



DEPARTMENT OF CHEMICAL ENGINEERING
BMS COLLEGE OF ENGINEERING, BENGALURU
Autonomous College under VTU

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VISION	MISSION
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 5years

SECOND YEAR SYLLABUS BOOK

(3rd and 4th Semesters)

With effect from the A.Y. 2015-16

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DEPARTMENT OF CHEMICAL ENGINEERING
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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	Able to apply the knowledge of mathematics, science, engineering fundamental, and an engineering specialization to the solution of Chemical engineering problems
PO2	Ability to identify, formulate, research literature to analyse engineering problem for conclusion using first principles of mathematics, chemical science and engineering sciences
PO3	Design chemical engineering processes that meet the specified needs with the appropriate consideration for the public health and safety, and the cultural, and environment considerations
PO4	Conduct research, analysis and interpretation of data for synthesis of the information to provide valid conclusions
PO5	Select and apply appropriate techniques, modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations
PO6	Capable of applying broad reasoning by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice
PO7	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of sustainable development
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices
PO9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings
PO10	Communicate effectively with the community and with the society at large and design documentation, make effective presentations, and give and receive clear instructions
PO11	Demonstrate knowledge and understanding of the engineering and management principles and apply to work as a member in multidisciplinary environments
PO12	Recognise the need for life-long learning in the broadest context of technology change

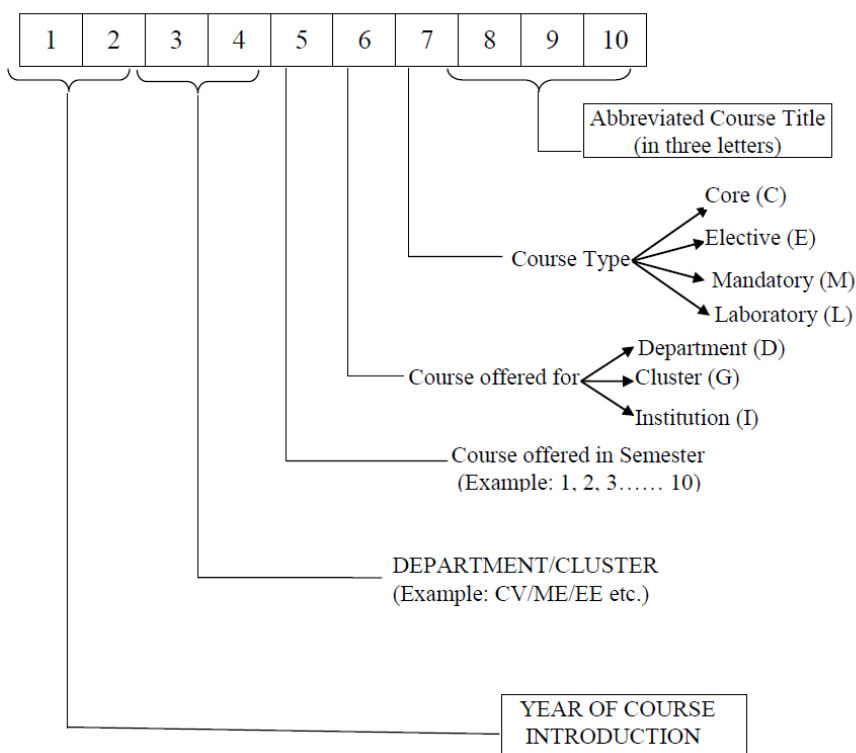


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NOTATIONS

AY	Academic Year
AAT	Alternative Assessment Tools
BOE	Board of Examiners
BOS	Board of Studies
CBCS	Choice Based Credit System
CGPA	Cumulative Grade Point Averages
CIE	Continuous Internal Evaluation
CO	Course Outcomes
DC	Departmental Core
GC	Group Core
HSS	Humanity and Social Science courses
IC	Institutional Core
IE	Institutional Elective
IL	Institutional Lab
LTPS	Lecture-Tutorial-Practical-Selfstudy
NFTE	Not Fit for Technical Education
PCC	Professional Core Courses
PEO	Programme Educational Objective
PO	Programme Outcomes
PEC	Professional Elective Courses
SEE	Semester End Examination
SGPA	Semester Grade Point Average
ST	Studio

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	G	C	S	A	P	Statistics and Probability	3	1	0	0	4					
2.	1	5	C	H	4	D	C	E	Q	D	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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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-Jordan 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 $\frac{1}{3}$ rd, $\frac{3}{8}$ 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



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waveform, square 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 $P p + Q q = R$ (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. D'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

TEXT BOOKS:

