sessions

Practical

1. Design of piping & piping networks.
2. Selection, specification & power requirements of process pumps, fans and blowers.
3. Design of settling equipments like Dor thickeners, dust chambers, cyclone separators and centrifuges.
4. Design of agitated vessels using various types of impellers.
5. Design of Conveyor system for solids.

Recommended Books

1. Luding, E.E. : Applied Process Design in Chemical in Petrochemical Plants, Gulf Publishing Company.
2. Perry, J.H. : Chemical Engineers Handbook, McGraw Hill.
3. Joshi, M.V. : Process Equipment Design, Macmillan Indian.
4. Peters, M.S. and Timmerhaus, K.D. Plant Design and Economics for Chemical Engineers McGraw Hill.

Title	**CHEMICAL ENGINEERING COMPUTATION LAB. (Practical)**			**Credits**	1
Code	CHE 307	**Semester:-**5th		**L T P**	- - 3
Max.Marks	**End term**	**Mid term**	**Practical: 25**	**Elective**	N

Pre requisites	-	**Contact Hours**	14 Practical Sessions

Practical

Errors analysis, Solution of linear and non-linear algebric equations.
Numerical differential & integration.
Interpolation.
Least squares approximation.
Ordinary and partial differential equations.
Development of computer programs based on the above topics using Matlab and their applications in chemical process computations.

Recommended Books:

1. Grewal, B.S. : Numerical Methods in Engineering and Science, Khanna Publishers, N. Delhi, 2001.
2. Sastry, S.S. : Introductory Methods of Numerical Analysis, Prentice Hall of India.

Sixth semester

Title	**CHEMICAL REACTION ENGINEERING-II**			**Credits**	4
Code	CHE 308	**Semester:-**6th		**L T P**	3 1 -
Max.Marks	**End term 50**	**Mid term 50**	**Practical**	**Elective**	N
Pre requisites	**-**			**Contact Hours**	42

THEORY

Note for the Examiner	**Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.**

SECTION- A

Heterogeneous catalyses: A brief review of catalyses catalytic specificity. Preparation of catalysts, catalyst poisoning and catalyst regeneration.
Fluid Solid catalytic reaction: Kinetics; external transport processes, Reaction -and diffusion within porous spherical catalyst pellet. Effective diffusivity, thermal conductivity and effectiveness factors.

SECTION- B

Fluid - fluid reactions rate equations and their application to the design of reactors.
Fluid Solid non-catalytic reactors rate equations and their application to the design of reactors.
Analysis of rate data design outline and selection of fixed bed, fluidised bed and slurry reactors for fluid solid catalytic reactions.

Recommended Books

1. Levenspiel, O : Chemical Reaction Engg., John Wiley
2. Fogler, H.S. : The elements of Chemical Kinetics, McGraw Hill.
3. Smith, J.M. : Chemical Engineering Kinetics, McGraw Hill.
4. Walas, S.M. : Reaction Kinetics for Chemical Engg., McGraw Hill.
5. Hills, C.J. : An Introduction to Chem. Engg., Kinetics and Reactor Design.

Title	**MASS TRANSFER-II (Theory)**			**Credits**	5
Code	CHE 309	**Semester:-**6th		**L T P**	3 1 3
Max.Marks	**End term 50**	**Mid term 50**	**Practical : 25**	**Elective**	N
Pre requisites	**-**			**Contact Hours**	42 (Theory) 14 (Practical Sessions)

THEORY

Note for the Examiner	**Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.**

SECTION- A

Absorption: Equilibria for absorption systems – use of Raoult's law, Henry's law for solubility predictions, Selection of absorbent, limiting liquid gas ratios, absorption factor use in design of plate absorbers. Kremser equation for ideal plates and translation of ideal plates to real plates using various efficiencies. Concept of transfer units for the design of packed absorbers.
Distillation: Limitations and applications, prediction of VLE using thermodynamic & experimental

techniques. Dew point & bubble point estimations for binary & multicomponent mixtures. Distillation methods – flash distillation, differential distillation for binary systems, steam distillation, optimum reflux ratio. Fractionation of binary mixtures using McCabe – Thiele method and enthalpy concentration method (Ponchon and Savarit method). Packed distillation columns. Azeotropic & extractive distillation preliminaries and molecular distillation.

SECTION- B

Liquid-Liquid Extraction: Ternary Equilibria and its representation on various plots. Selection criteria for solvent, Multistage extraction using partially miscible & immiscible solvents. Stagewise contact for countercurrent and crosscurrent extraction. Constructional details of equipment like mixer-settler, packed columns, pulsed extractor, sieve-tray extractor and centrifugal extractor.

Leaching: Preparation of solid, countercurrent and crosscurrent multistage contact Shank's system. Constructional details of equipment like Rotocel extractor, Hildebrandt extractor, Bollman extractor, Kennedy Extractor & Beet-Sugar Diffusion battery extractor.

Adsorption: Types of adsorption, nature of adsorbents, equilibria for adsorption systems. Brief manufacture and commercial applications and characteristics for common adsorbents. Stagewise & continuous contacting of fluid and solid phase. Description of contact filtration adsorption system. Hypersorber Ion-exchange system.

Crystallization: Growth and properties of crystals saturation, nucleation, growth of crystals, effect of impurities on crystal formation, effect of temperature on solubility, fractional crystallization, yield of crystals, crystal purity, yield calculation using phase diagram, energy requirements using enthalpy-concentration diagram. Methods of creating super saturation-Meirs supersolubility curve. Mechanism and methods for nucleation. Derivation for ideal growth of crystals and discussion of actual growth. Swanson-Walker and various vacuum crystallizers.

