



**DEPARTMENT OF CHEMICAL ENGINEERING**  
**B.M.S. COLLEGE OF ENGINEERING, BENGALURU**  
Autonomous College under VTU

<b>VISION</b>	<b>MISSION</b>
PROMOTING PROSPERITY OF MANKIND BY AUGMENTING HUMAN RESOURCE CAPITAL THROUGH QUALITY TECHNICAL EDUCATION & TRAINING	ACCOMPLISH EXCELLENCE IN THE FIELD OF TECHNICAL EDUCATION THROUGH EDUCATION, RESEARCH AND SERVICE NEEDS OF SOCIETY

**DEPARTMENT OF CHEMICAL ENGINEERING**  
**Program Accredited by NBA in Tier-1 format for 5 years**

**SCHEME AND SYLLABUS BOOK**  
**for the Batches**  
**2014-18, 2015-19, 2016-20, 2017-21**

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**DEPARTMENT VISION**

Be a globally recognized Chemical Engineering Department by imparting quality education

**DEPARTMENT MISSION**

- High-quality education and experience to the budding Chemical Engineers
- Chemical Engineering graduates to assume positions in process and other allied industries
- Foster and encourage the pursuit of excellence in chemical science and engineering
- Inculcate global research potential

**PROGRAM EDUCATIONAL OBJECTIVES (PEOs)**

PEO1: Graduates pursue profession in chemical & allied engineering

PEO2: Graduates work in diversified team

PEO3: Graduates will pursue higher education & research

**PROGRAM SPECIFIC OUTCOMES (PSOs)**

PSO1: Graduates will be able to separate and purify petrochemicals, pharmaceuticals and health care products

PSO2: Graduates will automate and control processes by applying mathematics, process control, instrumentation, simulation and process modelling

PSO3: Graduates will design equipment for modern science applications



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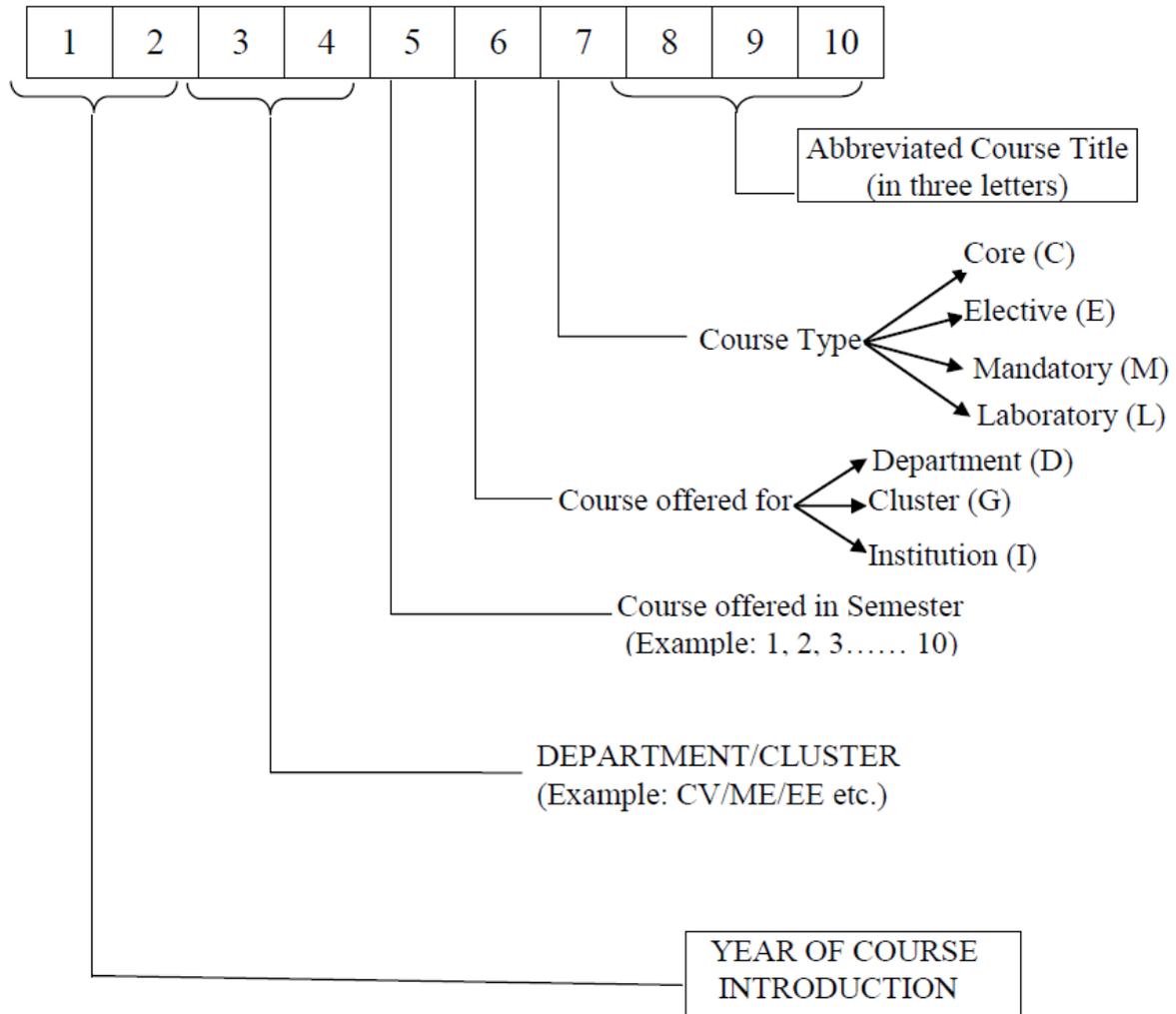
**PROGRAM OUTCOMES (POS)**

PO1	<b>Engineering knowledge:</b> Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
PO2	<b>Problem analysis:</b> Identify, formulate, review research literature, and analyze complex Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	<b>Design/development of solutions:</b> Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	<b>Conduct investigations of complex problems:</b> Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
PO5	<b>Modern tool usage:</b> Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	<b>The engineer and society:</b> Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	<b>Environment and sustainability:</b> Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	<b>Ethics:</b> Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	<b>Individual and team work:</b> Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	<b>Communication:</b> Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	<b>Project management and finance:</b> Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	<b>Life-long learning:</b> Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.



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**NOMENCLATURE FOR THE COURSE CODE**





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**SCHEME OF INSTRUCTION FOR THIRD SEMESTER**

Sl. No.	Subject Code										Subject Title	Credit Hours/Week				
												L	T	P	S	Total
1.	1	5	M	A	3	G	C	A	P	M	Applied Mathematics	3	1	0	0	4
2.	1	5	C	H	3	D	C	C	T	N	Chemical Technology	3	0	0	0	3
3.	1	5	C	H	3	D	C	F	M	E	Fluid Mechanics	3	0	1	2	6
4.	1	5	C	Y	3	D	C	C	E	M	Technical Chemistry	3	0	1	0	4
5.	1	5	C	H	3	D	C	M	O	P	Mechanical Operations	3	0	1	2	6
6.	1	5	C	H	3	D	C	M	S	B	Material Science and Biomaterials	2	0	0	0	2
	Total											17	1	3	4	25

**SCHEME OF INSTRUCTION FOR FOURTH SEMESTER**

Sl. No.	Subject Code										Subject Title	Credit Hours/Week				
												L	T	P	S	Total
1.	1	5	M	A	4	D	C	S	A	P	Statistics and Probability	3	1	0	0	4
2.	1	5	C	H	4	D	C	E	Q	D	Chemical Process Equipment Drawing	2	0	0	0	2
3.	1	5	C	H	4	D	C	P	T	D	Process Engineering Thermodynamics	3	1	0	0	4
4.	1	5	C	H	4	D	C	H	T	R	Process Heat Transfer	3	0	1	2	6
5.	1	5	C	H	4	D	C	P	P	C	Process Principles and Calculation	3	1	0	0	4
6.	1	5	C	H	4	D	C	A	I	A	Analytical Instruments for Analysis	2	0	1	2	5
	Total											16	3	2	4	25



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**SCHEME OF INSTRUCTION FOR FIFTH SEMESTER**

Sl. No	Subject Code										Subject Title	Credit Hours/Week				
												L	T	P	S	Total
1.	1	6	C	H	5	D	C	C	R	1	Chemical Reaction Engineering-I	3	0	1	2	6
2.	1	6	C	H	5	D	C	M	T	1	Mass Transfer-I	3	0	1	2	6
3.	1	6	C	H	5	D	C	C	E	D	Chemical Equipment Design	3	1	0	0	4
4.	1	6	C	H	5	D	C	P	C	M	Pollution Control & Management	3	0	0	0	3
Group A																
5.	1	6	C	H	5	D	E	L	A	1	Food Engineering	3	0	0	0	3
	1	6	C	H	5	D	E	L	A	2	Petroleum Refining					
Group B																
6.	1	6	C	H	5	D	E	L	B	1	Nano Materials and Technology	3	0	0	0	3
	1	6	C	H	5	D	E	L	B	2	Polymer Materials & Processing					
	Total											18	1	2	4	25

**SCHEME OF INSTRUCTION FOR SIXTH SEMESTER**

Sl. No	Subject Code										Subject Title	Credit Hours/Week				
												L	T	P	S	Total
1.	1	6	C	H	6	D	C	C	R	2	Chemical Reaction Engineering-II	3	0	0	0	3
2.	1	6	C	H	6	D	C	P	C	E	Process Control Engineering	3	0	1	2	6
3.	1	6	C	H	6	D	C	M	T	2	Mass Transfer-II	3	0	1	2	6
4.	1	6	C	H	6	D	C	T	R	P	Transport Phenomena	3	1	0	0	4
Group C																
5.	1	6	C	H	6	D	E	L	C	1	Numerical Techniques in Chemical Engineering	3	0	0	0	3
	1	6	C	H	6	D	E	L	C	2	Operations Research					
Group D																
6.	1	6	C	H	6	D	E	L	D	1	Computer Interface in Chemical Engineering	3	0	0	0	3
	1	6	C	H	6	D	E	L	D	2	Interfacial Phenomena					
Total											18	1	2	4	25	



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**SCHEME OF INSTRUCTION FOR SEVENTH SEMESTER**

Sl. No	Subject Code										Subject Title	Credit Hours/Week				
												L	T	P	S	Total
1.	1	6	C	H	7	D	C	C	P	U	Chemical Plant Utilities	3	0	0	0	3
2.	1	6	C	H	7	D	C	B	C	E	Biochemical Engineering	3	0	0	0	3
3.	1	6	C	H	7	D	C	P	E	D	Chemical Process Equipment Design & Drawing	3	0	1	2	6
4.	1	6	C	H	7	D	C	P	M	S	Chemical Process Modelling & Simulation	2	0	1	2	5
5.	1	6	H	S	7	D	C	E	I	E	Economics in Engineering	2	0	0	0	2
6.	1	6	C	H	7	D	C	P	P	W	Pre-Project Work	0	0	2	0	2
<b>Group E</b>																
7.	1	6	C	H	7	D	E	L	E	1	1. Finite Element Analysis	1	0	0	0	1
	1	6	C	H	7	D	E	L	E	2	2. Fermentation Technology					
	1	6	C	H	7	D	E	L	E	3	3. Smart Materials					
	1	6	C	H	7	D	E	L	E	4	4. SKADA and PLC					
<b>Institutional Elective Courses</b>																
8.	1	6	C	H	7	I	E	C	P	#	1. Non-Conventional Energy Technology 2. Composite Materials	3	0	0	0	3
<b>Total</b>											17	0	4	4	25	



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**SCHEME OF INSTRUCTION FOR EIGHTH SEMESTER**

Sl. No.	Subject Code											Subject Title	Credit Hours/Week				
													L	T	P	S	Total
1.	1	6	H	S	8	D	C	M	M	E	Management and Entrepreneurship	3	0	0	0	3	
2.	1	6	C	H	8	D	C	P	M	F	Project Management and Finance	2	0	0	2	4	
3.	1	6	C	H	8	D	C	F	P	W	Final Project Work	0	0	12	0	12	
4.	1	6	H	S	8	I	E	L	S	X	1. Yoga 2. NCC 3. NSS 4. Sports Activities 5. Cultural Activities 6. Internship with NGO	0	0	1	0	1	
6.	1	6	C	H	8	D	C	I	R	S	Internship & Related Seminar	0	0	2	0	2	
Institutional Elective Courses																	
7.	1	6	C	H	8	I	E	C	K	#	1. Waste Water treatment 2. Pilot Plant Studies	3	0	0	0	3	
	Total											8	0	15	2	25	



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Course Title	APPLIED MATHEMATICS													
Course Code	1	5	M	A	3	G	C	A	P	M	Credits	04	L – T – P- S	3 – 1 – 0 - 0
CIE	100 marks (50% weightage)						SEE		100 marks (50% weightage)					

**PREREQUISITES:** Concepts of Trigonometry, Trigonometric formulas, Concepts of differentiation, partial differentiation and integration, solution to ordinary differential equations

**Course Objectives:** The purpose of the course is to make the students well conversant with Fourier-Series, Fourier Transforms, formulate physical problems in terms of Partial Differential Equations, find insight into the physical behaviour of systems from mathematical solution and develop computational skills using efficient numerical methods for problems in science and engineering

**SYLLABUS:**

**UNIT-1**

**Introduction:** Elementary row transformations, Echelon form of a matrix, rank of a matrix by elementary row transformations. Consistency of system of linear equations and solution

**Solution of a system of non-homogenous equations:** Gauss elimination method, LU decomposition method, Gauss-Seidel method, Eigenvalues and eigenvectors of matrices.

(7L+2T=09Hrs)

**Suggested Reading:** Inverse of a matrix by Gauss-Jordon method, largest eigenvalues and corresponding eigenvectors using Rayleigh power method and Reduction of a matrix to diagonal form

**UNIT-2**

**Numerical methods:** Solution of algebraic and transcendental equations: Newton-Raphson method.

**Finite Differences and interpolation:** Forward differences, backward differences. Newton-Gregory forward interpolation formula, Newton-Gregory backward interpolation formula, Lagrange's interpolation formula and Lagrange's inverse interpolation

**Numerical integration:** Simpson's  $1/3^{\text{rd}}$ ,  $3/8^{\text{th}}$  rule, Weddle's rule. **Numerical solution of ordinary differential equations:** Runge-Kutta method of fourth order.

(8L+2T=10Hrs)

**Suggested Reading:** Euler's modified method and Milne's method to solve ordinary differential equations. Solution of simultaneous differential equations by Runge-Kutta method of fourth order

**UNIT-3**

**Fourier series:** Periodic function, Dirichlet's conditions, and statement of Fourier Theorem. Fourier series of periodic function of period  $2l$ , Fourier series of functions having points of discontinuity.

**Applications:** Fourier series of typical waveforms -saw toothed waveform, triangular waveform, square



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waveform, half-wave rectifier, full wave rectifier and modified saw tooth waveform. Practical harmonic analysis.

**Fourier Transforms:** Concept of finite Fourier Transform, Infinite Fourier Transform: Fourier Sine and Cosine transforms and properties. Inverse Transforms.

**(9L+4T=13Hrs)**

**Suggested Reading:** Half range Fourier series, Convolution theorem, Parseval's identities for Fourier transform and Physical Significance of Parseval's identities

**UNIT-4**

**Partial differential equations:** Formation of Partial differential equations-elimination of arbitrary constants, elimination of arbitrary functions. Equations of first order- The linear equation  $Pp + Qq = R$  (Lagrange's partial differential equation). **Applications:** One-dimensional heat equation and wave equation (without proof), various possible solutions of these by the method of separation of variables.

**(7L +2T=09Hrs)**

**Suggested Reading:** Direct integration method. Method of separation of variables. Alembert's solution of wave equation. Solution of boundary value problems using Fourier Transform method

**UNIT- 5**

**Calculus of variations:** Variation of function and functional, Euler's equation and variational problem. **Applications:** Geodesics on a plane, Geodesics of a right circular cylinder, hanging cable Brachistochrone problem.

**(5L +2T=07Hrs)**

**Suggested Reading:** Geodesics of a right circular cone, minimal surface of revolution

**MATHEMATICS LAB**

1. Solution of system of algebraic equations using Gauss Seidel method
2. LU decomposition of matrices.
3. Eigenvalues and eigenvectors of matrices-stability of a system of differential equation-
4. Eigenvalue problem.
5. Largest eigenvalue and corresponding eigenvector of a matrix.
6. Diagonalisation of matrices

**TEXTBOOKS:**

1. Higher Engineering Mathematics, B. S. Grewal, 43<sup>rd</sup> edition, 2013, Khanna Publishers.
2. Advanced Engineering Mathematics, 5th edition by Dennis G. Zill and Cullen, Jones and Bartlett India Pvt. Ltd.

**REFERENCE BOOKS**



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1. Advanced Engineering Mathematics, Erwin Kreyszig, 10<sup>th</sup> edition Vol. 1 and Vol. 2, 2014, Wiley-India.
2. Higher Engineering Mathematics, B. V. Ramana, 7<sup>th</sup> reprint, 2009, Tata Mc. Graw Hill.

**E-books**

- [1] Engineering Mathematics, [K. A. Stroud, Dexter J. Booth](http://books.google.co.in/books/about/Engineering_Mathematics.html?id=FZncL-xB8dEC&redir_esc=y), Industrial Press, 2001 [http://books.google.co.in/books/about/Engineering\\_Mathematics.html?id=FZncL-xB8dEC&redir\\_esc=y](http://books.google.co.in/books/about/Engineering_Mathematics.html?id=FZncL-xB8dEC&redir_esc=y).
- [2] Advanced Engineering Mathematics, P. V. O'Neil, 5<sup>th</sup> Indian reprint, 2009, Cengage learning India Pvt. Ltd.
- [3] [3\)http://ocw.mit.edu/courses/mathematics/](http://ocw.mit.edu/courses/mathematics/) (online course material)

**MOOCs & Online Courses:**

- (1) <http://nptel.ac.in/courses.php?disciplineId=111>
- (2) <https://www.khanacademy.org/>
- (3) <https://www.class-central.com/subject/math> (MOOCS)

Course Code	CO #	COURSE OUTCOME (CO)	PO	Bloom's level
<b>15CH/BT3GCAPM</b>	CO 1	Compute solution of a system of algebraic equations.	2, 3	2, 3
	CO 2	Calculate solutions of algebraic and transcendental equations, ordinary differential equations numerically.	2, 3	2, 3
	CO 3	Express given functions to form Fourier series.	2, 3, 4	2, 3, 4
	CO 4	Demonstrate an understanding of Fourier transforms techniques.	2, 3, 4	2, 3, 4
	CO 5	Employ analytical techniques to solve partial differential equations with appropriate boundary conditions.	2, 3, 4	2, 3, 4
	CO 6	Use calculus of variations to find the extremal of a functional	2, 3	2, 3

**ASSESSMENT:**

- Each unit consists of one full question.
- Each full question consists of three or four subdivisions.
- Five full questions to be answered.
- To set one question from Units 1, 2, 5 and two questions from Unit 3 and Unit 4

Questions for CIE and SEE will be designed to evaluate the various educational components (Blooms taxonomy) such as:

- Remembering and understanding the course contents (weightage: 40%)
- Applying the knowledge acquired from the course (weightage: 35%)
- Analyzing various engineering problems (weightage: 15%)
- Understanding of various system models (weightage: 5%)



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<b>Course Title</b>	<b>Mathematics-I</b>	<b>Course Code</b>	<b>15MA3IMMAT</b>
<b>Credits</b>	<b>00</b>	<b>L – T – P- S</b>	<b>0 – 0 – 0 - 0</b>
<b>Contact hours</b>	<b>48 hours (36L+12T)</b>	<b>III semester Lateral Entry students</b>	

**PREREQUISITES:** Basic concepts of Trigonometry, Trigonometric formulas, concept of differentiation, concept of integration.

**Course Objectives:** To provide students with a solid foundation in mathematical fundamentals such as differentiation, differential equations, vectors and orthogonal curvilinear coordinates for different branches of engineering.

**UNIT 1**

**Differential and integral calculus**

List of standard derivatives including hyperbolic functions, rules of differentiation. Differentiation of product of two functions using Leibnitz rule (direct problems). Taylor's and Maclaurin's series expansion for functions of single variable. List of standard integrals, integration by parts. Definite integrals – problems.

**(7L+2T=09Hrs)**

**UNIT 2**

**Polar coordinates and partial derivatives**

Polar curves: Polar coordinates, angle between radius vector and tangent, angle between two polar curves. Partial differentiation. Total differentiation-Composite and Implicit functions. Taylor's and Maclaurin's series expansion for functions of two variables. Jacobians and their properties (without proof) – Problems.

**(7L+3T=10Hrs)**

**UNIT 3**

**First order ordinary differential equations**

Introduction to first order differential equations. Linear equation and its solution. Bernoulli's equation and its solution. Exact differential equation and its solution. Orthogonal Trajectories.

**(6L+2T=08Hrs)**

**UNIT 4**

**Second and higher order ordinary differential equations**

Ordinary differential equations with constant coefficients: Homogeneous differential equations, non-homogeneous differential equations – Particular integral for functions of the type  $f(x) = e^{ax}$ ,  $\sin(ax)$ ,  $\cos(ax)$ ,  $x^n$ ,  $e^{ax}\sin(bx)$ ,  $e^{ax}\cos(bx)$ . Method of variation of parameters. Cauchy's and Legendre differential equations.

**(7L+2T=09Hrs)**

**UNIT 5**

**Vector calculus and orthogonal curvilinear coordinates (occ)**

Recapitulation of scalars, vectors and operation on scalars and vectors. Scalar and vector point functions. Del operator, gradient-directional derivative, divergence, curl and Laplacian operator. Vector identities (without proof). Cylindrical and Spherical polar coordinate systems. Expressing a vector point function in cylindrical and spherical systems. Expressions for gradient, divergence, curl and Laplacian in OCC.

**(6L+2T=08Hrs)**



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**TEXTBOOK:**

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2. Higher Engineering Mathematics, B. V. Ramana, 7<sup>th</sup> reprint, 2009, Tata Mc. Graw Hill.

**REFERENCE BOOK:**

1. Higher Engineering Mathematics, B. S. Grewal, 43<sup>rd</sup> edition, 2014, Khanna Publishers
2. Advanced Engineering Mathematics, 4<sup>th</sup> edition, 2011, by Dennis G. Zill and Cullen, Jones and Bartlett India Pvt. Ltd.

**E BOOKS**

- (1) Engineering Mathematics, [K. A. Stroud, Dexter J. Booth](http://books.google.co.in/books/about/Engineering_Mathematics.html?id=FZncL-xB8dEC&redir_esc=y), Industrial Press, 2001 [http://books.google.co.in/books/about/Engineering\\_Mathematics.html?id=FZncL-xB8dEC&redir\\_esc=y](http://books.google.co.in/books/about/Engineering_Mathematics.html?id=FZncL-xB8dEC&redir_esc=y).
- (2) Advanced Engineering Mathematics, P. V. O'Neil, 5<sup>th</sup> Indian reprint, 2009, Cengage learning India Pvt. Ltd.
- (3) <http://ocw.mit.edu/courses/mathematics/> (online course material)

**ONLINE COURSES**

- (1) <https://www.khanacademy.org/Math>
- (2) <https://www.class-central.com/subject/math> (MOOCS)
- (3) E-learning: [www.vtu.ac.in](http://www.vtu.ac.in) .

Course Code	CO	PO	Bloom's level
15MA3IMMAT	<b>CO-1:</b> Understand the basic concepts of differentiation and integration.	1	2
	<b>CO-2:</b> Apply the concepts of polar curves and multivariate calculus.	1	2
	<b>CO-3:</b> Apply analytical techniques to compute solutions of first and higher order ordinary differential equations.	1	3
	<b>CO-4:</b> Apply techniques of vector calculus to engineering problems.	1	3
	<b>CO-5:</b> Comprehend the generalization of vector calculus in curvilinear coordinate system.	1	3



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Course Title	CHEMICAL TECHNOLOGY													
Course Code	1	5	C	H	3	D	C	C	T	N	Credits	04	L - T - P - S	3 - 0 - 0 - 0
CIE	100 marks (50% weightage)						SEE		100 marks (50% weightage)					

**PREREQUISITES:** Engineering Chemistry and Elements of Engineering Drawing

**SYLLABUS:**

**UNIT- I**

**Introduction to CT and fuels:** Introduction- Components of flow sheet. Fuels and Industrial gases- Hydrogenation of coal, coking of coal, LNG, LPG, Petroleum technology- Constituents, distillation of crude petroleum. Cryogenic industry-Nitrogen and Oxygen by Linde-Frankl process.

10 Hrs

**UNIT- II**

**Inorganic chemicals:** Sulphuric acid - DCDA Process. Alkali industry- Soda Ash, Caustic soda. Nitrogen Industries- Ammonia and Nitric Acid. Phosphoric acid (HCl leaching method).

08 Hrs

**UNIT- III**

**Natural industries:** Oil industry: vegetable oil extraction, Refining and hydrogenation. Surfactant industry: Manufacture of soap and detergents. Pulp and paper industry- Sulfate process, effluent treatment for sulfate process.

09 Hrs

**UNIT IV**

**Commercial industries:** Fermentation industry-Manufacture of ethyl alcohol. Polymer industry - LDPE, PVC. Rubber industry-Natural rubber and SBR.

06 Hrs

**UNIT- V**

**Miscellaneous industries:** Paints-Zinc oxide, Titanium dioxide. Cement Industry-Lime stone beneficiation and Cement. Fertilizers- Urea, NPK, bio fertilizers.

