DEPARTMENT OF CHEMICAL ENGINEERING
B.M.S. COLLEGE OF ENGINEERING, BENGALURU
Autonomous Institute, Affiliated to VTU

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VISION	MISSION
PROMOTING THE 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, Second Cycle format for 6 years

Scheme and Syllabus Book
(3rd to 8th Semester)
Batch 2023-2027

Contents Particulars	Pages

DEPARTMENT VISION

Be a Globally Recognized Chemical Engineering Department

DEPARTMENT MISSION

M1: Imparting Quality education and exposure to the budding chemical engineers.
M2: Foster and encourage the pursuit of excellence in chemical science and engineering with research potential.
M3: Chemical engineering graduates to acquire coveted positions in industries and society.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Graduates secure profession in chemical & allied engineering.
PEO2: Graduates pursue higher education & research in world class organization.
PEO3: Graduates work in diversified fields towards sustainable society.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Graduates will apply the knowledge of natural sciences and chemical engineering for feasible synthesis, separation, and purification of products.
PSO2: Graduates will ensure intrinsic process safety and sustainability by automation and control of processes.
PSO3: Graduates will design and optimize process equipment for engineering applications.

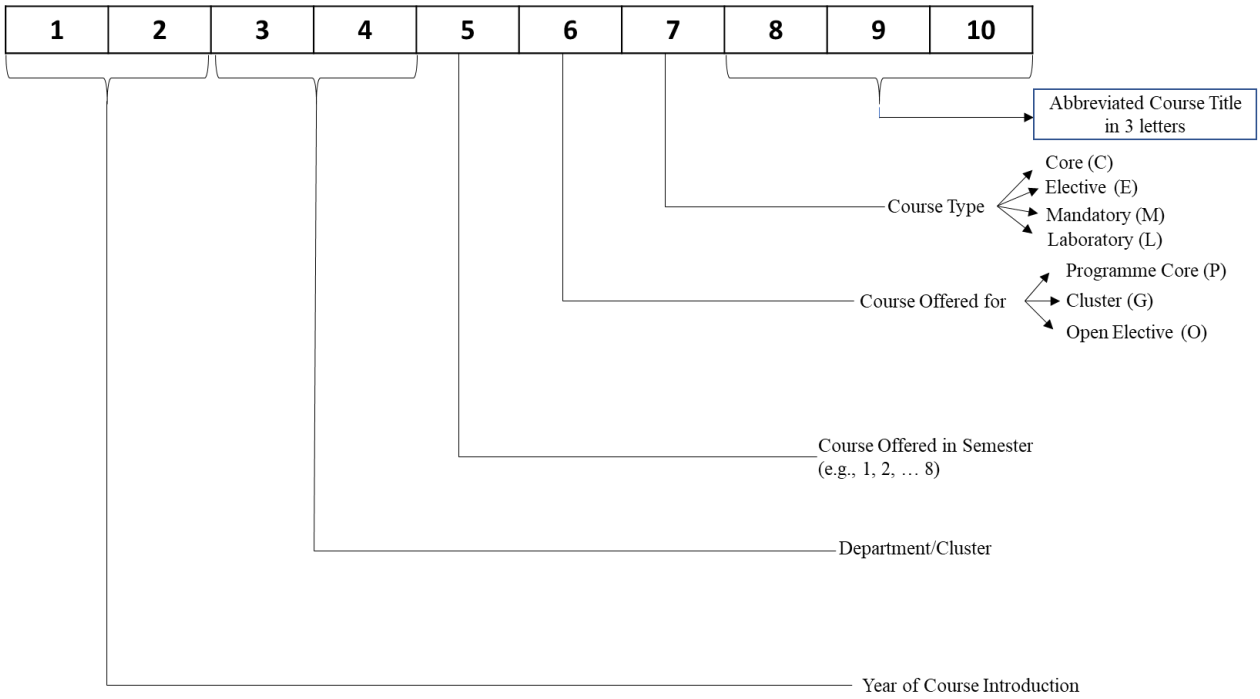
Program Outcomes

PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions:** 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	**Conduct investigations of complex problems:** 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	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society:** 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	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication:** 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	**Project management and finance:** Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning:** 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.

NOTATIONS

AY	Academic Year
AAT	Alternative Assessment Tools
BOE	Board of Examination
BOS	Board of Studies
CBCS	Choice Based Credit System
CGPA	Cumulative Grade Point Averages
CIE	Continuous Internal Evaluation
CO	Course Outcomes
PC	Programme Core Course
GC	Group Core
HSS	Humanity and Social Science courses
IC	Institutional Core
OE	Open Elective
IL	Institutional Lab
LTP	Lecture-Tutorial-Practical
NFTE	Not Fit for Technical Education
IPCC	Integrated Programme Core Course
PSO	Programme Specific Outcomes
PO	Programme Outcomes
PEC	Programme Elective Courses
SEE	Semester End Examination
SGPA	Semester Grade Point Average
ST	Studio

NOMENCLATURE FOR THE COURSE CODE



DEPARTMENT OF CHEMICAL ENGINEERING
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SCHEME OF INSTRUCTION FOR THIRD SEMESTER

Course Type	Code	Course Title	Credits			Total	Contact Hours/ week
			L	T	P		
BS	23MA3BSTFN	Transform Calculus, Fourier Series and Numerical Techniques	2	1	0	3	4
ES	23CY3ESMCA	Material Chemistry and Applications	3	0	0	3	3
PC	23CH3PCPPC	Process Principles and Calculations	2	1	0	3	4
PC	23CH3PCMOP	Mechanical Operations	3	0	1	4	5
PC/IPCC	23CH3PCFME	Fluid Mechanics	3	0	1	4	5
PC/IPCC	23CH3PCTD1	Process Engineering Thermodynamics- I	2	0	0	2	2
BS	23CH3BSBFE	Biology for Engineers	2	0	0	2	2
AE/SDC	23CH3AEAWE	Advanced MS Word & Excel for Engineers	0	0	1	1	2
BS	22CH3BSMAT	Additional Mathematics-I	0	0	0	0	2
NCMC	23NCMC3NS1	National Service Scheme-1	0	0	0	0	2
	23NCMC3YG1	Yoga-1					
	23NCMC3PE1	Physical Education-1					
TOTAL			17	2	3	22	29

Additional NCMC courses introduced for the 2023-27 batch:

Code	Course Title
24NCMC3IM1	Indian Music-1
24NCMC3WM1	Western Music - 1
24NCMC3ID1	Indian Dance- 1
24NCMC3WD1	Western Dance - 1
24NCMC3TA1	Theatre Arts -1
24NCMC3FA1	Fine Arts -1
24NCMC3MM1	Multimedia - 1

SCHEME OF INSTRUCTION FOR FOURTH SEMESTER

Course Type	Code	Course Title	Credits			Total Credits	Contact Hours/ week
			L	T	P		
BS	23MA4BSSAP	Statistics and Probability	2	1	0	3	4
ES	23CH4ESANI	Analytical Instruments	3	0	1	4	5
PC	23CH4PCTD2	Process Engineering Thermodynamics - II	3	0	0	3	3
PC	23CH4PCMT1	Mass Transfer-I	3	0	0	3	3
PC/IPCC	23CH4PCHTR	Process Heat Transfer	3	0	1	4	5
PC/IPCC	23CH4PCPCM	Pollution Control and Management	3	0	0	3	3
UHV	23MA4AEUHV	Universal Human Values	0	1	0	1	2
AE	23CH4AESIM	Simulation Laboratory	0	0	1	1	2
BS	22MA4BSMAT	Additional Mathematics-II	0	0	0	0	2
NCMC	23NCMC4NS2	National Service Scheme-2	0	0	0	0	2
	23NCMC4YG2	Yoga-2	0	0	0	0	
	23NCMC4PE2	Physical Education-2	0	0	0	0	
TOTAL			17	2	3	22	29

Additional NCMC courses introduced for the 2023-27 batch:

Code	Course Title
24NCMC4IM2	Indian Music-2
24NCMC4WM2	Western Music - 2
24NCMC4ID2	Indian Dance- 2
24NCMC4WD2	Western Dance - 2
24NCMC4TA2	Theatre Arts -2
24NCMC4FA2	Fine Arts -2
24NCMC4MM2	Multimedia - 2

SCHEME OF INSTRUCTION FOR FIFTH SEMESTER

Course Type	Code	Course Title	Credits			Total Credits	Contact Hours/ week
			L	T	P		
PC	23CH5PCCR1	Chemical Reaction Engineering – I	3	0	1	4	5
PC	23CH5PCTRP	Transport Phenomena	2	1	0	3	4
PC	23CH5PCMT2	Mass Transfer - II	3	0	1	4	5
PC	23CH5PCCTN	Chemical Technology	3	0	0	3	3
HS	23CV5HSEVS	Environmental Studies	1	0	0	1	1
PE	23CH5PELA1	Computer Interface in Chemical Engineering	3	0	0	3	3
	23CH5PELA2	Numerical Techniques in Chemical Engineering					
	23CH5PELA3	Optimization of Chemical Processes					
AE	23CH5AERMI	Research Methodology & IPR	2	0	0	2	2
PW	23CH5PCPW1	Project Based on Modern Simulation Tools	0	0	2	2	4
NCMC	23NCMC5NS3	National Service Scheme-3	0	0	0	0	2
	23NCMC5YG3	Yoga-3					
	23NCMC5PE3	Physical Education-3					
Details of 40 AICTE Activity Points							
TOTAL			17	1	4	22	29

Additional NCMC courses introduced for the 2023-27 batch:

Code	Course Title
24NCMC5IM5	Indian Music-5
24NCMC5WM5	Western Music - 5
24NCMC5ID5	Indian Dance- 5
24NCMC5WD5	Western Dance - 5
24NCMC5TA5	Theatre Arts -5
24NCMC5FA5	Fine Arts -5
24NCMC5MM5	Multimedia - 5

SCHEME OF INSTRUCTION FOR SIXTH SEMESTER

Course Type	Code	Course Title	Credits			Total Credits	Contact Hours/ week
			L	T	P		
PC	23CH6PCCR2	Chemical Reaction Engineering – II	2	1	0	3	4
PC	23CH6PCEIE	Economics in Engineering	2	0	0	2	2
PC	23CH6PCPCE	Process Control Engineering	3	0	1	4	5
PC	23CH6PCPMS	Process Modelling and Simulation	2	0	1	3	4
PE	23CH6PELB1	Interfacial Phenomena	3	0	0	3	3
	23CH6PELB2	Petroleum Refining					
	23CH6PELB3	Polymer Processing					
OE	25MC6OECH1	Characterization of Polymers, Elastomers and Composites	3	0	0	3	3
	25MC6OECH2	Polymeric Biomaterials: Structure, Properties, Function and Performance					
	25MC6OECH3	Introduction to Operations Research					
	25MC6OECH4	Cryogenic Hydrogen Technology					
	25MC6OECH5	Agricultural Economics					
PW-2	23CH6PCPPW	Pre-Final Project Work	0	0	2	2	4
AE	23CH6AEPMF	Project Management and Finance (MOOC)	2	0	0	2	2
NCMC	23NCMC6NS4	National Service Scheme-4	0	0	0	0	2
	23NCMC6YG4	Yoga-4					
	23NCMC6PE4	Physical Education-4					
Details of 60 AICTE Activity Points Earned							
		TOTAL	17	1	4	22	29

Additional NCMC courses introduced for the 2023-27 batch:

Code	Course Title
24NCMC6IM6	Indian Music -6
24NCMC6WM6	Western Music - 6
24NCMC6ID6	Indian Dance- 6
24NCMC6WD6	Western Dance - 6
24NCMC6TA6	Theatre Arts -6
24NCMC6FA6	Fine Arts -6
24NCMC6MM6	Multimedia - 6

SCHEME OF INSTRUCTION FOR SEVENTH SEMESTER

Course Type	Code	Course Title	Credits			Total Credits	Contact Hours/ week
			L	T	P		
PC	25CH7PCPED	Process Equipment Design	2	1	0	3	4
PC	25CH7PCBCE	Biochemical Engineering	3	0	0	3	3
PE	23CH7PELC1	Food Engineering	3	0	0	3	3
	23CH7PELC2	Nanomaterials and Characterization					
	23CH7PELC3	Recycle and Reuse of waste materials for sustainable development					
OE	25MC7OECH1	Technologies for Clean and Renewable Energy Production	3	0	0	3	3
	25MC7OECH2	Hydrogen Energy: Production, Storage, Transportation & Safety					
	25MC7OECH3	Physics of Renewable Energy Systems					
PW	23CH7PCFPW	Final Project Work	0	0	7	7	14
HS	25MA7HSIKL	Indian Knowledge System	1	0	0	1	1
Details of 80 AICTE Activity Points Earned							
TOTAL			12	1	7	20	28