Practical

1. Determination of mass transfer coefficients for naphthalene-air system.
2. To determine drying rate curves for different wet solids in a batch drier under constant drying conditions
3. Fractional approach to equilibrium for liquid-liquid extraction from single drop.
4. Verification of Rayleighôs equation for differential distillation.
5. Determination of flooding velocities in packed columns.
6. Determination of HETP for packed distillation columns.
7. Study and operation of a pilot sized distillation column under total reflux.
8. Study of different mass transfer equipments.

Recommended Books

1. Treybal, Robert E. : Mass Transfer Operations, 3rd Edition, McGraw-Hill, 1981.
2. Sherwood,T.K., Pigford, R.L & Wilke,C.R. : Mass Transfer, McGraw-Hill, Chemical Engineering Series, 1975.
3. Skelland, A.H.P. : Diffusion Mass Transfer, John Wiley &Sons., New York, 1974.
4. McCabe, Warren L., Smith Julian C. and Harriot, H.P. : Unit-Operations of Chemical Engg., 7th Edition, McGraw-Hill, 2005.
5. King, C.J. : Separation Processes, Tata McGraw Hill Publishing Co. Ltd., New Delhi , 1982.
6. Geankoplis, C.J. : Transport Process and Separation Processes, 4th Edition, Prentice Hall Inc., New Delhi, 2003.

Title	PROCESS DYNAMICS & CONTROL			Credits	5
Code	CHE 310		Semester:-6th	L T P	3 1 3
Max.Marks	End term 50	Mid term 50	Practical : 25	Elective	N
Pre requisites	-			Contact Hours	42 (Theory) 14 (Practical Sessions)

THEORY

Note for the Examiner	**Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.**

SECTION- A

Incentives for chemical process control, design aspects of a process control system. Difference between feedback and feed forward control configuration. Hardware elements of a control system, Block Diagrams.

Laplace transform and transfer functions. Difference between lumped and distributed parameter systems, Dynamic behaviour of first and higher order systems, interacting and non-interacting systems, dead time.

Different modes of control actions and their basic characteristics, controllers and their characteristics, control valve.

SECTION- B

Closed-loop transfer functions, transient response of simple control systems, Routh stability criterion, Root Locus.

Introduction to frequency response: Bode diagrams, control system design by frequency response: Ziegler-Nichols controller settings, stability using frequency response, gain margin and phase margin.

Introduction to advanced control techniques such as cascade control, feed forward control, ratio control, inferential control.

Practical

1. U-Tube manometer
   (a) To plot the response curve for a given input to a U-tube manometer.
   (b) To determine the transfer function from the response curve obtained in part (a).
2. Time constant of a mercury thermometer
   To study the dynamics of the given thermometer and compare the theoretical value of its time constant with the experimental value.
3. Analysis of valve
   Develop a block diagram representing the dynamic bahavoiur of the given globe valve.
4. (a) Liquid level measurement
   With the given Bubbler System for Liquid Level Measurement, evaluate liquid height in the tank and compare it with actual values.
   (b) Calibration of Pressure Gauge
   Calibrate a pressure gauge in the range 0 psi to 60 psi.
5. Temperature control system

To maintain the temperature of the fluid at the set point value.

6. Time constant of liquid level tank
   To study the dynamics of liquid level in a tank and compare the analytical value of the time constant with the experimental value.
7. Liquid level control
   (a) To carry out the closed loop experiment on the given liquid level control system and record its response for step change in the inlet flow.
   (b) To plot the experimental response curve and comment on the response obtained.
8. Compurec
   Pressure control simulation with step input and sinusoidal input.

Recommended Books

1. Coughanowr, D.R. : Process Systems Analysis and Control, 2nd Edition. Mc Graw Hill, 1991.
2. Stephanopolous G. : Chemical Process Control -An Introduction to Theory and Practice, Prentice Hall of India, New Delhi, 2008.
3. Luyben W. L. and Luyben M.L.: Essentials of Process control, Mc Graw Hill International Editions, 1997.
4. Ogata K.: System Dynamics, 4th Edition, Pearson Education, 2004.
5. Harriott, P. : Process Control, TMH Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1972.

Title	**CHEMICAL TECHNOLOGY (ORGANIC)**			**Credits**	5
Code	CHE 311	**Semester:-**6th		**L T P**	3 1 3
Max.Marks	**End term 50**	**Mid term 50**	**Practical: 25**	**Elective**	N
Pre requisites	-			**Contact Hours**	42 (Theory) 14 (Practical Sessions)

THEORY

Note for the Examiner	**Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.**

SECTION- A

Oils & Fats: Introduction, Extraction of oils from vegetable oils, refining of oils and fats, hydrogenation of oils.

Soaps and Detergents: Introduction, Raw materials, Manufacture of soap, Classification of deterdents, finishing of detergents.

Water: Sources and Constraints, Consumption patterns; Impurities: dissolved, suspended, colloidal; Hardness of water; Water softening; Lime soda, Ion exchange.

Desalination: Classification of processes; Evaporative processes, Multieffect evaporation, multistage flash, vapour compression; Membrane processes, Reverse osmosis, electrodialysis.

SECTION- B

Pulp & paper: Introduction, Raw Materials, types of pulp, Manufacture of paper.

Sugar: Introduction; Sugar extraction, defacation, sulphitation, carbonation, concentration, crystallization, drying, refining; Uses of molasses and bagasse.

Carbon Technology: Introduction, Classification of activated carbons, raw materials and manufacture

of activated carbons, precursors for carbon fibres, manufacture of carbon fibres from polyacrylonitrile, manufacture of carbon black by furnace black process, applications.

Nanotechnology: Introduction and synthesis of nano particles by RF plasma process.

Practicals

1. *Oils & Fats*: Determination of Acid value, Iodine value, Saponification value.
2. *Carbohydrates*: Reducing and non reducing sugars by (i) Fehlings method (ii) Pavy's method.
3. *Soaps*: Determination of free and combined alkali, total fatty matter, moisture and insoluble.