06 Hrs

**TEXTBOOKS:**

1. George T. A. and Shreve's, Chemical process industries, 5th edition, McGraw Hill International Ltd., 1984.

2. Gopal Rao, M. and Marshall Sitting, Dryden's Outlines of Chemical Technology, 3<sup>rd</sup> Edition, Affiliated East West Press Pvt. Ltd., New Delhi, 1997

**REFERENCE BOOKS:**

1. Shukla SD and Pandey GN, Text book of chemical technology Volume 2, Vikas Publishing house Pvt Ltd., New Delhi, 1979.

**E BOOKS**



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- [1] Handbook of Chemical Technology and Pollution Control (Third Edition): <http://www.sciencedirect.com/science/book/9780120887965>
- [2] Chemical Technology: An Integral Textbook: <http://www.wiley.com/WileyCDA/WileyTitle/productCd-3527304460.html>

**MOOC's and ONLINE COURSES:**

- (1) <http://nptel.ac.in/courses/103103029/>
- (2) <http://www.myopencourses.com/subject/chemical-technology-i-2#videos>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
CO1	Acquainted with processing & flow diagram for manufacture of organic and inorganic chemicals.	PO2
CO2	Comprehend the construction of various unit operations & processes involved for designing a process flow diagram.	PO3
CO3	Identify the engineering problems associated with the various processes and apply broad cognitive to assess the societal issues.	PO6

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100 (Weightage 50%)
Theory Component	Three Internals Test (Best of Two)	80%
	Quiz (Two Quizzes or AAT)	20%
Semester End Examination (Written Examination for Three Hours)		Marks 100 (Weightage 50%)

**Assessment Pattern:**

Component	Test 1	Test 2	Quiz 1/AAT	Quiz 2 /AAT	Total Marks
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



**DEPARTMENT OF CHEMICAL ENGINEERING**  
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Course Title	FLUID MECHANICS														
Course Code	1	5	C	H	3	D	C	F	M	E	Credits	06	L – T – P- S	3 – 0 – 1 - 2	
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

**PREREQUISITES:** Engineering Physics and Engineering Maths

**SYLLABUS:**

**UNIT-I**

**Fluid statics and its applications:** Concept of unit operations, Concept of Momentum Transfer, Nature of fluids and pressure concept, Variation of pressure with height - hydrostatic equilibrium, Barometric equation, Measurement of fluid pressure-U-tube manometers, Inverted U-Tube manometer, Continuous gravity decanter, Centrifugal decanter and Differential manometers.

**Fluid flow phenomena:** Types of fluids - shear stress and velocity gradient relation, Newtonian and non - Newtonian fluids, Viscosity of gases and liquids. Types of flow - laminar and turbulent flow, Reynolds stress, Eddy viscosity, Flow in boundary layers, Reynolds number, Boundary layer separation and wake formation.

07 Hrs

**UNIT-II**

**Basic equations of fluid flow:** Average velocity, Mass velocity, Continuity equation, Euler and Bernoulli equations, Modified equations for real fluids with correction factors. Pump work in Bernoulli equation.

**Flow of compressible fluids:** Basic equations of Compressible flow (Continuity, Bernoulli's or Energy equations, Momentum Equations and Equation of state), stagnation properties, Compressible fluid through Venturi, Concept of Mach number, Velocity of sound or Pressure wave in a fluid Ideal gas equation.

10 Hrs

**UNIT-III**

**Flow of incompressible fluids in conduits and thin layer:** Laminar flow through circular and non-circular conduits. Hagen-Poiseuille equation, Turbulent flow in pipes and closed channels Friction factor chart. Friction from change in velocity or direction, form friction losses in Bernoulli equation.

09 Hrs

**UNIT - IV**

**Metering of fluids:** Pipes, Fittings and valves, Measurement of liquid, Pitot-Static tube, gas flow rates by Orifice meter, Venturi meter, Rotameter and Pitot tube. Flow through open channels - weirs and notches.

**Transportation of fluids:** Performance and characteristics of pumps—centrifugal pump construction, NPSH, pump work and efficiency

07 Hrs

**UNIT- V**

**Dimensional analysis:** Dimensional homogeneity, Rayleigh's and Buckingham's II - methods. Significance of different dimensionless numbers. Elementary treatment of similitude between model and prototype.

06Hrs

**LABORATORY COMPONENT**



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1. Determination of Friction factor in circular pipes
2. Determination of Friction factor in non-circular pipes.
3. Friction in helical spiral coils.
4. Flow rate measurement using Orifice meters (incompressible fluid)
5. Measurement of pressure drop in Packed bed
6. Measurement of pressure drop in Fluidized bed
7. Study and development of characteristics for centrifugal pump
8. Study of various pipe fittings and their equivalent lengths
- 9 Fluid flow measurement using Venturi and Orifice meters (incompressible fluid)
10. Reynold's apparatus

**TEXTBOOK:**

1. McCabe. W. L. f et. al. "Unit Operations of Chemical Engineering", 5<sup>th</sup>edition., McGraw Hill New York 1993.
2. Bansal R. K, A Textbook of Fluid Mechanics (VTU), Edition 2005, Laxmi Publications.

**REFERENCE BOOKS:**

1. R. K Rajput, "A Text Book on Fluid Mechanics", 2<sup>nd</sup> Edition 2002, S Chand and company Ltd.
2. Coulson J. and Richardson. J. F. ., 'Chemical Engineering' Vol. II L., 5th edn., Asian Books (p) Ltd., New Delhi, 1998.

**E BOOKS**

- [1] Multimedia Engineering Fluid Mechanics: <https://ecourses.ou.edu/cgi-bin/ebook.cgi?topic=fl>
- [2] Elementary Fluid Mechanics: <http://www.worldscientific.com/worldscibooks/10.1142/5895>

**MOOC's & ONLINE COURSES:**

- (1) <http://www.learnerstv.com/video/Free-video-Lecture-2626-Engineering.htm#>
- (2) <http://www.myopencourses.com/subject/fluid-mechanics-2#downloads>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
CO1	Understand of basic principles of fluid mechanics including pressure concept and boundary layer analysis.	PO1
CO2	Ability to analyze fluid flow problems with the application of mass, momentum and energy equation.	PO4
CO3	Select relevant flow metering equipment, evaluate their performance and limitations	PO2
CO4	Develop correlations between process variables using dimensional analysis.	PO3
CO5	Conduct experiments for fluid flows in circular, non-circular pies and other geometries	PO9



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**ASSESSMENT:**

Continuous Internal Assessments		Marks 100% (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	40%	Course Instructor
	Quiz (Two Quizzes)	10%	Course Instructor
Laboratory Component	Laboratory Component	30%	Course Instructor
Self-Study Component	Open Ended Experiments/Term Papers/Modelling/Seminar/Mini projects.	20%	Committee constituted by HOD
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

Component	Theory (50%)			Practical (30%)		Self-Study (20%) by AAT	Total Marks
	Test 1	Test 2	Quiz	Records & Performances	Lab Test		
Max. Marks	20	20	10	20	10	20	100
Reduced CIE	10	10	5	10	5	10	50



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Course Title	TECHNICAL CHEMISTRY													
Course Code	1	5	C	Y	3	D	C	C	E	M	Credits	04	L – T – P- S	3 – 0 – 1 - 0
CIE	100 marks (50% weightage)						SEE		100 marks (50% weightage)					

**PREREQUISITES:** Engineering Chemistry and Environmental studies

**SYLLABUS:**

**UNIT-1**

**Reaction mechanisms:** Introduction to Chemical bonds, Reactivity of organic compounds and electronic effects in molecules. Reactive intermediates-Carbon based-formation, structure and stability of Carbocation, Carbanion and Carbon free radicals with examples. Nucleophilic aliphatic substitution: Mechanism, Rate law and stereochemistry of the  $S_N1$ ,  $S_N2$  and  $S_Ni$  reactions with examples. Elimination: Mechanism, Rate Law and stereochemistry of the  $E_1$ ,  $E_2$  and  $E_{1cB}$  reactions with examples. Electrophilic aromatic substitution: Directing effect of substitutions (ortho/meta/para) in benzene with examples.

08 Hrs

**UNIT-2**

**Organic transformations:** Conversion of alkenes to alcohols: Oxymercuration (Markovnikov) and demercuration / Hydroboration and oxidation (Anti-Markovnikov). Oxidations: Definition, examples of Chromium, Peroxides, Sulfoxide based reagents and transformations. Mechanism and application of Collins reagent in the oxidation of primary and secondary alcohols. Reduction: Definition, Dissolving metal reduction. Metal Hydride reductions involving- metal borohydrides and metal catalyzed reduction. Organometallic Reagents: Definition, synthesis and applications of Grignard reagent, and organolithium agents. Industrial production of methanol, methyl-tert-butyl-ether (MTBE) and ethylene glycol.

08 Hrs

**UNIT-3**

**Basics of organic absorption spectroscopy:** Electromagnetic radiation: Franck-Condon Principle, UV Spectroscopy- Definition, Electronic transitions-  $\sigma-\sigma^*$ ,  $n-\sigma^*$ ,  $\pi-\pi^*$ ,  $n-\sigma^*$ . Applications in the diagnosis of conjugated and non-conjugated alkenes, Effect of alkyl substituents on the absorption maximum. Problems related to calculation of  $\lambda_{max}$  and energy

**IR Spectroscopy:** Basics, IR absorption and chemical structure, Wavenumber, Factors determining IR absorption peak position and intensity, Hooke's law, Identification of organic functional groups. Application of IR in determination of greenhouse gases and automobile pollutants

**NMR Spectroscopy:** Introduction, Nuclear spin, magnetogyric ratio, spin state, chemical shift, integration, relationship between chemical shift and structure, spin-spin splitting, n+1 rule, use of deuterium in NMR,  $^1H$  NMR of selected aliphatic and aromatic alkanes, alkenes and alcohols.

08Hrs



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**UNIT-4**

**Pharmaceuticals:** Introduction, General Classification, drug-design-objectives and governed factors. Therapeutic action and application of analgesics (Ibuprofen from isobutyl benzene)

**Insecticides:** Introduction, General classification - natural (Botanical and Bio-rational formulations) and synthetic (Inorganic and Organic) pesticides - synthesis, governing factors, uses, limitations of organophosphate (malathion), N-methyl carbamate (Carbaryl), Neo-nicotinoid (Imidacloprid) and Cyclopentadienes (Dieldrin).

07Hrs

**UNIT-5**

**Dyes:** Classification - structure and method of application, colour and constitution-chromophore, auxochrometheory, origin of colour, Synthesis and applications of Anionic dye (Methyl orange or Helianthin from Aniline), Diazo dye (Congo red from nitrobenzene), Triarylmethane dye (Malachite green from benzaldehyde) and Vat dye (Indigotin from o-nitrotoluene).

**Soaps and detergents:** Introduction to oils and fats, properties and uses, vegetable oils examples analysis of oil- Acid value, saponification value and iodine value and their importance. Soaps-definition, types of manufacture of soap, Hydrolyzer process. Detergents-definition, various constituents of a detergent, Surfactants-anionic, cationic, zwitterionic and non-ionic. Cleansing action of detergent, advantages of detergents over soaps.

[08 Hrs]

**TEXTBOOKS:**

1. A text book of Organic Chemistry by Arun Bahl and B. S. Bahl, 18<sup>th</sup> revised edition, S Chand, 2006
2. Organic chemistry by Graham Solomons, T. W. and Craig B. Fryhle, (WSE) 10<sup>th</sup> edition, Wiley India, 2010

**REFERENCE BOOKS:**

1. Organic Chemistry by Robert Thornton Morrison, Robert Neilson Boyd and S. K. Bhattacharjee, 7<sup>th</sup> edition, Pearson Prentice Hall, 2011
2. Advanced Organic Chemistry: Reactions, Mechanisms and Structure by Michael B. Smith and Jerry March, (WSE) 4<sup>th</sup> edition, Wiley, 2008
3. Organic Chemistry by Marc G. Loudon, 4<sup>th</sup> Edition, 2009
4. Technical Chemistry Lab Manual, written by faculty, Dept. of Chemistry, BMSCE, Bangalore.
5. Laboratory manual of Organic Chemistry by Raj K. Bansal, 5<sup>th</sup> revised edition, New Age International, 2013.

**E-BOOKS:**

- [1] Basic Principles of Organic Chemistry by John D. Roberts, Marjorie C. Caserio, 2<sup>nd</sup> edition, Addison-Wesley, 1977
- [2] Virtual Textbook of Organic Chemistry by William Reusch, Michigan State University, 1999

**MOOCs:**



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(1) [nptel. ac. in/courses. php?disciplineId=104](http://nptel.ac.in/courses.php?disciplineId=104)

(2) <http://ocw.mit.edu/courses/audio-video-courses/#chemistry>

(3) <https://legacy.saylor.org/chem103/Intro/>

**LIST OF EXPERIMENTS**

1. Nitration of nitrobenzene to m-dinitrobenzene
2. Preparation of benzoic acid from benzaldehyde
3. Bromination of acetanilide to p-bromoacetanilide
4. Synthesis of acetyl salicylic acid (Aspirin) from salicylic acid
5. Preparation of  $\alpha$ -phenylazo- $\beta$ -naphthol (Sudan Yellow) from aniline
6. Study of geometrical isomerism - Maleic acid into fumaric acid using UV-Vis (demo)
7. Estimation of phenol by bromination
8. Estimation of a keto group by iodination
9. Estimation of esters by hydrolysis
10. Estimation of saponification value of an oil or fat
11. Estimation of carboxylic acid by iodometric titration

**COURSE OUTCOMES (COs):**

<b>CO1</b>	Ability to define, describe and solve different mechanisms of organic transformations
<b>CO2</b>	Ability to understand organic functionalization and application to oxidation and reduction reactions
<b>CO3</b>	Ability to analyze and interpret an organic structure based on its absorption spectrum
<b>CO4</b>	Ability to understand functional group dynamics and their usefulness in medicine and pesticides
<b>CO5</b>	Ability to identify, interpret colour based on structure and validate by modern spectroscopic tool
<b>CO6</b>	Ability to conduct experiments and write mechanisms of electrophilic substitution reaction - nitration and halogenation, Oxidation of aldehydes and their application to synthesis of pharma product - aspirin and dye - sudan yellow. They shall survey and estimate various organic functional groups using environmentally benign organic reagents.

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100% (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	40%	Course Instructor
	Quiz (Two Quizzes)	10%	Course Instructor
Laboratory Component	Laboratory Component	50%	Course Instructor
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	



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**Assessment Pattern:**

Component	Theory (50%)			Practical (50%)			Total Marks
	Test 1	Test 2	Quiz	Records & Performances	Lab Test	Viva- Voice/ AAT	
Max. Marks	20	20	10	20	20	10	100
Reduced CIE	10	10	5	10	10	5	50



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Course Title	MECHANICAL OPERATIONS														
Course Code	1	5	C	H	3	D	C	M	O	P	Credits	06	L - T - P - S	3 - 0 - 1 - 2	
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

**PREREQUISITES:** Engineering Mechanics and Engineering Mathematics

**SYLLABUS:**

**UNIT- I**

**Particle Technology:** Ideal and actual screen, Differential and cumulative size analysis, Particle size analysis, Specific surface area, Effectiveness and Problems. Standard screen series, Motion of screens, Gyrotory screen shaker, Vibrating screen shaker, Trammels and Sub sieve analysis.

07 Hrs

**UNIT- II**

**Size Reduction:** Forces used, Characteristics of products, Laws of size reduction, Work Index, Verification of laws, Problems. Open circuit grinding, Closed circuit grinding, Wet & dry grinding, Equipment: Jaw crusher, Gyrotory crusher, Attrition mill, Ball mill, Roll crusher, Fluid energy mill & Hammer mill.

06 Hrs

**UNIT- III**

**Flow of Fluid past Immersed Bodies:** Drag, Drag coefficient, Particle Reynolds number. Ergun equation and its modifications, Particle size determination by Kozeny Carman equation, Types of fluidization & Applications. Conveying of solids-Belt conveyors Chain conveyors.

**FILTRATION:** Classification, Modification of Kozeny - Carman equation for filtration. Industrial filters: Filter press, Leaf filter, Rotary drum filter, Bag filter, Suspended batch centrifuge; Filter aids. Principles of cake filtration.

10Hrs

**UNIT- IV**

**Motion Of Particles Through Fluids:** Equation for one dimensional motion of particles through a fluid in gravitational and centrifugal field, Terminal settling velocity, motion of spherical particle in different regions, Criterion for settling, Hindered settling, Cyclones, hydro cyclones and air elutriator, Heavy media separation.

**Sedimentation:** batch settling test, theories, Application of batch settling test to design a continuous thickener and related problems, Storage of solids, open and closed storage.

10 Hrs

**UNIT- V**

**Agitation and Mixing:** Types of impellers. Flow patterns in agitated vessels, Prevention of swirling, Power correlation and calculation. **Mixers:** Muller mixer, Ribbon blender, internal screw mixer, tumbling mixer. **Separations:** Electrostatic separation, Jigging, Froth floatation. **Size enlargement:** Pelletization, agglomeration

06 Hrs



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**LABORATORY COMPONENT:**

1. Air elutriation
2. Air permeability
3. Batch sedimentation
4. Beaker decantation
5. Drop weight crusher
6. ICI sedimentation
7. Jaw crusher
8. Leaf filter
9. Plate and frame filter press
10. Screen effectiveness

**TEXTBOOKS:**

1. McCabe, Warren, L., Smith, Julian, C. and Harriott, Peter, Unit operations of chemical engineering, 5th edition, McGraw-Hill, Singapore, 2000.

**REFERENCE BOOKS:**

1. Badger, Walter, L. and Banchero, Julius, T. Introduction to Chemical Engineering, 3<sup>rd</sup> edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 1997.
2. Richardson, J. F., Harker, J. H., and Backhurst, J. R. Particle Technology and Separation Processes, 2nd volume, 5th edition, Replika Books Pvt. Ltd., New Delhi, 2003

**E BOOKS**

- [1] Mechanical Operations Fundamental Principles and Applications: [https://books.google.co.in/books/about/Mechanical\\_Operations\\_Fundamental\\_Principles?id=O0DPOKxC0YEC&hl=en](https://books.google.co.in/books/about/Mechanical_Operations_Fundamental_Principles?id=O0DPOKxC0YEC&hl=en)
- [2] Ebook Library chemical engineering mechanical Operations: <http://csfbook.sourceforge.net/pdf/chemical-engineering-mechanical-operations.pdf>

**MOOC's & ONLINE COURSES:**

- (1) <http://nptel.ac.in/courses.php>
- (2) <http://www.msubbu.in/sp/mo/>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
<b>CO1</b>	Apply the basic working principles of different size reduction equipment for particle size analysis	PO2
<b>CO2</b>	Design and analyse the flow of fluids through bed of solids and fluid layers	PO3
<b>CO3</b>	Familiarise with the different types of mixing, agitation and solid conveyers	PO2
<b>CO4</b>	Acquaintance of the principles of separating high value solids	PO2
<b>CO5</b>	Conduct experiments for particle size analysis, separation of high value products by filtration, sedimentation and decantation techniques	PO9



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**ASSESSMENT:**

<b>Continuous Internal Assessments</b>		<b>Marks 100% (Weightage 50%)</b>	<b>Assessment</b>
Theory Component	Three Internals (Best of Two)	40%	Course Instructor
	Quiz (Two Quizzes)	10%	Course Instructor
Laboratory Component	Laboratory Component	30%	Course Instructor
Self-Study Component	Open Ended Experiments/Term Papers/Modelling/Seminar/Mini projects.	20%	Committee constituted by HOD
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

<b>Component</b>	<b>Theory (50%)</b>			<b>Practical (30%)</b>		<b>Self-Study (20%) by AAT</b>	<b>Total Marks</b>
	<b>Test 1</b>	<b>Test 2</b>	<b>Quiz</b>	<b>Records &amp; Performances</b>	<b>Lab Test</b>		
Max. Marks	20	20	10	20	10	20	100
Reduced CIE	10	10	5	10	5	10	50



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Course Title	MATERIAL SCIENCE AND BIOMATERIALS													
Course Code	1	5	C	H	3	D	C	M	S	B	Credits	02	L – T – P- S	2 – 0 – 0 - 0
CIE	100 marks (50% weightage)						SEE			100 marks (50% weightage)				

**PREREQUISITES:** Engineering Chemistry and Engineering Physics

**SYLLABUS:**

**Unit - I**

**Introduction:** Introduction to material science, classification of engineering materials and their industrial applications. Crystal imperfections: point, line and surface imperfections.

04 Hrs

**Unit – II**

**Deformation of Materials and Fracture:** Elastic deformation: elastic behaviour, atomic model derivation to find Young's modulus of material, relaxation processes for anelastic behaviour, spring-dashpot model for viscoelastic deformation.

**Plastic Deformation:** Stress-strain curve, deformation by slip, deformation in polycrystalline materials, brittle and ductile fractures.

07 Hrs

**Unit- III**

**Heat Treatment:** Annealing, normalizing, hardening, martempering, austempering, hardenability, quenching, tempering, carburizing, cyaniding, nitriding, flame hardening.

04 Hrs

**Unit- IV**

**Typical Engineering Materials:** Metals and non-metals: General properties of ferrous metals, non-ferrous metals and Alloys for high temperature service. Ceramic materials: Structure, polymorphism, mechanical, electrical and thermal properties of ceramics.

06Hrs

**Unit -V**

**Biopolymers:** Classification of biopolymers, mechanical properties and applications in Orthopaedic, dental and cardiovascular.

05 Hrs

**TEXTBOOKS:**

1. Hajra Choudhury, S. K., Material Science and Processes, Indian Book Distributing Co., 2<sup>nd</sup> edition, Calcutta, India, 1982.

2. V Raghavan, Materials Science and Engineering, Prentice-Hall of India Private Limited, 5<sup>th</sup> edition, New Delhi, India, 2005.



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**REFERENCE BOOKS:**

1. Callister's Materials Science and Engineering adapted by R Balasubramaniam, Wiley India (P) Limited, 7th edition, New Delhi, India, 2011.

**E BOOKS**

[1] Materials Science: [https://books.google.co.in/books/about/Materials\\_Science.html](https://books.google.co.in/books/about/Materials_Science.html)

[2] Materials Science: <https://booksonweb.files.wordpress.com/2011/09/material-science-kakani-2004.pdf>

**MOOC's & ONLINE COURSES:**

[1] <http://ocw.mit.edu/courses/materials-science-and-engineering/>

[2] <http://freevideolectures.com/Course/3086/Introduction-to-Biomaterials#>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
CO1	Understand plastic, elastic behavior of materials and their industrial applications	PO1
CO2	Analyze physical properties of various materials through phase transformations during heat treatment methods.	PO2
CO3	Select suitable metals and biopolymers based on the properties for specific applications	PO12

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100 (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
Semester End Examination (Written Examination for Three Hours)		Marks 100 (Weightage 50%)	

**Assessment Pattern:**

Component	Test 1	Test 2	Quiz 1/AAT	Quiz 2 /AAT	Total Marks
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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Course Title	STATISTICS AND PROBABILITY													
Course Code	1	5	M	A	4	G	C	A	P	M	Credits	04	L – T – P- S	3 – 1 – 0 - 0
CIE	100 marks (50% weightage)						SEE		100 marks (50% weightage)					

**PREREQUISITES:** Basic concepts of statistics. Concepts of Probability, addition theorem, conditional probability, Bayes' theorem, discrete random variable, Binomial distribution

**Course Objectives:** Student will get acquainted with the procedure of collecting, designing, analyzing and drawing inference about the data.

**SYLLABUS:**

**UNIT-1**

**Statistics & probability distributions:** Curve fitting:  $y = a + bx$ ,  $y = a + bx + cx^2$ ,  $y = ab^x$ , statistical measures, Correlation and regression. Introduction to Discrete distribution: Poisson distribution- problems, Continuous distributions: Normal, Gamma distribution, problems.

**8L+3T=11Hrs**

**UNIT-2**

**Joint probability and markov chain:** Introduction. Joint Probability distributions: Case of discrete random variables-Marginal probability distributions, independent random variables, mathematical expectation, correlation, covariance.

Introduction- classification of stochastic processes. Probability vectors, stochastic matrices, fixed points, regular stochastic matrices. Markov chains, higher transition probabilities, stationary distribution of regular Markov chains and absorbing states.

**6L+2T=08Hrs**

**UNIT-3**

**Design of experiments:** Principles of experimental design – Randomization, Replication, Local Control. Randomized block design, Completely Randomized block design, Latin Square Design, Factorial Experiments –Problems.

**7L+2T=09Hrs**

**UNIT-4**

**Statistical inference –I:** Introduction, Population and sampling, sampling distributions: sampling distributions of means. Statistical estimation – point, interval; procedure for testing of hypothesis, level of significance, construction of confidence interval. [Large sample] Test of significance for single mean, difference between two means, single proportion, difference between two proportions, and difference of two Standard deviations.

**7L+2T=09Hrs**

**Suggested Reading:** sampling distributions of proportions, sampling distributions of differences and sum

**UNIT-5**

**Statistical inference – II:** [Small sample] Test of significance for single mean, difference between two means, paired t- test, ratio of variances (F- distribution), Chi -Square distribution-goodness of fit, independence of attributes. Analysis of variance (one-way and two-way classifications). Non



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parametric test – Wilcoxon Rank Sum test and Kruskal – Wallis One Way Analysis of Variance by Ranks

**8L+3T=11Hrs**

**TEXTBOOKS:**

1. Probability and Statistics for Engineers and Scientists, Ronald Walpole, Raymond Myers, Sharon Myers, Keying Ye, 9<sup>th</sup> edition, 2013, Pearson New International Edition.
2. Applied Statistics and Probability for Engineers, Douglas C Montgomery, George C Runger, 5<sup>th</sup> edition, 2010, Wiley.
3. Fundamentals of Biostatistics, Khirfan A Khan, Atiya Khanum, 3<sup>rd</sup> edition, 2012, Ukaaz Publications.