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

REFERENCE BOOKS

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



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E-books

- [1] Engineering Mathematics, [K. A. Stroud](#), [Dexter J. Booth](#), Industrial Press, 2001
http://books.google.co.in/books/about/Engineering_Mathematics.html?id=FZncL-xB8dEC&redir_esc=y.
- [2] Advanced Engineering Mathematics, P. V. O'Neil, 5th 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
15CH/BT3GCAPM	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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Course Title	Mathematics-I	Course Code	15MA3IMMAT
Credits	00	L – T – P- S	0 – 0 – 0 - 0
Contact hours	48 hours (36L+12T)	III semester Lateral Entry students	

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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TEXT BOOK:

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

REFERENCE BOOK:

1. Higher Engineering Mathematics, B.S. Grewal, 43rd edition, 2014, Khanna Publishers
2. Advanced Engineering Mathematics, 4th 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.
- (2) Advanced Engineering Mathematics, P. V. O'Neil, 5th 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](https://www.khanacademy.org/Math)
- (2) [https:// www.class-central.com/subject/math](https://www.class-central.com/subject/math) (MOOCS)
- (3) E-learning: www.vtu.ac.in .

Course Code	CO	PO	Bloom's level
15MA3IMMAT	CO-1: Understand the basic concepts of differentiation and integration.	1	2
	CO-2: Apply the concepts of polar curves and multivariate calculus.	1	2
	CO-3: Apply analytical techniques to compute solutions of first and higher order ordinary differential equations.	1	3
	CO-4: Apply techniques of vector calculus to engineering problems.	1	3
	CO-5: 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 (HCI 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

TEXT BOOKS:

1. George T.A. and Shreve's, Chemical process industries, 5th edition, McGraw Hill International Ltd., 1984.
2. GopalRao, M. and Marshall Sitting, Dryden's Outlines of Chemical Technology, 3rd Edition, Affiliated East West Press Pvt. Ltd., New Delhi, 1997

REFERENCE BOOKS:

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

E BOOKS

- [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>



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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

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



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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 equations. 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

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

TEXT BOOK:

1. McCabe. W. L. f et. al. "Unit Operations of Chemical Engineering", 5thedition., 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", 2nd 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.



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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.	PO2
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	PO5
CO4	Develop correlations between process variables using dimensional analysis.	PO3
CO5	Conduct experiments for fluid flows in circular, non-circular pipes and other geometries	PO9

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/TermPapers/Modelling/Seminar/Mini projects.	20%	Committee constituted by HOD
Semester End Examination (Written Examination for Three Hours)		Marks 100 (Weightage 50%)	

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- $\sigma-\sigma^*$, $n-\sigma^*$, $\pi-\pi^*$, $n-\pi^*$. Applications in the diagnosis of conjugated and non-conjugated alkenes, Effect of alkyl substituents on the absorption maximum. Problems related to calculation of λ_{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]

UNIT-4



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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, auxochromethery, 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]

TEXT BOOKS:

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

REFERENCE BOOKS:

1. Organic Chemistry by Robert Thornton Morrison, Robert Neilson Boyd and S.K. Bhattacharjee, 7th edition, Pearson Prentice Hall, 2011
2. Advanced Organic Chemistry: Reactions, Mechanisms and Structure by Michael B. Smith and Jerry March, (WSE) 4th edition, Wiley, 2008
3. Organic Chemistry by Marc G. Loudon, 4th 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, 5th revised edition, New Age International, 2013.

E-BOOKS:

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

MOOCs:

- (1) nptel.ac.in/courses.php?disciplineId=104
- (2) <http://ocw.mit.edu/courses/audio-video-courses/#chemistry>



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(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 α -phenylazo- β -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):

CO1	Ability to define, describe and solve different mechanisms of organic transformations
CO2	Ability to understand organic functionalization and application to oxidation and reduction reactions
CO3	Ability to analyze and interpret an organic structure based on its absorption spectrum
CO4	Ability to understand functional group dynamics and their usefulness in medicine and pesticides
CO5	Ability to identify, interpret colour based on structure and validate by modern spectroscopic tool
CO6	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
Semester End Examination (Written Examination for Three Hours)		Marks 100 (Weightage 50%)	

Assessment Pattern:

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

LABORATORY COMPONENT:

1. Air elutriation



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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, 3rd 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_Princi.html?id=OODPOKxC0YEC&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
CO1	Apply the basic working principles of different size reduction equipments for particle size analysis	PO4
CO2	Design and analyse the flow of fluids through bed of solids and fluid layers	PO3
CO3	Familiarise with the different types of mixing, agitation and solid conveyers	PO2
CO4	Acquaintance of the principles of separating high value solids	PO2
CO5	Conduct experiments for particle size analysis, separation of high value products by filtration, sedimentation and decantation techniques	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/TermPapers/Modelling/Seminar/Mini projects.	20%	Committee constituted by HOD
Semester End Examination (Written Examination for Three Hours)		Marks 100 (Weightage 50%)	

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	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 anelasticbehaviour, spring-dashpot model for viscoelastic deformation.