Recommended Books

1. Shreev, R.N. & Brink, J.A. : Chemical Process Industries, 5th Edition, McGraw Hill, 1987.
2. Austine, G.T. : Shreeves Chemicals Process Industries, 5th Edition, Mc Graw Hill, 1984.
3. Dryden, C.E., Rao M.G. & Silting, M. : Outlines of Chemical Technology, 3rd Edition, Affiliated East West Press Pvt. Ltd., N. Delhi, 2008.
4. Pandey, G.N. : Chemical Technology, Volume-II, Lion Press, Kanpur.
5. Donnet J. B., Bansal R. C. : Carbon Fibres, Marcel Dekker Inc.
6. Donnet J. B., Bansal R. C., Wang M. J. : Carbon Black, Marcel Dekker Inc.
7. Bansal R. C., Donnet J. B., Stoeckli F : Active Carbon, Marcel Dekker Inc.

SEVENTH SEMESTER

Title	**Transport Phenomena**			**Credits**	3
Code	CHE 401	**Semester:-**7th		**L T P**	3 - -
Max.Marks	**End term 40**	**Mid term 35**	**Practical**	**Elective**	N
Pre requisites	**-**			**Contact Hours**	42

THEORY

Note for the Examiner	**Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.**

SECTION-A

Transport of momentum, heat and mass by molecular motion-Newton's law of Viscosity, Fourier's law of heat conduction, Fick's law of diffusion.

Transport properties – Viscosity, thermal conductivity and mass diffusivity.

Emphasis on the analogy between momentum, heat and mass transfer with respect to transport mechanism and governing equations.

Development of mathematical models of transfer process through shell momentum balance, shell energy balance and shell mass balance for solving specific problems of transport of momentum, heat and mass in laminar flow or in solids in one dimension.

SECTION-B

Development of general differential equations of fluid flow, heat transfer and mass transfer and their applications in solving one-dimensional steady state and unsteady state problems of momentum, heat and mass transfer.

Interphase transport of momentum, heat and mass and dimensionless correlation for each one of them.

Momentum, heat and mass transfer analysis.

***Books Recommended*:**

1. Bird, R.B., Stewart, W.E. and Lightfoot, E.N. : Transport Phenomena, 2nd Edition, John Wiley & Sons, 200
2. Weity, J.R. Wilson, R.E. and Wicks, C.E. : Fundamentals of Momentum Heat and Mass Transfe Edition, John Wiley & Sons, 2001.
3. Bennett.C.O. and Myres J.E. : Momentum, Heat and Mass Transfer, McGraw Hill.

Title	**Environmental Engineering**			**Credits**	5
Code	CHE 402	**Semester:-**7th		**L T P**	3 1 3
Max.Marks	**End term 50**	**Mid term 50**	**Practical: 25**	**Elective**	N
Pre requisites	**-**			**Contact Hours**	42 (Theory) 14 (Practical Sessions)

THEORY

Note for the Examiner	**Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.**

SECTION-A

Ambient air and water standards. Principal sources of pollution.

Inter-relationship between energy and environment pollution. Prevention of environmental pollution

through conservation, raw material substitutions, process and equipment modifications. A case study on the concept of zero discharge.

Air Pollution:

- Principal air pollutants and their usual sources.
- Effect of air pollutants on human health, animals, vegetation and materials.
- Atmospheric dispersion of air pollutants, temperature inversions, Estimation of pollutants by Gaussian plume model.
- Process and equipments used for the control of particulate pollutants.

SECTION-B

Water Pollution:

- Types of water pollutants, their sources and effects.
- BOD and COD
- Waste water treatment techniques and equipments, flocculation, skimming, floatation, etc.
- Primary Treatment-through settling.
- Secondary Treatment-Aerobic and anaerobic digestion, activated sludge process, trickle filter and oxidation ponds.

Solid wastes: Control and disposal, sanitary landfill, incineration, pyrolysis gasification and recycling.

***Books Recommended*:**

1. Perkins, H.C. : Air Pollution, McGraw Hill, N.Y.
2. Rao, C.S. : Environmental Pollution Control Engineering, 2nd Edition, New A International Pvt. Ltd., 2006.
3. Williamson, S.J. : Fundamental of Air Pollution, Addison Wesley Co. N.Y.
4. Numerow, N.L. : Liquid Wastes of Industry, Addison Wesley Co., N.Y.
5. Sincero, A.P. and Sincero, G.A. : Environmental Engineering, Prentice-Hall of India, 1999.
6. Hammer, M.J. and Jr. Hammer, M.J. : Water and Wastewater Technology, 6th Edition, Prentice-Hall India, 2008.
7. Mahajan, S.P. : Pollution Control of Process Industries, Tata McGraw Hill.
8. Metcalf and Eddy : Waste-Water Engineering, 4th Edition, Tata McGraw Hill, 2007.

Environment Engineering Laboratory (PRACTICALS)

1. To find BOD of water sample.
2. To find COD of waste sample.
3. To find the total dissolved solids (TDS) and its volatile and non-volatile components.
4. To find the total suspended solids (TSS) and its volatile and non-volatile components.
5. To do the chromium separation by different techniques from electroplating wastes.
6. To find the phenol content of water sample and evolution of parameters.
7. To operate the electrodialysis apparatus.
8. To find the biodegradation constant (K) and the effect of timing on it.
9. To use the membrane separation techniques for salt brine and reverse osmosis process for sugar.
10. To use stack monitoring kit to find:
    a. Efficiency of a cyclone.
    b. Dust sampling.

Note: Any six of the above mentioned experiments are to be conducted.