**REFERENCE BOOKS:**

1. Schaum's Outline of Probability and Statistics, 4<sup>th</sup> edition, 2013, Schaum's outlines.
2. An Introduction to Biostatistics, P. S. S. Sundar Rao and J. Richard, 4<sup>th</sup> edition, 2006 Prentice Hall of India.

**E BOOKS AND ONLINE COURSE MATERIALS**

1. Statistics online computational resource wiki. stat. ucla. edu/socr/index. php/Probability and\_statistics\_EBook
2. accessengineeringlibrary. com/. . . /schaums-outline-of-probability-and-statistics-fourth-edition.
3. Fundamentals of Statistics and Probability for Engineers, T. T. Soong, John Wiley and Sons Ltd.
4. fastebook. org/. . . /fundamentals-of-biostatistics-khan-and-khanum. html

**ONLINE COURSES**

- (1) <http://ocw.mit.edu/courses/mathematics/18-05-introduction-to-probability-and-statistics-spring-2014/>
- (2) <http://nptel.ac.in/courses/111105041/INPTEL> >> Mathematics >>Probability and Statistics
- (3) <https://www.khanacademy.org/Math>
- (4) <https://www.class-central.com/subject/math> (MOOCS)
- (5) E-learning: [www.vtu.ac.in](http://www.vtu.ac.in)

On Completion of the course the student will have the ability to

Course Code	COURSE OUTCOMES	PO	Bloom's level
15MA4DCSAP	<b>CO-1:</b> Estimate the closeness of two variables and prediction of one variable from the other. (To obtain the degree of relationship between two variables and perform regression analysis)	1, 2	
	<b>CO-2:</b> Apply the basic principles of probability and probability distributions to the problems in Bio-technology.	1, 2	
	<b>CO-3:</b> Apply the concepts of Markov chain to the field of genetics.	1, 2	4
	<b>CO-4:</b> Demonstrate an understanding of sampling and its various techniques.	2, 4	4



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	<b>CO-5:</b> To draw inferences about the characteristics of population from the samples based on the parametric and non-parametric tests.	2, 4	4
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**ASSESSMENT:**

- Each unit consists of one full question.
- Each full question consists of three or four subdivisions.
- Five full questions to be answered.
- To set one question from Units 2, 3, 4 and two questions from Unit 1 and Unit 5.

Questions for CIE and SEE will be designed to evaluate the various educational components (Blooms taxonomy) such as:

- Remembering and understanding the course contents (weightage: 40%)
- Applying the knowledge acquired from the course (weightage: 35%)
- Analyzing various engineering problems (weightage: 15%)
- Understanding of various system models (weightage: 5%)



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**MATHEMATICS DEPARTMENT SYLLABUS (2011-2012)**  
**FOR STUDENTS ADMITTED TO II YEAR THROUGH LATERAL ENTRY**  
(Common to all branches)

<b>Course Title</b>	<b>Mathematics-II</b>	<b>Course Code</b>	<b>15MA4IMMAT</b>
<b>Credits</b>	<b>00</b>	<b>L – T – P- S</b>	<b>0 – 0 – 0 - 0</b>
<b>Contact hours</b>	<b>48 hours (36L+12T)</b>	<b>IV semester Lateral Entry students</b>	

**PREREQUISITES:** Basic concepts of Trigonometry, Trigonometric formulas, concept of differentiation, concept of integration.

**Course Objectives:** To provide students with a solid foundation in mathematical fundamentals such as Laplace Transforms, Solution of ordinary differential equations using Laplace Transforms, vector integration, computation of area and volume using double integrals triple integrals respectively.

**UNIT 1**

**Laplace transforms**

Laplace transforms of standard functions. Properties and problems. Laplace Transform of Periodic functions with plotting. Unit step function.

**6L+2T=8 Hrs**

**UNIT 2**

**Inverse laplace transforms**

Inverse Laplace transforms of standard functions. Properties and problems. Solution of ODE-Initial and Boundary value Problems.

**7L+2T=9 Hrs**

**UNIT 3**

**Double integral**

Evaluation of double integral. Change of order of integration. Change of variables to polar coordinates. Application: Area.

**8L+3T=11 Hours**

**UNIT 4**

**Triple integrals and improper integrals**

Evaluation of triple integral. Application: Volume. Gamma and Beta functions-definition Relation between Gamma and Beta functions. Properties and Problems.

**6L+2T=8 Hours**

**UNIT 5**

**Vector integration**

Line integral. Green's theorem. Stokes' theorem. Gauss divergence theorem.

**(6L+2T=8Hrs)**

**TEXTBOOK:**

1. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley Precise Textbook series, Vol. 1 and Vol. 2, 10<sup>th</sup> edition, 2014, Wiley- India.
2. Advanced Engineering Mathematics, 4th edition, 2011, by Dennis G. Zill and Cullen, Jones and Bartlett India Pvt. Ltd

**REFERENCE BOOK:**



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1. Higher Engineering Mathematics, B. S. Grewal, 43<sup>rd</sup> edition, 2014, Khanna Publishers.
2. Higher Engineering Mathematics, B. V. Ramana, 7<sup>th</sup> reprint, 2009, Tata Mc. Graw Hill.

**E BOOKS**

- [1] Engineering Mathematics, [K. A. Stroud, Dexter J. Booth](http://books.google.co.in/books/about/Engineering_Mathematics.html?id=FZncL-xB8dEC&redir_esc=y), Industrial Press, 2001 [http://books.google.co.in/books/about/Engineering\\_Mathematics.html?id=FZncL-xB8dEC&redir\\_esc=y](http://books.google.co.in/books/about/Engineering_Mathematics.html?id=FZncL-xB8dEC&redir_esc=y).
- [2] Advanced Engineering Mathematics, P. V. O'Neil, 5<sup>th</sup> Indian reprint, 2009, Cengage learning India Pvt. Ltd.
- [3] (<http://ocw.mit.edu/courses/mathematics/>) (online course material)

**ONLINE COURSES**

- (1) <https://www.khanacademy.org/Math>
- (2) <https://www.class-central.com/subject/math> (MOOCS)
- (3) E-learning: [www.vtu.ac.in](http://www.vtu.ac.in)

Course Code	CO	PO	Bloom's level
15MA4IMMAT	<b>CO-1:</b> Use Laplace transforms to solve differential equations.	1	3
	<b>CO-2:</b> Apply double integrals to compute areas.	1	3
	<b>CO-3:</b> Learn to use triple integrals in computing volumes.	1	3
	<b>CO-4:</b> Use Gamma and Beta functions to evaluate integrals.	1	2
	<b>CO-5:</b> Ability to understand the use of integral calculus in scalar and vector fields.	1	3



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Course Title	CHEMICAL PROCESS EQUIPMENT DRAWING														
Course Code	1	5	C	H	4	D	C	E	Q	D	Credits	02	L – T – P- S	2 – 0 – 0 - 0	
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

**PREREQUISITES:** Engineering Drawing, Elements of Mechanical Engineering

**SYLLABUS:**

**UNIT - I**

Equipment and piping symbols, Vessel component; Vessel opening, Manholes, Vessel enclosures, Vessel support, Jackets and fermenter

05 Hrs

**UNIT - II**

Flanged pipe joint, Union joint and gland and stuffing box expansion joint

06 Hrs

**UNIT – III**

**Valves:** Stop valve, Globe valve, and Non-return valve.

09Hrs

**Pumps:** Centrifugal and Gear pumps

06Hrs

**Note:**

1. All units have only drawing component
2. First angle projection to be followed.
3. Examination consists of one compulsory question from unit -1 and Unit-II 10 marks and 30 marks respectively.
4. One question from Unit-III for 60 marks (UNIT-III will have choice)

**TEXTBOOKS:**

1. Gopal Krishna, K. R., Machine Drawing, 21st edition, Subhas publications, Bangalore, 2012.

**REFERENCE BOOKS:**

1. Bhatt. N. D., Machine Drawing, 14th edition, Charotar Publishing House Pvt. Ltd., Anand-Gujarat, 2011.
2. Joshi. M. V., Process Equipment Design, 3rd edition, Macmillan India Ltd., Delhi, 2006

**E BOOKS**

- [1] An introduction to machine drawing and design: <http://www.gutenberg.org/files/39033/39033-h/39033-h.htm>
- [2] Machine drawing: <http://www.uiet.co.in/downloads/20140911122818-Machine%20Drawing.pdf>

**MOOC's and ONLINE COURSES:**

- [1] <http://nptel.ac.in/syllabus/syllabus.php?subjectId=103107080>
- [2] <http://nptel.ac.in/syllabus/syllabus.php?subjectId=112106075>

**COURSE OUTCOMES (COs):**



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COURSE OUTCOMES		PROGRAMM E OUTCOMES
<b>CO1</b>	Get familiarised with different equipment symbols used to draw process flow diagram	PO2
<b>CO2</b>	Visualize and draw different views of vessels and their components using conventional tools	PO2
<b>CO3</b>	Draw assembled sectional views of valves, pumps and pipe fittings using conventional method	PO3

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100 (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	80%	Course Instructor
	Quiz (Two Quizzes or AAT)	20%	Course Instructor
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	
<ul style="list-style-type: none"> <li>Examination consists of one compulsory question from Unit -1 and Unit-II 10 marks and 30 marks respectively.</li> <li>One question from Unit-III for 60 marks (UNIT-III will have choice)</li> </ul>			

**Assessment Pattern:**

Component	Test 1	Test 2	Quiz 1/AAT	Quiz 2 /AAT	Total Marks
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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Course Title	PROCESS ENGINEERING THERMODYNAMICS													
Course Code	1	5	C	H	4	D	C	P	T	D	Credits	04	L – T – P- S	3 – 1 – 0 - 0
CIE	100 marks (50% weightage)						SEE		100 marks (50% weightage)					

**PREREQUISITES:** Engineering Chemistry and Engineering mathematics

**SYLLABUS:**

**UNIT - I**

**Introduction to Thermodynamics:** Basic concepts, P-V-T behavior of pure fluids, Equations of state: Ideal gas law, Equations for real gases - Vander Waals equation, Virial equation. Compressibility charts.

**Processes involving ideal gas law:** Constant volume, Constant pressure, Constant temperature, Adiabatic and Polytrophic processes.

[6L+3T=09Hrs]

**UNIT - II**

**Thermodynamic Properties of Pure Fluids and Solutions:** Relationships among thermodynamic properties, Clausius-Clapeyron equations, Heat capacity, Entropy and other forms of energy relations, Joule Thomson coefficient. Gibbs-Helmholtz equation, Thermodynamics diagrams, partial molar properties and its calculations.

[11L+ 2T=13Hrs]

**UNIT- III**

**Properties of Solutions:** Chemical potential, Fugacity in solutions, Henry's law and dilute solutions, Activity in solutions, Activity coefficients, Gibbs-Duhem equations, Property changes of mixing, Heat effects of mixing processes, Excess properties.

**Phase Equilibria:** Criteria of phase equilibrium, Criterion of stability, Duhem's theorem, Vapour-Liquid Equilibrium, Phase diagrams for binary solutions, VLE in ideal solutions, Activity coefficient.

[11L+2T=13Hrs]

**UNIT - IV**

**Non-Ideal solutions:** Azeotropes, Activity coefficient equations: Van Laar equation, Margules and Willson equations; Consistency test for VLE data: Slope method, Midpoint method, Redlich-Kister method and partial pressure data

[4L+3T=07Hrs]

**UNIT - V**

**Chemical Reaction Equilibrium:** Reaction Stoichiometry, Criteria of chemical reaction equilibrium, Equilibrium constant and standard free energy change, Feasibility of chemical reaction; Equilibrium constant: Effect of temperature, Evaluation, Giauque Functions, Effect of pressure; Equilibrium conversion: Effect of pressure, inert materials, excess of reactants, products, Phase rule for reacting system.

[7L+3T=10Hrs]

**TEXTBOOKS:**

1. Smith J. M. and Van Ness H. C, "Introduction to Chemical Engineering Thermodynamics", 5<sup>th</sup> edition, McGraw Hill, New York, 1996.
2. Narayanan, K. V. "Chemical Engineering Thermodynamics", Prentice Hall of India Private Limited, New Delhi, 2001.



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**REFERENCE BOOKS:**

1. Rao, Y. V. C Chemical Engineering Thermodynamics, New Age International Publication, Nagpur, 2000.
2. Gopinath Halder, "Introduction to chemical engineering thermodynamics", PHI Learning Pvt. Ltd., New Delhi, 2009

**E BOOKS**

- [1] Kevin Dahm, "Fundamentals of Chemical Engineering Thermodynamics": <https://books.google.co.in/books>
- [2] Dimitrios Tassios, "Applied Chemical Engineering Thermodynamics": <https://books.google.co.in/books>

**MOOC's and ONLINE COURSES:**

- [1] <http://elearning.vtu.ac.in/06ME33.html>
- [2] MOOC's Course on Thermodynamics: [https://www.iitbombayx.in/courses/IITBombayX/ME209xA15/2015\\_T1/about](https://www.iitbombayx.in/courses/IITBombayX/ME209xA15/2015_T1/about)

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
CO1	Understand fundamental properties of fluids and solve problems related heat and work	PO2
CO2	Establish relations between thermodynamic energy functions	PO2
CO3	Generate VLE data using various correlations	PO4
CO4	Apply the knowledge of equilibrium conversion to determine the feasibility of reactions	PO4

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100 (Weightage 50%)	Assessment by
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
Semester End Examination (Written Examination for Three Hours)		Marks 100 (Weightage 50%)	

**Assessment Pattern:**

Component	Test 1	Test 2	Quiz 1/AAT	Quiz 2 /AAT	Total Marks
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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<b>Course Title</b>	<b>PROCESS HEAT TRANSFER</b>													
<b>Course Code</b>	<b>1</b>	<b>5</b>	<b>C</b>	<b>H</b>	<b>4</b>	<b>D</b>	<b>C</b>	<b>H</b>	<b>T</b>	<b>R</b>	<b>Credits</b>	<b>06</b>	<b>L – T – P- S</b>	<b>3 – 0 – 1 - 2</b>
<b>CIE</b>	<b>100 marks (50% weightage)</b>						<b>SEE</b>	<b>100 marks (50% weightage)</b>						

**PREREQUISITES:** Engineering Mathematics and Engineering Physics

**SYLLABUS:**

**UNIT -I**

**Introduction:** Various modes of heat transfer Viz. Conduction, Convection and Radiation.  
**Conduction:** Fourier's law, Steady state unidirectional heat flow through single and multiple layer slabs, spheres and cylindrical surfaces for constant and variable thermal conductivity.

9Hrs

**UNIT-II**

**Insulation:** Properties of insulation materials, Types of insulation, Critical and Optimum thickness of insulation. **Fin:** Types of fins, Heat dissipation from a fin losing heat at tip, Heat flow through infinitely long rectangular fin, heat dissipation from fin insulated at tip. Fin efficiency and fin effectiveness-derivation and problems. Elementary treatment of unsteady state heat conduction.

10Hrs

**UNIT -III**

**Convection:** Individual and over all heat transfer coefficient, LMTD, LMTD correction factor, Heat Transfer with Phase Change: Boiling phenomena, Nucleate and film boiling, **Condensation:** Film and Drop wise condensation, Nusselt's equations.

7 Hrs

**UNIT -IV**

**Evaporation:** Methods of Feeding multi effect evaporator, working of single effect natural Circulation evaporator. Enthalpy Balance for single effect evaporator and calculations, BPE, Durhring's Chart, Economy and capacity of Evaporators.

7 Hrs

**UNIT-V**

**Radiation:** Definitions for absorptivity, reflectivity, emissive power and intensity of radiation, black body radiation, grey body radiation Stefan-Boltzman's Law, Wien's displacement Law, Kirchoff's Law, view factors. Radiation between surfaces-different shapes, radiation involving gases and vapors, radiation shields.

6 Hrs

**LABORATORY COMPONENT**

1. Shell and Tube Heat Exchanger
2. Double Pipe Heat Exchanger
3. Vertical condenser
4. Emissivity
5. Helical coil Heat Exchanger
6. Transient Heat Conduction (constant temperature)
7. Bare Tube Heat Exchanger
8. Fin Tube Heat Exchanger
9. Packed Bed Heat Exchanger
10. Transient Heat Conduction (constant flux)



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**TEXTBOOKS:**

1. Kern D. Q., "Process Heat Transfer" Mc GrawHill, New York, 1965
2. McCabe, Warren, L., Smith, Julian, C. and Harriott, Peter, "Unit operations of chemical engineering", 5th edition, McGraw-Hill, Singapore, 2000.

**REFERENCE BOOKS:**

1. Coulson J. M. and Richardson J. F. "Unit Operations of Chemical Engineering, 5<sup>th</sup> edition, Chemical Engineering Pergamon and ELBS, Mc Graw Hill, New York 2000.
2. P. K. Nag, Heat and Mass Transfer, 2<sup>nd</sup> edition, TataMcGrawhillpublications.

**E-BOOKS**

- [1] Rao Y. V. C, Heat Transfer, 1<sup>st</sup> edition, Universities Press (India) Ltd., New Delhi, 2000.
- [2] Dutta, B. K, Heat Transfer: Principles and Applications, PHI Learning Pvt. Ltd., New Delhi, 2006

**MOOC's and ONLINE COURSES:**

- [1] <http://textofvideo.nptel.iitm.ac.in/103103031/lec1.pdf>
- [2] <https://www.mooc-list.com/course/heat-transfer-saylororg%3Fstatic%3Dtrue+%3Dcd=7&hl=en&ct=clnk&gl=in>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
CO1	Understand the principles of heat transfers and perform heat flux calculations for constant & variable area elements	PO2
CO2	Estimation of optimum insulation thickness and select different shapes of extended surfaces to enhance overall heat transfer co-efficient.	PO4
CO3	Perform preliminary design of heat transfer equipment using data with and without phase change	PO3
CO4	Comprehend and apply the laws governing radiation mode	PO2
CO5	Conduct experiments to estimate the individual & overall heat transfer co-efficient of heat exchanger for with and without phase change	PO9

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100% (Weightage 50%)	Assessment by
Theory Component	Three Internals (Best of Two)	40%	Course Instructor
	Quiz (Two Quizzes)	10%	Course Instructor
Laboratory Component	Laboratory Component	30%	Course Instructor



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Self-Study Component	Open Ended Experiments/Term Papers/Modelling/Seminar/Mini projects.	20%	Committee constituted by HOD
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

Component	Theory (50%)			Practical (30%)		Self-Study (20%) by AAT	Total Marks
	Test 1	Test 2	Quiz	Records & Performances	Lab Test		
Max. Marks	20	20	10	20	10	20	100
Reduced CIE	10	10	5	10	05	10	50



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Course Title	PROCESS PRINCIPLES AND CALCULATIONS													
Course Code	1	5	C	H	4	D	C	P	P	C	Credits	04	L – T – P- S	3 – 1– 0- 0
CIE	100 marks (50% weightage)						SEE		100 marks (50% weightage)					

**PREREQUISITES:** Engineering Mathematics and Engineering chemistry

**SYLLABUS:**

**UNIT I**

**Units and Dimensions:** Fundamental and derived units, conversion of units, dimensional consistency of equations, dimensionless groups and constants, conversion of equations. [4L+1T=05 Hrs]

**Basic Chemical Calculations:** Concept of mole, mole fraction, compositions of mixtures of solids, liquids and gases. Concept of normality, molarity, molality, parts per million. Use of semi log and triangular graphs, Ideal gas law, Amagat's law and Dalton's law and related problems.

[6L+2T=08 Hrs]

**UNIT II**

**Psychrometry:** Vapour pressure concept, Clausius-Clapyron equation, Cox chart and its use, Psychrometry, absolute humidity, molal humidity, relative humidity, dry bulb, wet bulb thermometry, humidity chart, humidification and dehumidification, and air-conditioning. [8L+2T=10Hrs]

**UNIT III**

**Steady State Material Balance with Reaction:** Principles of stoichiometry, concept of limiting and excess reactants and inert, fractional and percentage conversion, fractional yield and percentage yield, selectivity and related problems.

[7L+4T=11Hrs]

**UNIT IV**

**Calculations related fuels and combustion:** Ultimate and proximate analysis of fuels, calculations involving burning of solid, liquid and gaseous fuels, excess air, air-fuel ratio calculations.

[7L+2T=09Hrs]

**UNIT V**

**Energy balance:** General steady state energy balance equation, heat capacity, enthalpy, heat of formation, heat of reaction, heat of combustion, and heat of mixing, determination of heat of formation at standard and elevated temperatures, theoretical flame temperature and adiabatic flame temperature.

[7L+2T=09Hrs]

**TEXTBOOKS:**

1. K. V. Narayanan and B. Lakshmikutty Stoichiometry and Process Calculations, 2<sup>nd</sup> edition, 2009, PHI Learning private Ltd. New Delhi.
2. Bhatt B. L. and Vora S. M. Stoichiometry, 3<sup>rd</sup> edition, 1996, Tata McGraw Hill Publishing Ltd., New Delhi.

**REFERENCE BOOKS:**



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1. Hougen O. A., Waston K. M. and Ragatz R. A., Chemical Process Principles Part -I' Material and Energy Balances, 2<sup>nd</sup> edition, CBS publishers and distributors, New Delhi, 1995.
2. Himmelblau D. M., Basic Principles and Calculations in Chemical Engineering, 6<sup>th</sup> edition, Prentice Hall of India, New Delhi 1997. Charts: Psychrometric chart, steam tables

**E-BOOKS**

- [1] K. V. Narayanan, B. Lakshmikutty, "Stoichiometry and process calculations", <https://books.google.co.in/books?id=52tqCFSC0ZgC&printsec>
- [2] Gavhane, K. A, "Introduction to Process Calculations Stoichiometry", <https://books.google.co.in/books?id=80v3hRHoEv0C&printsec>

**MOOC's and ONLINE COURSES:**

- [1] <http://www.nptel.ac.in/syllabus/103102017/>
- [2] <http://elearning.vtu.ac.in/10BT46.html>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
CO1	Understand and verify the unit consistency of equations and unit conversion.	PO2
CO2	Formulate and solve material and energy balance for processes involving single & multiple components with & without reactions.	PO3
CO3	Apply the basics of material balance for air-fuel ratio calculations, excess and limiting reactant calculations	PO4

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100 (Weightage 50%)	Assessment by
Theory Component	Three Internals (Best of Two)	80%	Course Instructor
	Quiz (Two Quizzes or AAT)	20%	Course Instructor
Semester End Examination (Written Examination for Three Hours)		Marks 100 (Weightage 50%)	

**Assessment Pattern:**

Component	Test 1	Test 2	Quiz 1/AAT	Quiz 2 /AAT	Total Marks
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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Course Title	ANALYTICAL INSTRUMENTS FOR ANALYSIS													
Course Code	1	5	C	H	4	D	C	A	I	A	Credits	05	L – T – P- S	2 – 0– 1- 2
CIE	100 marks (50% weightage)						SEE		100 marks (50% weightage)					

**PREREQUISITES:** Engineering Physics, Engineering Chemistry and Technical Chemistry

**SYLLABUS:**

**UNIT – I**

**Introduction:** Introduction to classical qualitative and quantitative analysis, classification of instrumental methods, Errors, precision and accuracy of instruments, statistical methods of data handling. 04Hrs

**UNIT II**

**Spectroscopy:** Beer's Law, deviation of Beer's Law, instrumentation of UV and IR spectroscopy: Monochromatic Source, grating systems and types of detectors, different sampling techniques and application of UV & IR Spectroscopy. 06Hrs

**UNIT – III**

**Gravimetric analysis:** Principle of Thermogravimetric analyzer (TGA), construction of TGA, principle of bomb Calorimeter (BC), principle of Differential scanning calorimeter (DSC), Instrumentation of TGA and BC, Application of TGA and BC instruments. 05Hrs

**UNIT – IV**

**Gas chromatography:** Introduction, Principle, carrier gas, stationary phase, instrumentation, column detectors (TCD, FID, ECD), qualitative and quantitative analysis. 06 Hrs

**UNIT – V**

**High performance liquid chromatography:** Principle, instrumentation, types of columns, sample injection, detectors used like (absorbance, refractive index, and electrochemical measurements), criteria for mobile phase selection and application of HPLC. 05Hrs

**LABORATORY COMPONENT**

1. Determination of Pka value of a component using UV-spectroscopy
2. Study of Chemical Reaction Kinetics using UV-System
3. Effect of temperature on viscosity of oils using red wood viscometer
4. Determination of concentration of mixed alkali metal by Flame photometer
5. Determination of moisture content in a liquid and solid samples using KF titration
6. Thin layer Chromatography
7. Gas Chromatography
8. Bomb calorimeter for analysis of calorific value of given sample.
9. Electro analytical instrument like conductivity cell and its measurements

**TEXTBOOK:**



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1. Instrumental Methods of Chemical Analysis; Gurudeep R. Chatwal and Sham K. Anand, Himalaya Publishing House
2. Douglas A. Skoog, F. James Holler, Stanley R. Crouch., "Principles of Instrumental Analysis", 6<sup>th</sup> Edition, published by Thomson Brooks/Cole, 2007.