SCHEME OF INSTRUCTION FOR EIGHT SEMESTER

Course Type	Code	Course Title	Credits			Total Credits	Contact Hours/ week
			L	T	P		
PE	23CH8PELD1	Advanced Separation Techniques	3	0	0	3	3
	23CH8PELD2	Pilot Plant and Scale-up Studies					
OE	25MC8OECH1	Chemical Process Safety	3	0	0	3	3
	25MC8OECH2	Industrial Safety Engineering					
INT	23CH8SRINT	Internship (16-20 weeks)	0	0	6	6	12
Details of 100 AICTE Activity Points Earned							
TOTAL			3	0	9	12	18

THIRD SEMESTER

Course Title	Transform Calculus, Fourier Series and Numerical Techniques				
Course Code	23MA3BSTFN	Credits	03	L – T – P	2 – 1 – 0
CIE	100 marks (50% Weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Calculus and Differential Equations and Advanced Calculus and Numerical Methods

SYLLABUS:

UNIT-I

LAPLACE TRANSFORMS

Definition and Laplace transforms of elementary functions (statements only). Problems on Laplace transform of $e^{at}f(t)$, $t^n f(t)$, $\frac{f(t)}{t}$. Laplace transforms of derivatives and integrals. Laplace Transform of periodic functions (statement only) and unit-step function – problems. Inverse Laplace transforms definition and problems. solution of differential equations. **08 Hrs**

UNIT-II

FOURIER SERIES

Introduction to infinite series, convergence and divergence. Periodic functions, Dirichlet's condition. Fourier series of periodic functions with period and arbitrary period. Complex Fourier series. Practical harmonic analysis. **08 Hrs**

UNIT-III

INFINITE FOURIER TRANSFORMS

Definition, Fourier sine and cosine transforms –Problems.

Inverse Infinite Fourier transforms, Inverse Fourier cosine and sine transforms - Problems.

Convolution theorem (only statement) – problems. **08 Hrs**

UNIT-IV

NUMERICAL SOLUTIONS OF PDE

Classifications of second-order partial differential equations, finite difference approximations to derivatives. Solution of one-dimensional heat equation by Schmidt explicit

formula and Crank- Nicholson method. Solution of one-dimensional wave equation using explicit three level formula and implicit scheme. **08 Hrs**

UNIT-V

CALCULUS OF VARIATIONS

Definition, Variation of a functional, Euler's equation, variational problems. Applications: Hanging cable problem, Brachistochrone problem.

Z-TRANSFORMS

Definition, Standard z-transforms, damping rule, Shifting rule, Initial value and final value theorems-problems. Inverse z-transform and applications to solve difference equations.**08 Hrs**

After successfully completing the course, the student will be able to understand the topics:

Course Outcomes		Program Outcomes	Levels
CO 1	Apply the concepts of Transform Techniques, optimization and Finite Difference Methods to solve engineering problems.	1	3
CO 2	Analyze the solution of differential equations using Transform Techniques, optimization and Finite Difference Methods	1	1
CO 3	Demonstrate the importance of Transform Techniques, optimization and Finite Difference Methods in engineering using programming tools.	5, 9, 10	1

Assessment:

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

Assessment Pattern:

Component	Theory (100%)			Total Marks
	Test 1	Test 2	AAT	
Max. Marks	40	40	20	100
Reduced CIE	20	20	10	50

Two best scores out of the three tests will be considered for CIE.

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

SUGGESTED LEARNING RESOURCES:

Textbooks:

1. B. S. Grewal, "Higher Engineering Mathematics", Khanna publishers, 44th Ed.2018
2. E. Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons, 10th Ed. (Reprint), 2016.

Reference Books:

1. B.V. Ramana, "Higher Engineering Mathematics", McGraw-Hill Education, 11th edition.
2. Srimanta Pal & Subodh C. Bhunia, "Engineering Mathematics ", Oxford University Press, 3rd Reprint, 2016.
3. N.P Bali and Manish Goyal, "A textbook of Engineering Mathematics", Laxmi Publications.
4. C. Ray Wylie, Louis C. Barrett, "Advanced Engineering Mathematics", McGraw –Hill Book Co. New York, Latest edition
5. Gupta C.B, Sing S.R and Mukesh Kumar, "Engineering Mathematics for Semester I and II", Mc-Graw Hill Education (India) Pvt. Ltd 2015.
6. H.K. Dass and Er. Rajnish Verma, "Higher Engineering Mathematics", S. Chand Publication, 2014.
7. James Stewart: "Calculus", Cengage publications, 7th edition, 4th Reprint 2019.

Web Links and Video Lectures (E-Resources):

1. http://www.class-central.com/subject/math(MOOCs)
2. http://academicearth.org/
3. http://www.bookstreet.in.
4. VTU e-Shikshana Program VTU EDUSAT Program

Course Title	Materials Chemistry and Applications				
Course Code	23CY3ESMCA	Credits	03	L – T – P	3 – 0 – 0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Engineering Physics and Engineering Chemistry

UNIT-I

Structure and Bonding:

Types of bonds: Ionic bond - Lattice energy, Born-Haber Cycle, calculation of lattice energies of NaCl and MgO, effect of lattice energy on solubility of ionic compounds.

Covalent bond - Molecular orbital theory (stability, bond order, and magnetic properties). Metallic bond - Band theory, electrical properties of metals, semiconductors and insulators, band gaps, effect of doping.

Secondary bonding -Dipole-dipole, dipole – induced dipole, London dispersion/Van der Waals, Hydrogen bond (Intra molecular and Inter molecular types). Effect of secondary bonding on properties of materials.

8 Hrs

UNIT-II

Structure of Solids:

Types of solids: General features and classification. Crystal systems and unit cells, Symmetry, Bravais lattices, Lattice planes and Miller indices, X-ray diffraction - Bragg's equation - numerical. PXRD – Indexing of data, Calculation of particle size - Debye Scherrer equation, Neutron diffraction – principle and applications.

Defects: Point, line, surface, bulk defects, relevance of defects in materials science. Intercalation compounds.

Electron diffraction –Principle and construction, working and applications of Scanning electron microscopy, Transmission electron microscopy.

8 Hrs

UNIT-III

Materials for catalysis:

Introduction, significance to industry. General features of homogeneous and heterogeneous catalysis, catalytic promoters and poisons, catalyst support.

Mechanism of catalysis by taking an example. Acid and base catalysis, metal ions, organo-metallic complexes- meaning, significance, two examples in each case with mechanism, phase transfer catalysis.

Shape selective catalysis - zeolites as catalysts - composition and structure, Preparation, properties and applications. Catalysts used in steam reforming and cracking. Environmental catalysis - catalysts used in catalytic converters.

8 Hrs

UNIT-IV

Phase Equilibria:

Azeotropes: Miscible liquids - ethanol-water system. Partially miscible liquids - phenol-water system. Critical solution temperature (CST), immiscible liquids and steam distillation. Nernst distribution law. Calculation of the partition coefficient. Applications of distribution law.

Phase diagram and phase transformations: Phase rule, single component system for Iron, binary phase diagrams - lever rule, phase diagrams for Lead-Tin, and Iron - Iron-Carbide systems. Isothermal transformation (TTT) curves for eutectoid steel.

Phase diagram and phase transformations: Phase rule, Single component system for Iron, Binary phase diagrams for Lead-Tin, Copper-Zinc and Iron- Iron-Carbide systems. Isothermal transformation (TTT) Curves for eutectoid steel.

Typical engineering materials: Metals and non-metals, General properties of ferrous metals, non-ferrous metals and alloys, Copper and its alloys, lead and its alloys, Nickel and its alloys, Alloys for high temperature service.

8 Hrs

UNIT-V

Industrial Materials:

Typical engineering materials - Metals and non-metals, General properties of ferrous metals, non-ferrous metals and alloys, Copper and its alloys, Lead and its alloys, Nickel and its alloys, Alloys for high-temperature applications.

Glass - properties, types, and manufacture of soda glass. Composition and applications of borosilicate, metallic glass, optical glasses and polycarbonate glasses, safety glass, fire and bulletproof glasses.

Lubricants - General Introduction - Types of Lubricants with examples (Solid, liquid, Greases, emulsion, and Gaseous lubricants). Properties - Viscosity index (VI)determination, numerical, mechanism of action of lubricants.

7 Hrs

Textbooks:

1. Shikha Agarwal, “Engineering Chemistry - Fundamentals and Applications,” Cambridge University Press, 2016
2. P. C. Jain and Monica Jain, Dhanpat Rai, Engineering Chemistry, Publishing Company (P) Ltd. 16th edition.
3. V. Raghavan, Materials Science and Engineering: A First Course, Prentice Hall India Learning Private Limited; 6th revised edition.

Reference Books:

1. Solid state chemistry and its applications - A.R. West, 2nd edition, John Wiley & Sons, Inc.
2. Callister's Materials Science and Engineering, R. Balasubramaniam, 2nd edition, John Wiley & Sons, Inc.
3. S. O. Pillai, Solid State Physics, New Age International, 2006, 8th edition.
4. Julio de Paula, Atkins' Physical Chemistry, Peter Atkins, Oxford University Press, 11th edition.
5. James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Okhil K. Medhi, Inorganic Chemistry; Principles of Structure and Reactivity, Pearson Education India, 4th edition.

MOOCs:

1. https://nptel.ac.in/noc/individual_course.php?id=noc18-cy01
2. https://nptel.ac.in/courses/104104101/
3. https://nptel.ac.in/courses/104103019/

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO 1	Understand the basic principles of structure and bonding, catalysis, phase equilibria and Industrial Materials	PO1	2
CO 2	Based on the acquired knowledge, analyze the structure, topology, composition, catalytic properties and applications of materials.	PO2	2
CO 3	Apply the principles of materials chemistry in addressing societal problems.	PO6	3

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	Process Principles and Calculations				
Course Code	23CH3PCPPC	Credits	03	L – T – P	2 – 1– 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. Basic Chemical Calculations: Concept of mole, mole fraction, compositions of mixtures of solids, liquids and gases. Concepts of normality, molarity, molality, parts per million, Ideal gas law, Amagat's law and Dalton's law and related problems.

[3L+4T=7Hrs]

UNIT -II

Material Balance without reaction: General material balance equation for steady and unsteady state operations. Typical steady-state material balances in distillation, absorption, extraction, and crystallization.

Material balances involving bypass, recycling and purging: Drying, mixing and evaporation.

[4L+6T=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.

[3L+4T=7Hrs]

UNIT-IV

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

[3L+6T=9Hrs]

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.

[2L+4T=6Hrs]

Textbooks

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=80v3hRHoEv0C&printsec

MOOC's and Online Courses:

1. http://www.nptel.ac.in/syllabus/103102017/
2. http://elearning.vtu.ac.in/10BT46.html

SEE Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Apply basic to convert units from one set to another and to check equations' dimensional consistency.	PO1	2
CO2	Understand mole concept, conversion, selectivity and related terms, as well as their applicability in various processes.	PO1	3
CO3	Formulate material balance problems of various unit operation and unit processes.	PO2	2
CO4	Solve material balance problems various unit operation and unit processes.	PO2	3
CO5	Analyse and interpret complex problems involving air-fuel ratios calculations and provide viable solutions using fundamental principles.	PO3	2
CO6	Formulate and solve energy balance problems of various unit processes.	PO2	2

Assessment:

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

Assessment Pattern:

Component	Theory (100%)			Total Marks
	Test 1	Test 2	AAT	
Max. Marks	40	40	20	100
Reduced CIE	20	20	10	50

Course Title	Mechanical Operations				
Course Code	23CH3PCMOP	Credits	04	L – T – P	3 – 0 – 1
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, screen effectiveness and related problems. Standard screen series, motion of screens, gyratory screen shaker, vibrating screen shaker, trammels and sub-sieve analysis.

7 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, Gyratory crusher, Ball mill, Fluid energy mill & Hammer mill, numerical on critical speed of ball mill.

6 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-Carmen equation, types of fluidization and applications, numerical on applications of these equations. Conveying of solids-belt conveyors Chain conveyors.

FILTRATION: Classification, modification of Kozeny-Carman equation for filtration, principles of cake filtration, numerical on determination of cake and filter medium resistance. Industrial filters: Leaf filter, rotary drum filter, bag filter, suspended batch centrifuge, filter aids.