Title	Process Modelling & Simulation			Credits	1
Code	CHE 403	Semester:-7th		L T P	- - 3
Max.Marks	End term	Mid term	Practical:25	Elective	N
Pre requisites	-			Contact Hours	14 (Practical Sessions)

Practical

Functional design, property estimate as inputs for design. System concepts for computer aided design, computer aided flow sheet design. Process analysis. Process variables selection, equipment design through the selection of free parameters subject to constraints and other parameters, modular design. Simulation optimality. Dynamic design including control stability.

Typical equipments to be considered: heat exchangers, distillations columns, reactor and process equipments.

***Books Recommended*:**

1. Luyben, W.L. : Process Modeling, Simulation & Control, Mc Graw-Hill Book Co.
2. Franks, R.G. E. : Modeling and Simulation in Chemical Engineering, Wiley Interscience.
3. Mischke, C. : Computer Aided Design, Prentice Hall.

Title	Process Plant Design-II			Credits	1
Code	CHE 405	Semester:-7th		L T P	- - 3
Max.Marks	End term	Mid term	Practical:25	Elective	N
Pre requisites	-			Contact Hours	14 (Practical Sessions)

Practical

1. Process design and specifications of double pipe heat exchanger, shell and tube heat exchanger, plate type heat exchanger, condenser and reboiler.
2. Design of distillation column, calculation of number of plates, height and design of fractionator internals- sieve tray.
3. Absorber/Stripper design of stage-wise and continuous contact equipment (packed column), height of column and diameter calculations. HTU and NTU.
4. Design aspects of fixed bed reactors and fluidized bed reactors.

***Books Recommended*:**

1. Coulson, Richardson & Sinnott, R.K. : Chemical Engineering, Volume 6 – An Introduction to Che Engineering Design, 4th Edition, Pergamon Press, 2007.
2. Ludwig, E.E. : Applied Process Design in Chemical and Petrochemical P 2nd Edition, 1977.
3. Perry, J.H. : Chemical Engineers Handbook, 8th Edition, McGraw Hill, 20
4. Kern, D.Q. : Process Heat Transfer, McGraw Hill, 1965.
5. Shell and Tube Type Heat Exchangers, Indian Standards. : Instt., IS: 43-197.
6. Treybal, Robert E. : Mass Transfer Operations, 3rd Edition, McGraw- 1981.

7.	Levenspiel, O.	:	Chemical Reaction Engineering, 3rd Edition, John Wiley and Sons, 2004.
8.	Walas, S.M.	:	Reaction Kinetics for Chemical Engg., McGraw Hill.
9.	Scott Fogler, H.	:	Elements of Chemical Reaction Engineering, 4th Edition, Prentice Hall, 2007.

EIGHT SEMESTER

Title	**Process Instrumentation**			**Credits**	4
Code	CHE 407	**Semester:-**8th		**L T P**	3 1 -
Max.Marks	**End term 50**	**Mid term 50**	**Practical**	**Elective**	N
Pre requisites	-			**Contact Hours**	42

THEORY

Note for the Examiner	**Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.**

SECTION-A

General Concept: Need and classification of measurements and instruments, Basic and auxiliary functional elements of a measurement system.

Static and Dynamic Characteristics of Instruments:

Static Characteristics: Range and span, accuracy and static error, reproducibility and drift, sensitivity and dead zone.

Dynamic Characteristics: Speed of response and lag, fidelity and dynamic error, dead time.

Temperature measurement:

Thermal expansion methods – bimetallic thermometers, liquid-in-glass thermometer and filled-in-system thermometers.

Thermocouples, metal resistance thermometers and thermistors, optical and radiation pyrometers, radiation receiving elements.

Pressure measurement:

Use of manometers, Bourdon gauge, bellows type gauge. Vacuum measurement–Mcleod gauge, thermoionic type ionization gauge, pirani vacuum gauge. Measurement of pressure in corrosive fluids: Diaphragm seal, liquid seal and purge system.

SECTION-B

Liquid level measurement:

Direct measurement of liquid level –Float & tape liquid level gauge, float and shaft liquid level unit, hydraulic remote transmission of liquid level.

Level measurement in open vessels: Bubbler system, diaphragm box system, air trap system. Level measurement in pressure vessels – Differential pressure manometer, use of liquid seals with a manometer, displacement float liquid level gauge. (6 Hrs.)

Measurement of viscosity, conductivity, humidity and pH.

Density measurement – liquid level method, displacement meter and hydrometer.

Measurement of weight – spring scale, pneumatic force meter and hydrostatic force meter.

Process Instrumentation–Recording instruments, indicating and signaling instruments, control centre, transmission of instrument reading, instrumentation diagrams.

***Books Recommended*:**

1. Eckman, Donald P. : Industrial Instrumentation, CBS Publisher and Distributors, Indian F 2004.
2. Singh, S.K. : Industrial Instrumentation and Control, 2nd Edition, Tata McGraw – Hill, 2007.
3. Considine, D.N. : Process Instruments and Controls Handbook 2nd Edition, McGraw Hill,
4. Fribance, A.E. : Industrial Instrumentation Fundamentals, Tata McGraw – Hill Publish

Ltd., 1962.
5. Patranabis, D. : Principles of Industrial Instrumentation, 2nd Edition, Tata McGraw Hill Publishing Co. Ltd., 1999.

Title	**Process Engineering Economics**			**Credits**	4
Code	CHE 408	**Semester:-**8th		**L T P**	3 1 -
Max.Marks	**End term 50**	**Mid term 50**	**Practical**	**Elective**	N
Pre requisites	**-**			**Contact Hours**	42

THEORY

Note for the Examiner	**Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.**

SECTION-A

Cost estimation: Factors affecting investment and production costs. Capital investments, fixed investments and working capital. Cost indices. Estimating equipment costs by scaling 6/10 factor rule. Methods for estimating capital investment. Estimation of total product cost. Different costs involved in the total product costs. Different cost involved in the total product for a typical chemical process plant.