**REFERENCE BOOKS:**

1. Lloyd R. Snyder, Joseph J. Kirkland, John W. Dolan., "Introduction to Modern Liquid Chromatography", 3<sup>rd</sup> Edition, Wiley-Blackwell, scholarly publishing.
2. H. H. Willard, L. L. Merritt, J. N. Dean and F. A. Settle, "Instrumental methods of analysis", I. B. H. Publishing House, New Delhi

**E-BOOKS**

- [1] Gregory S. Patience, "Experimental Methods and Instrumentation for Chemical Engineers": <https://books.google.co.in/books?id>
- [2] Sharma, B. K., "Instrumental Methods of Chemical Analysis": <https://books.google.co.in/books?id>

**MOOC's and ONLINE COURSES:**

- [1] <http://www.myopencourses.com/subject/modern-instrumental-methods-of-analysis>
- [2] <http://nptel.ac.in/courses/103108100/module1/module1.pdf>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
CO1	Apply the theoretical concepts behind the functioning analytical instrument	PO1
CO2	Understand the impact, complexity of each instrument, its strength and its limitation	PO2
CO3	Select the instruments based on appropriate criteria, analyze and interpret the experimental data	PO4
CO4	Analyze and interpret the experimental data to provide valid conclusions	PO4
CO5	Conduct experiments using various instruments for physical and chemical analysis	PO9

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100% (Weightage 50%)	Assessment by
Theory Component	Three Internals (Best of Two)	40%	Course Instructor
	Quiz (Two Quizzes)	10%	Course Instructor
Laboratory Component	Laboratory Component	30%	Course Instructor



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Self-Study Component	Open Ended Experiments/Term Papers/Modelling/Seminar/Mini projects.	20%	Committee constituted by HOD
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

Component	Theory (50%)			Practical (30%)		Self-Study (20%) by AAT	Total Marks
	Test 1	Test 2	Quiz	Records & Performances	Lab Test		
Max. Marks	20	20	10	20	10	20	100
Reduced CIE	10	10	5	10	5	10	50



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Course Title	CHEMICAL REACTION ENGINEERING-I													
Course Code	1	6	C	H	5	D	C	C	R	1	Credits	06	L – T – P- S	3 – 0 – 1 - 2
CIE	100 marks (50% weightage)						SEE		100 marks (50% weightage)					

**PREREQUISITES:** Engineering Chemistry, Engineering Maths and Technical Chemistry

**SYLLABUS:**

**UNIT-I**

**Introduction:** Scope of Chemical Reaction Engineering, Classification of reactions, Rate equation and rate of reaction, Factors affecting rate of reaction, Chemical kinetics and Thermodynamics Equilibrium, Temperature-dependency of rate constant from Arrhenius, Collision and Transition state theories. Molecularity and order of reactions.

07 Hrs

**UNIT-II**

**Non-Elementary reactions:** Difference between elementary and non- elementary reactions. Kinetic models and mechanisms for non-elementary reactions and types of reactors.

06 Hrs

**UNIT-III**

**Homogeneous reactions:** Interpretation of batch reactor data. Constant & Variable Volume batch reactor. Analysis: Differential method, Integral method, half-life method, method of excess and method of isolation (for Reversible and Irreversible reactions up to second order).

**Design of ideal reactors:** Concept of ideality, Development of design equations for batch, tubular and stirred tank reactors for both constant and variable volume reactions. Evaluation of rate equations from data obtained in these reactors

10Hrs

**UNIT – IV**

**Multiple reactor systems:** Plug flow and Mixed flow reactors in Series & parallel reactions, Reactors of different types and sizes in series, Comparison of Ideal Reactors and General graphical comparison.

**Design of reactors for multiple reactions:** Design of Batch reactor, Plug and Mixed flow reactors for Parallel, Series and Series-Parallel reactions (Only irreversible reactions must be considered).

10Hrs

**UNIT- V**

**Non-isothermal reactors:** Introduction, Material, Energy balances and conversions. Analysis of Non Isothermal Reactor: Design procedure (For single/simple reactions only). Optimum temperature Progression.

06 Hrs

**LABORATORY COMPONENT**

1. Batch Reactor
2. Isothermal plug flow reactor
3. Mixed flow reactor
4. Semi batch reactor
5. Packed bed Reactor
6. RTD Studies in Tubular Reactor
7. Effect of temperature on Rate of reaction



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8. RTD Studies in mixed flow reactor
9. RTD Studies in plug flow reactor

**TEXTBOOK:**

1. Octave Levenspiel, Chemical Reaction Engineering, 3<sup>rd</sup> Edition, John Wiley & Sons, 2001.
2. H. Scott Fogler, Elements of Chemical Reaction Engineering. 3<sup>rd</sup> Edition, Prentice Hall, 2001.

**REFERENCE BOOKS:**

1. J. M. Smith, Chemical Engineering Kinetics, 3<sup>rd</sup> Edition, McGraw Hill, 1984
2. K. A. Gavhane, Chemical Reaction Engineering-I, Volume-1, Nirali Prakashan., ISBN-13: 9788185790879, 2011.

**E BOOKS**

- [3] Fundamentals of Chemical Reaction Engineering by M E Davis: <http://authors.library.caltech.edu/25070/1/FundChemReaxEng.pdf>
- [4] Chemical Reaction Engineering: Beyond the Fundamentals by Doraiswamy : <https://www.crcpress.com/Chemical-Reaction-Engineering-Beyond-the-Fundamentals/Doraiswamy-Uner/9781439831229>
- [5] Fundamentals of Chemical Reaction Engineering, Mark E. E. Davis, Robert J. J. Davis <http://www.e-booksdirectory.com/details.php?ebook=2512>

**MOOC's & ONLINE COURSES:**

- 1) <http://ocw.mit.edu/courses/chemistry/5-68j-kinetics-of-chemical-reactions-spring-2003/index.htm>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
CO1	Formulate and analyse the rate equations for different reactions using suitable mechanism for reaching a sustainable conclusion	PO2
CO2	Analyse and interpret the data to determine rate equation and estimate the performance equation of ideal systems	PO4
CO3	Develop optimal operational conditions for ideal reactor with single and multiple reactions	PO3
CO4	Predict reactor performance for non-isothermal conditions with consideration of public health and safety during operations	PO3
CO5	Conduct experiments in teams to collect kinetic data from both ideal and non-ideal reactors	PO9
CO6	Interpret experimental data to estimate and provide valid conclusions in terms of their kinetics and behaviour for ideal & non-ideal reactors	PO4

**ASSESSMENT:**



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Continuous Internal Assessments		Marks 100% (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	40%	Course Instructor
	Quiz (Two Quizzes)	10%	Course Instructor
Laboratory Component	Laboratory Component	30%	Course Instructor
Self-Study Component	Open Ended Experiments/Term Papers/Modelling/Seminar/Mini projects.	20%	Committee constituted by HOD
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

Component	Theory (50%)			Practical (30%)		Self-Study (20%) by AAT	Total Marks
	Test 1	Test 2	Quiz	Records & Performances	Lab Test		
Max. Marks	20	20	10	20	10	20	100
Reduced CIE	10	10	5	10	5	10	50



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Course Title	MASS TRANSFER-I													
Course Code	1	6	C	H	5	D	C	M	T	1	Credits	06	L – T – P- S	3 – 0 – 1 - 2
CIE	100 marks (50% weightage)						SEE			100 marks (50% weightage)				

**PREREQUISITES:** Engineering Chemistry, Engineering Maths and Technical Chemistry

**SYLLABUS:**

**UNIT-I**

**INTRODUCTION:** Diffusion in fluids, Diffusion in solids, Measurement and Calculations of diffusivities. Eddy diffusion: Mass Transfer coefficients and their correlations, Theories of Mass Transfer, Interphase Mass Transfer, J-factor. Equipment: Membrane Operations-Ultrafiltration, microfiltration and reverse osmosis.

10Hrs

**UNIT-II**

**HUMIDIFICATION OPERATIONS:** Vapour pressure Curve, Enthalpy of pure substance, Humidity and related terminologies, Psychrometric chart, Adiabatic-Saturation Curves, Wet bulb temperature, Lewis Relation and gas liquid contact operations. Equipment-Water Cooling towers and spray chamber.

07 Hrs

**UNIT-III**

**DRYING:** Introduction to drying operation, Equilibrium, Drying rate curves, Mechanism of drying. Equipment: Direct, and indirect batch driers, and rotary, spray and drum continuous driers.

07 Hrs

**UNIT – IV**

**ADSORPTION AND ION EXCHANGE:** Theories of adsorption, Industrial adsorbents. Material balance for co-current, cross current and counter current operations: Fixed Bed Adsorption, Adsorption of liquids and Ion Exchange.

08 Hrs

**UNIT- V**

**CRYSTALLIZATION:** Factors governing nucleation and crystal growth rates, Controlled growth of crystals, Incorporation of principles into design of equipment, Crystallizer equipment: Vacuum crystallizers and Draft Tube- Baffle Crystallizer.

07Hrs

**LABORATORY COMPONENT**

1. Diffusion co-efficient of organic vapour into air
2. Surface evaporation
3. Drying characteristics
4. Single stage adsorption
5. Solid dissolution
6. Multistage adsorption
7. Wetted wall column



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**TEXTBOOK:**

1. Robert E. Treybal, "Mass transfer operations", 3<sup>rd</sup> edition, McGraw Hill publications, 1980.
2. McCabe & Smith, "Unit operations in chemical engineering", 6<sup>th</sup> edition, McGraw Hill publications, 2001.

**REFERENCE BOOKS:**

1. Coulson and Richardson, "Chemical Engineering", Vol I, II, IV & V, 4<sup>th</sup> edition, Pergamon press.
2. Badger, W. L. and Banchero J. T., "Introduction to Chemical Engineering", 3<sup>rd</sup> edition, McGraw Hill International Edition., 1999.

**E BOOKS**

- [1] Mass Transfer in Chemical Engineering Processes, by Jozef Markoš  
<http://www.e-booksdirectory.com/details.php?ebook=6659>
- [2] Ion Exchange: Studies and Applications, Ayben Kilislioglu,  
<http://www.e-booksdirectory.com/details.php?ebook=10637>
- [3] Transport Processes and Unit Operations by Geankoplis  
<http://chembookneed.blogspot.in/2010/08/transport-processes-and-unit-operations.html>

**MOOC's & ONLINE COURSES:**

- [1] Mass Transfer operations 1 <https://www.coursebuffet.com/sub/chemical-engineering/480/mass-transfer-operations-i>
- [2] Mechanical heat and mass transfer <https://www.springboard.com/udemy/mechanical-heat-and-mass-transfer/>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMM E OUTCOMES
CO 1	Formulate equation to estimate diffusivities in fluids & solids using first principles of engineering sciences	PO1
CO 2	Apprehend the analogies in transport processes for validating and reaching substantiated conclusions.	PO2
CO 3	Apply mass transfer fundamentals to calculate rates of mass transfer and design the system components for various operations.	PO3
CO 4	Apply of the principles of novel separation process to assess societal, health and safety by consequent responsibilities	PO7
CO 5	Conduct experiments in teams related to various mass transfer operations.	PO9
CO 6	Interpret experimental data to estimate mass transfer co-efficient and provide valid conclusions on suitability of the process.	PO3



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**ASSESSMENT:**

Continuous Internal Assessments		Marks 100% (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	40%	Course Instructor
	Quiz (Two Quizzes)	10%	Course Instructor
Laboratory Component	Laboratory Component	30%	Course Instructor
Self-Study Component	Open Ended Experiments/Term Papers/Modelling/Seminar/Mini projects.	20%	Committee constituted by HOD
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

Component	Theory (50%)			Practical (30%)		Self-Study (20%) by AAT	Total Marks
	Test 1	Test 2	Quiz	Records & Performances	Lab Test		
Max. Marks	20	20	10	20	10	20	100
Reduced CIE	10	10	5	10	5	10	50



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Course Title	CHEMICAL EQUIPMENT DESIGN														
Course Code	1	6	C	H	5	D	C	C	E	D	Credits	04	L – T – P- S	3 – 1 – 0 - 0	
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

**PREREQUISITES:** Engineering Drawing and Process Equipment drawing

**SYLLABUS:**

**UNIT – I**

**INTRODUCTION:** Basic considerations in design, General design procedure, Equipment classification. Various components of process equipment, Design parameters and Pressure vessel codes  
[6L= 06Hrs]

**UNIT – II**

**DESIGN CONSIDERATIONS:** Material selection, factors affecting design, Stresses due to static and dynamic loads (Internal & External), Temperature effects and Economic considerations.

**DESIGN OF PRESSURE VESSELS:** Design parameters, conditions & stresses, Design of shell and other vessel components. Design of vessel closures - Flat, Formed/Tori spherical heads, Elliptical, Hemispherical and Cylindrical heads. Numerical design problems using process parameters.

[11L+ 3T=14Hrs]

**UNIT- III**

**VESSEL COMPONENT DESIGN:** Design of supports for vessels - Bracket, Lug, Leg, Saddle and Skirt supports. Design of flanges & nozzles - Classification of flanges. Flange thickness calculation, Gasket selection and design, Bolt selection and calculation, Nozzle design.

**REACTION VESSELS:** Design of reaction tanks with agitator, Types of agitators, baffles, Power requirement calculations with tank dimensions, Numerical problems.

[11L+3T=14Hrs]

**UNIT – IV**

**STORAGE VESSELS:** Process conditions and design parameters for storage of volatile, non-volatile fluids & gases, Design of cylindrical tanks with fixed roofs, Annular ring, Base plate and selection of vessels accessories & mountings. Numerical problems with bill of materials and cost estimation.

[7L+2T=09Hrs]

**UNIT - V**

**PIPE LINE DESIGN:** Economic Pipe line sizing, Optimum size of delivery line in pumping operations with rating. Concepts of P&I Diagrams with P&I Diagram for simple processes.

[7L+2T=09Hrs]

**TEXTBOOKS:**

1. V V Mahajani & S B Umarji, "Joshi's Process Equipment Design" – Trinity Press, Delhi, India 4<sup>th</sup> edition.
2. S. D. Dawande, "Process Design of Equipment", Vol 1, Central Techno Publications. 3<sup>rd</sup> edition, 2003.
3. Brownell & Young, "Process equipment design" Wiley student, 1<sup>st</sup> edition, 2009.

**REFERENCE BOOKS:**

1. Don W. Green & Robert H. Perry, "Chemical Engineers Handbook", 8<sup>th</sup> edition, McGraw Hill, 2014.
2. Code for United Pressure Vessel, IS 2825, Bureau of Indian standards, , New Delhi, 1969.

**E BOOKS**



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[1] Joshi's Process equipment design

[https://books.google.co.in/books/about/Joshi\\_s\\_Process\\_Equipment\\_Design.html?id=UTC1bc3PCNeC&redir\\_esc=y](https://books.google.co.in/books/about/Joshi_s_Process_Equipment_Design.html?id=UTC1bc3PCNeC&redir_esc=y)

**MOOC's and ONLINE COURSES:**

[1] <http://nptel.ac.in/courses/103103027/28>

[2] <http://nptel.ac.in/courses/103103027/8>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
CO1	Realize the practical applications of basic engineering design principles using first principles of mathematics and engineering sciences.	PO2
CO2	Apply reasoning and select suitable materials based on the process to assess the health and safety of the society.	PO6
CO3	Design on various reaction/pressure vessel components with environmental consideration.	PO3
CO4	Estimation of sizing of pipes, pumps & storage vessel with its accessories to provide the valid conclusions for their use.	PO4

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100 (Weightage 50%)	Assessment by
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
Semester End Examination (Written Examination for Three Hours)		Marks 100 (Weightage 50%)	

**Assessment Pattern:**

Component	Test 1	Test 2	Quiz 1/AAT	Quiz 2 /AAT	Total Marks
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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Course Title	POLLUTION CONTROL & MANAGEMENT														
Course Code	1	6	C	H	5	D	C	P	C	M	Credits	03	L – T – P- S	3 – 0 – 0 - 0	
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

**PREREQUISITES:** Engineering Chemistry and Engineering Physics

**SYLLABUS:**

**UNIT - I**

**WATER POLLUTION:** Water as Resource, Drinking water quality, water consumption standards, Types of Water Pollutants and sources, State and central wastewater quality and its various discharge standards. Wastewater Sampling and Characteristics - Physical, Chemical and Biological characteristics of wastewater: Solving numerical on the sampling, characteristics and estimation of wastewater flow rates.

06Hrs

**UNIT – II**

**WASTEWATER TREATMENT:** Preliminary/Primary/physical unit operations, Chemical unit processes, Secondary/Biological treatment process, aerobic/anaerobic attached and suspended growth process, Sludge treatment & Disposal. Numerical problems.

07Hrs

**UNIT- III**

**TERTIARY/ADVANCED WASTEWATER TREATMENT:** Ultrafiltration, Filtration, Adsorption on Activated Carbon, Ion Exchange, Reverse Osmosis, Electro dialysis cell. Wastewater treatment in Industries: Paper and Pulp, distillery, Leather, Food processing such dairy and fruit processing and Textile processing.

09Hrs

**UNIT- IV**

**AIR POLLUTION:** Definition, Sources, Classification, Properties of air pollutants, and Effects of air pollution on health, vegetation and materials. Air pollution sampling: Ambient sampling and Stack sampling, Analysis of air pollutants, Control methods and Equipment for particulates and gaseous pollutants, Applications to Industries: Thermal power plants, Metallurgical and Cement industries.

**NOISE POLLUTION:** Definition, Sources, Effects of Noise, Equipment for Noise Measurement, Approaches for Noise Control.

10Hrs

**UNIT –V**

**SOLID WASTE MANAGEMENT:** Definitions, Characteristics and perspectives, Types of solid wastes, Sources of Solid waste, Properties of solid waste –Numerical problems, Solid waste Management – An Overview: - Material flow in society, Reduction in raw material usage, Solid waste generation, and reuse with materials, energy recovery.

07Hrs

**TEXTBOOKS:**

1. Environmental Engineering by Howard S. Peavey, Donald R. Rowe, George Tchobanoulous, McGraw-Hill International Editions.
2. Wastewater Engineering – Treatment, Disposal and Reuse, METCALF AND EDDY, INC. 3<sup>rd</sup> Edition Tata McGraw-Hill Publishing Company Limited.

**REFERENCE BOOKS:**



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1. C S Rao, Environmental Pollution Control Engineering, New Age International Publisher, 2011.
2. M N. Rao, Air Pollution, Tata McGraw-Hill Publishing Company Limited

**E BOOKS**

- [3] Air Pollution by Mn Rao and Hvn Rao: <http://www.avlib.in/ebook/title/air-pollution-mn-rao-and-hvn-rao-.html>
- [4] <https://www.free-ebooks.net/ebook/introduction-to-wastewater-treatment>

**MOOC's & ONLINE COURSES:**

- [1] [http://www.openculture.com/free\\_certificate\\_courses](http://www.openculture.com/free_certificate_courses)
- [2] <https://www.class-central.com/subject/civil-environmental-engineering>
- [3] <https://www.class-central.com/subject/environmental-science>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
<b>CO1</b>	Apply reasoning to identify the components of environmental eco systems and effect of pollutant on environment.	PO6
<b>CO2</b>	Characterize the various parameters for treatment of water, waste water and solid waste from their sources to provide valid conclusions.	PO4
<b>CO3</b>	Understand the impact of recovery, recycle of the useful resources from the wastes by adopting advanced techniques to demonstrate the need for sustainable development.	PO7
<b>CO4</b>	Identify and demonstrate the knowledge to use suitable equipment for abatement and control of air & noise pollution	PO7

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100 (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

Component	Test 1	Test 2	Quiz 1/AAT	Quiz 2 /AAT	Total Marks
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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Course Title	FOOD ENGINEERING													
Course Code	1	6	C	H	5	D	E	L	A	1	Credits	03	L – T – P- S	3 – 0 – 0 - 0
CIE	100 marks (50% weightage)						SEE			100 marks (50% weightage)				

**PREREQUISITES:** Engineering Chemistry and Technical Chemistry

**SYLLABUS:**

**UNIT - I**

**INTRODUCTION TO FOOD ENGINEERING:** Introduction: general aspects of food industry, world food demand and Indian scenario, Physical properties of food materials: Rheological models, Water activity, Fluid Flow in Food Processing: Liquid Transport Systems; Pipes for Processing Plants, Pumps for food plants; Numerical on fluid flow in food processing.

05Hrs

**UNIT – II**

**FOOD PROCESSING AND PRESERVATION:** Food deterioration – Causes, Aims and objectives of preservation and processing.

**FOOD CONTAMINATION AND ADULTERATION:** Types of adulterants and contaminants, Intentional adulterants, Metallic contamination, Incidental adulterants, Nature and effects, food laws and standards, Hazard analysis and critical control points or HACCP, Food Safety and Standards Authority of India (FSSAI)

07Hrs

**UNIT- III**

**HIGH-TEMPERATURE PRESERVATION:** Introduction to Thermal Processing; Pasteurisation; Commercial Sterilization Kinetics of Microbial Death; Thermal Death Time; Heat Transfer in Thermal Processing; Integrated F Value; Numericals; Batch & continuous Retorts for Thermal processing; Cold sterilization: Gamma irradiation; Microwave & Ohmic heating

**LOW-TEMPERATURE PRESERVATION:** principles of low temperature preservation; freezing rate & freezing point; physical properties of frozen food; food quality during frozen storage; freezing equipment, plate freezer, blast freezer, fluidised bed freezer, scraped surface freezer; cryogenic and immersion freezing; prediction of freezing time using Plank's equation & Nagaoka's equation.

10Hrs

**UNIT- IV**

**FOOD ADDITIVES:** Introduction and need for food additives, Types of additives – antioxidants, chelating agents, colouring agents, curing agents, emulsions, flavors and flavor enhancers, flavor improvers, humectants and anti-caking agents, leavening agents, nutrient supplements, non-nutritive sweeteners, pH control agents. Preservatives: types and applications, Stabilizers and thickeners, other additives, Additives and food safety.

07Hrs

**UNIT –V**

**EXTRUSION PROCESSES:** Introduction to Extrusion, Basic Principles, Extrusion Systems, Cold Extrusion, Extrusion Cooking, Single Screw Extruders, Twin-Screw Extruders.

**PACKAGING CONCEPTS:** Introduction to packaging, food protection, product containment, commutation, convenience, mass transfer in packaging materials, and permeability of packaging material to fixed gases, innovations in food packaging, passive packaging, active packaging, intelligent



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packaging, food packaging and product shelf-life. Advances in aseptic processing and packaging, nutrition labelling.

10Hrs

**TEXTBOOKS:**

1. R. Paul Singh and Dennis R. Introduction to Food Engineering, Elsevier Science & Technology, 5<sup>th</sup> Edition, ISBN: 9780123985309, 2013.

**REFERENCE BOOKS:**

1. P. G. Smith, Introduction to Food Process Engineering Second Edition, Springer Press, ISBN 978-1-4419-7661-1, 2009
2. Subbulakshmi G. and Shobha A. Udipi, Food Processing and Preservation, New Age International Pvt. Ltd., ISBN: 8122412831, 2001

**E BOOKS**

[1] Food Engineering 1, Gustavo V. Barbosa-Canovas & Pablo Juliano

<http://www.eolss.net/ebooklib/ebookcontents/e5-10-themecontents.pdf>

[2] Food Processing, Carl J. Schaschke: <http://bookboon.com/en/food-processing-ebook>

**MOOC's & ONLINE COURSES:**

[1] <https://www.coursetalk.com/subjects/food-nutrition/courses>

[2] <https://www.springboard.com/topic/food-engineering>

[3] <http://elearning.vtu.ac.in/06BT74.html>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		Programme Outcomes
CO1	Identify sources of contaminants, adulterants and hazard analysis to ensure the safe food processing.	PO1
CO2	Comprehend the engineering solutions involved in the packaging improvements for sustainable development of food industry.	PO7
CO3	Understand the impact of nutritional properties of food on societal and health	PO6
CO4	Discern different technological change and recent advancements involved in food preservation	PO12

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100 (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
Semester End Examination (Written Examination for Three Hours)		Marks 100 (Weightage 50%)	



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**Assessment Pattern:**

<b>Component</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Quiz 1/AAT</b>	<b>Quiz 2 /AAT</b>	<b>Total Marks</b>
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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Course Title	PETROLEUM REFINING														
Course Code	1	6	C	H	5	D	E	L	A	2	Credits	03	L – T – P- S	3 – 0 – 0 - 0	
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

**PREREQUISITES:** Engineering Chemistry and Technical Chemistry

**SYLLABUS:**

**Unit - I**

**COMPOSITION of CRUDE:** Classification, Evaluation of petroleum, UOP-k factor. TBP analysis, EFV analysis, Average boiling point, ASTM curves, Thermal properties of petroleum fractions

06Hrs

**Unit – II**

**PRODUCT PROPERTIES AND TEST METHODS:** Reid vapor pressure analysis, Octane Number, Oxidation stability, Additives for gasoline. Characterization: flash point, fire point, Diesel and its properties, Grades of diesel, Diesel additives.

07Hrs

**Unit- III**

**CRUDE PRETREATMENT:** Pumping of crude oil, Dehydration of crude by chemical, gravity, centrifugal, electrical de-salter. Heating of crude and crude distillation  
**TREATMENT TECHNIQUES:** Types of impurities present, Production and treatment of LPG and LNG technology. Sweetening operations for gases: Catalytic desulphurisation

10Hrs

**Unit- IV**

**CATALYTIC CRACKING:** Various catalytic cracking processes: Fluid catalytic cracking-flexi cracking. Theory of coking, various types of coking processes. Naphtha cracking, theory and catalyst used for hydro cracking

**CATALYTIC REFORMING:** Theory of reforming, Factors influencing reforming, catalysts, feedstock requirements.

10Hrs

**UNIT -V**

**THERMAL PROCESSES:** Reactions- theory of thermal cracking. Properties of cracked materials and factors influencing the properties of cracked materials.

06Hrs

**TEXTBOOKS:**

1. Bhaskara Rao, Modern Petroleum Refining Processes Oxford & IBH Publication, 3<sup>rd</sup> Edition, Reprint, 1999.
2. Nelson, Petroleum Refinery Engineering - McGraw Hill, 41 Edition, 14th ' Reprint, 1982.