10 Hrs

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, numerical on settling of particles. Cyclones, hydro-cyclones, and heavy media separation.

SEDIMENTATION: Batch settling test, theories, application of batch settling test to design a continuous thickener and related numerical.

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, and internal screw mixer. Separations: electrostatic separation, jigging, froth floatation.

6 Hrs

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.
2. Kiran D Patil, Mechanical Operations Fundamental Principles and Applications, 2nd Edition Nirali Prakashan, India, 2012

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=O0DPOKxC0YEC&hl=en
2. Ebook Library chemical engineering mechanical Operations: http://csfbook.sourceforge.net/pdf/chemical-engineering-mechanical-operations.pdf

MOOC's and Online Courses:

1. http://nptel.ac.in/courses.php
2. http://www.msubbu.in/sp/mo/

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Apply basic principles of mechanical operations	PO1	1
CO2	Develop solutions by applying mass and force balance for unit operations.	PO2	2
CO3	Analyse the working of equipment with an understanding of the requirements of professional engineering practice.	PO3	3
CO4	Apply the knowledge of solid-solid and gas-solid separation techniques for various applications including coal, mineral beneficiation, and environmental pollution control.	PO4	2
CO5	Conduct experiments and evaluate in team for different mechanical operations to derive valid conclusions.	PO9	3
CO6	Present the experimental observations in the form of a lab report.	PO2	3

Assessment:

Continuous Internal Assessments		Marks 100% (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	40%	Course Instructor
	Quiz (One Quiz or AAT)	10%	
Laboratory Component	Laboratory Component	50%	
Semester End Examination (Written Examination for Three Hours)		Marks 100 (Weightage 50%)	

Assessment Pattern:

Component	Theory (50%)			Practical (50%)		Total Marks
	Test 1	Test 2	Quiz/AAT	Records & Performances	Lab Test	
Max. Marks	20	20	10	30	20	100
Reduced CIE	10	10	5	15	10	50

Course Title	Fluid Mechanics				
Course Code	23CH3PCFME	Credits	04	L – T – P	3 – 0 – 1
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Engineering Physics and Engineering Maths

SYLLABUS:

UNIT-I

Fluid statics and its applications: Introduction, fluid properties, Pressure concept- Pascal's Law, Hydrostatic law, Pressure at a point in compressible fluid (Barometric Equation), Measurement of fluid Pressure-U-tube manometers, Inverted U-Tube manometer and Differential manometers.

Fluid flow phenomena: Types of fluids - shear stress and velocity gradient relation, Newtonian and Non - Newtonian fluids, Types of fluid flow, Reynold's stress, Reynolds number, Eddy viscosity, Flow in boundary layers, Boundary layer separation and wake formation.

10 Hrs

UNIT-II

Kinetics of Flow: Basic equations of fluid flow- Continuity equation, mass velocity, momentum equation, Bernoulli's equation, modified equations for real fluids with correction factors.

Flow of incompressible fluids in pipes: Shear-stress distribution in a cylindrical pipe, friction factor, laminar flow in pipes, turbulent flow, friction factor chart and related numerical. Energy loss due to friction (Minor and Major losses).

10 Hrs

UNIT-III

Flow of compressible fluids: Introduction**,** Basic equations of Compressible flow (Continuity, Bernoulli's or Energy equations, Velocity of sound or Pressure wave in a fluid, Stagnation properties, Concept of Mach number, Area–velocity relationship for compressible flow, Mass flow rate of compressible fluid through Venturimeter, Pitot static tube.

7 Hrs

UNIT - IV

Transportation of fluids: Applications of Bernoulli's Equation- Venturi meter, Orifice meter, Pitot tube, Rotameter and related numerical. Pumps & Classification, construction and working of centrifugal pump, Heads and efficiency, pump work, Introduction to Priming and Cavitation, Characteristic curves of centrifugal pump, Net positive suction head and suction height.

7 Hrs

UNIT- V

Dimensional analysis: Introduction, Primary and derived quantities, Dimensional homogeneity, Methods of dimensional analysis (Rayleigh's and Buckingham's II – method). Significance of different dimensionless numbers.

5 Hrs

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. Demonstration of fluid flow phenomena using Reynold's apparatus

Textbooks:

1. McCabe. W. L. f et. al. "Unit Operations of Chemical Engineering", 5th 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 Textbooks: 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.

E-Books:

1. Multimedia Engineering Fluid Mechanics: https://ecourses.ou.edu/cgibin/ebook.cgi?topic=fl
2. Elementary Fluid Mechanics: http://www.worldscientific.com/worldscibooks/10.1142/5895

MOOC's and Online Courses:

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

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Apply basic principles of pressure & conservation laws to solve fluid flow problems	PO1	1
CO2	Explain the construction and working of fluid flow equipment	PO3	2
CO3	Develop correlations/solutions for flow processes that meet specific needs	PO3	3
CO4	Estimate energy requirements and losses in transportation and metering of fluids.	PO2	2
CO5	Conduct fluid flow experiments in a team and derive valid conclusions.	PO9	3
CO6	Present the experimental observations in the form of a lab report.	PO2	3

Assessment:

Continuous Internal Assessments		Marks 100% (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	40%	Course Instructor
	Quiz (One Quiz or AAT)	10%	
Laboratory Component	Laboratory Component	50%	
Semester End Examination (Written Examination for Three Hours)		Marks 100 (Weightage 50%)	

Assessment Pattern:

Component	Theory (50%)			Practical (50%)		Total Marks
	Test 1	Test 2	Quiz/AAT	Records & Performances	Lab Test	
Max. Marks	20	20	10	30	20	100
Reduced CIE	10	10	5	15	10	50

Course Title	Process Engineering Thermodynamics-I				
Course Code	23CH3PCTD1	Credits	02	L – T – P	2 – 0 – 0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Engineering Chemistry and Engineering mathematics

SYLLABUS:

UNIT- I

INTRODUCTION: The scope of thermodynamics, different approaches, heat and work, state and its forms, intensive and extensive properties, system and types of system, energy and its evaluation for various types of system, equilibrium concept, processes and types, concept of stability, zeroth law of thermodynamics, phase rule, temperature scale

4 Hrs

UNIT- II

FIRST LAW OF THERMODYNAMICS: Joule's paddle wheel experiment, internal energy, first law of thermodynamics, reversible and irreversible processes with examples, first law application to closed, open and steady state flow systems and numerical.

EVALUATION OF VARIOUS FORMS OF ENERGY: Enthalpy and its evaluation, principle and working of flow calorimeter, numerical on enthalpy calculations.

6 Hrs

UNIT- III

VOLUMETRIC PROPERTIES OF PURE FLUIDS: P-V-T behavior of pure fluids, equations of state and ideal gas law, equations of state for real gases: Virial equation and its applications, ideal gas temperatures and universal gas constant; cubic equations of state- van der Waals equation and determination of parameters, theorem of corresponding states; acentric factor, Pitzer correlations and compressibility charts.

5 Hrs

UNIT-IV

PROCESSES INVOLVING IDEAL GAS LAW: Implied property relations for an ideal gas law, equations for process calculations-constant volume, constant pressure, constant temperature, adiabatic and polytrophic processes, numerical to evaluate energy interactions of various processes.

6 Hrs

UNIT- V

SECOND LAW OF THERMODYNAMICS: Limitations of first law of thermodynamics, general statements of the second law, entropy, Carnot theorem and equations, Clausius inequality, concept of entropy increase-mathematical statement of the second law, calculation of entropy changes. Ideal work and lost work, and third law of thermodynamics.

5 Hrs

Textbooks:

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.

Reference Books:

1. Rao, Y.V.C Chemical Engineering Thermodynamics, New Age International Publication, Nagpur, 2000.
2. Halder, Gopinath, "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. DimitriosTassios, "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

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Apply the fundamental concepts of thermodynamics to various systems	PO1	1
CO2	Formulate equations for energy functions	PO2	2
CO3	Apply various thermodynamics laws to real and ideal systems	PO2	3
CO4	Comprehend the relations between fundamental properties of pure fluids with governing equations.	PO2	2
CO5	Evaluate the various energy properties of pure fluids for different processes	PO3	3
CO6	Interpret the directional change by applying the thermodynamic concepts for the steady-state process	PO3	2

Assessment:

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

Assessment Pattern:

Component	Theory (100%)			Total Marks
	Test 1	Test 2	AAT	
Max. Marks	40	40	20	100
Reduced CIE	20	20	10	50

Course Title	Biology for Engineers				
Course Code	23CH3BSBFE	Credits	02	L – T – P	2 – 0 – 0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

Prerequisites: Natural Sciences

SYLLABUS:

UNIT-I

MICROBIOLOGY: Definition, characteristics, importance, classification of microorganisms, reproduction cycle, growth kinetics curve, sources of nutrients to formulate the growth medium, types of sterilization of microorganisms, applications of microorganisms. **06 Hrs**

UNIT-II

BIOMOLECULES: Introduction to biomolecules, General classification, important functions and structure of carbohydrates, lipids, vitamins, and proteins. **05 Hrs**

UNIT-III

ENZYMES & GENETICS: Enzymes: Introduction, Enzyme commission's nomenclature, enzyme substrate, mechanism of enzyme action; Genetics: Introduction to genetics, genetic engineering, and its application; structure, functions & importance of DNA, RNA, genes & chromosomes. **06 Hrs**

UNIT-IV

TISSUE CULTURE: Animal & plant tissue culture, Harvesting and isolating cells, Preparation of growth media, Cell culture techniques and Applications. **05 Hrs**

UNIT-V

IMMUNOLOGICAL SCIENCE & BIO-NANO SCIENCE: Immune system and its types; Functional properties of antibodies; Helper T cells and T cell activation; Nano Biomolecules and its various types; Principles and Application of Biosensor. **05 Hrs**

Textbooks:

1. Dr. Sohini Singh and Dr. Tanu Allen, "Biology for Engineers", Vayu Education of India, New Delhi, 2014.
2. Molecular Biology of the cell. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter, Garland Science; 5th edition.

Reference Books:

1. Lehninger Principles of Biochemistry by David L. Nelson and Michael M. Cox, 7th Edition, W. H. Freeman and Company, New York.

E-Books:

1. www.bio12.com/ch3/RaycroftNotes.pdf
2. www.engineering.uiowa.edu/bme050/cvb-solids.pdf
3. www.biologyjunction.com/mendelian_genetics.html

MOOC's and Online Courses:

1. Biology for engineers and other non-biologists: https://onlinecourses.nptel.ac.in/noc19_ge31/preview
2. Biology & Life Sciences: https://www.edx.org/course/subject/biology-life-sciences

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Understand the biological living organisms' concepts from an engineering perspective.	PO1	1
CO2	Appreciate the importance of microbiology and immunological science.	PO1	1
CO3	Integrate biological principles for developing next-generation technologies for the development of artificial systems and mimicking human action.	PO2	3
CO4	Comprehend the cellular and make-up structural functions of biomolecules.	PO1	2
CO5	Apprehend the different applications of tissue cultures.	PO1	3
CO6	Apply the knowledge of biological science related to multidisciplinary areas.	PO2	2

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%	
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	Advanced MS Word & Excel for Engineers				
Course Code	23CH3AEAWE	Credits	01	L – T – P	0 – 0 – 1
CIE	50 marks	SEE	50 marks		

PREREQUISITES: Fundamentals of computers

LABORATORY COMPONENT:

1. Basic mathematical operations in MS excel
2. Data visualization in MS excel
3. Cell operations in MS excel
4. Data analysis in MS excel
5. Automatic table numbering in MS word
6. Automatic figure numbering in MS word
7. Automatic table of contents in MS word
8. Formatting of tables in MS word
9. Formatting of figures in MS word
10. Keyboard shortcuts for MS word and excel

Textbooks:

1. Wallace Wang, Microsoft Office 2019 for Dummies, 2nd edition, John Wiley & Sons, Inc., 2016.
2. Mariano Martin, Introduction to Software for Chemical Engineers, CRC Press, Taylor & Francis Group.

MOOCs and ONLINE COURSE:

1. https://elearn.nptel.ac.in/shop/nptel/digital-skilling/

Assessment:

COURSE OUTCOMES (COs):

Course Outcomes		Program Outcomes	Levels
CO1	Perform basic calculations in MS Excel	PO5	3
CO2	Analyze the data in MS Excel	PO5	2
CO3	Develop effective plots for experimental data in MS Excel	PO5	3
CO4	Format reports in MS Word with ease	PO5	2

ASSESSMENT:

Assessments	Marks 100 (Weightage 100%)	Assessment
CIE (Lab examination)	Marks 50 (Weightage 50%)	Course Instructor
Semester End Examination (Lab examination)	Marks 50 (Weightage 50%)	Examiners

Assessment pattern:

Scheme of Continuous Internal Evaluation (CIE):

Criteria	Lab conduction (30 M)			Lab Test (20 M)	Total Marks (50 M)
Marks	Lab activities	Record writing	Viva-voce		
	15	10	5	20	50

Lab Test:

One experiment will be allotted for each student Details of marks for each experiment.