Interest and Investment Costs: Simple and compound interest. Nominal and effective rates of interest. Continuous interest ordinary annuity. Perpetuities and capitalized costs.

Taxes and Insurance: Types of taxes and tax returns, types of insurance and legal responsibility.

Depreciation: Types of depreciation. service life salvage value, present value and methods of determining depreciation, single unit and group depreciation.

SECTION-B

Profitability, Alternative Investments and Replacements: Mathematical methods of profitability evaluation. Cash flow diagrams. Determination of acceptable investments. Alternatives when 'an investment must be made and analysis with small increment investment, replacement. Breakeven analysis. Balance sheet and income statement.

Optimum Design: Procedure with one variable, optimum reflux ratio in distillation and other examples.

Preliminary Steps in Plant Design: Plant design factors. project organization, plant location, preliminary data collection, process engineering

***Books Recommended*:**

1. Peters, M.S. & Timmerhaus, K.D. : Plant Design and Economics of Chemical Engineers, Mc Graw Hill New York, 4th Edition, 1991.
2. Ulrich, G.D. : A Guide to Chemical Engineering Process Design & Economics, John Wiley, 1984.
3. Guthrie, K.M. : Process Plant Estimating, Evaluation & Control, Craftsman Solano Beach, Calif, 1947.
4. Jelen, F.C. : Cost and Optimisation Engineering, McGraw Hill, New York, 1970.
5. Holland, F.A. & Wastson, F.A. : Introduction to Process Economics, 2nd Edition, Wiley, 1983.
6. Bassel, W.D. Preliminary Chemical Engineering Plant Design, Elsevier, New York 1976.

Paper Title : PROJECT WORK
Paper Code CHE 406

Each student is required to submit a project report on the design of a chemical plant, selecting the best process with optimum equipment size and operating conditions. The object is to test the ability of the student to apply his entire knowledge of Chemical Engineering principles to conceptualize, analyze and solve the problems. To judge his knowledge and originality and capacity for application of laboratory data in designing chemical plants and to determine the level of his proficiency at the end of the course.

Title	**COMPREHENSIVE VIVA**			**Credits**	01
Code	CHE 409	**Semester:-**8th		**L T P**	- - -
Max. Marks	**End term--25**	**Mid term- -**	**Practical-**	**Elective**	N
Pre requisites				**Contact Hours**	
The viva-voce examinations will be comprehensive and covering mainly chemical engineering and technology subjects covered during all the semester including the Eight Semester.					

Title	**Literature Survey, Report Writing & Seminar**			**Credits**	**No Credit**
Code	CHE 410	**Semester:-**8th		**L T P**	- - 3
Max.Marks	**End term**	**Mid term**	**Practical: s or x**	**Elective**	N
Pre requisites	**-**			**Contact Hours**	14 (Practical Sessions)

Practical

Forms of technical reports: aims and forms according to type of readership and extent of circulation. Abstracts, extended abstracts, tables, graphs. Visual representation of data: slides, microfilms, others techniques including those of audio-visual representation. Correct use of audio equipment.

Research papers and their presentation and publication. Information retrieve direct and through abstracts.

Practical training in writing and presentation of technical reports through audio-visual means. Technique of effective public speaking organized and imprompt discussions.

Preparation of technical report on an assigned topic after survey of scientific, technical and commercial literature, using card indexes, microfilms and other information retrieval methods.

Use of Computer softwares for report writing.

***Books Recommended*:**

1. Mikdran, A.M. : Use of Engineering Literature, Butter Worths.
2. Sottle, R.T. : The Use of Chemical Literature, Butter Worths.
3. Hoover, H. : Essentials For TheTechnical Writer, John Wiley.
4. Robertson, W.S. & Siddle, W.D. : Technical Writing and Presentation, Pergamon.

Paper Title: Open Elective (Theory)

Course Duration: 42 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

FUEL CELL TECHNOLOGY (Theory)

Section-A

Overview of fuel cells: Low and high temperature fuel cells;
Fuel cell thermodynamics - heat, work potentials, prediction of reversible voltage, fuel cell efficiency.
Fuel cell reaction kinetics - electrode kinetics, overvoltages, Tafel equation, charge transfer reaction, exchange currents,
Electrocatalyses - design, activation kinetics,
Fuel cell charge and mass transport - flow field, transport in electrode and electrolyte.

Section-B

Fuel cell characterization: - in-situ and ex-situ characterization techniques, i-V curve, frequency response analyses; Fuel cell modeling and system integration: - 1D model - analytical solution and CFD models. Balance of plant; Hydrogen production from renewable sources and storage; safety issues, cost expectation and life cycle analysis of fuel cells.

Books Recommended

Text books:
1. O'Hayre, R.P.,S. Cha, W. Colella, F.B.Prinz, Fuel Cell Fundamentals, Wiley, NY (2006).
2. Basu,S.(Ed) Fuel Cell Science and Technology,Springer, N.Y.(2007).
3. Liu, H.,Principles of fuel cells, Taylor & Francis, N.Y. (2006)

Reference Books:
4. Bard,A. J. , L. R., Faulkner,Electrochemical Methods, Wiley, N.Y.(2004)

NANO TECHNOLOGY (Theory)

Section-A

Introduction: Plenty of room at the bottom-Feynman's concept, evolution of ultra-fine materials, the missing link between conventional laws in physics and chemistry and new theories.
Building Blocks of Nanotechnology: covalent architecture, coordinated architecture and weakly bound aggregates, Interactions and topology
Chemical Properties: The effect of nanoscale metals on chemical reactivity, effect of nanostructure on mass transport, metal nanocrystallites support on oxides, supported nanoscale catalysts.