Plastic Deformation: Stress-strain curve, deformation by slip, deformation in polycrystalline materials, brittle and ductile fractures. 07 Hrs



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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

TEXT BOOKS:

1. HajraChoudhury, S. K., Material Science and Processes, Indian Book Distributing Co., 2nd edition, Calcutta, India, 1982.
2. V Raghavan, Materials Science and Engineering, Prentice-Hall of India Private Limited, 5th edition, New Delhi, India, 2005.

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
- [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	PO2
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



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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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4th SEMESTER

Course Title	STATISTICS AND PROBABILITY													
Course Code	1	5	M	A	4	G	C	S	A	P	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)

TEXT BOOKS:

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

REFERENCE BOOKS:

1. Schaum's Outline of Probability and Statistics, 4th edition, 2013, Schaum's outlines.
2. An Introduction to Biostatistics, P. S. S. SundarRao and J. Richard, 4th 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](https://www.khanacademy.org/Math)
- (4) [https:// www.class-central.com/subject/math](https://www.class-central.com/subject/math) (MOOCS)
- (5) E-learning: 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	CO-1: 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	3
	CO-2: Apply the basic principles of probability and probability distributions to the problems in Bio-technology.	1,2	3
	CO-3: Apply the concepts of Markov chain to the field of genetics.	1,2	4
	CO-4: Demonstrate an understanding of sampling and its various techniques.	2,4	4
	CO-5: 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%)

MATHEMATICS DEPARTMENT SYLLABUS (2011-2012)
FOR STUDENTS ADMITTED TO II YEAR THROUGH LATERAL ENTRY

(Common to all branches)

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

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



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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)**

TEXT BOOK:

1. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley Precise Textbook series, Vol. 1 and Vol. 2, 10th 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:

1. Higher Engineering Mathematics, B.S. Grewal, 43rd edition, 2014, Khanna Publishers.
2. Higher Engineering Mathematics, B.V. Ramana, 7th 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.
- [2] Advanced Engineering Mathematics, P. V. O'Neil, 5th 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](https://www.khanacademy.org/Math)
- (2) [https:// www.class-central.com/subject/math](https://www.class-central.com/subject/math) (MOOCS)
- (3) E-learning: www.vtu.ac.in

Course Code	CO	PO	Bloom's level
15MA4IMMAT	CO-1:Use Laplace transforms to solve differential equations.	1	3
	CO-2: Apply double integrals to compute areas.	1	3
	CO-3:Learn to use triple integrals in computing volumes.	1	3
	CO-4: Use Gamma and Beta functions to evaluate integrals.	1	2
	CO-5: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)

TEXT BOOKS:

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>



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COURSE OUTCOMES (COs):

COURSE OUTCOMES		PROGRAMME OUTCOMES
CO1	Get familiarised with different equipment symbols used to draw process flow diagram	PO2
CO2	Visualize and draw different views of vessels and their components using conventional and modern tools	PO5
CO3	Draw assembled sectional views of valves, pumps and pipe fittings using conventional method and Solid edge tool	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) <ul style="list-style-type: none">Examination consists of one compulsory question from Unit -1 and Unit-II 10 marks and 30 marks respectively.One question from Unit-III for 60 marks (UNIT-III will have choice)		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 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]**

TEXT BOOKS:

1. Smith J. M. and Van Ness H.C, "Introduction to Chemical Engineering Thermodynamics", 5th 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

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

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" McGrawHill, 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, 5th edition, Chemical Engineering Pergamon and ELBS, McGraw Hill, New York 2000.
2. P. K. Nag, Heat and Mass Transfer, 2nd edition, Tata McGrawhill publications.

E-BOOKS

- [1] Rao Y. V. C, Heat Transfer, 1st 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+%&cd=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
Self-Study Component	Open Ended Experiments/Term Papers/Modeling/Seminar/Mini projects.	20%	Committee constituted by HOD
Semester End Examination (Written Examination for Three Hours)		Marks 100 (Weightage 50%)	



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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

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]



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TEXT BOOKS:

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

REFERENCE BOOKS:

1. Hougen O. A., Waston K. M. and Ragatz R.A., Chemical Process Principles Part -I' Material and Energy Balances, 2nd edition, CBS publishers and distributors, New Delhi, 1995.
2. Himmelblau D.M., Basic Principles and Calculations in Chemical Engineering, 6th 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=80v3hRH0Ev0C&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%)	



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Assessment Pattern:

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Max. Marks	40	40	10	10	100
Reduced CIE	20	20	5	5	50

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



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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

TEXT BOOK:

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", 6th Edition, published by Thomson Brooks/Cole, 2007.

REFERENCE BOOKS:

1. Lloyd R. Snyder, Joseph J. Kirkland, John W. Dolan., "Introduction to Modern Liquid Chromatography", 3rd 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	PO2
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	Conduct experiments using various instruments for physical and chemical analysis	PO9



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