1. Write-up 05
2. Activity 05
3. Output 05
4. Viva-voce 05

Total : 20

Eligibility for Semester End Examination

Submission and certification of lab records is compulsory to attend SEE. Minimum marks required in CIE to attend semester end examination is 35% of maximum 50 marks: Lab Performance (35% of 30 Marks) and Lab Test (35% of 20 Marks).

Semester End Examination:

All 10 experiments are included for the practical examination.

Scheme of Semester End Examination (SEE):			
1	• Exam will be conducted for 50 marks in 3 hrs duration. • One activity will be allotted for each student.		
2	Minimum marks required in SEE to pass: 20 out of 50 marks		
3	Write-up	10 marks	50 marks
4	Activity	15 marks	
5	Execution and output	15 marks	
6	Viva- voce	10 marks	

Course Title	National Service Scheme -1				
Course Code	23NCMC3NS1	Credits	00	L – T – P	0 – 0 – 0
Non-Credit Mandatory Course		SEE			P/NP

Course Title	Yoga-1				
Course Code	23NCMC3YG1	Credits	00	L – T – P	0 – 0 – 0
Non-Credit Mandatory Course		SEE		P/NP	

Module-1

Introduction and Trends of Yoga

- Meaning, Definition, and Importance of Yoga
- History and Philosophical Aspects of Yoga
- Need for and Importance of Yoga in the Modern World

Teaching Learning process: Chalk and talk method, PowerPoint presentation and YouTube videos, Animation videos methods. Creating real-time stations in classroom discussions. Giving activities & assignments.

Module-2

Means of Yogic Practices

- Introduction to Prayer and Its Importance
- Concept of Asana, Types and Benefits of Asana
- Concept of Pranayama, types, and benefits of Pranayama
- Concept and types of Mudras and Bandha
- Concept of Meditation and its benefits

Teaching Learning process: Chalk and talk method, PowerPoint presentation and YouTube videos, Animation videos methods. Creating real-time stations in classroom discussions. Giving activities & assignments.

Module-3

Meaning, techniques, precautions & effects of the following

- Classification of Asanas - Meditative Asanas – Relaxative Asanas – Cultural Asanas. - safety measure and precautions while performing asanas.
- Pranayama – different phases in Pranayama practices: Puraka (Inhalation), Kumbhaka (Retention) and Recaka (Exhalation), - safety measures and precautions while performing pranayama.
- Meditation - Its techniques & benefits.
- Practicing methods and benefits of Kriyas, Bandha and Mudra.

Teaching Learning process: Chalk and talk method, PowerPoint presentation and YouTube videos, Animation videos methods. Creating real-time stations in classroom discussions. Giving activities & assignments & Practical sessions.

Module-4

Application of Yoga

- Yoga for Health and Wellness
- Yoga for Aged Population
- Yoga for Otherly able population
- Yoga for Elite Sports Persons

Teaching Learning process: Chalk and talk method, PowerPoint presentation and YouTube videos, Animation videos methods. Creating real-time stations in classroom discussions. Giving activities & assignments.

Module-5

Yoga and Stress Management:

- Concept of Stress according to Yoga
- Stress Management and Relaxation Techniques
- Postural deformities and corrective measures
- Yoga and development of Social qualities of personality - Co-operation - Simplicity - Tolerance - Social adjustments - Yoga and personal efficiency. Improvement of personal efficiency through yoga

Teaching Learning process: Chalk and talk method, Demonstration and assessment method, PowerPoint presentation and YouTube videos, Animation videos methods. Creating real-time stations in classroom discussions. Giving activities & assignments.

Course outcome (Course Skill Set):

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

1. Demonstrate an understanding of anatomy and physiology as it applies to the intentional integration of breath, postures, and movement within the practice of yoga
2. Identify asana specific to their desired health benefits and create a yoga practice
3. Apply their understanding of yogic text and principles to their daily lives and yoga practice

Books:

1. Yoga – A Healthy Way of Living" by NCERT
2. Iyengar, BKS., (2003). The Art of Yoga. New Delhi: Harper Collins Publishers.
3. Nagendra, H.R., and Nagarathana, R., (2004). Yoga perspective in stress management. Bangalore: Swami Vivekananda Yoga Prakashana.

Activity-based Learning (suggested Activities in Class)/ Practical Based learning

- Asanas practice session, Contents related activities (Activity-based discussions)
- For active participation of students, instruct the students to prepare Flowcharts and Handouts
- Organizing Group wise discussions and Health issues-based activities.
- Quizzes and Discussions
- Seminars and assignments

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Teachers shall adopt suitable pedagogy for the effective teaching-learning process. The pedagogy shall involve the combination of different methodologies which suit modern technological tools and software to meet the present requirements of the Global employment market.
  (i) Direct instructional method (Low /Old Technology),
  (ii) Flipped classrooms (High/advanced Technological tools),
  (iii) Blended learning (combination of both),
  (iv) Enquiry and evaluation-based learning,
  (v) Personalized learning,
  (vi) Problems-based learning through discussion,
  (vii) Following the method of expeditionary learning Tools and techniques,

Apart from conventional lecture methods, various types of innovative teaching techniques through videos, and animation films may be adapted so that the delivered lesson can progress the students in theoretical applied and practical skills in teaching of the concepts of Health and Wellness in general.

Course Title	Physical Education-1				
Course Code	23NCMC3PE1	Credits	00	L – T – P	0 – 0 – 0
Non-Credit Mandatory Course		SEE		P/NP	

Module-1

Engineering Technology in Sports:

Introduction to Sports Technology, Technological innovations in sports, Use of technology in performance enhancement and analysis, Computer applications in sports

Module-2

Fitness and Healthy Lifestyle:

- Health and Safety in Daily Life at Work- Balance diet
- Yogic practice
- Aerobic Dance/Zumba

Module-3

Sports Training

- Meaning, definition, aim and objectives of sports training.
- Principles, Characteristics of sports training.
- Basic skills and techniques of the Sports/Game. (Each student shall involve in minimum 02 games).

Module-4

Ethics in Sports:

Ethics in Sports - Nature, Characteristics and Needs, Ethical practices in the field of Sports, Code of Conduct, Ethical Value System - Distributive Justice, Individual freedom of Choice, Professional Codes. Their application in the field of sports, Sports as a Profession - Conflict between organization demand, Individual needs and professional ideal, Conflicts the Sports Managers encounter, Social and Ethical - responsibilities of different Sports Association, Clubs, Manager, Coach and Sports Persons, Morale of Sportsmen- Role of Organizations I Association and Sports Manager in the area.

Module-5

Fundamental Exercise

Head, Neck and Facial Exercises, Shoulder and Chest Exercises, Abdominal, Hip and Trunk Exercises, Upper arm, lower Arm, Wrist and Finger Exercises, Thigh, Knee, Calf, Ankle and Finger Exercises

Course outcome

1. Understand fundamental concepts of physical education and sports.
2. Apply in advanced sports technology with personal accountability, integrity and social responsibility for outcome and through dynamic work-teams that uses resources efficiently.
3. Acquire fundamental theory, training methods and sports pedagogy.
4. Create a wider base of personnel to pursue various sport related careers.

Books:

1. Managing Sporting Events- Jerry Solomon (Human kinetics)
2. Managing Sports Organizations- Ruben Acosta Hernandez
3. Contemporary Sports management- Janet. B. Parks & Jerome Quarter man
(Publishers Human Kinetics)
4. Bompa T. (1999). Periodization- Theory and Methodology of Training (4th ed). Champaign,
Illinois: Human Kinetics.
5. Singh H (1999). Science of Sports Training. New Delhi. DVS Publication.
6. Uppal AK (1999). Sports Training. New Delhi. Friends Publication
7. Franz K. F. et. al., Editor, Routledge Handbook of Sports Technology and Engineering (Routledge, 2013)
8. Steve Hake, Editor, The Engineering of Sport (CRC Press, 1996)
9. Dixon, Sharon. The science and engineering of sport surfaces. Routledge, 2015.
10. Franz K. F. et. al., Editor the Impact of Technology on Sports II (CRC Press, 2007)
11. John Mongilo, (2001), "Nano Technology 101 "New York: Green wood publishing group.
12. Magdalinski, Tara. Sport, technology, and the body: The nature of performance. Routledge, 2009.

Activity-based Learning (suggested Activities in Class)/ Practical Based learning

- Contents and Practical related activities (Activity-based Skills practice/discussions)
- For active participation of students, instruct the students to prepare Flowcharts and Handouts
- Organizing Group wise discussions and Health issues-based activities
- Quizzes and discussions
- Seminars and assignments

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Teachers shall adopt suitable pedagogy for effective teaching - learning process. The pedagogy shall involve the combination of different methodologies which suit modern technological tools and software to meet the present requirements of the Global employment market.
  (i) Direct instructional method (Low /Old Technology),
  (ii) Flipped classrooms (High/advanced Technological tools),
  (iii) Blended learning (combination of both),
  (iv) Enquiry and evaluation-based learning,
  (v) Personalized learning,
  (vi) Problems based learning through discussion,
  (vii) Following the method of expeditionary learning Tools and techniques,

- Apart from conventional lecture methods, various types of innovative teaching techniques through videos, animation films may be adapted so that the delivered lesson can progress the students in theoretical applied and practical skills in teaching of the concepts of Health and Wellness in general.

FOURTH SEMESTER

Course Title	Statistics and Probability				
Course Code	23MA4BSSAP	Credits	03	L – T – P	2 – 1 – 0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

Prerequisites: Basic concepts of Statistics and Probability, addition theorem, conditional probability, Bayes' theorem, discrete random variable, Binomial distribution. Basic concepts of statistics. Matrices.

Course Objectives:

- To get acquainted with the procedure of collecting, designing, analyzing and drawing inference about the data
- To have insight into Statistical methods, Correlation and regression analysis.
- To develop probability distribution of discrete and continuous random variables, Joint probability distribution occurs in design engineering.

Teaching-Learning Process (General Instructions)

These are sample Strategies; which teachers can use to accelerate the attainment of the various course outcomes.

- In addition to the traditional lecture method, different types of innovative teaching methods may be adopted so that the delivered lessons shall develop students' theoretical and applied mathematical skills.
- State the need for Mathematics with Engineering Studies and Provide real-life examples.
- Support and guide the students for self–study.
- You will also be responsible for assigning homework, grading assignments and quizzes, and documenting students' progress.
- Encourage the students for group learning to improve their creative and analytical skills.

UNIT-I

STATISTICS & PROBABILITY

Curve fitting – Principle of least squares, fitting a straight line, fitting of a parabola, fitting of the exponential curve of the $y = ab^x$. Correlation and Regression

Probability distributions: Discrete distribution - Poisson distribution. Continuous distribution-Normal distribution. **[08 Hrs]**

UNIT-II

JOINT PROBABILITY AND MARKOV CHAIN

Joint Probability Distributions: Discrete random variables, Mathematical expectations, Covariance and Correlation.

Markov Chain: Markov Chain, Probability vectors, stochastic matrices, fixed point vector, regular stochasticmatrices. Higher transition probabilities, stationary distribution of regular Markov chain. **[08 Hrs]**

UNIT-III

STATISTICAL INFERENCE – I

Introduction, 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. **[08 Hrs]**

UNIT-IV

STATISTICAL INFERENCE – II

[Small sample] Test of significance for single mean, difference between two means, pairedt-test, ratio of variances (F- distribution), Chi -Square distribution-goodness of fit, independence of attributes. Analysis of variance (one-way and two-way classifications). **[08 Hrs]**

UNIT-V

DESIGN OF EXPERIMENTS

Principles of experimental design – Randomization, Replication, Local Control. Randomized block design, Completely Randomized block design, Latin Square Design–Problems. **[08 Hrs]**

Textbooks:

1. Fundamentals of Biostatistics, Khirfan A. Khan, Atiya Khanum, 3rd edition, 2012, UkaazPublications.
2. An Introduction to Biostatistics, P. S. S. Sundar Rao and J. Richard, 4th edition, 2006,Prentice Hall of India.