**REFERENCE BOOKS:**

1. Ram Prasad, Petroleum Refining Technology- Khanna Publishers, 1<sup>st</sup> Edition, 2000.
2. Sland W. F. and Davidson R. L. Petroleum Processing - McGraw Hill, 1967

**E BOOKS**

[1] <http://www.ebooksbucket.com/engineering/petroleum-engineering>



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[2] Fundamentals of Petroleum Refining, <http://ebookchemical.blogspot.in/2015/05/free-download-fundamentals-of-petroleum.html>

[3] Handbook of Petroleum Refining Processes, Robert A. Meyers  
<http://www.amazon.com/Handbook-Petroleum-Processes-McGraw-Hill-Handbooks-ebook/dp/B000TO0T12>

**MOOC's & ONLINE COURSES:**

[1]. <https://www.mooc-list.com/tags/refining?static=true>

[2] <https://www.class-central.com/subject/engineering>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		Programme Outcomes
CO1	Infer & identify data of composition and thermal properties in refining during treatment of petroleum.	PO2
CO2	Familiarise with the different reforming techniques used for petroleum industries that meet the specific needs with approximate considerations.	PO3
CO3	Get acquainted with cracking processes to obtain desired products, considering the impact of the processes on environment to assess the society	PO6

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100 (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
Semester End Examination (Written Examination for Three Hours)		Marks 100 (Weightage 50%)	

**Assessment Pattern:**

Component	Test 1	Test 2	Quiz 1/AAT	Quiz 2 /AAT	Total Marks
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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Course Title	NANO MATERIALS AND TECHNOLOGY													
Course Code	1	6	C	H	5	D	E	L	B	1	Credits	03	L – T – P- S	3 – 0 – 0 - 0
CIE	100 marks (50% weightage)						SEE			100 marks (50% weightage)				

**PREREQUISITES:** Engineering Chemistry, Technical Chemistry and Engineering Physics

**SYLLABUS:**

**UNIT - I**

**INTRODUCTION:** Beginning of Nanotechnology, Feynman's predictions, Moore's Law, atomic size and crystallography.

**INSTRUMENTS FOR CHARACTERIZATION:** Particle size determination, Surface structure, Microscopy: Transmission Electron Microscopy, Field Ion Microscopy, Scanning Microscopy; Spectroscopy: Infrared and Raman Spectroscopy, Photoemission and X-ray Spectroscopy, Magnetic resonance.

07Hrs

**UNIT – II**

**PROPERTIES OF INDIVIDUAL NANOPARTICLES:** Metal nanoclusters, Semiconducting nanoparticles, rare gas and molecular clusters, methods of synthesis: RF Plasma, Chemical Methods, Thermolysis, Pulsed Laser methods.

**CARBON NANOSTRUCTURES:** Carbon molecule, Clusters, Carbon nanotubes, Applications Bulk nanostructured materials: Solid disordered nanostructures, nanostructure crystals.

10Hrs

**UNIT- III**

**NANOSTRUCTURED FERROMAGNETISM:** Basics of ferromagnetism, Effect of bulk nanostructuring of magnetic properties, dynamics of nanomagnets. Optical and vibrational spectroscopy: Infrared frequency range, luminescence, nanostructures in zeolite cage.

06Hrs

**UNIT- IV**

**QUANTUM WELLS, WIRES AND DOTS:** Preparation of quantum nanostructures, Excitons, Single electron tunneling, applications: Infrared Detectors and Quantum dot lasers.

**BIOLOGICAL MATERIALS:** Biological building blocks, biological nanostructures. Microelectromechanical systems (MEMSs): Fabrication, Devices and Applications, Nanoelectromechanical Systems (NEMSs) - Fabrication, Devices, Applications.

10Hrs

**UNIT -V**

**APPLICATIONS OF NANOTECHNOLOGY:** Nanosensors: Chemical, Mechanical, biological and gas sensors, Drug delivery Nanoparticles, Nano-porous solids for catalysis and Nanocosmetics.

06Hrs

**TEXTBOOKS:**

1. Charles P. Poole, Jr., Frank J. Owens, Introduction to Nanotechnology, John Wiley and Sons, 2009.
2. Manasi Karkare, Nanotechnology – Fundamentals and Applications, International Publishing House Pvt. Ltd., 2010



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**REFERENCE BOOKS:**

1. Handbook of Nanostructured Materials and Nanotechnology, Vol. 1-5, Academic Press, Boston, 2000.
2. CNR Rao, Nanoworld: An introduction to nanoscience and technology, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, 2010.

**E BOOKS**

- [1]. [http://www.nanowerk.com/nanotechnology/periodicals/ebook\\_a.php](http://www.nanowerk.com/nanotechnology/periodicals/ebook_a.php)
- [2] <http://www.e-booksdirectory.com/listing.php?category=238>

**MOOC's & ONLINE COURSES:**

- [1] <https://www.class-central.com/subject/engineering>
- [2] <https://www.mooc-list.com/course/nanotechnology-basics-coursera?static=true>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
CO1	Understand the nanoscale hypothesis and its future	PO1
CO2	Comprehend/select the suitable fabrication technique for the synthesis of nanoparticles and nanomaterial	PO2
CO3	Identify and apply approximate instrumental techniques for characterization of nanoparticles with an understanding of their limitations to assess for future reasoning	PO2
CO4	Demonstrate the applications of nanotechnology to engineering and medical systems to assess the societal health and safety	PO7

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100 (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
Semester End Examination (Written Examination for Three Hours)		Marks 100 (Weightage 50%)	

**Assessment Pattern:**

Component	Test 1	Test 2	Quiz 1/AAT	Quiz 2 /AAT	Total Marks
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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Course Title	POLYMER MATERIALS & PROCESSING													
Course Code	1	6	C	H	5	D	E	L	B	2	Credits	03	L – T – P – S	3 – 0 – 0 – 0
CIE	100 marks (50% weightage)						SEE		100 marks (50% weightage)					

**PREREQUISITES:** Engineering Chemistry and Technical Chemistry

**SYLLABUS:**

**UNIT – I**

**PRINCIPLES OF PROCESSING OF POLYMERS:** Melt processing of thermoplastics. Classification of processes, crystallization, orientation & shrinkage, Co polymers blendings, Compounding for engineering application, Stress – strain behavior, Practical assessment for long term behavior.

06Hrs

**UNIT – II**

**POLYMER EXTRUSION:** Single screw and double screw extruders, Extruder zones, Extruder screws, Power calculation. Die and calibration equipment, Co extrusion, Extrusion coating, Extrusion film blowing, Reactive extrusion, Extrusion blow moulding for PET bottles, Wire drawing-PVC, Spinning . Application of various extruded products, Rheological aspects of extrusion and extrusion defects, Operations and maintenance of extrusion equipment.

09Hrs

**UNIT- III**

**INJECTION MOULDING:** Reciprocating screw injection moulding, Single impression mould, Multi-impression moulds. Hot runner moulds, gates, mould Clamping force calculations, Control of pressure, Temperature and time of injection. Thermoset and Fiber reinforced polymer injection moulding, Sandwich moulding and Injection blow moulding, Rheological aspects and defects of injection, Comparison of injection moulding and extrusion injection moulding, Operations and maintenance of injection moulding equipment, Reaction injection moulding, Applications of all Operations.

10 Hrs

**UNIT- IV**

**COMPRESSION MOULDING, TRANSFER MOULDING, CALENDERING:** Compression moulding: Applications, Principles, Derivation of compression mould thickness or compaction force, Transfer moulding, Principles and operation of calendaring, Derivation of film thickness and pressure required for rollers, Guage control during calendaring, Application of PVC calendered products.

07Hrs

**UNIT –V**

**THERMOFORMING AND ROTATIONAL MOULDING:** Thermoforming: Basic principles, Vacuum forming, Pressure forming, Description of operations. Product design. Application. Derivation of thermoformed product thickness. Rotational moulding: Principles. Operation & applications.

07Hrs

**TEXTBOOKS:**

1. Morton Jones, 'Principles of Polymer Processing, Chapman & Hall; 1<sup>st</sup> edition, 1989 (December 31, 1989), ISBN-13: 978-0412267000.
2. R, J. Crawford, 'Plastic Engineering, 2<sup>nd</sup> Edition, Pergamon Press, 1987, ISBN: 0080326269, 9780080326269.

**REFERENCE BOOKS:**



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1. 'Principles of Polymer Engineering', N. G. McCrum, C. P. Buckley and C. B. Bucknall, 2<sup>nd</sup> Edition, Oxford University Press 1998, ISBN-13: 9780198565260.

**E BOOKS**

- [1]. Principles of Polymer Processing, by Zehev Tadmor Author · Costas G. Gogos Author  
<https://www.overdrive.com/media/105670/principles-of-polymer-processing>
- [2] Polymer Processing and Characterization, Sabu Thomas, Deepalekshmi Ponnamma, Ajesh K. Zachariah: <https://www.crcpress.com/Polymer-Processing-and-Characterization/Thomas-Ponnamma-Zachariah/9781926895154>

**MOOC's & ONLINE COURSES:**

<https://www.quora.com/Are-there-any-good-online-polymer-introductory-courses#!n=12>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		Programme Outcomes
CO1	Apprehend molten flow behaviour of polymer materials to design processes that meets the specific needs.	PO3
CO2	Familiarise with various processing techniques by applying reasoning informed by the contextual knowledge to assess the society.	PO6
CO3	Select suitable techniques by understanding their applications and impact of the processes to demonstrate the knowledge of need for sustainable development	PO7

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100 (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
Semester End Examination (Written Examination for Three Hours)		Marks 100 (Weightage 50%)	

**Assessment Pattern:**

Component	Test 1	Test 2	Quiz 1/AAT	Quiz 2 /AAT	Total Marks
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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Course Title	CHEMICAL REACTION ENGINEERING-II													
Course Code	1	6	C	H	6	D	C	C	R	2	Credits	03	L – T – P- S	3 – 0 – 0 - 0
CIE	100 marks (50% weightage)						SEE			100 marks (50% weightage)				

**PREREQUISITES:** Chemical Reaction Engineering-1 and Engineering Mathematics

**SYLLABUS:**

**UNIT - I**

**BASICS of NON-IDEAL FLOW:** Importance & interpretation of RTD, C, E & F curves & Statistical interpretation, Dispersion model. Tanks in series model, Conversion in non- ideal flow reactors for simple systems.

06Hrs

**UNIT – II**

**NON CATALYTIC SYSTEMS:** Introduction to Fluid-Fluid reactions, Kinetics for straight mass transfer without reaction, Kinetics for direct mass transfer with reaction for all types of reactions, significance of Hatta Number and related problems on fluid-fluid reactions,

**FLUID PARTICLE REACTIONS:** Introduction to Fluid-Particle reactions, selection of suitable model, Kinetics for different rate controlling steps for spherical particles of unchanging size and shrinking spherical particles, limitation of the shrinking core model, rate determining steps with combination of resistances and related problems.

10Hrs

**UNIT- III**

**CATALYSIS:** Introduction to catalysis, Properties of catalysts, Estimation methods for catalytic properties, Promoters, inhibitors etc., Mechanism of catalysis, Rate equations for different rate controlling steps.

06Hrs

**UNIT- IV**

**DEACTIVATION:** Deactivating catalyst, Mechanism, rate & performance equation,

**SOLID CATALYZED REACTIONS:** Rate equation for surface kinetics, heterogeneous systems, Pore diffusion resistance combined with surface kinetics, Thiele modulus and enhancement factor.

10Hrs

**UNIT -V**

**PERFORMANCE EQUATION FOR DIFFERENT REACTION SYSTEMS:** Performance equations for reactors containing porous catalyst particles, Experimental methods for finding rates, Packed bed catalytic reactor & reactors with suspended solid catalyst.

**GAS-LIQUID REACTORS:** Trickle Bed, Slurry reactors. Three phase fluidized bed.

07Hrs

**TEXTBOOK:**

1. Octave Levenspiel, Chemical Reaction Engineering, 3<sup>rd</sup> Edition, Jhon Wiley & Sons, 2001.
2. H. Scott Fogler, Elements of Chemical Reaction Engineering. 3<sup>rd</sup> Edition Prentice Hall, 2001.

**REFERENCE BOOKS:**

1. J. M. Smith, Chemical Engineering Kinetics -3<sup>rd</sup> Edition, McGraw Hill., 1984
2. K. A. Gavhane, Chemical Reaction Engineering-I, series Volume-1, Nirali Prakashan., ISBN-13: 9788185790879, 2011.



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**E BOOKS**

- [1] Fundamentals of Chemical Reaction Engineering by M E Davis: <http://authors.library.caltech.edu/25070/1/FundChemReaxEng.pdf>
- [2] Chemical Reaction Engineering: Beyond the Fundamentals by Doraiswamy : <https://www.crcpress.com/Chemical-Reaction-Engineering-Beyond-the-Fundamentals/Doraiswamy-Uner/9781439831229>
- [3] Fundamentals of Chemical Reaction Engineering, Mark E. E. Davis, Robert J. J. Davis <http://www.e-booksdirectory.com/details.php?ebook=2512>

**MOOC's & ONLINE COURSES:**

- 2) <http://ocw.mit.edu/courses/chemistry/5-68j-kinetics-of-chemical-reactions-spring-2003/index.htm>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		Programme Outcomes
CO1	Apply knowledge of material balance to design non-ideal systems & analyse/interpret its performance with ideal systems.	PO4
CO2	Develop rate expression for different reaction mechanisms using suitable models for catalytic & non catalytic reactions with an understanding of the their limitations	PO5
CO3	Develop design equation using models for heterogeneous reaction systems that meets the specific needs with approximate consideration of economics and safety	PO3

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100 (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
Semester End Examination (Written Examination for Three Hours)		Marks 100 (Weightage 50%)	

**Assessment Pattern:**

Component	Test 1	Test 2	Quiz 1/AAT	Quiz 2 /AAT	Total Marks
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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Course Title	PROCESS CONTROL ENGINEERING														
Course Code	1	6	C	H	6	D	C	P	C	E	Credits	06	L – T – P- S	3 – 0 – 1 - 2	
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

**PREREQUISITES:** Engineering Maths and Basic Electrical Engineering

**SYLLABUS:**

**UNIT-I**

**FIRST ORDER SYSTEMS:** Thermometer level in a tank, mixing tank, STR, Linearization of I-order systems in series, Response for various input forcing functions

05Hrs

**UNIT-II**

**SECOND ORDER SYSTEMS:** Characteristics of manometer and damped vibrator. Transfer functions. Response for various input forcing functions, response for step input for under damped case-terms associated, transportation lag.

10Hrs

**UNIT – III**

**CLOSED LOOP SYSTEM:** Basic components, Servo and regulator control, Controllers- P, I, D and On-Off modes, Controller Combinations-Final control elements-Valves, actuators and valve positioners

07Hrs

**UNIT – IV**

**CLOSED LOOP RESPONSE:** Block diagram, closed loop transfer function, Transient response of servo and regulator control systems with various controller modes and their characteristics.

07Hrs

**UNIT- V**

**STABILITY:** Stability of linear control systems, RouthTest, Frequency Response- Bode diagrams,

**CONTROL SYSTEM DESIGN BY FREQUENCY RESPONSE:** Bode criterion, Gain and Phase margins. Ziegler-Nichols controller tuning, Cohen-Coon controller tuning

**ROOTLOCUS:** Rules for plotting and problems.

10Hrs

**LABORATORY COMPONENT**

1. Thermometer
2. Single tank-Step Response
3. Non-Interacting Tanks-Step Response
4. Interacting Tanks-Step Response
5. Pressure Vessel
6. Single tank-Impulse Response
7. Non-Interacting Tanks-Impulse Response
8. Interacting Tanks-Impulse Response
9. Level control-P controller, PI controller, PD controller, PID controller
10. Valve characteristics
11. Temperature Control-P Controller, PI Controller, PID Controller



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**TEXTBOOK:**

1. Coughner & Koppel, Process System Analysis and Control-McGrawHill, New Delhi, 2<sup>nd</sup> Edition, 1991.

**REFERENCE BOOKS:**

1. Coulson & Richardson, Chemical Engineering Vol 3, 3<sup>rd</sup> Edition-Pergamon Press, 1998.
2. George Stephanopoulos, Chemical Process Control-and Introduction to Theory & Practical, Prentice Hall New Delhi, 1998.

**E BOOKS**

- [1] <http://www.ourmumbaicity.com/ebooks>  
 [2] <http://www.leka.lt/sites/default/files/dokumentai/process-control.pdf>

**MOOC's & ONLINE COURSES:**

- [1]. <https://www.mooc-list.com/>  
 [2] <http://elearning.vtu.ac.in/06IT64.html>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
<b>CO 1</b>	Formulate transfer functions, predict responses to various forcing functions to interpret the data to provide valid conclusions.	PO4
<b>CO 2</b>	Select suitable controller and evaluate the response behaviour of the controllers to model complex engineering problems with an understanding of the limitations	PO5
<b>CO 3</b>	Verify the stability of control systems to understand the impact of the professional engineering solutions and demonstrate the knowledge of need for sustainable development	PO7
<b>CO 4</b>	Conduct experiments in teams to collect data for different functional inputs to various process with and without controllers	PO9
<b>CO 5</b>	Interpret experimental data to estimate and provide valid conclusions which encourages to recognise the need to engage in independent and life-long learning	PO12

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100% (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	40%	Course Instructor
	Quiz (Two Quizzes)	10%	Course Instructor
Laboratory Component	Laboratory Component	30%	Course Instructor



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Self-Study Component	Open Ended Experiments/Term Papers/Modelling/Seminar/Mini projects.	20%	Committee constituted by HOD
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

Component	Theory (50%)			Practical (30%)		Self-Study (20%) by AAT	Total Marks
	Test 1	Test 2	Quiz	Records & Performances	Lab Test		
Max. Marks	20	20	10	20	10	20	100
Reduced CIE	10	10	5	10	5	10	50



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Course Title	MASS TRANSFER-II														
Course Code	1	6	C	H	6	D	C	M	T	2	Credits	06	L – T – P- S	3 – 0 – 1 - 2	
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

**PREREQUISITES:** Mass Transfer-1 and Engineering Maths

**SYLLABUS:**

**UNIT-I**

**GAS LIQUID CONTACTING SYSTEMS:** Liquid and gas dispersion: Types, construction and working of tray and packed columns, types and properties of packing, tray efficiencies, HETP and HTU concepts, Concept of flooding, weeping, and entrainment, Comparison of tray and packed columns.

**ABSORPTION:** Equilibrium solubility of gases in liquids, One component transferred: Material balances, Counter current multistage operations: Isothermal only, Continuous contact equipment: Absorption of one component, Overall coefficients and transfer units, dilute solutions, Overall heights of transfer units, Design of packed towers from the data of NTU. Absorption with chemical reaction

10Hrs

**UNIT-II**

**DISTILLATION:** Introduction, Vapour liquid equilibrium, Estimation of VLE data, VLE for multicomponent systems, Flash vapourisation, Simple or differential distillation, Steam distillation, Continuous rectification, Design using McCabe Thiele method for binary mixtures and related problems.

09Hrs

**UNIT-III**

**DESIGN OF DISTILLATION COLUMN:** Ponchon-Savarit method, Efficiencies- overall, local, and Murphree plate efficiencies: Reboilers, Use of open steam, Vacuum, Molecular, Extractive and Azeotropic distillations.

07Hrs

**UNIT-IV**

**LIQUID-LIQUID EXTRACTION:** Introduction, Ternary equilibrium, Solvent selection, Equipment and flow sheets: Single stage, multi-stage cross-current, Insoluble systems, Continuous counter current multistage extraction, Equipment: Stage efficiency, stage type extractors (no design aspects): Mixer-settler cascades, Continuous contact equipment: packed towers, Rotating disc contactor, Pulsed column, Scheibel extractor, and centrifugal extractor.

07Hrs

**UNIT- V**

**LEACHING OPERATION:** Introduction, Preparation of solid, Equipment for unsteady state operation and steady state operation, Methods of calculation: Equilibrium diagrams, Single stage and multi-stage cross and counter current operations, Counter current, constant underflow case, leaching operation.

06Hrs

**LABORATORY COMPONENT**

1. Simple distillation
2. Steam distillation
3. Single stage leaching
4. Packed column distillation
5. Single stage extraction
6. Multistage extraction
7. Multistage Leaching



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**TEXTBOOK:**

1. Robert E Treybal, Mass Transfer Operations-3<sup>rd</sup> edition, McGrawHill, 1981.
2. McCabe & Smith, Unit Operations in Chemical Engineering, 6<sup>th</sup> edition, McGraw Hill, 2001

**REFERENCE BOOKS:**

1. Coulson and Richardson, Chemical Engineering, Vol-II and V-4<sup>th</sup> Edition PergamonPress, 1998.
2. Badger & Banchero, Introduction to Chemical Engineering-TMH, 1998.

**E BOOKS**

- [1] Mass Transfer in Chemical Engineering Processes, by Jozef Markoš  
<http://www.e-booksdirectory.com/details.php?ebook=6659>
- [2] Ion Exchange: Studies and Applications, Ayben Kilislioglu,  
<http://www.e-booksdirectory.com/details.php?ebook=10637>
- [3] Transport Processes and Unit Operations by Geankoplis  
<http://chembookneed.blogspot.in/2010/08/transport-processes-and-unit-operations.html>

**MOOC's & ONLINE COURSES:**

- [1] <http://elearning.vtu.ac.in/BT32.html>
- [2] <http://nptel.ac.in/courses/103104046/>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMM E OUTCOMES
CO1	Design various mass transfer equipment that meets the specific needs with approximate consideration of economics, public health and safety	PO3
CO2	Use the knowledge of mass balance and composition balance in interfacial mass transfer to analyse and interpret experimental and theoretical data	PO4
CO3	Apply the concept of interfacial mass transfer in multiphase contact processes to understand the impact of engineering solutions in environmental contexts and society	PO7
CO4	Conduct experiments in teams to collect data for different mass transfer operations	PO9
CO5	Interpret experimental data to estimate and provide valid conclusions which encourages to recognise the need to engage in independent and life-long learning	PO12



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**ASSESSMENT:**

Continuous Internal Assessments		Marks 100% (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	40%	Course Instructor
	Quiz (Two Quizzes)	10%	Course Instructor
Laboratory Component	Laboratory Component	30%	Course Instructor
Self-Study Component	Open Ended Experiments/Term Papers/Modelling/Seminar/Mini projects.	20%	Committee constituted by HOD
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

Component	Theory (50%)			Practical (30%)		Self-Study (20%) by AAT	Total Marks
	Test 1	Test 2	Quiz	Records & Performances	Lab Test		
Max. Marks	20	20	10	20	10	20	100
Reduced CIE	10	10	5	10	5	10	50



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Course Title	TRANSPORT PHENOMENA														
Course Code	1	6	C	H	6	D	C	T	R	P	Credits	04	L – T – P- S	3 – 1 – 0 - 0	
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

**PREREQUISITES:** Engineering Drawing and Process Equipment drawing

**SYLLABUS:**

**UNIT – I**

**INTRODUCTION:** Momentum, Energy and Mass Transport operations, Newton's law of viscosity (NLV), Newtonian and Non-Newtonian fluids, Fourier's law of heat conduction (FLHC), Fick's law of diffusion (FLD), Effect of temperature and pressure on transport properties of fluids. Numerical problems.

[6L+1T=07Hrs]

**UNIT – II**

**VELOCITY DISTRIBUTION IN LAMINAR FLOW:** Different Flow situations, Steady state Shell momentum balances Boundary conditions applicable to momentum transport problems, Flow over a flat plate, Flow through a circular tube, Flow through Annulus. Flow between parallel plates and a slit. Numerical problems.

[11L+ 3T=14Hrs]

**UNIT- III**

**STEADY STATE SHELL ENERGY BALANCES:** General Boundary conditions applicable to energy transport problems of chemical engineering, Heat conduction through compound walls, Overall heat transfer coefficient based on inner and outer surface area.

**TEMPERATURE DISTRIBUTION IN SOLIDS AND IN LAMINAR FLOW:** Heat conduction with internal generation by electrical, nuclear, viscous energy sources, Numerical problems. Heat conduction in cooling fin, forced and free convection heat transfer.

[10L+4T=14Hrs]

**UNIT – IV**

**CONCENTRATION DISTRIBUTIONS IN LAMINAR FLOW:** Steady state shell mass balances, General Boundary conditions applicable to mass transport problems of chemical engineering, Diffusion through stagnant gas and liquid films, Equimolar counter diffusion. Numerical problems.

**CONCENTRATION DISTRIBUTIONS IN LAMINAR FLOW:** Diffusion with homogeneous and heterogeneous reaction. Diffusion into falling film- Forced convection mass transfer. Numerical problems.