General principles for synthesis of monodispersed nanoparticles, metals and intermetallics, Ceramics, composites, nanoparticles, colloids/Micelles/vesicles/Polymers/glasses, Crystalline, and zeolite hosts.
Review of fundamental behaviour of 0-D(nanoclusters), 1-D(nanowires), 2-D(thin film multilayers), and 3-D(bulk nanostructures) materials. Introduction to size dependent phenomenon in nanostructure for various applications, specific production techniques like chemical vapor deposition, arc ignition etc. Formation of clusters and nanoparticles from supersaturated vapor and selected properties,

sputtering and thermal evaporation and laser methods. Synthesis of nanoparticles by chemical routes.

Section-B

Approches to production: Top down and bottom up, Mechanical attrition, high energy ball milling, and mechanical attrition, nanocomposites by mechano-chemistry, mechanism of grain size reduction, property of microstructure relationships.
Characterization techniques : Tools in nanotechnology: Scanning electron microscopy(SEM), Transmission electron microscopy and high resolution(TEM), energy dispersive spectroscopy (EDX), Atomic force microscopy(AFM), Magnetic force microscopy(MFM), Chemical Force Microscopy(CFM), Focused ion beam, nanolithography, powder x-ray diffractometry, UV visible.

Nanomaterials: CNTs, Polymer Nanocomposites nanoceramics, nanometals, nanopolymers, structures-properties-applications, Quantum dots. Concepts Bio-Nanotechnology.
Applications: Nanotherapeutics, Molecular diagnostics, tissue engineering, nanopumps, nanorobtoics cells, molecular motors, nanomembranes, Organic molecular based computers, bionanodevices (sensors & actuators).]

Books Recommended

1. Nanoscale Materials in Chemistry by Kenneth J. Khabhunde (ed.) Wiley Interscience.
2. Nanotechnology – An introduction to nanostructure of technique by Michel Kohler and Wolfgang Frittsche 2004- Wiley VCH
3. Springer Handbook of Nanotechnology by Bharat Bhushan
4. Encyclopedia of Nanotechnology- Hari Singh Nalwa.
5. Nanostructures and Nanomaterials by G. Cao, Imperial College Press, 2004
6. Introduction to Nanotechnology by Owen and Poole, Wiley
7. Nano-materials by A. K. Bandopadhyay, New Age International

POLYMER SCIENCE AND ENGINEERING (Theory)

Section-A

Chemistry of polymers:
Monomers, functionality, degree of polymerizations, classification of polymers, glass transition, melting transition, criteria for rubberiness,
Polymerization methods: addition and condensation; their kinetics, copolymerization, monomer reactivity ratios and its significance, kinetics, different copolymers, random, alternating, azeotropic copolymerization, block and graft copolymers, techniques for copolymerization-bulk, solution, suspension, emulsion.

Polymer Characterization:
Solubility and swelling, concept of average molecular weight, determination of number average, weight average, viscosity average and Z-average molecular weights, polymer crystallinity, analysis of polymers using IR, XRD, thermal (DSC, DMTA, TGA), microscopic (optical and electronic) techniques.

Section-B

Polymer Technology:
Polymer compounding-need and significance, different compounding ingredients for rubber and plastics, crosslinking and vulcanization

Polymer processing:
Compression molding, transfer molding, injection molding, blow molding, reaction injection molding, extrusion, pultrusion, calendaring, rotational molding, thermoforming, rubber processing in two-roll mill, internal mixer.

Books Recommended:

1. Williams, D.J. : Polymer Science and Engineering, Prentice Hall Inc.
2. Rodriguez, F. : Principles of Polymer Systems, Tata McGraw Hill Pub.
3. Odian,G. : Principles of Polymerization, McGraw Hill.
4. Collins, E.A., Bares, J. & Billmeryer, F.W., Experiments in Polymer Science, Wiley Inter Science.
5. Kumar, A. & Gupta, S.K. : Fundamental of Polymer Science and Engineering, Tata McGraw Hill Pub.
6. Middleman, S. : Fundamentals of Polymer Processing, McGraw Hill, New York.
7. Moore, G.R. and Kline, D.E., "Properties and Processing of Polymers for Engineers", Society of Plastics Engineers, Prenticeï Hall, Englewood Cliffs, NJ, 1984
8. Tadmor, Z. and Gogos, C.G.: Principles of Polymer Processing, John Wiley & Sons, 1979.

OPERATIONS RESEARCH (Theory)

Section-A

Linear Programming: problem formulation, graphical method, simplex method, duality sensitivity analysis.
Transportation model, Transhipment problem, traveling salesman problem, Assignment models, Sequencing model, Replacement model.

Section-B

Theory of Games: Pure strategy games, principle of dominance; mixed strategy games (Algebraic, Graphical & Linear programming method), 2-person, non-zero- sum games.

Queuing Theory: Introduction, elementary queuing system; single channel queuing model, queuing cost behaviour, multiple channel queuing model, Poisson arrivals and Erlang service distribution; benefits and limitations of queuing theory.

Books Recommended:

1. Vohra, N.D. : Quantitative Techniques in Management; 2nd Edition, Tata McGraw Hill.
2. Gupta, P.K. and Hira, D.S. : Operation Research, S. Chand, New Delhi.
3. Swarup Kanti, Gupta, P.K. and Man Mohan : Operation Research, 12th revised Edition, Sultan Chand & Sons, New Delhi;

SUPPLY CHAIN & LOGISTIC MANAGEMENT (Theory)

Section-A

Introduction to Supply Chain Management: Definition; Scope & Importance of Supply Chain Management; Key drivers Of the SCM; Features of Supply Chain Management; Supply Chain Network –

1st Tier , 2nd Tier; Network decisions in SCM; Suppliers and Customers; Customer Service Dimension (Seven "R" Principles, Service after sale, Customer delight)

Role of Logistics in Supply Chains: Definition of Logistics Management; Scope and role of Transportation, Traffic & transportation; Relationship between transportation and other business functions, Transport Economics: Distance – volume-density, Freight Cost, Handling, Liability, market factors; Third party logistics (3 PL) & fourth party logistics service provider (4 PL), Logistics equipment; Reverse Logistics, Government rule & regulations related to Logistics; Purchase Cycle, Make or Buy, Price analysis, Negotiations.