Reference Books:

1. Applied Statistics and Probability for Engineers, Douglas C. Montgomery, George C. Runger, 6th edition, Wiley.
2. Biostatistics, P. N. Arora, P. K. Malhan, 2nd edition, 2013, Himalaya Publishing House.

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

	Course Outcomes	Program Outcomes	Strength
CO 1	Apply the basic principles of statistics and probability, Markov chain and design of experiments to the problems in Engineering.	1	3
CO 2	Apply the concepts of Sampling distributions to Analyze and interpret the data from real world examples.	1	3
CO 3	Demonstrate an understanding of sampling distributions and principles of experimental design.	1,6,9,10	3,1,1,1

E books and online course materials:

1. https://www.coursera.org/learn/basic-statistics
2. https://www.coursera.org/learn/probability-intro
3. https://www.classcentral.com/course/udacity-intro-to-statistics-361
4. http://wiki.stat.ucla.edu/socr/index.php/Probability_and_statistics_EBook

Online Courses and Video Lectures:

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

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Title	Analytical Instruments				
Course Code	23CH4PCANI	Credits	04	L – T – P	3 – 0– 1
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, Types of calibration curves for data handling and interpretation.

6 Hrs

UNIT – II

SPECTROSCOPY: UV spectral region, Origin of light absorptions in UV and IR, Electronic transitions of organic compounds, Modes of vibrations in IR spectra, 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.

10 Hrs

UNIT – III

GRAVIMETRIC ANALYSIS: Principle of Thermogravimetric analyser (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.

7 Hrs

UNIT – IV

GAS CHROMATOGRAPHY: Introduction, Principle, carrier gas, stationary phase, instrumentation, principles of column detectors: TCD, FID, ECD and PID, qualitative and quantitative analysis.

10 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.

6 Hrs

LABORATORY COMPONENT

1. Determination of Pka value of a component using UV-spectroscopy
2. Qualitative Analysis of UV-spectroscopy of $KMnO_4$.
3. Effect of temperature on viscosity of oils using Red wood viscometer
4. Determination of concentration of alkali metal by Flame photometer
5. Determination of moisture content in a liquid and solid sample using KF titration
6. Qualitative Analysis using Turbidometer
7. Thin layer Chromatography
8. Bomb calorimeter for analysis of calorific value of given sample.

9. Electro analytical instrument like conductivity cell and its measurements

Textbooks:

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

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Understand the theoretical concepts behind the functioning of analytical instruments	PO1	1
CO2	Understand the impact, complexity, strength and limitations of each instrument	PO1	3
CO3	Select suitable instruments based on their applicability	PO5	2
CO4	Conduct experiments in teams using various instruments for physical and chemical analysis	PO8	2
CO5	Present the experimental observations in the form of a lab report.	PO2	3
CO6	Engage in life-long learning in context of technological change in instrumentations.	PO11	2

Assessment:

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

Assessment Pattern:

Component	Theory (50%)			Practical (50%)		Total Marks
	Test 1	Test 2	Quiz/AAT	Records & Performances	Lab Test	
Max. Marks	20	20	10	30	20	100
Reduced CIE	10	10	5	15	10	50

Course Title	Process Engineering Thermodynamics-II				
Course Code	23CH4PCTD2	Credits	03	L–T–P	3–0–0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Engineering Chemistry, Engineering mathematics and Process Engineering Thermodynamics -I

SYLLABUS:

UNIT - I

THERMODYNAMIC PROPERTIES OF PURE FLUIDS: Thermodynamic properties, Relationships among thermodynamic properties, Heat capacity, Entropy and other forms of energy relations, two phase systems-Clapeyron and Clausius-Clapeyron equations, Temperature dependence of vapor pressure of liquids, Alternative equations for liquids, Joule-Thomson coefficient, Gibbs-Helmholtz equation, Thermodynamic diagrams.

10 Hrs

UNIT - II

RESIDUAL PROPERTIES: Residual properties, Fugacity, Fugacity coefficient, Fugacity in solutions, Henry's law and dilute solutions, Activity, Activity in solutions, Activity coefficients, Property changes of mixing.

SOLUTION THERMODYNAMICS: Partial molar properties and Gibbs- Duhem equations, Numerical on estimation of partial molar properties.

10 Hrs

UNIT- III

PHASE EQUILIBRIA: Criteria of phase equilibrium, Chemical potential, Criterion of stability, Duhem's theorem, Vapour-Liquid Equilibrium, Phase diagrams for binary solutions, VLE in ideal solutions, Simple models for vapour liquid equilibrium, VLE-Qualitative behaviour, Raoult’s law, Henry’s law and Modified Raoult’s laws, Numerical on Dew and bubble point temperature and pressure, VLE from K value correlations, Flash calculations.

07 Hrs

UNIT - IV

NON-IDEAL SOLUTIONS: Excess properties, 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.

06 Hrs

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, Effect of pressure; Equilibrium conversion: Effect of pressure, inert materials, excess of reactants, products, Phase rule for reacting system.

06 Hrs

Textbooks:

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.

Reference Books:

1. Rao, Y.V.C Chemical Engineering Thermodynamics, New Age International Publication, Nagpur, 2000.
2. Halder, Gopinath, “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. DimitriosTassios, “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

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Apply the knowledge of classical thermodynamics to predict the thermodynamic properties of ideal and real gases	PO1	1
CO2	Derive thermodynamic relations between thermodynamic properties	PO2	3
CO3	Estimate properties of ideal and real gases from the thermodynamic relations.	PO2	2
CO4	Apply equations of state for describing the phase behaviour of various fluids.	PO3	3

CO5	Evaluate the equilibrium conversion in a reversible reaction using the Gibbs phase rule criteria	PO3	2
CO6	Assessment of the phase behaviour and equilibrium data of both pure and multicomponent systems by using phase equilibrium criteria.	PO3	2

Assessment:

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

Assessment Pattern:

Component	Theory (100%)			Total Marks
	Test 1	Test 2	AAT	
Max. Marks	40	40	20	100
Reduced CIE	20	20	10	50

Course Title	Mass Transfer-I				
Course Code	23CH4PCMT1	Credits	03	L – T – P	3 – 0 – 0
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, Wilke-Lee and Wilke and Chang equations for determination of Diffusivities, diffusion in solids, and calculations of diffusivities.
Eddy diffusion, individual and overall mass transfer coefficients and their correlations, theories of mass transfer, interphase mass transfer. **10 Hrs**

UNIT-II

HUMIDIFICATION OPERATIONS: Vapour pressure curve, enthalpy of pure substance, humidity and related terminologies, Psychometric chart and evaluation of absolute humidity, molal humidity, relative humidity, and others. Adiabatic-Saturation curves, wet bulb temperature, Lewis relation and gas-liquid contact operations, dehumidification. Equipment: water cooling towers and spray chamber. **10 Hrs**

UNIT-III

DRYING: Introduction to drying operation, equilibrium, drying rate curves, time of drying, and mechanism of drying. Equipment: classification, direct, and indirect batch driers, and rotary, spray and drum continuous driers. **06 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. **07 Hrs**

UNIT- V

CRYSTALLIZATION: Factors governing nucleation and crystal growth rates, methods of obtaining super-saturation, Mier's super-saturation theory. Crystallizer equipment: vacuum, Swenson-walker, and draft tube- baffle crystallizers. **06 Hrs**

Textbooks:

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

Reference Books:

1. Coulson and Richardson, "Chemical Engineering", Vol I, II, IV & V, 4th edition, Pergamon Press.

2. Badger, W.L. and Banchero J.T.,"Introduction to Chemical Engineering", 3rd 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. Transport Processes and Unit Operations by Geankoplis http://chembookneed.blogspot.in/2010/08/transport-processes-and-unit-operations.html

MOOC's:

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/

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Comprehend the basic principles of diffusion, humidification, drying, adsorption and crystallization.	PO1	1
CO2	Formulate equations to estimate diffusivities and mass transfer flux in fluids and solids using first principles of engineering sciences.	PO2	3
CO3	Apply the principles of mass transfer to solve the problems related to diffusion, humidification, adsorption, drying, and crystallization	PO2	3
CO4	Analyze the psychrometric chart to calculate the various parameters of the air-water vapour mixture.	PO2	2
CO5	Select the appropriate humidifier, dryer, and crystallizer based on the requirement.	PO5	2

Assessment:

Continuous Internal Assessments		Marks 100% (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	80%	Course Instructor
	AAT	20%	

Semester End Examination (Written Examination for Three Hours)	Marks 100 (Weightage 50%)

Assessment Pattern:

Component	Theory (100%)			Total Marks
	Test 1	Test 2	AAT	
Max. Marks	40	40	20	100
Reduced CIE	20	20	10	50

Course Title	Process Heat Transfer				
Course Code	23CH4PCHTR	Credits	04	L – T – P	3 – 0 – 1
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.

7 Hrs

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 the tip, Heat flow through the infinitely long rectangular fin, heat dissipation from fin insulated at the tip. Fin efficiency and fin effectiveness-derivation and problems. Elementary treatment of unsteady state heat conduction.

10 Hrs

UNIT -III

CONVECTION: Individual and overall heat transfer coefficient, LMTD, LMTD correction factor, Heat Transfer with Phase Change: Boiling phenomena, Nucleate and film boiling.

CONDENSATION: Film and Dropwise condensation, Nusselt's equations.

10 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.

6 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'sLaw, view factors. Radiation between surfaces-different shapes, radiation involving gases and vapours, and 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)

Textbooks:

1. Kern D. Q.,"Process Heat Transfer" McGraw-Hill, NewYork,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 McGraw Hill 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

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Level
CO1	Apply the principles of heat transfer and perform heat flux calculations for constant & variable area elements	PO2	3
CO2	Estimate of optimum insulation thickness and select different shapes of extended surfaces to enhance overall heat transfer co-efficient.	PO2	2

CO3	Perform preliminary design of heat transfer equipment using data with and without phase change	PO3	2
CO4	Comprehend and apply the laws governing radiation mode	PO1	1
CO5	Conduct experiments in teams and estimate the heat transfer co-efficient for fluids with and without phase change	PO9	2
CO6	Present the experimental observations in the form of a lab report.	PO10	3

Assessment:

Continuous Internal Assessments		Marks 100% (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	40%	Course Instructor
	Quiz (One Quiz or AAT)	10%	
Laboratory Component	Laboratory Component	50%	
Semester End Examination (Written Examination for Three Hours)		Marks 100 (Weightage 50%)	

Assessment Pattern:

Component	Theory (50%)			Practical (50%)		Total Marks
	Test 1	Test 2	Quiz/AAT	Records & Performances	Lab Test	
Max. Marks	20	20	10	30	20	100
Reduced CIE	10	10	5	15	10	50

Course Title	Pollution Control and Management				
Course Code	23CH4PCPCM	Credits	03	L – T – P	3– 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-IS10500, water consumption standards as per National building codes (NBC), Types of Water Pollutants and sources, State and central wastewater quality and prevailing discharge standards. Wastewater Sampling and Characteristics - Physical, Chemical and Biological characteristics of wastewater: Solving numerical on the sampling and analysis

6 Hrs

UNIT - II

WASTEWATER TREATMENT: Preliminary/Primary/physical unit operations, Chemical unit processes, Secondary/Biological treatment process, aerobic/anaerobic attached and suspended growth process. Activated sludge process: Process analysis: Completely mixed with recycle, Sequential Batch Reactor (SBR), Rotating biological contactor/disc (RBC), Trickling filter, UASB digester, aerated lagoon, stabilization ponds. – Standard type and modifications. Aerators/diffusers and Sludge Treatment & Disposal. With applicable numerical

10 Hrs

UNIT – III

TERTIARY/ADVANCED WASTEWATER TREATMENT: Ultrafiltration, Filtration, Adsorption on Activated Carbon, Ion Exchange, Reverse Osmosis.
BIOLOGICAL NUTRIENT REMOVAL: Introduction, Biological nitrogen removal-, Nitrification–denitrification. Physicochemical process for nitrogen removal - Air stripping

6 Hrs

UNIT- IV

AIR POLLUTION & CONTROL: Definition, Sources, Classification, Properties of air pollutants, and Effects of air pollution on health, vegetation, and materials. Ambient sampling and Stack sampling & Analysis of air pollutants, Control methods Equipment for particulates and gaseous pollutants.
NOISE POLLUTION: Definition, Sources, Effects of Noise, Equipment for Noise Measurement, Approaches for Noise Control. **7 Hrs**

UNIT –V

SOLID WASTE MANAGEMENT: Definitions, Characteristics, Types, Sources and Properties of solid waste with numericals.