[7L+3T=10Hrs]

**UNIT - V**

**ANALOGIES BETWEEN MOMENTUM, HEAT AND MASS TRANSPORT:** Reynold's, Prandtl's and Chilton & Colburn analogies.

**EQUATIONS OF CHANGE:** Equation of continuity, Equation of motion; Navier-Stokes equation, Euler's equation.

[5L+2T=07Hrs]

**TEXTBOOKS:**

1. Bird, Stewart and Lightfoot, 'Transport Phenomena', 2<sup>nd</sup> Edition, Academic Press, 1994

**REFERENCE BOOKS:**

1. Welty, Wikes and Watson, 'Momentum Heat and Mass Transport, 4<sup>th</sup> Edn. John Wiley

**E BOOKS**



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[1]. <http://www.freeengineeringbooks.com/Chemical/Transport-Phenomena.php>

[2] <http://www.hailienene.com/resources/transport-phenomena.pdf>

**MOOC's and ONLINE COURSES:**

[1]. <https://www.mooc-list.com/course/basics-transport-phenomena-edx?static=true>

[2]. <https://www.springboard.com/topic/transport-phenomena>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
<b>CO1</b>	Analyze the steady state operations for momentum, heat & mass transfers to interpret practical data to provide valid conclusions	PO4
<b>CO2</b>	Apply appropriate reasoning for shell momentum, energy & mass balances for laminar flows across various geometry and boundary conditions to predict and model the behaviour.	PO5
<b>CO3</b>	Understand the impact of equation of changes in various co-ordinate systems with its influence on analogies between momentum, heat and mass transport which encourages them to engage in independent and life-long learning	PO12

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100 (Weightage 50%)	Assessment by
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

Component	Test 1	Test 2	Quiz 1/AAT	Quiz 2 /AAT	Total Marks
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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Course Title	NUMERICAL TECHNIQUES IN CHEMICAL ENGINEERING														
Course Code	1	6	C	H	6	D	E	L	C	1	Credits	03	L – T – P- S	3 – 0 – 0 - 0	
CIE	100 marks (50% weightage)						SEE			100 marks (50% weightage)					

**PREREQUISITES:** Heat Transfer, Chemical Reaction Engineering-1, Chemical Reaction Engineering 2, and Engineering Mathematics

**SYLLABUS:**

**UNIT - I**

**MATHEMATICAL FORMULATION OF THE PHYSICAL PROBLEMS:** Applications of law of conservation of mass in: mixing tank system, equilibrium batch still and single stage extraction. Applications of law of conservation of energy in: Gas compression, system, and Flow of heat from a fin and related numerical problems for all above physical systems.

07 Hrs

**UNIT – II**

**MATHEMATICAL FORMULATION OF COMPLEX PROBLEMS:** Mass transfer with reaction for gas-liquid contact, heat transfer through multiwall cylinders and spheres, heat transfer in a jacketed vessel, rate expression for series and parallel homogenous reactions and related numerical problems.

06 Hrs

**UNIT- III**

**APPLICATION OF NON-LINEAR ALGEBRAIC EQUATION:** Pressure drop in pipe, Minimum fluidization velocity – Use of Newton – Raphson method.

**APPLICATION OF INITIAL VALUE PROBLEMS:** Stirred tank with coil heater, Series of stirred tanks with coil heaters, Batch reactors, Plug flow reactors and unsteady state stirred tank reactors – Use of RK method.

**APPLICATION OF FINAL VALUE PROBLEMS:** One dimensional steady state heat conduction, Chemical reaction and diffusion in a pore – Use of discretization technique.

10Hrs

**UNIT- IV**

**FORMULATIONS OF PARTIAL DIFFERENTIAL EQUATIONS:** Formulations of partial Differential equations for the continuity equation, Fick's second law of diffusion and heat conduction in rectangular coordinates.

**SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS:** Solution for heat conduction equation, solution for Laplace's equation using finite difference method.

**FINITE DIFFERENCES METHOD FOR STAGE PROCESSES:** Analysis of stage-wise Processes like multistage counter-current extraction, stirred-tank reactor system.

10 Hrs

**UNIT –V**

**Applications of Laplace Transforms:** Applications to chemical engineering like level/temperature in a single tank system, mixing tank, CSTR with first order reaction, interacting system and non-interacting system.

06Hrs

**TEXTBOOKS:**

1. Mickley H. S., Sherwood T. K. and Reed C. E., Applied Mathematics in Chemical Engineering - 3rd Edition, Tata McGraw Hill, 1999.
2. Jenson V. G. & Jeggreys G. V., Mathematical Methods in Chemical Engineering, 1977



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**REFERENCE BOOKS:**

1. Rose L. M. Applications of Mathematical Modeling to Process Development and Design, -Applied Science Publishers Ltd., London, 1998.
2. William. L Luyben, Process Modeling Simulation and Control for Chemical Engineering 2nd Edition, McGraw Hill, 1990.

**E BOOKS**

- [1] <http://www.amazon.in/Applied-Mathematics-Modeling-Chemical-Engineers-ebook/dp/B009I06RKU>
- [2]. <http://www.worldcat.org/title/applied-mathematics-in-chemical-engineering/oclc/557742198>

**MOOC's & ONLINE COURSES:**

- [1] <https://www.mooc-list.com/categories/mathematics?static=true>
- [2] [http://www.moocs.co/Higher\\_Education\\_MOOCs.html](http://www.moocs.co/Higher_Education_MOOCs.html)

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		Programme Outcomes
CO 1	Develop ordinary and partial differential equations to solve chemical engineering problems for reaching substantiated conclusions using first principles of mathematics	PO2
CO 2	Use knowledge of numerical methods to solve the developed differential equations to analyse and interpret the behaviour of different processes.	PO4
CO 3	Apply finite difference method to predict and model various unit operations and processes by understanding the limitations	PO5

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100 (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
Semester End Examination (Written Examination for Three Hours)		Marks 100 (Weightage 50%)	

**Assessment Pattern:**

Component	Test 1	Test 2	Quiz 1/AAT	Quiz 2 /AAT	Total Marks
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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<b>Course Title</b>	<b>OPERATIONS RESEARCH</b>													
<b>Course Code</b>	<b>1</b>	<b>6</b>	<b>C</b>	<b>H</b>	<b>6</b>	<b>D</b>	<b>E</b>	<b>L</b>	<b>C</b>	<b>2</b>	<b>Credits</b>	<b>03</b>	<b>L – T – P- S</b>	<b>3 – 0 – 0 - 0</b>
<b>CIE</b>	<b>100 marks (50% weightage)</b>										<b>SEE</b>	<b>100 marks (50% weightage)</b>		

**PREREQUISITES:** Engineering Mathematics and

**SYLLABUS:**

**UNIT - I**

**INTRODUCTION:** Definition. Scope of Operations Research, Approach and limitations of O. R- Models, Characteristics and phases of O. R, Linear Programming Problems: Mathematical formulation of L. P, Problems and Graphical solution method.

06Hrs

**UNIT – II**

**ASSIGNMENT PROBLEMS:** Balanced and Unbalanced assignment problems, Maximization assignment problems, travelling salesman problems.

06Hrs

**UNIT- III**

**TRANSPORTATION PROBLEM:** Basic feasible solutions by different methods, finding optimal solution, MODI method, Degeneracy, Unbalanced transportation problems, Maximization Problems.

09Hrs

**UNIT- IV**

**SEQUENCING:** Johnson's algorithm, njobs-2machines, njobs-3, machines and njobs-n machines without passing sequence, 2jobs-n, machines, Graphical solutions.

08Hrs

**UNIT –V**

**PERT-CPM TECHNIQUES:** Network construction, Determining time estimates and critical path, in network analysis, Variance and probability of completing the project, Calculation of different floats, Project duration, Crashing of simple networks.

10Hrs

**TEXTBOOKS:**

1. S. D. Sharma, Operation Research-8<sup>th</sup> Edition, Kedarnath & Co, 2003.
2. Kantiswaroop, P. K. Gupta and Manmohan, Operation Research-9<sup>th</sup> Edition, S Chand & Co. 1999

**REFERENCE BOOKS:**

1. L. S. Srinath, Introduction to Pert and CPM-3<sup>rd</sup> Edition, EastWest, 1998
2. Hospach Buchan and Earnest Koenigberg, Scientific Inventory Management-1989.

**E BOOKS**

- [1] [http://www.faadooengineers.com/threads/3345-Operations-Research-\(OR\)-Ebook-Lecture-Notes-Handouts-Full-Syllabus](http://www.faadooengineers.com/threads/3345-Operations-Research-(OR)-Ebook-Lecture-Notes-Handouts-Full-Syllabus)
- [2] <http://www.freotechbooks.com/operations-research-f54.html>

**MOOC's & ONLINE COURSES:**

- [1] <https://www.springboard.com/topic/operations-research>
- [2] <https://www.quora.com/Are-there-good-online-courses-for-Operations-Research>

**COURSE OUTCOMES (COs):**



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<b>COURSE OUTCOMES</b>		Programme Outcomes
<b>CO1</b>	Use knowledge of linear programming to formulate, analyse complex problems to obtain optimum solutions for numerical problems	PO3
<b>CO2</b>	Apply appropriate techniques to solve assignment, transportation and sequencing problems for prediction its optimal solutions by understanding their limitations	PO5
<b>CO3</b>	Illustrate network constructions and find feasible Engineering solutions for optimization of societal problems	PO6

**ASSESSMENT:**

<b>Continuous Internal Assessments</b>		<b>Marks 100 (Weightage 50%)</b>	<b>Assessment</b>
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

<b>Component</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Quiz 1/AAT</b>	<b>Quiz 2 /AAT</b>	<b>Total Marks</b>
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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<b>Course Title</b>	<b>COMPUTER INTERFACE IN CHEMICAL ENGINEERING</b>													
<b>Course Code</b>	<b>1</b>	<b>6</b>	<b>C</b>	<b>H</b>	<b>6</b>	<b>D</b>	<b>E</b>	<b>L</b>	<b>D</b>	<b>1</b>	<b>Credits</b>	<b>03</b>	<b>L – T – P- S</b>	<b>3 – 0 – 0 - 0</b>
<b>CIE</b>	<b>100 marks (50% weightage)</b>						<b>SEE</b>		<b>100 marks (50% weightage)</b>					

**PREREQUISITES:** Chemical Reaction Engineering, Mass Transfer and Engineering Mathematics

**SYLLABUS:**

**UNIT - I**

**REVIEW ON C–PROGRAMMING:** Constant and name variable declaration, basic input and output statement, operators. Conditional statements: if-else, nested if-else and switch/case statements. Looping Statements: for loop, while loop and do-while loop statements. Arrays: Declaration of arrays, storing values in arrays, operations that can be performed on arrays, dimensional arrays for inter-function. Creating functions in C.

06Hrs

**UNIT – II**

**NUMERICAL COMPUTATION USING C:** Non-linear algebraic equation using Newton Raphson. Ordinary Differential Equation using R-K Method, Numerical Integration using Simpson’s 1/3 Rule. Curve fitting using linear regression and non-linear regression methods. Algorithm and C–programs for all numerical methods.

06Hrs

**UNIT- III**

**PREDICTION OF PHYSICAL PROPERTIES USING C:** Vapor- Liquid equilibria for binary mixtures, Calculation of Bubble Pressure and Bubble Point. Calculation of Dew Pressure and Dew point for Ideal Binary and multi-component system, Flash Vaporization for multi-component system.

07Hrs

**UNIT- IV**

**APPLICATIONS OF C IN HEAT AND MASS TRANSFER OPERATIONS:** Design of Distillation column, Design of single stage Evaporation, design of double pipe heat exchanger (Area, Number of tubes, Pressure drop) and design of shell and tube heat exchanger(Area, Number of tubes, Pressure drop).

**APPLICATION OF C IN REACTOR DESIGN:** Design of ideal isothermal Batch, plug flow and CSTR reactors. C-programing for CSTRs in series for both constant and variable volume.

10Hrs

**UNIT -V**

**INTRODUCTION TO MAT LAB:** MAT Lab environment, developing M-files, Basic output and input statements, conditional statements, looping statements and plotting.

**APPLICATIONS USING MAT LAB IN CHEMICAL ENGINEERING:** Specific volume of real gases, bubble point and dew point calculation, simple differential distillation, reactor tanks, crystallization.

10Hrs

**TEXTBOOKS:**

1. Raul Raymond Kapuno., “Programming for Chemical Engineers Using C, C++, and MATLAB”, Infinity Science Press, 2010.
2. Pradeep Ahuja, “Introduction to Numerical Methods in Chemical Engineering”, PHI Learning Pvt. Ltd., 2010

**REFERENCE BOOKS:**



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1. William. L Luyben, "Process Modeling Simulation and Control for Chemical Engineering", 2nd Edition., McGraw Hill, 1990

**E BOOKS**

- [1]. <http://www.amazon.in/Programming-Chemical-Engineers-MATLAB-Engineering/dp/1934015091>
- [2] <http://www.jblearning.com/catalog/9781934015094/>

**MOOC's & ONLINE COURSES:**

- [1]. <http://ocw.mit.edu/courses/>
- [2]. [http://www.openculture.com/engineering\\_free\\_courses](http://www.openculture.com/engineering_free_courses)

**COURSE OUTCOMES (COs):**

<b>COURSE OUTCOMES</b>		<b>Programme Outcomes</b>
<b>CO1</b>	Select and apply approximate C-programmes and MAT lab codes for solving complex chemical engineering problems	PO5
<b>CO2</b>	Use suitable numerical methods to solve iterative chemical engineering problems to provide valid conclusions	PO4
<b>CO3</b>	Apply the knowledge of C-programming concepts to design and interpret the behavior of mass, heat transfer and reaction engineering operations to assess societal, health, safety and legal issues.	PO6

**ASSESSMENT:**

<b>Continuous Internal Assessments</b>		<b>Marks 100 (Weightage 50%)</b>	<b>Assessment</b>
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

<b>Component</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Quiz 1/AAT</b>	<b>Quiz 2 /AAT</b>	<b>Total Marks</b>
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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Course Title	INTERFACIAL PHENOMENA														
Course Code	1	5	C	H	6	D	E	L	D	2	Credits	03	L – T – P – S	3 – 0 – 0 – 0	
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

**PREREQUISITES:** Chemical Reaction Engineering-1 and Engineering Mathematics

**SYLLABUS:**

**Unit - I**

**INTRODUCTION:** Concept of Interface, Surface Tension, Equivalence in the concepts of surface energy and surface tension, Applications on interfacial science in industries.

**EXCESS PRESSURE:** Generalized equation for excess pressure across a curved surface-the equation of Young and Laplace and its application, Kelvin's equation and its application, Capillary condensation, Super Saturation, Nucleation.

07Hrs

**UNIT – II**

**MEASUREMENT OF INTERFACIAL TENSION:** Capillary rise method, Drop weight method, Wilhelmy plate method, Du Nuoy method, Methods based on shape of static drops or bubbles.

06Hrs

**UNIT- III**

**WETTING FUNDAMENTALS AND CONTACT ANGLES:** Work of adhesion, cohesion, criteria for spreading of liquids, kinetics of spreading, lens formation-three phase systems. Young's equation, contact angle hysteresis

**EMULSIONS AND MICRO EMULSIONS:** The conditions required to form emulsions and micro-emulsions, charged colloids, emulsions in food science, photographic emulsions.

10Hrs

**UNIT- IV**

Electrical aspects of surfaces: The electrical double layer, Stern treatment of electrical double layer, Free energy of a diffused double layer, Repulsion between two plane double layers, colloidal dispersions, combined attractive and electrical interaction-DLVO theory.

07Hrs

**UNIT -V**

**SURFACTANTS:** Introduction to surfactants, common properties of surfactant solution, Thermodynamics of surfactant self-assembly, self-assembled surfactant structures, surfactants and detergency.

**SURFACTANT BASED SEPARATIONS:** Fundamentals, Classification of surface active molecules like proteins and enzymes, Surfactants at interphases and in-bulk, Liquid membrane permeation, Foam separations, Micellar separations, Soil remediation.

09Hrs

**TEXTBOOKS:**

1. Pallab Ghosh, Colloids and Interface Science, Prantice Hall Publications

**REFERENCE BOOKS:**

1. A. W. Adamson, Physical chemistry of surfaces, John Wiley, 1997. edition,
2. Duncan J. Shaw, Butter worth Heinemann, Introduction to colloid and surface chemistry, 4<sup>th</sup> edition.

**E BOOKS**

[1]. <http://www.freebookcentre.net/chemistry-books-download/An-Introduction-to-Surface-Chemistry.html>

[2] <https://archive.org/details/introductiontosu017148mbp>



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**MOOC's & ONLINE COURSES:**

[1]. <http://www.rsc.org/eic/2015/03/mooc-massive-open-online-course>

**COURSE OUTCOMES (COs):**

<b>COURSE OUTCOMES</b>		<b>Programme Outcomes</b>
<b>CO1</b>	Comprehend the concept of surface and interfacial tension to identify and select surface tension measuring instruments for measuring tensions.	PO2
<b>CO2</b>	Understand the impact of factors influencing stability of emulsions to demonstrate their engineering solutions in environmental context.	PO7
<b>CO3</b>	Comprehend about detergency, surfactants and their applications which encourages to engage in lifelong learning in the context of technological change	PO12

**ASSESSMENT:**

<b>Continuous Internal Assessments</b>		<b>Marks 100 (Weightage 50%)</b>	<b>Assessment</b>
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

<b>Component</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Quiz 1/AAT</b>	<b>Quiz 2 /AAT</b>	<b>Total Marks</b>
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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Course Title	CHEMICAL PLANT UTILITIES														
Course Code	1	6	C	H	7	D	C	C	P	U	Credits	03	L – T – P- S	3 – 0 – 0 - 0	
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

**PREREQUISITES:** Pollution Control and Management, Reaction Engineering and unit operations

**SYLLABUS:**

**Unit I**

**Compressed Air:** Types, construction and working of reciprocating (Single and double), centrifugal and gear compressors, fans and blowers. Power requirement and performance Calculations

**Vacuum Systems:** Basic Concepts of vacuum and pressure and its measurement, Components of a vacuum system like vacuum chamber, pumps, gauges, valves, seals, and many other subsidiary components. Vacuum Generation, application and Piping.

09Hrs

**Unit II**

**Steam and Power:** Fire tube boilers and water tube boilers, mountings and accessories Boiler performance and its Calculation, Cogeneration power plants, Fuels: Types, Calorific value. Proximate and ultimate analysis and its calculations

07Hrs

**Unit III**

**Refrigeration and Air Conditioning:** Refrigeration cycles, Refrigerants and their characteristics, chilled water plant, Coefficient of performance and Power requirement and related calculations. Air-conditioning systems and Cold Storage

**Insulation:** Types of insulation, Different types of insulating materials and their Characteristics. Selection criteria for insulating materials

09Hrs

**Unit IV**

**Cooling Water:** Principle and construction of cooling towers, humidification and dehumidification chambers and related calculation

**Utility Piping:** Chilled Water Insulation Piping, Compressed Air Piping, Water Utility Piping, Cooling Coil Heat Transfer, Anti Fire Pipes and steam piping, colour codes for piping.

07Hrs

**Unit V**

**Water and its treatment:** Sources of water, hard and soft water Requisites of industrial water and its uses, Methods of water treatment: Chemical softening, Demineralization Resins used for water softening, reverse osmosis and membrane separation, Effects of impure boiler feed water & its treatments.

07Hrs

**TEXTBOOKS:**

1. B. K. Sarkar, Thermal Engineering, 1<sup>st</sup> edition, Tata McGraw-Hill Education Pvt. Ltd., 2004.
2. C. P. Arora, Refrigeration and Air conditioning, 2<sup>nd</sup> Edition, McGraw Hill Companies, 2000.



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**REFERENCE BOOKS:**

1. Power Plant Engineering, P. K. Nag, Tata Mc Graw Hill-1998
2. Perry's Chemical Engineering Hand Book, 8th Edition, McGraw Hill

**E BOOKS**

- [1]. Chemical Plant Utilities by Sathiyamoorthy Manickkam, <https://www.lap-publishing.com/catalog/details//store/gb/book/978-3-659-97828-9/chemical-plant-utilities>
- [2]. Steam Plant Operation by Everett B. Woodruff, Herbert B. Lammers, Thomas F. Lammers, <https://www.accessengineeringlibrary.com/browse/steam-plant-operation-ninth-edition>

**MOOC's & ONLINE COURSES:**

- 1) <http://tafeqld.edu.au/course/15418/certificate-iv-process-plant-technology>
- 2) <https://training.gov.au/Training/Details/PMA40108>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		Programme Outcomes
<b>CO1</b>	Apprehend different utilities required for chemical plants	PO2
<b>CO2</b>	Select suitable type of equipment for pressure and vacuum	PO2
<b>CO3</b>	Equipment required for steam and co-generation	PO7
<b>CO4</b>	Equipment required for cooling processes	PO7
<b>CO5</b>	Identify Contaminants present in water and its treatment methods	PO12
<b>CO6</b>	Concepts of conservation of fuel, power and water by applying norms of good Engineering practice	PO8

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100 (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

Component	Test 1	Test 2	Quiz 1/AAT	Quiz 2 /AAT	Total Marks
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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Course Title	BIOCHEMICAL ENGINEERING														
Course Code	1	6	C	H	7	D	C	B	C	E	Credits	03	L – T – P – S	3 – 0 – 0 – 0	
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

**PREREQUISITES:** Mechanical Operations and Reaction Engineering

**SYLLABUS:**

**Unit I**

Introduction: Bioprocess engineering and technology. Role of Chemical engineer in bioprocess industry, Classification of micro-organisms based on structure, reproduction cycle and engineering applications, Nucleic Acids-Structure, Biological function and Importance for life.

05 Hrs

**Unit II**

Proteins and Enzymes: Enzyme commission's nomenclature of enzymes, Structure and functions of proteins, Methods of enzyme production and purification, Effect of Temperature and pH on the rates of enzyme catalyzed reactions

Kinetic models and equations of enzyme action: Michaelis-Menten rate equation-Steady state and equilibrium state, Experimental determination of rate parameters: Lineweaver-Burk, Eadie-Hofstee and Hanes-Woolf Plots

11 Hrs

**Unit III**

Enzyme Inhibition: Kinetics of inhibition reactions- Competitive, noncompetitive, uncompetitive, substrate and product inhibitions, Determination of kinetic parameters for various types of inhibitions. Evaluation of inhibition constant-Dixon method, Enzyme immobilization-Methods of enzyme immobilization and various applications

10 Hrs

**Unit IV**

Growth Kinetics of Microorganisms: Transient growth kinetics, Quantification of growth kinetics, Substrate limited growth, Models with growth inhibitors, Logistic equation, Continuous culture: Optimum Dilution rate in ideal chemostat.

07 Hrs

**Unit V**

Fermentation Technology: Operation and maintenance of typical aseptic aerobic fermentation processes, Sterilization of bioprocess equipment, Sources of nutrients to formulate the medium, alternate bioreactor configurations.

Downstream Processing: Cell disruption, Affinity chromatography, Freeze drying.

6 Hrs

**TEXTBOOKS:**

1. Bailey and Ollis, Biochemical Engineering Fundamentals, 2<sup>nd</sup> edition, McGraw Hill, 1976.
2. Shuler M. L. and Kargi. F, Bioprocess Engineering, 2<sup>nd</sup> edition, Prentice Hall, 2002.

**REFERENCE BOOKS:**

1. Biochemical Engineering by James Lee, Prentice Hall, University of Michigan, 1992.



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2. Microbiology Concept and Application by Pelczer, 5<sup>th</sup> edition, McGraw Hill, 2001.

**E BOOKS**

[1]. Biochemical Engineering and Biotechnology by Ghasem Najafpour Ghasem Najafpour, eBook  
ISBN: 9780080468020.

[2]. Biochemical Engineering by Shigeo Katoh, ISBN: 978-3-527-33804-7.

**MOOC's & ONLINE COURSES:**

1) <https://ocw.mit.edu/courses/biological-engineering>

2) <http://www.online.colostate.edu/degrees/biomedical-engineering>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		Programme Outcomes
CO1	Apply biology in bioprocess engineering	PO2
CO2	Understand functioning of molecules of life	PO2
CO3	Infer features of bioreactors to decide various processes	PO4
CO4	Identify enzymes for catalysed processes	PO2
CO5	Explain the kinetics of enzyme catalysed reaction	PO4
CO6	Perform the basis analytical techniques in downstream processing.	PO7

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100 (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
Semester End Examination (Written Examination for Three Hours)		Marks 100 (Weightage 50%)	

**Assessment Pattern:**

Component	Test 1	Test 2	Quiz 1/AAT	Quiz 2 /AAT	Total Marks
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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Course Title	CHEMICAL PROCESS EQUIPMENT DESIGN & DRAWING														
Course Code	1	6	C	H	7	D	C	P	E	D	Credits	06	L – T – P- S	3 – 0 – 1 - 2	
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

**PREREQUISITES:** Heat Transfer, Mass Transfer and Chemical Equipment Design

**SYLLABUS:**

Detailed chemical engineering process design of the following equipment. The necessary aspects studied in "Chemical Equipment Design" are to be applied for mechanical design. Use of standard code books are to be taught. The detailed dimensional drawings shall include sectional front view, top/side view depending on equipment and major component drawing with dimensioning and part template.

Unit I

Design of Heat transfer equipment: Double pipe Heat exchanger, Shell and Tube Heat exchanger, Horizontal Condenser, Vertical condenser and Rotary Dryer.

20 Hrs

Unit II

Design of Mass transfer equipment: Single Effect Evaporator, Bubble Cap Distillation Column Packed Bed Absorption Column

19 Hrs

**NOTE:**

- The question paper to contain two full design problems (100 Marks each) for the equipment from the above list and student to answer any One.
- One question should be framed from each unit.
- Choice between Unit 1 and Unit 2
- Perry's Chemical Engineers Handbook and IS Code 4503 for heat exchangers shall be allowed in the examination as reference.

**TEXTBOOKS:**

1. S B Thakore and B I Bhatt, Introduction to Process Engineering and Design, 3<sup>rd</sup> edition, Tata McGraw-Hill, 2011.
2. Donald Q. Kern, Process Heat Transfer, McGraw Hill, 1997
3. Robert E Treybal, Mass Transfer Operations, McGraw Hill, 1981.

**REFERENCE BOOKS:**

1. R. H. Perry and D. W. Green, Chemical Engineering Handbook, 7<sup>th</sup> edition, McGraw Hill, 1998.
2. J. M. Coulson and J. F. Richardson, Chemical Engineering, Vol. 6, Pergamon Press, 1993.
3. Shell and Tube Heat exchanger IS Code, IS 4503, BIS, New Delhi, 1969.