Section-B

Inventory Management: Inventory Control, Planning & Managing Inventories; Warehouse Management (Receipt, issue, storage and preservation, stock verification, In bound and out bound distribution operations); Order Management; Competitive advantage through logistics and supply chain management; Responsive Supply Chain; Supply chain process integration, performance measurement; Value Chain, Value System and Supply Chain.

Planning demand and supply: Planning & Sourcing in Supply Chain, Demand forecasting, Type and Time horizon of forecast and category of forecasting, aggregate planning; Financial issues in Supply Chain - Macro and micro view, Asset management, Du Pont Model, Supply Chain Costing; Decision environment in SCM; Global supply chain perspectives - New business models, role of IT in SCM.

Books Recommended:

1. Harald Dyckhoff et al, Ed.: Supply Chain Management and Reverse Logistics, Springer (India).
2. Jayashree Dubey and M.L. Saikumar Ed.: Supply Chain Management, IIPE Hyderabad and New Century Publication.
3. Sarika Kulkarni, Ashok Sharma: Supply Chain Management-Creating Linkages for Faster Business Turnaround, McGraw Hill.
4. RP Mohanty: Supply Chain Management-Theories and Practice, Biztantra.
5. Robert B. Handfield, Ernest L. Nicholas, Jr.: Introduction to Supply Chain Management,Pearson Education.
6. Ronald H. Ballou, Samir K. Srivastava: Business Logistics/Supply Chain Management, Pearson Education.
7. John Mentzer: Supply Chain Management, Response Books.
8. Janat Shah: Supply Chain Management, Pearson Publications.
9. N. Chandrasekaran: Supply Chain Management - Process, System and Practice, Oxford Press.

PROJECT MANAGEMENT AND ENTREPRENEURSHIP (Theory)

Section-A

Introduction to Projects: Meaning & Definition of Project, Attributes of a Project, Difference among Projects, Routine Activities and Programs; Project Life Cycle

Project Planning: Work Breakdown Structure, Types of Work Breakdown Structure, Planning Framework and Its Importance

Project Feasibility: Marketing, Technical & Financial Feasibility

Social Cost Benefit Analysis: Rationale, UNIDO and Little Mirrlees Approaches

Project Schedule Planning; Network Analysis Techniques; Project Implementation; Project Monitoring & Control

Section-B

Entrepreneur- Meaning & Definition of Entrepreneur, Characteristics of Entrepreneur, Nature and importance of Entrepreneur, Functions, Entrepreneur V/s Manager, Women Entrepreneurs.

Entrepreneurship: Concept, Policies Governing Entrepreneurs, Entrepreneurial Development Programmes, Contribution of Entrepreneurship to Economic Development

Institutions for Entrepreneurial Development; Role of Various Commercial Banks and Development financial Institutions.

Books Recommended:

1. UNIDO: Guidelines for Project Evaluation, United Nations, reprinted,1993..
2. Mannual for the preparation of Industrial Feasibility Studies, United Nations 1995.
3. Manual for Evaluation of Industrial Projects, United Nations, reprinted on 1993..
4. IMD little and J.A. Mirrlees: Project Apraisal and Planning in Developing Countries, 1975.
5. Prasanna Chandra: Projects: Preparation, Appraisal Budgeting and Control, 7th edition, TMH.
6. Vasanta Desai: Dynamics of entrepreneurial development and management, 11th edition, Himalaya pub.
7. Vasanta Desai: Entrepreneurial development, and Management, 13th edition, Himalaya pub., Harper Collins, edition- Paperback.
8. Peter F. Drucker: Innovation and development.

Paper Title: Departmental Elective (Theory)

Course Duration: 45 Lectures of one hour each.

Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

PETROLEUM PROCESSING ENGINEERING (Theory)

Section-A
Introduction to petroleum industry, world petroleum resources, petroleum industry in India. Origin, exploration & drilling of petroleum crude. Transportation of crude and products. Crude pretreatment: Refining and distillation of petroleum crude, composition and classification of petroleum crude, methods of evaluation: ASTM, TBP and EFV distillation. Properties and specifications of petroleum products such as LPG, gasoline,naphtha, kerosene, diesel, lubricating oils and waxes.
Section-B
Separation Processes: Design and operation of topping and vacuum distillation units and tube still furnaces. Solvent extraction processes for lube oil base stock and for aromatics from naphtha and

kerosene steams, solvent dewaxing.
Conversion Processes: Thermal cracking: visbreaking and coking processes, catalytic cracking, thermal reforming and catalytic reforming, alkylation, polymerization, isomerisation and hydroprocessing.
Safety and pollution considerations in refineries.

Practicals

1. To plot ASTM distillation curve for gasoline, diesel oil.
2. To determine Flash point (Closed – cup) and smoke point for kerosene.
3. To determine Aniline point, Diesel Index and cetane number for diesel oil.
4. To determine pour point and cloud point for furnace oil and diesel oil.
5. To determine viscosity at different temperatures using Ostwald viscometer for hydrocarbon solvents.
6. To determine softening point and penetration number for asphalt and grease samples.
7. To determine viscosity index of lubricating oil by Redwood viscometer.
8. To determine water content in petroleum products by Dean and Starks method.