E-WASTE MANAGEMENT What is E-Waste, Indian and global scenario of e-Waste, Growth of Electrical and Electronics industry in India, E-waste generation in India, Composition of e-waste, Possible hazardous substances present in e-waste, Environmental and Health implications.
The hazardous waste (Management and Handling) rules 2003, E-waste management rules 2015, Regulatory compliance including roles and responsibility of different stakeholders – producer, manufacturer, consumer, Proposed reduction in the use of hazardous substances (RoHS), Extended producer responsibility (EPR). **10 Hrs**

Textbooks:

1. Environmental Engineering by Howard S. Peavey, Donald R. Rowe, George Techobanolous, McGraw-Hill International Editions.
2. Wastewater Engineering – Treatment, Disposal and Reuse, METCALF AND EDDY, INC. 3rd Edition Tata McGraw-Hill Publishing Company Limited.
3. M N. Rao, Air Pollution, Tata McGraw-Hill Publishing Company Limited

Reference Books:

1. S P Mahajan, Pollution Control in Process Industries McGraw Hill Education 2017
2. C S Rao, Environmental Pollution Control Engineering, New Age International Publisher, 2011.
3. Johri R., "E-waste: implications, regulations, and management in India and current global best practices", TERI Press, New Delhi.
4. Rumana Riffat, Taqsim Husnain, Fundamentals of Wastewater Treatment and Engineering, CRC Press, 2022

E-Books:

1. Air Pollution by M N Rao and HVN Rao: http://www.avlib.in/ebook/title/air-pollution-mn-rao-and-hvn-rao-.html
2. https://www.free-E-Books:.net/ebook/introduction-to-wastewater-treatment

MOOC's and Online Courses:

1. https://www.basel.int/Implementation/TechnicalAssistance/MOOC/tabid/4966/Default.aspx
2. https://www.class-central.com/subject/civil-environmental-engineering
3. https://www.class-central.com/subject/environmental-science

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Programme Outcomes	Levels
CO1	Understand quality standards, sources pollution and pollutant types, and discharge regulations in accordance with national standards, with proficiency in sampling and analysis techniques.	PO6	1
CO2	Demonstrate comprehensive knowledge of treatment methods and evaluate characteristics.	PO2	2
CO3	Display expertise in advanced wastewater treatment technologies to enhance water quality.	PO6	3
CO4	Explain biological nutrient removal and apply techniques.	PO7	2
CO5	Identify, evaluate, and propose solutions for air, noise, solid, and e-waste management	PO11	2

Assessment:

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

Assessment Pattern:

Component	Theory (100%)			Total Marks
	Test 1	Test 2	AAT	
Max. Marks	40	40	20	100
Reduced CIE	20	20	10	50

Course Title	Universal Human Values				
Course Code	23MA4AEUHV	Credits	01	L – T – P	0– 1 – 0
CIE	50 marks (100% weightage)	SEE	50 marks (100% weightage)		

Course Objectives: To develop a holistic perspective based on self-exploration about themselves (human being), family, society, and nature/existence. Understanding (or developing clarity) of the harmony in the human being, family, society, and nature/existence.

UNIT – I

Course Introduction - Need, Basic Guidelines, Content and Process for Value Education

1. Purpose and motivation for the course, recapitulation from Universal Human Values-I
2. Self-Exploration–what is it? - Its content and process; 'Natural Acceptance' and Experiential Validation- as the process for self-exploration
3. Continuous Happiness and Prosperity- A look at basic Human Aspirations
4. Right understanding, Relationship and Physical Facility- the basic requirements for the fulfilment of aspirations of every human being with their correct priority
5. Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario
6. Method to fulfil the above human aspirations: understanding and living in harmony at various levels.

Include practice sessions to discuss natural acceptance in human beings as the innate acceptance of living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking.

UNIT – II

Understanding Harmony in the Human Being - Harmony in Myself!

1. Understanding human being as a co-existence of the sentient 'I' and the material 'Body'
2. Understanding the needs of Self ('I') and 'Body' - happiness and physical facility
3. Understanding the Body as an instrument of 'I' (I am being the doer, seer and enjoyer)
4. Understanding the characteristics and activities of 'I' and harmony in 'I'
5. Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail
6. Programs to ensure Sanyam and Health.

Include practice sessions to discuss the role others have played in making material goods available to me. Identifying from one's own life. Differentiate between prosperity and accumulation. Discuss programs for ensuring health vs dealing with disease.

UNIT –III

Understanding Harmony in the Family and Society- Harmony in Human- Human Relationship

1. Understanding values in human-human relationships; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship.
2. Understanding the meaning of Trust; Difference between intention and competence

3. Understanding the meaning of Respect, the Difference between respect and differentiation; the other salient values in the relationship
4. Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals
5. Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.

Include practice sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teachers-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives.

UNIT – IV

Understanding harmony in nature and existence - whole existence as coexistence

1. Understanding the harmony in nature
2. Holistic perception of harmony at all levels of existence.

UNIT – V

Implications of the above holistic understanding of harmony in professional ethics

1. Natural acceptance of human values
2. Definitiveness of ethical human conduct

Includes practice of exercises, and case studies in practice (tutorial) sessions.

Example: Discuss the conduct as an engineer or scientist etc.

At the end of the course, the student will have the ability to

CO1	Conduct self-exploration and distinguish between the values and skills, happiness and accumulation of physical facilities, the self and the body, intention and competence of an individual.
CO2	Analyze the value of harmonious relationships based on trust and respect in personal and professional life.
CO3	Examine the role of a human being in ensuring harmony in society and nature.
CO4	Apply the understanding of ethics in life and profession.

Textbooks:

1. Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 2010.

REFERENCE MATERIAL:

1. Ek Parichaya, A Nagaraj, Jeevan Vidy, Jeevan Vidya Prakashan, Amarkantak, 1999.
2. A.N. Tripathi, Human Values, New Age Intl. Publishers, New Delhi, 2004.
3. Annie Leonard, The Story of Stuff, 2010.
4. Mohandas Karamchand Gandhi, The Story of My Experiments with Truth
5. E. F Schumacher, Small is beautiful
6. Cecile Andrews, Slow is beautiful
7. J C Kumarappa, Economy of Permanence, 2017
8. Dharampal, Rediscovering India, 1963
9. Mohandas K. Gandhi, Hind Swaraj or Indian Home Rule
10. Maulana Abdul Kalam Azad, India Wins Freedom
11. Vivekananda- Romain Rolland (English)

Assessment pattern:

CIE and SEE for Universal Human Values Course with 1 credit:

CIE Component:

- Only one CIE shall be conducted after CIE2 and before CIE 3.
- CIE shall be conducted at the department level and by the respective faculty handling the course.
- Marks for CIE is 50.

The Marks distribution among various components of CIE is given hereunder:

Multiple-Choice Question: (MCQs)	10 marks
Attendance: Attendance >95% Attendance 85% - 95% Attendance 75%-85%	 05 marks 03 marks NO marks
Report Submission: i. Each student shall submit a report on his/her experiences about the course contents. ii. The report shall be a maximum of 2 pages and a minimum of 1 page. Marks for submission of report within the timelines and as per the format (as specified by the faculty)	05 marks
AAT component – Assessment shall be done using rubrics as specified by the faculty.	30 marks

SEE Component:

- Marks for SEE is 50.
- SEE shall have a maximum of 25 MCQs and a duration of 1 hour.
- The conduction of SEE shall be done in online mode with MCQs by the respective course instructor and marks shall be submitted to the COE office.
- The award of marks for SEE shall be completed well before the commencement of regular SEE.
- Awarding grades will be based on CIE and SEE marks.
- The course addresses Program Outcomes, PO8, PO9, PO10 and PO12

Course Title	Simulation Laboratory				
Course Code	23CH4AESIM	Credits	01	L – T – P	0– 0 – 1
CIE	50 marks (100% weightage)	SEE	50 marks (100% weightage)		

PREREQUISITES: Fluid mechanics, Mechanical operations, Process Heat Transfer and Chemical Engineering Thermodynamics

List of Experiments

1. Bubble point and Dew point calculation for a two-component mixture
2. Pressure drop in a pipe for Newtonian Fluid
3. Computation of energy efficiency in a crusher
4. Design and optimization of shell and tube heat exchanger
5. Simulation of flash separator
6. Simulation of continuous filtration operation
7. Simulation of refrigeration cycle
8. Simulation of flow in Static Mixer
9. Simulation of Heat transfer in a heating coil
10. Data Analysis using Artificial Intelligence and Machine Learning (AI&ML)

Assessment Pattern:

SCHEME OF CONTINUOUS INTERNAL EVALUATION (CIE):

Criteria	Lab conduction (30 M)			Lab Test (20 M)	Total Marks (50 M)
Marks	Conduction of experiment and reporting	Record writing	Viva-voce		
	15	10	5	20	50

TEST:

One experiment will be allotted for each student Details of marks for each experiment.

1. Write-up 05
2. Conduction of experiment 05
3. Interpretation of observations and calculations 05
4. Viva-voce 05

Total : 20

ELIGIBILITY FOR SEMESTER END EXAMINATION

Submission and certification of lab manual and record is compulsory to attend SEE. Minimum marks required in CIE to attend semester end examination is 35% of maximum 50 marks: Lab conduction (35% of 30 Marks) and Lab Test (35% of 20 Marks).

SEMESTER END EXAMINATION:

All 10 experiments are included for the practical examination.

Scheme of Semester End Examination (SEE):			
1	Exam will be conducted for 50 marks in 3 hrs duration One experiment will be allotted for each student		
2	Minimum marks required in SEE to pass: 20 out of 50 marks		
3	Write-up	10 marks	50 marks
4	Conduction of experiment	15 marks	
5	Calculation and inferences	15 marks	
6	Viva- voce	10 marks	

Course Title	National Service Scheme -2				
Course Code	23NCMC4NS2	Credits	00	L – T – P	0 – 0 – 0
Non-Credit Mandatory Course		SEE			P/NP

Course Title	Yoga-2				
Course Code	23NCMC4YG2	Credits	00	L – T – P	0 – 0 – 0
Non-Credit Mandatory Course		SEE		P/NP	

Module-1

Introduction and Trends of Yoga

- Meaning, Definition, and Importance of Yoga
- History and Philosophical Aspects of Yoga
- Need for and Importance of Yoga in the Modern World

Teaching Learning process: Chalk and talk method, PowerPoint presentation and YouTube videos, Animation videos methods. Creating real-time stations in classroom discussions. Giving activities & assignments.

Module-2

Means of Yogic Practices

- Introduction to Prayer and Its Importance
- Concept of Asana, Types and Benefits of Asana
- Concept of Pranayama, types, and benefits of Pranayama
- Concept and types of Mudras and Bandha
- Concept of Meditation and its benefits

Teaching Learning process: Chalk and talk method, PowerPoint presentation and YouTube videos, Animation videos methods. Creating real-time stations in classroom discussions. Giving activities & assignments.

Module-3

Meaning, techniques, precautions & effects of the following

- Classification of Asanas - Meditative Asanas – Relaxative Asanas – Cultural Asanas. - safety measure and precautions while performing asanas.
- Pranayama – different phases in Pranayama practices: Puraka (Inhalation), Kumbhaka (Retention) and Recaka (Exhalation), - safety measures and precautions while performing pranayama.
- Meditation - Its techniques & benefits.
- Practicing methods and benefits of Kriyas, Bandha and Mudra.

Teaching Learning process	Chalk and talk method, PowerPoint presentation and YouTube videos, Animation videos methods. Creating real-time stations in classroom discussions. Giving activities & assignments & Practical sessions.

Module-4

Application of Yoga

- Yoga for Health and Wellness
- Yoga for Aged Population
- Yoga for Otherly able population
- Yoga for Elite Sports Persons

Teaching Learning process	Chalk and talk method, PowerPoint presentation and YouTube videos, Animation videos methods. Creating real-time stations in classroom discussions. Giving activities & assignments.

Module-5

Yoga and Stress Management:

- Concept of Stress according to Yoga
- Stress Management and Relaxation Techniques
- Postural deformities and corrective measures
- Yoga and development of Social qualities of personality - Co-operation - Simplicity - Tolerance - Social adjustments - Yoga and personal efficiency. Improvement of personal efficiency through yoga

Teaching Learning process	Chalk and talk method, Demonstration and assessment method, PowerPoint presentation and YouTube videos, Animation videos methods. Creating real-time stations in classroom discussions. Giving activities & assignments.