**E BOOKS**

- [1]. S. D. Dawande, Process Design of Equipment, Vol. 2, 3<sup>rd</sup> edition, Central Techno Publications, 2003



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[2]. R. H. Perry and D. W. Green, Chemical Engineering Handbook, 7<sup>th</sup> edition, McGraw Hill, 1998

**MOOC's & ONLINE COURSES:**

- 1) <http://nptel.ac.in/courses/103103027/>
- 2) <https://ocw.mit.edu/courses/chemical-engineering/>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
CO1	Congregate the data from the literature, Handbook, Code book	PO4
CO2	Analyze, interpret the literature data	PO2
CO3	Design the heat and mass transfer equipment	PO3
CO4	Select the details of accessories based on technical needs and availability	PO8
CO5	Decide on the incorporation of inherent safety standards	PO12
CO6	Draft the equipment as per the design	PO3

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100% (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	40%	Course Instructor
	Quiz (Two Quizzes)	10%	Course Instructor
Laboratory Component	Laboratory Component	30%	Course Instructor
Self-Study Component	Open Ended Experiments/Term Papers/Modelling/Seminar/Mini projects.	20%	Committee constituted by HOD
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

Component	Theory (50%)			Practical (30%)		Self-Study (20%) by AAT	Total Marks							
	Test 1	Test 2	Quiz	Records & Performances	Lab Test									
Max. Marks	20	20	10	20	10	20	100							
Reduced CIE	10	10	5	10	5	10	50							
Course Title	<b>CHEMICAL PROCESS MODELLING &amp; SIMULATION</b>													
Course Code	1	6	C	H	7	D	C	P	M	S	Credits	05	L - T - P - S	2 - 0 - 1 - 2
CIE	100 marks (50% weightage)					SEE		100 marks (50% weightage)						

**PREREQUISITES:** Chemical Reaction Engg, Heat transfer, mass transfer, thermodynamics and numerical techniques

**SYLLABUS:**

**UNIT I**



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Fundamentals of Modeling: Introduction to process modeling, Needs of model and their classification, Model building, Precautions in model building, Principles of model formulation, Fundamental laws, Review of shell balance approach, Models based on thermodynamic principles, Concept of degree of freedom analysis, Concept of equilibrium and kinetics.

5 Hrs

**UNIT II**

Models of reactors: Two heated tanks, Gas phase pressurized CSTR, Non isothermal CSTR: Perfectly mixed cooling jacket, Plug flow cooling jacket, Lumped Jacket Model, Lumped metal model, Reactor model with mass transfer, Bioreactor models. Fluidized bed reactor model

6 Hrs

**UNIT III**

Models of Heat Transfer equipment: One and Two dimensional heat conduction, Numerical solution of one-dimensional transient heat conduction in a rectangular slab, cylinder, and sphere using the finite difference method.

5 Hrs

**UNIT IV**

Models of Separation Processes: Single-Component Vaporizer: Steady State model, liquid phase dynamic model, Liquid and vapor dynamic model, Thermal equilibrium model. Development of detailed mathematical models of multicomponent flash drum. Model of ideal binary distillation column, multicomponent non-ideal distillation column and Batch distillation with holdup.

6 Hrs.

**UNIT V**

Simulation: Introduction to process simulation, Tools of simulation: Features, advantages and limitations. Approaches of simulation: Modular approach and Equation solving approach. Flow sheeting, Introduction to dynamic simulation and process optimization.

4 Hrs

**LABORATORY COMPONENT**

Simulation Using UniSim® Simulation Software

1. Simulation of Mixer, Heater and Pump.
2. Simulation of Heat Exchanger
3. Simulation of Flash Drum for Binary Mixture
4. Simulation of Distillation Column
5. Simulation of Refrigeration Gas Plant
6. Simulation of Conversion Reactor
7. Simulation of Equilibrium Reactor
8. Simulation of Two Stage Compression System
9. Simulation of Absorption Column
10. Dynamic Simulation using Reactor

**TEXTBOOKS:**

1. William. L Luyben, "Process Modeling Simulation and Control for Chemical Engineering", 2nd Edition., McGraw Hill, 1990.



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2. Pradeep Ahuja, “Introduction to Numerical Methods in Chemical Engineering”, PHI Learning Pvt. Ltd., 2010.

3. B. V. Babu, “Process Plant Simulation”, Oxford University Press, 2004

**REFERECE BOOKS:**

1. Enes Kadic, Theodore J. Heindel, “An Introduction to Bioreactor Hydrodynamics and Gas-Liquid Mass Transfer”, Willey, April 2014.

**E BOOKS**

[1]. Chemical Process Technology and Simulation by Srikumar Koyikkal, ISBN-13: 978-8120347090

[2]. Chemical Process Modelling and Computer Simulation by Amiya K. Jana

**MOOC’s & ONLINE COURSES:**

1) <http://nptel.ac.in/courses/103107096/>

2) <http://www.myopencourses.com/subject/process-modelling-and-simulation-1>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
CO1	Understand the physical laws and mathematical models for reactor modules	PO12
CO2	Select suitable shell balance approach to build models for heat transfer	PO6
CO3	Select suitable shell balance approach to build models for separation processes	PO6
CO4	Apply the simulation principles to solve build in models for reactors, heat transfer and separation processes	PO5
CO5	Conduct Simulation experiments individually and in team using UNISIM	PO9
CO6	Infer and interpret the simulation data by applying norms of Engineering practice	PO8



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**ASSESSMENT:**

Continuous Internal Assessments		Marks 100% (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	40%	Course Instructor
	Quiz (Two Quizzes)	10%	Course Instructor
Laboratory Component	Laboratory Component	30%	Course Instructor
Self-Study Component	Open Ended Experiments/Term Papers/Modelling/Seminar/Mini projects.	20%	Committee constituted by HOD
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

Component	Theory (50%)			Practical (30%)		Self-Study (20%) by AAT	Total Marks
	Test 1	Test 2	Quiz	Records & Performances	Lab Test		
Max. Marks	20	20	10	20	10	20	100
Reduced CIE	10	10	5	10	5	10	50



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Course Title	ENGINEERING ECONOMICS														
Course Code	1	6	H	S	7	D	C	E	I	E	Credits	02	L – T – P- S	2 – 0 – 0- 0	
CIE	100 marks (50% weightage)											SEE	100 marks (50% weightage)		

**PREREQUISITES:** Chemical Technology and Chemical Equipment Design

**SYLLABUS:**

**UNIT I**

**Introduction to Process Engineering Economics:** Factors affecting plant location, Factors affecting plant layout, feasibility survey

4 Hrs

**UNIT II**

**Cost analysis:** Fixed and working capital investment, cost indexes, estimating equipment cost by scaling, component of total product cost, problems

6 Hrs

**UNIT III**

**Interests:** simple, compound, nominal and effective interest rates, continuous interest, present worth and discount, Types of tax, problems on interest

5 Hrs

**UNIT IV**

**Depreciation:** types of depreciation, methods for determining depreciation: straight-line method, Unit of production method, Text book declining-balance method, double-declining balance method, sum-of-the-years-digits method and sinking-fund method, problems on depreciation

6 Hrs

**UNIT V**

**Financial Statements:** Balance Sheet, Income Statement, Profit and Loss statement, Concept of breakeven point and chart, Break–even analysis, problems

5 Hrs

**TEXTBOOKS**

1. Peters, M. S. and Timmerhaus, L. D. Plant Design and Economics for Chemical Engineering, 4th edition, McGraw-Hill International, New Delhi, 1991.
2. Banga, T. R. and Sharma, S. C. Industrial Organization and Engineering Economics, 24th edition, Khanna Publishers, New Delhi, 2011.

**REFERENCE BOOKS**

1. Panneer Selvam. R. Engineering Economics, 1<sup>st</sup> edition, PHI Learning Private Limited, New Delhi, 2013.
2. Phaneesh, K. R. Engineering Economics, 5<sup>th</sup> edition, Sudha Publications, Bangalore, 2013.

**E BOOKS**

[1] Process Engineering Economics by James Riley Couper, CRC Press, 2003

[https://books.google.co.in/books/about/Process\\_Engineering\\_Economics.html?id=qE6fZQnIjDUC](https://books.google.co.in/books/about/Process_Engineering_Economics.html?id=qE6fZQnIjDUC)

[2] Chemical Engineering Economics by D. E. Garrett, Springer Science & Business Media, 2012



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[https://books.google.co.in/books?id=hB3tCAAAQBAJ&source=gbs\\_similarbooks](https://books.google.co.in/books?id=hB3tCAAAQBAJ&source=gbs_similarbooks)

MOOCs and ONLINE COURSES

1) <http://nptel.ac.in/courses/103103039/#>

2) <https://www.edx.org/course/introduction-economics-macroeconomics-snu-snu044-088-2x>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
CO1	Identify the factors while selecting plant location, plant layout and feasibility survey	PO6
CO2	Solve the problems related to estimation of product cost by making use of various costs	PO2
CO3	Differentiate different types of taxes and interest	PO2
CO4	Solve problems related to depreciation and interest	PO3
CO5	Obtain break-even point for a given production of materials and profit and loss statement	PO3
CO6	Create a balance sheet of an industry by considering various factors	PO3

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100 (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

Component	Test 1	Test 2	Quiz 1/AAT	Quiz 2 /AAT	Total Marks
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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<b>Course Title</b>	<b>PRE-PROJECT WORK</b>														
<b>Course Code</b>	<b>1</b>	<b>6</b>	<b>C</b>	<b>H</b>	<b>7</b>	<b>D</b>	<b>C</b>	<b>P</b>	<b>P</b>	<b>W</b>	<b>Credits</b>	<b>02</b>	<b>L – T – P- S</b>	<b>0 – 0 – 2 - 0</b>	
<b>CIE</b>	<b>100 marks (50% weightage)</b>										<b>SEE</b>	<b>100 marks (50% weightage)</b>			

A project is assigned at the beginning of the seventh semester. The project group should complete the preliminary literature survey & plan of project and submit the synopsis at the end of seventh semester with a literature survey and plan for the experimental work to be performed with all parameters.

**COURSE OUTCOMES (COs):**

<b>COURSE OUTCOMES</b>		<b>PROGRAMME OUTCOMES</b>
<b>CO1</b>	Perform extensive literature survey to understand the changes in the technological trends	<b>PO4</b>
<b>CO2</b>	Identify a feasible method to carry out the project work by considering professional ethics of engineering practice	<b>PO8</b>
<b>CO3</b>	To formulate one or more methodological approach to carry out the experiments to find a feasible solution for societal and environmental problems.	<b>PO6</b>
<b>CO4</b>	Communicate and present/publish effectively the methodological planned to carry out the project work.	<b>PO10</b>
<b>CO5</b>	Develop multidisciplinary skills to work as an individual and as a member or leader in diverse team	<b>PO9</b>
<b>CO6</b>	Relate the outcomes of the project where the knowledge on developed understanding will help in lifelong learning so as to suit the current technological trends	<b>PO12</b>

**ASSESSMENT:**

<b>Continuous Internal Assessments</b>		<b>Marks 100% (Weightage 50%)</b>	<b>Assessment</b>
Practical Component	Presentation Based on the Topics/problem taken up by the project group under the guidance by a faculty from the department /external guide from industries/other research organisation	Presentation 1 50%  Presentation 2 50%	Committee constituted by HOD
<b>Semester End Examination (Presentation)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Evaluation Parameters for Pre-project work**



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A U S N	Presentation of Slides (10 Marks)		Literature survey (10 marks)		Technical content (10 marks)		Communication (20 Marks)			
	Visibility of the Figures and texts in Ppt (5)	Contribution to slide preparation (5)	Extensive literature survey with recent publications (5)	Bibliography as per institution format (5)	Problem Formulation + statement of procedure (5)	Results, tabulation and demonstrations (5)	Oral (10)		Written/ report (10)	
							Able to explain the work done Clearly (5)	Audible, with good presentation skills (5)	Thesis / report as per institute guidelines (5)	Clarity in Table figure and references (5)

B U S N	Answer to Questions (10 Marks)	Time Management (10 Marks)		Team work (10 marks)		Developed understanding (10 marks)	Ethics (10 marks)	
	Questions from reports and ppt	Is report submitted on time? (5)	Time management in presentation (5)	Responsibility and initiatives taken (5)	Working in team (5)	Idea on extension of project work/ applications	Plagiarism checked (5)	Proper citation (5)



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Course Title	FINITE ELEMENT ANALYSIS													
Course Code	1	6	C	H	7	D	E	L	E	1	Credits	01	L – T – P- S	1 – 0 – 0 - 0
CIE	100 marks (50% weightage)						SEE			100 marks (50% weightage)				

**PREREQUISITES:**

**SYLLABUS:**

**Introduction to Finite Element Method:** Background and general description of the method, summary of the analysis procedure

**Theory of Finite element method:** Concept of element, various element shapes, displacement Models, shape functions, iso-parametric elements, formulation of element stiffness and loads, condensation of internal degrees of freedom.

07 Hrs

**Overall problem:** Assemblage of elements construction of stiffness matrix and loads, boundary conditions and solution of overall problem, Application to continuous beam, spring assemblage, stability of columns, curved beams and vibration problems and torsions of shafts.

06 Hrs

**TEXTBOOKS**

1. P Seshu, Finite Element Analysis, 1<sup>st</sup> Edition, Phi Learning, 2009.
2. Tirupathi Chandra Patla, Introduction to Finite Elements in Engineering, 4<sup>th</sup> Edition, 2012.

**REFERENCE BOOKS**

1. C. V. G. Vallabhan, Finite Element Method for Engineers, Narosa Book Distributors Pvt Ltd, 2011.

**E BOOKS**

- [1] The Finite Element Method in Engineering by Singiresu Rao, eBook ISBN: 9780080952048
- [2] An Introduction to the Finite Element Method by J Reddy, ISBN-13 : 9780072466850

**MOOCs and ONLINE COURSES**

- 1) [https://onlinecourses.nptel.ac.in/noc16\\_me02/preview](https://onlinecourses.nptel.ac.in/noc16_me02/preview)
- 2) <https://open.umich.edu/find/open-educational-resources/engineering/introduction-finite-element-methods>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
CO1	Develop shape functions and stiffness matrices for spring and bar elements	PO3
CO2	Develop global stiffness matrices and global load vectors	PO3
CO3	Apply natural and arial coordinate systems to constant strain triangle and linear strain triangle elements	PO4
CO4	Analyze planar structural systems using finite element modelling	PO4

**ASSESSMENT:**



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Continuous Internal Assessments		Marks 100 (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
Semester End Examination (Written Examination for Three Hours)		Marks 100 (Weightage 50%)	

**Assessment Pattern:**

Component	Test 1	Test 2	Quiz 1/AAT	Quiz 2 /AAT	Total Marks
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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<b>Course Title</b>	<b>FERMENTATION TECHNOLOGY</b>													
<b>Course Code</b>	<b>1</b>	<b>6</b>	<b>C</b>	<b>H</b>	<b>7</b>	<b>D</b>	<b>E</b>	<b>L</b>	<b>E</b>	<b>2</b>	<b>Credits</b>	<b>01</b>	<b>L – T – P- S</b>	<b>1 – 0 – 0 - 0</b>
<b>CIE</b>	<b>100 marks (50% weightage)</b>						<b>SEE</b>			<b>100 marks (50% weightage)</b>				

**PREREQUISITES:** Biology for Engineers, Chemical Technology and Reaction Engineering

**SYLLABUS:**

**Unit I**

Microbial growth kinetics-a review: Batch Culture; Continuous Culture; Fed-batch Culture. Isolation, preservation and improvement of industrial microorganisms: Isolation Methods utilizing the selection of desired characteristics; Isolation methods not utilizing the selection of desired characteristics; Preservation Methods: At low temperature, dehydration, and their quality control; the selection and isolation of induced mutants improving yields of secondary metabolites. Use of recombinant systems for the improvement of industrial microorganisms.

6hrs

**Unit II**

Media for industrial fermentations: typical media and formulation; sources of energy, carbon, nitrogen, minerals, vitamins, precursors, oxygen and others. Sterilization of Media: medium Sterilization; design of batch and continuous sterilization; sterilization of fermenter, feed, air; filtration of air and design of filters. Development of inocula for industrial fermentations: the development of inocula for yeast, bacterial, fungal and streptomycete processes; aseptic inoculation of plant Fermenters. Recovery and purification of fermentation products: filtration, centrifugation, cell Disruption, extraction, chromatography, ultra filtration, drying, crystallization and whole broth processing.

7 hrs

**TEXTBOOKS**

1. Peter F. Stanbury, Alan Whitaker and Hope, Principles of Fermentation Technology, Pergamon Press, 2<sup>nd</sup> Edition, Reprint 2010
2. Shuler M. L. and Kargi F, Bioprocess Engineering, 2nd Edition, Prentice Hall, 2002

**REFERENCE BOOKS**

1. Mitchell DA. Krieger N, Berovic, "Solid State Fermentation Bioreactors", Springer Press, Germany, 2005.

**E BOOKS**

- [1] Computer Applications in Fermentation Technology, <http://www.springer.com/in/book/9789401070065>
- [2] <https://www.crcpress.com/Fermentation-Microbiology-and-Biotechnology-Third-Edition/El-Mansi-Bryce-Demain-Allman/p/book/9781439855799>

**MOOCs and ONLINE COURSES**

- 1) <http://nptel.ac.in/courses/103107082/13>



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**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMM E OUTCOMES
<b>CO 1</b>	Introduce the students to the various concepts of fermentation	PO2
<b>CO 2</b>	Introduce the students to the role microorganism play in fermentation process	PO4
<b>CO 3</b>	Provide the students with the process understanding of alcoholic various fermentation processes.	PO6

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100 (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

Component	Test 1	Test 2	Quiz 1/AAT	Quiz 2 /AAT	Total Marks
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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Course Title	SMART MATERIALS														
Course Code	1	6	C	H	7	D	E	L	E	3	Credits	01	L – T – P – S	1 – 0 – 0 – 0	
CIE	100 marks (50% weightage)						SEE			100 marks (50% weightage)					

**PREREQUISITES:** Material Science and Biomaterials and polymer materials and Processing

**SYLLABUS:**

**Introduction to smart materials:** definition, type, properties and examples; Modeling of mechanical and electrical system: fundamental relationships in mechanics and electrostatics, work and energy; Piezoelectric materials, shape-memory materials, conductive polymers, pH and temperature sensitive polymer; Engineering and scientific applications of different smart materials, their preparation, characterization and use as smart products;

13Hrs

**TEXTBOOKS**

1. M. V. Ghandi and B. S. Thompson, Smart Materials and Structures, Chapman & Hall, 1992
2. A. V. Srinivasan and D. M. McFarland, Smart Structures, Cambridge University Press, 2001

**REFERENCE BOOKS**

1. H. Janocha (Ed. ), Adaptronics and Smart Structures, Springer, 1999
2. R. C. Smith, Smart Material Systems: Model Development (Frontiers in Applied Mathematics), SIAM, 2005

**E BOOKS**

[1] Smart Materials, Mel Schwartz, ISBN 9781420043723

**MOOCs and ONLINE COURSES**

- 1) <http://nptel.ac.in/courses/103107082/13>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
CO1	Knowledge and awareness of smart materials and concepts to engineering application areas	PO6
CO2	Critical understanding of mechanisms giving rise to the characteristic and beneficial properties of smart materials	PO2
CO3	Understanding of material systems that underlie the analysis and design of “smart” devices	PO3



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**ASSESSMENT:**

<b>Continuous Internal Assessments</b>		<b>Marks 100 (Weightage 50%)</b>	<b>Assessment</b>
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

<b>Component</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Quiz 1/AAT</b>	<b>Quiz 2 /AAT</b>	<b>Total Marks</b>
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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<b>Course Title</b>	<b>SKADA AND PLC</b>														
<b>Course Code</b>	<b>1</b>	<b>6</b>	<b>C</b>	<b>H</b>	<b>7</b>	<b>D</b>	<b>E</b>	<b>L</b>	<b>E</b>	<b>4</b>	<b>Credits</b>	<b>01</b>	<b>L – T – P- S</b>	<b>1 – 0 – 0- 0</b>	
<b>CIE</b>	<b>100 marks (50% weightage)</b>										<b>SEE</b>	<b>100 marks (50% weightage)</b>			

**PREREQUISITES:** Process Control Engineering

**SYLLABUS:**

Introduction, Programmable Logic Controller: Structure and Functioning, Programming a PLC, Meanings of symbols used in PLC Program: [Addressing Sample: I: 3/1, ]/[ , , (U), Timer, Case study (Chemical/ Allied Industry).

Introduction to Supervisory Control and Data Acquisition SCADA Functional requirements and Components, General features, Functions and Applications, Benefits, Configurations of SCADA, RTU (Remote Terminal Units) Connections, Case study (Chemical/ Allied Industry), SCADA Communication requirements, SCADA Communication protocols: Past Present and Future, Structure of a SCADA Communications Protocol.

13Hrs

**TEXTBOOKS**

1. Gary Dunning “introduction to Programmable logic controllers” 3 edition, CENGAGE learning
2. Practical SCADA for Industry, David Bailey, Edwin Wright Newnes, (an imprint of Elsevier), 2003

**REFERENCE BOOKS**

1. Overview of Industrial Process Automation, KLS Sharma, Elsevier Publication
2. John. W. Webb, Ronald A Reis, “Programmable Logic Controllers - Principles and Applications”, Prentice Hall Inc., New Jersey, 2003.
3. SCADA-Supervisory Control and Data Acquisition System, Stuart A. Boyer, ISA

**E BOOKS**

- [1] Programmable Logic Controllers, W. Bolton, Fourth Edition, Elsevier, ISBN-13: 978-0- 7506-8112-4
- [2] Practical SCADA for Industry, David Bailey, Edwin Wright Newnes, (an imprint of Elsevier), 2003, ISBN 07506 58053

**MOOCS AND ONLINE COURSES**

- 1) <http://nptel.ac.in/courses/112102011/>
- 2) <http://nptel.ac.in/courses/112103174/>



**DEPARTMENT OF CHEMICAL ENGINEERING**  
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**COURSE OUTCOMES (COs):**

<b>COURSE OUTCOMES</b>		<b>PROGRAMME OUTCOMES</b>
<b>CO1</b>	Explain the basic concepts, terminology, programming functions and entry level PLC applications.	PO12
<b>CO2</b>	Enumerate applications, sketch the architecture and describe major elements of SCADA.	PO5
<b>CO3</b>	List the communication requirements; describe protocols and structure of a SCADA Communications Protocol.	PO12

**ASSESSMENT:**

<b>Continuous Internal Assessments</b>		<b>Marks 100 (Weightage 50%)</b>	<b>Assessment</b>
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

<b>Component</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Quiz 1/AAT</b>	<b>Quiz 2 /AAT</b>	<b>Total Marks</b>
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



**DEPARTMENT OF CHEMICAL ENGINEERING**  
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Course Title	<b>COMPOSITE MATERIALS</b>														
Course Code	1	6	C	H	7	I	E	C	P	2	Credits	03	L – T – P- S	3 – 0 – 0- 0	
CIE	100 marks (50% weightage)						SEE			100 marks (50% weightage)					

**PREREQUISITES:** Material Science and biomaterials, Nanomaterial and Technology and polymer technology

**SYLLABUS:**

**Unit I**

**Introduction:** Introduction to ceramics & advanced ceramics materials, superior structural, optical and electrical properties of ceramic composites, classification & application of advanced ceramics based on their functions.

**Ceramic fabrication methods: Gas phase reactions methods:** direct metal oxidation & reaction bounding. **Liquid precursor methods:** Polymer pyrolysis. **Fabrication from powders:** melt casting and firing of compacted powders. All three methods for preparation of ultra-fine powders of metal-oxides, metal-nitrides and metal-carbides

**09Hrs**

**Unit II**

**Sintering of ceramics:** Fundamental concepts in sintering, driving forces for sintering and Fick's Law of Diffusion in crystalline solids

**Forming of ceramics composite materials:** Hot pressing, iso-static pressing, slip casting, tape-casting and pressure casting, sol-gel processes for the formation of monolithic ceramics

**Processing Techniques based on reaction methods:** Chemical vapour deposition (CVD), plasma-enhanced chemical vapour deposition (PECVD), processing methods for synthesis of fibers (Boron, Aramid, Carbon and glass fibers) and whiskers

**07Hrs**

**Unit III**

**Synthesis of mixed ceramic oxides: Mechanical methods:** Consolidation, mechano-chemical synthesis, **Evaporation of liquid methods:** Spray drying and Spray pyrolysis.

**Non-convectional Composites:** Polymer Clay Nanocomposites, Self-Healing Composites, Biocomposites, Laminates, Ceramic Laminates and Hybrid Composites.

**07 Hrs**

**Unit IV**

**Reinforcement:** Mechanism of reinforcement, masterbatch & compounding equipments used for reinforcement

**Reinforced metal matrix:** Methods for preparation of powdered metal matrix, fiber reinforced metal matrix. Types and Properties of matrix materials and its industrial application

**Ceramic reinforced matrix:** Cold pressing & sintering method, liquid silicon infiltration technique for synthesis of ceramic reinforced matrix, Types and properties of ceramic Matrix and its industrial applications.

**09 Hrs**

**Unit V**



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**Polymer composites:** Stress-Strain modulus relationship for fibre reinforced polymer composites, **manufacturing methods:** Hand layouts, filament winding, pultrusion, SMC and DMC. Applications of polymer reinforced composites in marine, aerospace, automobile, building & computer industry

**07 Hrs**

**TEXTBOOKS:**

1. M. N. Rahaman, "Ceramic processing and sintering", 2<sup>nd</sup> edition, Marcel Dekker, Inc, New York.
2. David Segal, "Chemical synthesis of advanced ceramic materials", Cambridge university press, Cambridge, New York.