Books Recommended:

1. Nelson, W.L. : Petroleum Refinery Engineering, 5th Edition, McGraw Hill, 1985.
2. Rao, B.K. : Modern Petroleum Refining Processes, 5th Edition, Oxford & I Publishing Co., 2009.
3. Guthrie, V.B. : Petroleum Products Handbook, McGraw Hill, 1960.
4. Hobson, G.D., Pohl. W. : Modern Petroleum Technology, 5th Edition, John Wiley, 1984.

INDUSTRIAL SAFETY & HAZARDS (Theory)

Section-A

Definition, identification, classification and assessment of various types of hazards in work-place environment, protective and preventive measures in hazard control.
Toxic Chemicals: maximum allowable concentrations and other standards. Biological threshold limit values.
Mechanical and electrical hazards. Personal protective equipments. Explosives and inflammable substances. Radioactive hazards. Fire prevention. Good housekeeping in industrial environment.

Section-B

Standard safety procedures and disaster control. Indian Legislation on safety and prevention of hazards and safety code: ISO 14000. Environmental impact assessment. Control strategies for hazardous wastes.
Case Studies of typical hazardous industries.

***Books Recommended*:**

1. Wills, G.L. : Safety in Process Plant Design.
2. Less, F.P. : Loss Prevention in Process Industries.
3. Chanleft, E.T. : Environmental Protection.
4. Berhowex, P.M. & Rudd, D.F : Strategy of Pollution Control.
5. Safety for Chemical Engineers : A.I.Ch.E. Publications, 1976-77.

PLANT UTILITIES (Theory)

Section-A

Importance of Process utilities in Chemical Plant.
Compressed air and Vacuum: Reciprocating air compressors, vacuum pumps, air receivers, piping systems.
Steam: Boiler, steam handling and distribution steam nozzles.

Section-B

Refrigeration: Air refrigeration cycle, vapour compression cycle, liquification processes.
Power Generation: Internal Combustion engines. Gas turbines, steam power plants.
Water: Water Resources, storage & distribution of water reuse & conservation of water.

***Books Recommended*:**

1. Jouganson, R. : Fan Engineering, Buffalo Rorge Co., 1970.
2. Wangham, D.A. : Theory and Practice of Heat Engines, ELBS Cambridge University Press, 1960.
3. Lyle, O. : Efficient Use of Steam, HMSO, 1963.
4. Stoccker, W.F. : Refrigeration and Air Conditioning, Mc-Graw Hill, 1950.
5. Kurl, W.F. J.H.M. : Reuse of Water in Industry, Butterworth, London.

PETROCHEMICAL TECHNOLOGY (Theory)

Section-A

General Introduction: Definition, history and economic perspective of petrochemical industry, raw materials for petrochemical industry-petroleum, natural gas, coal, bio-mass, agro-residues, etc.
First Generation Petrochemicals: Petrochemicals based on aliphatic, olefinic, acetylene,aromatics, etc. Hydrocarbons-processing and applications.
Second Generation Petrochemicals: Products based on Synthesis Gas, Method, Ethanol,Ethylene Oxide, Vinyl Chloride, Propylene Oxide, Isopropyl Alcohol, Acetone, AllylAlcohol, Glycerol, Phenol, Aniline.

Section-B

Nylon Monomers, Polyester Monomers, Styrene, Other Monomers - Bisphenol A, Epichlorophydrin, diisocyanates, Pentaerythritol, etc. - properties,process technologies and applications. .
Third Generation Petrochemicals: Important Polymers such as Polyethylene, Polypropylene and their Copolymers and other Derivatives Rubbers, Diene Polymers, Styrene Polymers,Vinyl Polymers and Condensation Polymers - properties, process technologies and applications.

***Books Recommended*:**

1. Steiner, H.: Introduction to Petroleum Chemicals, Pergamon Press.
2. Waddane, A.L. : Chemicals from Petroleum, John Murry.
3. Topchiev, A.V. : Synthetic Materials from Petroleum, Pergamon Press.
4. Astle, M.J. : The Chemistry of Petrochemicals, Reinhold.
5. Maiti, S.: Introduction to Petrochemicals, Oxford and IBH Pub. Co. Ltd., New Delhi, 1992.
6. Frank, H.G. & Stadelhofer, J.W.: Industrial Aromatic Chemistry, Springer Verlag Berlin, 1987.

BIOCHEMICAL ENGINEERING (Theory)

Section-A

Isolation and Utilization of Enzymes: Purification, immobilization, application of enzyme technology.

Kinetics of Enzyme-Catalyzed Reactions: The substrate, enzyme kinetics, factors affecting enzymatic activity and enzymatic reactions in heterogeneous reactions.

Metabolic Pathways and Energetics of the Cell: The concept of energy coupling, aerobic and anaerobic metabolism, photosynthesis and biosynthesis, transport across cell membranes.

Cellular Genetics and Control: Growth and reproduction of a single cell, alteration of cellular DNA, commercial applications.

Section-B

Kinetics of Substrate Utilization. Product Yield and Biomass Production: Growth cycle for batch cultivation and its mathematical modeling, products synthesis kinetics, thermal death kinetics of cells and spores.

Transport Phenomena in Microbial Systems: Gas-liquid mass transfer, determination of oxygen transfer rates, mass transfer, surface-area correlations for mechanically agitated vessels, scaling of mass transfer equipment, particulate mass transfer, heat transfer.

Design and Analysis of Biological Reactors: The ideal continuous-flow stirred-tank reactor (CSTR), residence time distribution, different types of reactors, relationship between batch and continuous biological reactors. Fermentation technology, product manufacture by fermentation, reactors for biomass production.

Books Recommended:

1. Balley & Ollis : Biochemical Engineering Fundamentals, McGraw Hill Book Co., 1986.
2. Aiba Humphrey & Millis : Biochemical Engineering, Academic Press, 1973.
3. Whitaker Stanbury & Whitaker, Hall : Principles of Fermentation Technology, Adita Books, New Delhi, 1997.