Course outcome (Course Skill Set):

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

4. Demonstrate an understanding of anatomy and physiology as it applies to the intentional integration of breath, postures, and movement within the practice of yoga
5. Identify asana specific to their desired health benefits and create a yoga practice
6. Apply their understanding of yogic text and principles to their daily lives and yoga practice

Books:

4. Yoga – A Healthy Way of Living" by NCERT
5. Iyengar, BKS., (2003). The Art of Yoga. New Delhi: Harper Collins Publishers.
6. Nagendra, H.R., and Nagarathana, R., (2004). Yoga perspective in stress management. Bangalore: Swami Vivekananda Yoga Prakashana.

Activity-based Learning (suggested Activities in Class)/ Practical Based learning

- Asanas practice session, Contents related activities (Activity-based discussions)
- For active participation of students, instruct the students to prepare Flowcharts and Handouts

- Organizing Group wise discussions and Health issues-based activities.
- Quizzes and Discussions
- Seminars and assignments

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Teachers shall adopt suitable pedagogy for the effective teaching-learning process. The pedagogy shall involve the combination of different methodologies which suit modern technological tools and software to meet the present requirements of the Global employment market.
  (i) Direct instructional method (Low /Old Technology),
  (ii) Flipped classrooms (High/advanced Technological tools),
  (iii) Blended learning (combination of both),
  (iv) Enquiry and evaluation-based learning,
  (v) Personalized learning,
  (vi) Problems-based learning through discussion,
  (vii) Following the method of expeditionary learning Tools and techniques,

Apart from conventional lecture methods, various types of innovative teaching techniques through videos, and animation films may be adapted so that the delivered lesson can progress the students in theoretical applied and practical skills in teaching of the concepts of Health and Wellness in general.

Course Title	Physical Education-2				
Course Code	23NCMC4PE2	Credits	00	L – T – P	0 – 0 – 0
Non-Credit Mandatory Course		SEE		P/NP	

Module-1

Engineering Technology in Sports:

Introduction to Sports Technology, Technological innovations in sports, Use of technology in performance enhancement and analysis, Computer applications in sports

Module-2

Fitness and Healthy Lifestyle:

- Health and Safety in Daily Life at Work- Balance diet
- Yogic practice
- Aerobic Dance/Zumba

Module-3

Sports Training

- Meaning, definition, aim and objectives of sports training.
- Principles, Characteristics of sports training.
- Basic skills and techniques of the Sports/Game. (Each student shall involve in minimum 02 games).

Module-4

Ethics in Sports:

Ethics in Sports - Nature, Characteristics and Needs, Ethical practices in the field of Sports, Code of Conduct, Ethical Value System - Distributive Justice, Individual freedom of Choice, Professional Codes. Their application in the field of sports, Sports as a Profession - Conflict between organization demand, Individual needs and professional ideal, Conflicts the Sports Managers encounter, Social and Ethical - responsibilities of different Sports Association, Clubs, Manager, Coach and Sports Persons, Morale of Sportsmen- Role of Organizations I Association and Sports Manager in the area.

Module-5

Fundamental Exercise

Head, Neck and Facial Exercises, Shoulder and Chest Exercises, Abdominal, Hip and Trunk Exercises, Upper arm, lower Arm, Wrist and Finger Exercises, Thigh, Knee, Calf, Ankle and Finger Exercises

Course outcome

5. Understand fundamental concepts of physical education and sports.
6. Apply in advanced sports technology with personal accountability, integrity and social responsibility for outcome and through dynamic work-teams that uses resources efficiently.
7. Acquire fundamental theory, training methods and sports pedagogy.
8. Create a wider base of personnel to pursue various sport related careers.

Books:

1. Managing Sporting Events- Jerry Solomon (Human kinetics)
2. Managing Sports Organizations- Ruben Acosta Hernandez
3. Contemporary Sports management- Janet. B. Parks & Jerome Quarter man
(Publishers Human Kinetics)
4. Bompa T. (1999). Periodization- Theory and Methodology of Training (4th ed). Champaign,
Illinois: Human Kinetics.
5. Singh H (1999). Science of Sports Training. New Delhi. DVS Publication.
6. Uppal AK (1999). Sports Training. New Delhi. Friends Publication
7. Franz K. F. et. al., Editor, Routledge Handbook of Sports Technology and Engineering (Routledge, 2013)
8. Steve Hake, Editor, The Engineering of Sport (CRC Press, 1996)
9. Dixon, Sharon. The science and engineering of sport surfaces. Routledge, 2015.
10. Franz K. F. et. al., Editor the Impact of Technology on Sports II (CRC Press, 2007)
11. John Mongilo, (2001), "Nano Technology 101 "New York: Green wood publishing group.
12. Magdalinski, Tara. Sport, technology, and the body: The nature of performance. Routledge, 2009.

Activity-based Learning (suggested Activities in Class)/ Practical Based learning

- Contents and Practical related activities (Activity-based Skills practice/discussions)
- For active participation of students, instruct the students to prepare Flowcharts and Handouts
- Organizing Group wise discussions and Health issues-based activities
- Quizzes and discussions
- Seminars and assignments

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Teachers shall adopt suitable pedagogy for effective teaching - learning process. The pedagogy shall involve the combination of different methodologies which suit modern technological tools and software to meet the present requirements of the Global employment market.
  (i) Direct instructional method (Low /Old Technology),
  (ii) Flipped classrooms (High/advanced Technological tools),
  (iii) Blended learning (combination of both),
  (iv) Enquiry and evaluation-based learning,
  (v) Personalized learning,
  (vi) Problems based learning through discussion,
  (vii) Following the method of expeditionary learning Tools and techniques,

- Apart from conventional lecture methods, various types of innovative teaching techniques through videos, animation films may be adapted so that the delivered lesson can progress the students in theoretical applied and practical skills in teaching of the concepts of Health and Wellness in general.

FIFTH SEMESTER

Course Title	Chemical Reaction Engineering – I				
Course Code	23CH5PCCR1	Credits	04	L – T – P	3-0-1
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Engineering Chemistry and Calculus and Differential Equations

SYLLABUS:

UNIT-I

Introduction: Scope of Chemical Reaction Engineering, Classification of reactions, Rate equation and rate of reaction, Factors affecting rate of reaction, Molecularity and order of reactions, Chemical kinetics and Thermodynamics Equilibrium, Temperature-dependency of rate constant from Arrhenius, Collision and Transition state theories, and numerical. **07 Hrs**

UNIT-II

Non-Elementary Reactions: Difference between elementary and non-elementary reactions. Kinetic models and mechanisms for non-elementary reactions. **10 Hrs**

Homogeneous Reactions: Types of reactors. Interpretation of batch reactor data. Constant & Variable Volume batch reactor. Analysis: Differential method, Integral method, half-life method, autocatalytic reactions, and numerical.

UNIT-III

10 Hrs

Design of Ideal Reactors: Development of design equations for batch, tubular, and stirred tank reactors for constant and variable volume reactions, evaluation of rate equations from data obtained in these reactors, and numerical.

Multiple Reactor Systems: Plug flow and Mixed flow reactors in Series & parallel arrangement, Reactors of different types and sizes in series, Comparison of Ideal Reactors and General graphical comparison, and numerical.

UNIT-IV

Design of Reactors for Multiple Reactions: Selectivity, yield, design of Batch reactor, Plug and Mixed flow reactors for Parallel reactions, Series reactions, and Series-Parallel reactions (Only irreversible reactions must be considered), and Numerical. Qualitative and quantitative discussion about product distribution. **06 Hrs**

UNIT-V

Non-Isothermal Reactors: Introduction, Energy balances around batch, plug flow, and mixed flow reactors, conversion. Design procedure (for single/simple reactions only), Optimum temperature Progression. **06 Hrs**

LABORATORY COMPONENT

1. Batch Reactor Studies for Bimolecular Saponification Reaction
2. Batch Reactor Studies for Second Order Saponification Reaction

3. Mixed Flow Reactor Studies for Second Order Saponification Reaction
4. RTD Studies in a Stirred Tank Reactor
5. Plug Flow Reactor Studies for Second Order Saponification Reaction
6. RTD Studies in a Tubular Flow Reactor
7. RTD Studies in a Packed Bed Reactor
8. Effect of temperature on the Kinetics of the Reaction
9. Semi Batch Reactor

Textbooks:

1. Octave Levenspeil, Chemical Reaction Engineering, 3rd Edition, John Wiley & Sons, 2001.
2. H. Scott Fogler, Elements of Chemical Reaction Engineering. 3rd Edition Prentice Hall, 2001.

Reference Books:

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

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 *Dora Swamy*: 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 and Online Courses:

1. http://ocw.mit.edu/courses/chemistry/5-68j-kinetics-of-chemical-reactions-spring-2003/index.htm
2. https://nptel.ac.in/courses/103/101/103101141/#

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Formulate the rate equations for different reactions using a suitable mechanism	PO2	2
CO2	Analyse and interpret the data to determine the rate equation for ideal reactors	PO2	3
CO3	Develop and estimate the performance equations of ideal reactors	PO3	2
CO4	Develop optimal operational conditions for an ideal reactor with single and multiple reactions	PO3	3
CO5	Apply the thermodynamic principles to understand the non-isothermal behavior of reactions	PO2	1

Assessment:

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

Assessment Pattern:

Component	Theory (50%)			Practical (50%)		Total Marks
	Test 1	Test 2	Quiz/AAT	Records & Performances	Lab Test	
Max. Marks	20	20	10	30	20	100
Reduced CIE	10	10	5	15	10	50

Course	Transport Phenomena				
Course Code	23CH5PCTRP	Credits	03	L – T – P	2-1-0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Fluid Mechanics, Process Heat Transfer, Mass Transfer-I, and Calculus and Differential Equations

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), Numerical problems. **04+1T = 06 Hrs**

UNIT-II

Steady-State Shell Momentum Balances: Different Flow situations, Steady state Shell momentum balances Boundary conditions applicable to momentum transport problems, Flow over a flat plate for Newtonian fluid and Non-Newtonian fluid, Flow through a circular tube for Newtonian fluid and Non-Newtonian fluid, Flow through Annulus. Flow between parallel plates and a slit. Numerical problems **06+2T= 10 Hrs**

UNIT-III

Steady-State Shell Energy Balances: General Boundary conditions applicable to energy transport problems of chemical engineering, Heat conduction through compound walls, and Overall heat transfer coefficient based on the inner and outer surface area. Heat conduction with internal generation by electrical, nuclear, viscous energy sources, Numerical problems. **06+2T = 10 Hrs**

UNIT-IV

Steady-State Shell Mass Balances: Steady-state shell mass balances, General Boundary conditions applicable to mass transport problems of chemical engineering, Diffusion through stagnant gas and liquid films, and Equimolar counter diffusion. Numerical problems. **03+2T = 07 Hrs**

Steady-State Shell Mass Balances with Reaction: Diffusion with homogeneous and heterogeneous reaction. Diffusion into falling film- Forced convection mass transfer. Numerical problems.

UNIT-V

Analogies between Momentum, Heat and Mass Transport: Reynold's, Prandtl's and Chilton & Colburn analogies. **04+1T=06 Hrs**

Equations of Change: Various coordinate systems, Equation of continuity, Equation of motion; Navier-Stokes equation, Euler's equation.

Textbooks:

1. Bird, Stewart and Lightfoot, 'Transport Phenomena', 2nd Edition, Wiley Publications, 2006.

Reference Books:

1. Christe John Geankoplis, Transport Process and Separation Process Principles, 4th Edition, Pearsons, 2015.
2. Welty, Wikes and Watson,' Momentum Heat and Mass Transport'', 4th Edition. John Wiley.
3. Byron Bird, Warren E. Stewart, Edwin N. Lightfoot and Daniel J. Klingenberg Introductory Transport Phenomena Wiley; 1st Edition, 2015.
4. Bodh Raj, Introduction to Transport Phenomena, PHI Learning Publications, 2015.

E-Books:

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://swayam.gov.in/nd1_noc20_bt30/preview
2. https://www.edx.org/course/the-basics-of-transport-phenomena

SEE Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Understand the relevance of transport phenomena in the transport process	PO11	1
CO2	Infer steady-state operation for momentum, heat & mass transfer	PO2	3
CO3	Apply reasoning to solve problems based on shell momentum, energy & mass balances across various boundary conditions.	PO4	3
CO4	Extend the knowledge of transport phenomena with reaction and without reactions.	PO3	2

CO5	Apply the equation of changes for systems of various geometry	PO3	2
CO6	Liken the similarities of transport process between momentum, heat, and mass transport	PO2	1

Assessment:

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

Assessment Pattern:

Component	Theory (100%)			Total Marks
	Test 1	Test 2	AAT	
Max. Marks	40	40	20	100
Reduced CIE	20	20	10	50

Course Title	Mass Transfer-II				
Course Code	23CH5PCMT2	Credits	04	L – T – P	3 – 0 – 1
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Process Principles and Calculations and Mass Transfer I

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. **10 Hrs**

Absorption: Solubility of gases in liquids, one component transferred: Material balances, Counter current multistage operations: Isothermal only, Continuous contact equipment: Overall coefficients and transfer units, Dilute solutions, Overall heights of transfer units, Design of packed towers from the data of NTU.