**REFERENCE BOOKS:**

1. Krishan K. Chawla, "Composite Materials Science and Engineering", 2<sup>nd</sup> Edition Springer New York Heidelberg Dordrecht London

**E BOOKS**

[1]. Composite Materials by Dr. H. K. Shivanand and B. V. Babu Kiran, ISBN: 9788184121452

[2]. Composite Materials by S. C. Sharma, ISBN: 9788173192579

**MOOC's & ONLINE COURSES:**

- 1) <http://nptel.ac.in/courses/101104010/>
- 2) <https://www.coursebuffet.com/sub/material-science/320/composite-materials>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
CO1	Classify composite materials based on the Industrials applications	PO2
CO2	Apprehend and select a suitable fabrication technique for processing of ceramic materials.	PO6
CO3	Distinguish between mechanical and chemical techniques for fabrication of composite materials	PO3
CO4	Custom the synthesized metal- matrix and ceramic-matrix composite materials to use in different engineering disciplines.	PO12
CO5	Comprehend the fabrication techniques for reinforced polymer materials to demonstrate the knowledge of sustainable development.	PO7

**ASSESSMENT:**



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<b>Continuous Internal Assessments</b>		<b>Marks 100 (Weightage 50%)</b>	<b>Assessment</b>
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

<b>Component</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Quiz 1/AAT</b>	<b>Quiz 2 /AAT</b>	<b>Total Marks</b>
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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Course Title	NON-CONVENTIONAL ENERGY TECHNOLOGY														
Course Code	1	6	C	H	7	I	E	C	P	1	Credits	03	L – T – P- S	3 – 0 – 0- 0	
CIE	100 marks (50% weightage)						SEE			100 marks (50% weightage)					

**PREREQUISITES:**

**SYLLABUS:**

**Unit I**

Introduction: Man and energy, worlds and India's production and reserves of energy, present and future power position, need for alternate energy, energy alternatives.

5 Hrs

**UNIT II**

Solar Energy: Introduction: Extra-terrestrial solar radiation, radiation at ground level, collectors. Solar cells, applications of solar energy

6 Hrs

**UNIT III**

Biomass & Geothermal: Biomass energy, introduction, biomass conversion, biogas production, ethanol production, pyrolysis and gasification, direct combustion, applications of biomass energy.

Recovery of thermal conversion products -combustion of waste materials & related calculations, waste incineration with heat recovery and use of refused derived fuels (RDF).

Geothermal Energy: introduction, resource types, resource base, applications for heating and electricity generation.

12 Hrs

**UNIT IV**

Wind and Hydro Energy Sources: Introduction: Basic theory, types of turbines, applications. Hydropower: Introduction, basic concepts, site selection, types of turbines, small scale hydropower.

10 hrs

**UNIT V**

Fuel Cells: Introduction Principle and operation of fuel cells, classification and types of fuel cells and application of fuel cells.

6 hrs

**TEXTBOOKS:**

1. G. D. Rai, Non-conventional energy resources.
2. B. H Khan, Delhi, Non-conventional energy resources, Tata McGraw Hill, New Delhi.
3. Fuel Cell Handbook, E G & G Technical Services, 7<sup>th</sup> edition, Inc. U. S. Department of Energy Office of Fossil Energy, National Energy Technology Laboratory.

**REFERENCE BOOKS:**

1. Harker and Back hurst , 'Fuel and energy' , Academic press, London 1981.
2. Harker and Allen Oliver and Boyd, Fuel science, 1972.
3. Howard S. Peavy, Donald R Rowe & George Tchobanoglous, Environmental Engineering, MeG Engineering Thermodynamics raw Hill International Editions

**E BOOKS**



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[1] Non-Conventional Energy Resources (Second Edition) by B. H. Khan, <https://www.abebooks.com/Non-Conventional-Energy-Resources-Second-Edition-B. H/4877611079/bd>

**MOOC's & ONLINE COURSES:**

1) <http://nptel.ac.in/courses/Webcourse-contents/>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
<b>CO1</b>	Familiarize with the various forms of energy resources	PO2
<b>CO2</b>	Understand the global distribution of energy resources with its environmental impacts.	PO6
<b>CO3</b>	Familiarize the various non-conventional energy resources	PO2
<b>CO4</b>	Design and Develop the requirements for economical utilization of non-conventional energy sources.	PO3
<b>CO5</b>	Design basic aspects to establish non-conventional energy harvesting units	PO7

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100 (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

Component	Test 1	Test 2	Quiz 1/AAT	Quiz 2 /AAT	Total Marks
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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<b>Course Title</b>	<b>MANAGEMENT AND ENTREPRENEURSHIP</b>														
<b>Course Code</b>	<b>1</b>	<b>6</b>	<b>H</b>	<b>S</b>	<b>8</b>	<b>D</b>	<b>C</b>	<b>M</b>	<b>M</b>	<b>E</b>	<b>Credits</b>	<b>03</b>	<b>L – T – P - S</b>	<b>3 – 0 – 0 - 0</b>	
<b>CIE</b>	<b>100 marks (50% weightage)</b>										<b>SEE</b>	<b>100 marks (50% weightage)</b>			

**SYLLABUS:**

**UNIT-I**

**MANAGEMENT:** Introduction-meaning-nature and characteristics of management, scope and functional area of management, management as a science or art of profession, management and administration roles of management, levels of management, Development of management thought - Early management approaches, Modern management approaches.

07Hrs

**UNIT-II**

**ENTREPRENEUR:** Meaning, evolution of the concept, functions of an Entrepreneur, Characteristics of an Entrepreneur, types of entrepreneur, Intrapreneur – an emerging class. Difference between Entrepreneur, Intrapreneur & Manager, Stages in Entrepreneurial process, Scope of Entrepreneur & Problems of Entrepreneur, Role of Entrepreneurs in economic development, Entrepreneurship-Meaning & Importance of Entrepreneurship in India. Its barriers, Women entrepreneur – Concept & steps to develop Women Entrepreneur

09Hrs

**UNIT-III**

**SMALL SCALE INDUSTRY:** Ancillary Industry and Tiny Industry , Definition;, Characteristics; Objectives, Scope and role of SSI in economic Development, Advantages of SSI, problems of SSI, Steps to start an SSI, Government Policy towards SSI; Introduction to GATT/ WTO/ LPG. Forms of ownership.

07Hrs

**UNIT-IV**

**SUPPORTING AGENCIES OF GOVERNMENT FOR SSI:** Meaning, Nature of support; Objectives, functions. **INSTITUTIONAL SUPPORT:** Different Schemes, TECKSOK, KIADB, KSSIDC, DIC, SISI NSIC, SIDBI, KSFC. Sources of financing an enterprise- long term and short term.

09 Hrs

**UNIT-V**

**PREPARATION OF PROJECT:** Meaning, Project identification, Project selection, Project Report - Need of Project, Contents: formulation: , Network Analysis Errors of project report, Project Appraisal, Feasibility Study-Market Feasibility Study, Technical Feasibility Study, Financial Feasibility Study, Social Feasibility Study.

07 Hrs

*Note: One question from each Unit of 20 marks each. Questions from Unit 2 and 4 will have internal choice.*



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**TEXTBOOKS**

1. Entrepreneurship and Management- S Nagendra and V S Manjunath- Pearson Publication 4 /e, 2009.
2. Dynamics of Entrepreneurial Development and Management-Vasant Desai-Himalaya Publishing House.
3. Principles of Management – PC Tripathi, and P N Reddy – Tata MacGraw Hill.

**REFERENCE BOOKS**

1. Entrepreneurship Development – Poornima M Charanthimath Pearson Education 2006.
2. Entrepreneurship and management - Shashi k Gupta- Kalyani publishers, Latest edition.

**EBOOKS**

[1] Organizational behaviour, Stephen P Robbins, Timothy A. Judge, Neharika Vohra, Pearson, 14/e, 2012

[2] Financial Management- Shashi k Gupta- Kalyani publishers, Latest edition

**MCOOS and ONLINE COURSE**

1) <https://www.mooc-list.com/course/entrepreneurship-openlearning>

2) <http://www.iimb.ernet.in/iimbx>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
CO1	Gain knowledge on Management concepts & its evolution.	PO11
CO2	Learn the application of Managerial skills & attributes.	PO11
CO3	Get an in depth knowledge of Entrepreneurial process & will be able to apply the Entrepreneurial skills.	PO12
CO4	Compile information & explore the business opportunities.	PO10
CO5	Able to prepare the Business plan.	PO12



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**ASSESSMENT:**

<b>Continuous Internal Assessments</b>		<b>Marks 100 (Weightage 50%)</b>	<b>Assessment</b>
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

<b>Component</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Quiz 1/AAT</b>	<b>Quiz 2 /AAT</b>	<b>Total Marks</b>
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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Course Title	PROJECT MANAGEMENT AND FINANCE														
Course Code	1	6	C	H	8	D	C	P	M	F	Credits	04	L – T – P – S	2 – 0 – 0 – 2	
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

**PREREQUISITES: Economics in Engineering, Statistics and Probability**

**SYLLABUS:**

**UNIT I**

**Project planning:** Overview of project planning, Resource Allocation strategies, generation and screening of project ideas and plans

04 Hrs

**UNIT II**

**Project analysis:** Analysis, Market and demand analysis, Technical analysis, financial requirements and estimation.

04 Hrs

**UNIT III**

**Project selection:** Time value of money, Investment criteria, Cash flows, Cost of capital, Risk factors and analysis and Analysis of rate of return.

04 Hrs

**UNIT IV**

**Financing of projects:** Raising capital methods and means, Venture capital, Credit risk rating, Case studies and corporate examples in brief

07 Hrs

**UNIT V**

**Project scheduling & execution:** CPM and PERT (Critical Path, Float, Total Float, AON, AOA Diagram), GANTT charts, LOB, Resource Allocation, ABC analysis, VED analysis, EOQ, CAT & RAT (Numerical problems included).

07 Hrs

**TEXTBOOKS**

1. Prassanna Chandra, "PROJECTS", Tata McGraw Hill, 7<sup>th</sup> edn.
2. Sadhan Choudhury, "Project Management": Tata McGraw-Hill Education, 1988

**REFERENCE BOOKS**

1. J. K. Sharma "OPERATION RESEARCH" MacMillan
2. Entrepreneurship Development, Colombo Plan Staff College for Technical Education, Tata Mc Graw Hill.

**E BOOKS**

- [1] Principles of Project Finance by E. R. Yescombe, 1<sup>st</sup> Edition: <https://www.amazon.com/Principles-Project-Finance-R-Yescombe-ebook/dp/B0027IS4WE>
- [2] Project Management by K. Nagarajan : <http://www.bookadda.com/books/project-management-k-nagarajan-8122428037-9788122428032>

**MOOC's & ONLINE COURSES:**

- 1) <https://alison.com/courses/Diploma-in-Project-Management>
- 2) <https://www.coursera.org/learn/project-management-basics>



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**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
<b>CO1</b>	To make the student understand the concept of a project with relevance to industry and chemical industry in particular.	PO11
<b>CO2</b>	To understand the various stages and procedures involved in conducting industrial projects.	PO11
<b>CO3</b>	To comprehend ideas like project selection, planning, implementation, success and review	PO10
<b>CO4</b>	Techniques of capital budgeting, venture capital generation with relevance to handling projects	PO9
<b>CO5</b>	Concepts of CPM and PERT, scheduling and forecasting with their importance in control of projects with change in technologies	PO4

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100% (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	60%	Course Instructor
	Quiz (Two Quizzes)	10%	Course Instructor
Self-Study Component	Term Papers/Modelling/Seminar/Mini projects.	40%	Committee constituted by HOD
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

Component	Theory (60%)				Self-Study (40%) by AAT	Total Marks
	Test 1	Test 2	Quiz1	Quiz2		
Max. Marks	20	20	10	10	40	100
Reduced CIE	10	10	5	5	20	50



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<b>Course Title</b>	<b>FINAL PROJECT WORK</b>														
<b>Course Code</b>	<b>1</b>	<b>6</b>	<b>C</b>	<b>H</b>	<b>8</b>	<b>D</b>	<b>C</b>	<b>F</b>	<b>P</b>	<b>W</b>	<b>Credits</b>	<b>12</b>	<b>L – T – P- S</b>	<b>0 – 0 – 12- 0</b>	
<b>CIE</b>	<b>100 marks (50% weightage)</b>						<b>SEE</b>			<b>100 marks (50% weightage)</b>					

The students in a group will be assigned an experimental, design, a case study or an analytical problem, to be carried out under the supervision of a guide. The project has to be assigned at the beginning of the seventh semester. The project group should complete the preliminary literature survey & plan of project and submit the synopsis at the end of seventh semester. The project work should be carried out and completed at the end of eighth semester, which is evaluated by a committee constituted by the HoD for assessment. One technical paper should be submitted at the end of the semester in reputed National/International journals for publications.

**COURSE OUTCOMES (COs):**

<b>COURSE OUTCOMES</b>		<b>PROGRAMM E OUTCOMES</b>
<b>CO1</b>	Design and carry out the experiments/design/theoretical design/ simulations work in team in the predetermined methodology.	PO4
<b>CO2</b>	Analyze and interpret the obtained data for optimum solution using suitable Engineering and IT tools.	PO5
<b>CO3</b>	Elucidate the short comings and identify the scope for future work	PO12
<b>CO4</b>	Communicate effectively the project the results/write effective reports to publicize the deduce solutions.	PO10
<b>CO5</b>	Develop ability to function and to work as an individual/ as a member/leader in diverse team	PO9
<b>CO6</b>	Understand the essence and need of professional ethics during project documentation	PO8

**ASSESSMENT:**

<b>Continuous Internal Assessments</b>		<b>Marks 100% (Weightage 50%)</b>	<b>Assessment</b>
Practical Component	The students will take-up the project assigned in the previous semester and will start carry out experiments/design/theoretical interpretation/simulations studies. The students will present and write reports of the findings. The evaluation will be based on the Rubrics framed.	Presentation 1 50%	Committee constituted by HOD
		Presentation 2 50%	Committee constituted by HOD
<b>Semester End Examination (Presentation)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Rubrics for the Evaluation of Final Project Work**

	<b>Inadequate</b>	<b>Average</b>	<b>Admirable</b>	<b>Outstanding</b>
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	Marks	5	7	9	10
<b>A</b>	<b>Organization of presentation (10 marks)</b>	Hard to follow sequence of information jumpy	Most of the information presented in sequence	Information presented in logical sequence and easy to follow	Information presented as interesting story in logical and easy to follow
<b>B</b>	<b>Background content (10 marks)</b>	Material not clearly related to topic or seminar	Material sufficient for clear understanding	Material sufficient for clear understanding and effectively presented	Material sufficient for clear understanding and exceptionally presented
<b>C</b>	<b>Results (Figures, table and graphs) (10 marks)</b>	Methods are too brief, figure are hard to read, some explanation missing	Majority of figures are clear, and reasonably explained	Most of the figures are clear, well explained	All figures are clear and exceptionally explained
<b>D</b>	<b>Contribution of work (5 Marks)</b>	Significance not mentioned just hinted	Significance mentioned	Significance explained	Significance exceptionally well explained
<b>E</b>	<b>Knowledge of subject (5 Marks)</b>	Don't have grasps of information, answered only rudimentary questions	At ease with information answered most questions	At ease, answered all questions, but failed to elaborate	Demonstrated full knowledge, answered all questions with elaboration
<b>F</b>	<b>Presentation skills (10 marks)</b>	<ul style="list-style-type: none"> <li>• Uses graphics that did not match the text</li> <li>• Reads most of the slides, no eye contact</li> <li>• 10 Spelling mistake in the slide</li> <li>• Incorrect pronounces of all term</li> <li>• Voice is low</li> </ul>	<ul style="list-style-type: none"> <li>• Uses graphics that relate to the text</li> <li>• Refer to slides, occasional eye contact</li> <li>• 5 Spelling mistake in the slide</li> <li>• Incorrect pronounces of some term</li> <li>• Voice is low-clear</li> </ul>	<ul style="list-style-type: none"> <li>• Uses graphics that explain the text and presentation</li> <li>• Refer to slides to make points, with eye contact</li> <li>• 3 Spelling mistake in the slide</li> <li>• Incorrect pronounces of some term</li> <li>• Voice is clear with few fluctuations</li> </ul>	<ul style="list-style-type: none"> <li>• Uses graphics that explain, reinforce text and presentation</li> <li>• Refer to slides to make points, with good eye contact</li> <li>• 2 Spelling mistake in the slide</li> <li>• Refer to the slides and make points Engaged with audience</li> <li>• Voice is clear and steady</li> </ul>

<b>Course Title</b>	<b>INTERNSHIP &amp; RELATED SEMINAR</b>													
<b>Course Code</b>	1	6	C	H	8	D	C	I	R	S	<b>Credits</b>	02	<b>L – T – P – S</b>	0 – 0 – 0 – 2



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<b>CIE</b>	<b>100 marks (50% weightage)</b>	<b>SEE</b>	<b>100 marks (50% weightage)</b>
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The students are expected to undergo in-plant training in any chemical industry or in a reputed research laboratory with pilot plant facility. This shall be for a minimum period of two weeks during the vacation of sixth & seventh semester. If it is not possible, the students may be permitted to go on industrial visit and they should visit minimum of five major chemical industries. The student should submit a report separately, at the beginning of the eighth semester which is evaluated by a committee constituted by the HoD for internal assessment.

**COURSE OUTCOMES (COs):**

<b>COURSE OUTCOMES</b>		<b>PROGRAMM E OUTCOMES</b>
<b>CO1</b>	Communicate & report the industrial practices through technical presentations	PO10
<b>CO2</b>	Develop inter personal relationship and work as a member in diversified areas	PO9
<b>CO3</b>	Understand the need of engineering solutions for sustainability and environmental conservation	PO7
<b>CO4</b>	Understand the essence and need of industrial ethics	PO8
<b>CO5</b>	Get to know the role of economics and management principles in the success of industrial operation	PO11

**ASSESSMENT:**

<b>Continuous Internal Assessments</b>		<b>Marks 100% (Weightage 50%)</b>	<b>Assessment</b>
Presentation	The Students will present the internship taken up in the semester vacation and submit the certificate issued by the industry along with the report.	100%	Committee constituted by HOD
<b>Semester End Examination (Presentation)</b>		<b>Marks 100 (Weightage 50%)</b>	



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<b>Course Title</b>	<b>WASTE WATER TREATMENT</b>														
<b>Course Code</b>	<b>1</b>	<b>6</b>	<b>C</b>	<b>H</b>	<b>8</b>	<b>I</b>	<b>E</b>	<b>C</b>	<b>K</b>	<b>1</b>	<b>Credits</b>	<b>03</b>	<b>L – T – P- S</b>	<b>3 – 0 – 0 - 0</b>	
<b>CIE</b>	<b>100 marks (50% weightage)</b>						<b>SEE</b>			<b>100 marks (50% weightage)</b>					

**SYLLABUS**

**Unit I**

Objectives of wastewater treatment. Flow measurements and Composition. Characterization -properties and analysis of wastewater. Rural wastewater systems: waste treatability studies-a bench scale and pilot scale. Effluent standards for discharge to water bodies and land applications- state and central

06 Hrs

**Unit II**

Microbiology of waste treatment- Growth and inhibition of bacteria, Kinetics of Biological growth Batch culture substrate limited growth, Cell growth and substrate utilization, Effects of endogenous metabolism & kinetics. Manod's and Michaelis menton kinetics and their applications, Determination of kinetic coefficients

10 Hrs

**Unit III**

Fundamentals of process analysis, Reaction Kinetics, Reaction Kinetics, Mass balance analysis Reactors and their hydraulic characteristics Reactor selection & kinetics-Batch, Plug flow Reactor selection & kinetics - Completely stirred tank Reactor selection & kinetics-packed and fluidized bed reactor.

10 Hrs

**Unit IV**

Sewerage System- Design of sanitary sewer. Sewerage System- Design of storm water sewers, Physical and Chemical treatment of wastewater, Screens, Comminuters, Grit chambers, Sedimentation, Chemical treatment.

07 Hrs

**Unit V**

Biological treatment process. Activated sludge process- standard type and modifications. Aerators. Trickling filter, Aerated lagoon, Stabilization ponds Treatment disposal of sludge Sludge characteristics, Concentration. Anaerobic sludge digestion. Aerobic Sludge digestion, Sludge conditioning, Dewatering and drying. Incineration and wet oxidation

06 Hr

**TEXTBOOKS**

1. Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, 4<sup>th</sup> edition, McGraw-Hill Higher Education; 2002.
2. Fair, Geyer & Okun's, Water and Wastewater Engineering: Water Supply and Wastewater Removal, 3<sup>rd</sup> Edition, Willy, 2010.

**REFERENCE BOOKS**



**DEPARTMENT OF CHEMICAL ENGINEERING**  
**B.M.S. COLLEGE OF ENGINEERING, BENGALURU**  
**Autonomous College under VTU**

1. W. W. Eckenfelder D. J. O'Connor, Biological Waste Treatment, 1<sup>st</sup> Edition, Elsevier.
2. Walter J. Weber, Jr, Physicochemical processes for water quality control, Interscience, New York (1972).

**E BOOKS**

- [1] Fundamentals of Wastewater Treatment and Engineering, by Rumana Riffat, 1<sup>st</sup> Edition.

**MOOC's & ONLINE COURSES:**

- 1) <https://www.mooc-list.com/tags/wastewater-treatment>
- 2) <https://online-learning.tudelft.nl/courses/introduction-to-treatment-of-urban-sewage/>

**COURSE OUTCOMES (COs):**

COURSE OUTCOMES		PROGRAMME OUTCOMES
<b>CO1</b>	Understanding the fundamentals and importance of Wastewater treatment and its objectives with the basic concept of contaminants and its effects on the environment	PO6
<b>CO2</b>	Understand the different streams of wastewater and its disposal on the natural environmental based on the assimilation criteria and rural water supply and sanitations with design criteria for sanitary, storm sewers.	PO7
<b>CO3</b>	Understanding the microbiology of wastewater and its importance during the treatment.	PO7
<b>CO4</b>	Understand the conventional wastewater treatment methods such as physical, chemical and biological with advanced treatment criteria based on the regional requirement.	PO6

**ASSESSMENT:**

Continuous Internal Assessments		Marks 100 (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

Component	Test 1	Test 2	Quiz 1/AAT	Quiz 2 /AAT	Total Marks
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50



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Course Title	<b>PILOT PLANT STUDIES</b>														
Course Code	1	5	C	H	8	I	E	C	K	2	Credits	03	L – T – P- S	3 – 0 – 0 - 0	
CIE	100 marks (50% weightage)						SEE			100 marks (50% weightage)					

**SYLLABUS**

<b>Unit I</b>
<b>INTRODUCTION:</b> Evolution of process system, Role of pilot plants, Major Factors in Scale –Up, Concept of prototypes, models, scale ratios, element.
<b>Unit II</b>
<b>SIMILARITY:</b> Principles Of Similarity: Geometric similarity. Distorted similarity. Static, dynamic, kinematics, thermal and chemical similarity with examples, Dimensional Analysis.
<b>Unit III</b>
<b>REGIME CONCEPT:</b> Static regime. Dynamic regime. Mixed regime concepts. Criteria to decide the regimes. Equations for scale criteria of static, dynamic processes, Extrapolation. Boundary effects.
<b>Unit IV</b>
<b>SCALE UP OF MIXING PROCESS AND CHEMICAL REACTORS:</b> Mixing Processes: Scale-up relationships, Scale-up of polymerization units, Continuous stages gas liquid slurry processes. Fluid-fluid Reactors: Scale-up considerations in packed bed absorbers and bubble columns, Applicability of models to scale-up.
<b>UNIT V</b>
<b>SCALE UP OF MASS AND HEAT TRANSFER PROCESSES:</b> Continuous Mass Transfer Process: Fundamental considerations scale-up procedure for distillation, Absorption, Stripping and extraction units. Scale up of momentum and heat transfer systems.

**TEXTBOOKS**

1. Attilio Bisio, Robert L. Kabel, *Scale up of Chemical Processes*, L. Kabel, John Wiley & Sons, 1985
2. Johnstone and Thring, *Pilot Plants Models and scale up method in Chemical Engineering*, McGraw Hill, 1957

**REFERENCE BOOKS**

1. J. K. Sharma “OPERATION RESEARCH” MacMillan
2. Entrepreneurship Development, Colombo Plan Staff College for Technical Education, Tata Mc Graw Hill.



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**COURSE OUTCOMES (COs):**

<b>COURSE OUTCOMES</b>		<b>PROGRAMME OUTCOMES</b>
<b>CO1</b>	Understand the concept of Pilot Plant Scale up.	PO3
<b>CO2</b>	Understand the principles of Similarity.	PO2
<b>CO3</b>	Understand the concept of different regimes for scale up.	PO3
<b>CO4</b>	Ability to scale up Mixing system and chemical reactors.	PO4
<b>CO5</b>	Ability to scale up Mass and Heat Transfer Processes	PO4

**ASSESSMENT:**

<b>Continuous Internal Assessments</b>		<b>Marks 100 (Weightage 50%)</b>	<b>Assessment</b>
Theory Component	Three Internals (Best of Two)	80%	Course instructor
	Quiz (Two Quizzes or AAT)	20%	Course instructor
<b>Semester End Examination (Written Examination for Three Hours)</b>		<b>Marks 100 (Weightage 50%)</b>	

**Assessment Pattern:**

<b>Component</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Quiz 1/AAT</b>	<b>Quiz 2 /AAT</b>	<b>Total Marks</b>
Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50