UNIT-II

Distillation: Introduction, Vapour liquid equilibrium, Estimation of VLE data, VLE for multicomponent systems, Flash vaporization, Simple distillation, Steam distillation, Continuous rectification, Design of distillation column using McCabe Thiele method for binary mixtures and related problems. **10 Hrs**

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. **06 Hrs**

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: Rotating disc contactor, Pulsed column, and Centrifugal extractor. **07 Hrs**

UNIT- V

Leaching Operation: Introduction, Preparation of solid, Equipment for unsteady state operation and steady state operation: Dorr thickener, Kennedy extractor and Bollman extractor, Methods of calculation: Equilibrium diagrams, Single stage and multi-stage cross and counter current operations, Counter current leaching operation with constant underflow. **06 Hrs**

LABORATORY COMPONENT

1. Single stage adsorption
2. Diffusion of organic vapour into air
3. Mass transfer coefficient using wetted wall column
4. Two-stage adsorption
5. Simple distillation
6. Packed column distillation
7. Single stage Liquid-Liquid extraction
8. Solid Dissolution
9. Single Stage Leaching
10. Steam distillation
11. Drying characteristics

Textbooks:

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

Reference Books:

1. Coulson and Richardson, "Chemical Engineering", Vol II, & IV, 4th Edition, Pergamon press, 1998
2. Badger, W.L. and Banchero J.T., "Introduction to Chemical Engineering", 3rd 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. Transport Processes and Unit Operations by Geankoplis, http://chembookneed.blogspot.in/2010/08/transport-processes-and-unitoperations.html

MOOC's and Online Courses:

1. http://elearning.vtu.ac.in/BT32.html
2. http://nptel.ac.in/courses/103104046/

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Programme Outcomes	Levels
CO1	Apply the understanding of interfacial mass transfer to various gas/liquid/solid contact operations.	PO2	1
CO2	Demonstrate the knowledge of construction & working of industrial-scale equipment for mass transfer	PO3	2
CO3	Perform elementary design of mass transfer equipment	PO4	3
CO4	Investigate engineering tasks and the industrial applications of mass transfer operations.	PO2	2
CO5	Conduct hands-on experiments in a team.	PO9	3
CO6	Perform the experimental calculations individually, draw/state conclusions and present a record.	PO3	3

Assessment:

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

Assessment Pattern:

Component	Theory (50%)			Practical (50%)		Total Marks
	Test 1	Test 2	AAT	Records & Performances	Lab Test	
Max. Marks	20	20	10	30	20	100
Reduced CIE	10	10	5	15	10	50

Course Title	Chemical Technology				
Course Code	23CH5PCCTN	Credits	03	L – T – P	3 – 0 – 0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Mechanical operations, Process Thermodynamics-I, Process Thermodynamics-II

SYLLABUS:

UNIT-I

CHEMICAL PROCESS INDUSTRIES AND FUELS: Introduction- Components of flow sheet: Unit operations, unit processes, mass and material balance equations. **10 Hrs**

FUELS AND INDUSTRIAL GASES- Coking of coal, LPG, LNG, Petroleum technology- Constituents, distillation of crude petroleum.

CRYOGENIC INDUSTRY-Nitrogen and Oxygen by Linde–Frankl's process.

UNIT-II

INORGANIC CHEMICALS: Sulphuric acid - DCDA Process; Alkali industry- Soda Ash, Caustic soda; Nitrogen Industries- Ammonia and Nitric Acid; and Phosphoric acid –Hydrochloric acid leaching method. **07 Hrs**

UNIT-III

NATURAL INDUSTRIES: Sugar Industry; Oil industry: Vegetable oil extraction; Refining and hydrogenation and Surfactant industry: Manufacture of soaps and detergents. **06 Hrs**

UNIT-IV

COMMERCIAL INDUSTRIES: Fermentation Manufacturing of ethyl alcohol, and penicillin; Polymer industry - LDPE, PVC; Rubber Industry-Natural rubber and SBR; Paper industry- Pulp from sulphate process, paper from pulp, treatment of effluent from sulphate process. **10 Hrs**

UNIT-V

MISCELLANEOUS INDUSTRIES: Paints- Zinc oxide, Titanium dioxide; Cement Industry 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, 3rd Edition, Affiliated East West Press Pvt. Ltd., New Delhi, 1997.

Reference Books:

1. Shukla S. D. and Pandey G. N., Textbook of chemical technology, Volume 2, Vikas Publishing House Pvt. Ltd., New Delhi, 1979.
2. Chemical Process Technology, O.P. Gupta, 1st edition, Khanna Publishing House, 2018.

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: https://www.wiley.com/en-in/Chemical+Technology:+An+Integral+Textbook-p-9783527670611

MOOC's and Online Courses:

1. http://nptel.ac.in/courses/103103029/
2. http://www.vlab.co.in/ba-nptel-labs-chemical-engineering

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Programme Outcomes	Levels
CO1	Analyse and describe the unit operations/processes adopted for the synthesis of chemicals.	PO2	3
CO2	Draw the flow sheets for the production of chemicals.	PO2	2
CO3	Understand and infer the impact of professional engineering solutions in societal and environmental contexts for the manufacture of chemicals.	PO7	3

CO4	Communicate the details of the process flow diagram and the importance of various unit operations/processes.	PO10	2

Assessment:

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

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	Environmental Studies				
Course Code	23CV5HSEVS	Credits	01	L – T – P	1-0-0
CIE	50 marks (50% weightage)	SEE	50 marks (50% weightage)		

COURSE OBJECTIVE: The course enables the students to:

Develop a sense of responsibility about the environment, natural resources, their conservation, awareness about the ill effects of pollution and understand the concept, structure, and function of different ecosystems.

SYLLABUS:

UNIT-I

Introduction to Environment: Definition, about Earth. Atmosphere, Hydrosphere, Lithosphere and Biosphere, Structure of Atmosphere, Internal structure of the Earth Ecosystem, Balanced ecosystem, types of Ecosystem Effects of Human Activities on Environment. Environmental Impact Assessment (EIA)

UNIT-II

Natural Resources: Water resources its availability, Mineral resources, Forest resources

UNIT-III

Energy Resources: Conventional and Non-conventional energy resources. Hydroelectric, Wind power, solar, Biogas, Fossil fuel-based energy resources – Coal, Oil & Gas, Nuclear power, Hydrogen as an alternate future source of energy

UNIT-IV

Environmental Pollution: Effects and Control of Pollution i) Water pollution, ii) Land pollution, and iii) Noise pollution

UNIT-V

Current environmental issues & importance: Population growth effects & Control, Climatic changes, Global warming. Acid rain Ozone layer depletion & effects, Environmental protection; Role of Government initiatives by Non-Govt. Organizations

13 Hrs

Textbooks:

1. Dr. Geetha Balakrishanan, K G Lakshminarayana Bhatta, “Environmental studies”, S M Publications, 5th edition, 2017.

2. N S Subramanyam, AV S S Sambamurthy, “Ecology”, Alpha Science International Ltd, 2nd Edition, 2006

3. Dr. J.P.Sharma, “Environmental studies”. Laxmi Publications, 3rd edition, 2009.

4. Smriti Srivastava, “Environment and Ecology”, S K Kataria & Sons, 2023

References:

1. Benny Joseph, "Environmental Studies", Mc Graw Hill Education, 3rd edition, 2017

2. Dr. D.L.Manjunath, "Environmental Studies", Pearson Education India, 3rd edition, 2009.

CIE: Two CIEs will be conducted for 25 marks each, with MCQ 10 and descriptive 15 marks. An average of two is to be considered**.**

SEE paper pattern: SEE to be conducted for 50 marks, with MCQ for 20 marks, and descriptive for 30 marks. SEE may be online or offline.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Identify and discuss the components and impacts of human activities on environment, conservation and on protection of natural resources	PO1, 6, 7	2, 2, 3
CO2	Identify and establish relationship between social, economic and ethical values from environmental perspectives	PO1, 6, 7	2, 2, 3

Course	Computer Interface in Chemical Engineering				
Course Code	23CH5PELA1	Credits	03	L – T – P	3-0-0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Chemical Reaction Engineering, Heat Transfer, Mass Transfer, and Transform Calculus, Fourier Series and Numerical Techniques.

SYLLABUS:

UNIT-I

Review on Python Programming: Variable, values, expressions, input and output statement, operators, conditional execution, alternative execution, chained conditionals, nested conditionals, and related programs. For loop, and while loop statements, and related programs. **06 Hrs**

UNIT-II

Numerical Computation Using Python: Non-linear algebraic equation using Newton Raphson. Ordinary differential equation using R-K Method, numerical integration using Simpson's $1/3^{rd}$ Rule. Curve fitting using linear regression and non-linear regression methods. Algorithm and programs for all numerical methods. **07 Hrs**

UNIT-III

Prediction of Physical Properties Using Python: 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. **10 Hrs**

Applications of Python in Chemical Engineering: Design of isothermal and non-isothermal batch, plug flow and CSTR reactor. Design of Distillation column, Design of double pipe heat exchanger, shell and tube heat exchanger, and single stage evaporator.

UNIT-IV

Introduction to Mat Lab: MAT Lab environment, developing M-files, Basic output and input statements, conditional statements, looping statements and plotting and related MAT lab programs. **06 Hrs**

UNIT-V

Applications of MAT Lab in Heat and Mass Transfer Operations: Design of distillation column, design of single stage evaporator, design of double pipe heat **10 Hrs**

exchanger (Area, Number of tubes, Pressure drop) and design of shell and tube heat exchanger (Area, Number of tubes, Pressure drop).

Application of MAT Lab in Reactor Design: Design of ideal isothermal batch, plug flow and CSTR rectors. MAT Lab Program for CSTRs in series for both constant and variable volume.

Textbooks:

1. Charles R. Severance., "Python for Everybody: Exploring Data Using Python 3", 4th Edition, 2016.
2. Nayef Ghasem, "Numerical Methods in Chemical Engineering Using Python® and Simulink®", 1st Edition, CRC Press, 2023.

Reference Books:

1. Steven C. Chapra., "Applied Numerical Methods with MATLAB® for Engineers and Scientists", 3rd Edition, Mc. Graw Hill, 2012.
2. William. L Luyben, "Process Modeling Simulation and Control for Chemical Engineering", 2nd Edition., Mc. Graw Hill, 1990.

E-Books:

1. Yeong Koo Yeo, "Chemical Engineering Computation with MATLAB®", 2nd Edition, CRC Press, 2020. https://www.amazon.in/Chemical-Engineering-Computation-MATLAB%C2%AE-Yeong-ebook/dp/B08NCC33WK.
2. Mariano Martín Martin, "Introduction to Software for Chemical Engineers", 2nd Edition, CRC Press, 2019. https://www.routledge.com/Introduction-to-Software-for-Chemical-Engineers-Second-Edition/Martin/p/book/9781138324213.

MOOC's and Online Courses:

1. MATLAB Programming for Numerical Computation, NPTEL Swayam Course, by Prof. Nithin Kaisare, IIT Madras, https://archive.nptel.ac.in/courses/103/106/103106118/

SEE Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Understand the basics of python and MAT lab programs.	PO1	2
CO2	Apply the concept of python and MAT lab programs to solve non-linear equations using suitable numerical methods.	PO2	2
CO3	Select and apply approximate python and MAT lab programs for solving complex chemical engineering problems	PO5	3
CO4	Design and interpret the behavior of mass, heat transfer and reaction engineering operations to assess societal, health, safety and legal issues.	PO6	2

Assessment:

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

Assessment Pattern:

Component	Theory (100%)			Total Marks
	Test 1	Test 2	AAT	
Max. Marks	40	40	20	100
Reduced CIE	20	20	10	50

Course Title	Numerical Techniques in Chemical Engineering					
Course Code	23CH5PELA2	Credits	03	L – T – P	3-0-0	
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)			

PREREQUISITES: Heat Transfer, Chemical Reaction Engineering-1, Chemical Reaction Engineering 2, Calculus and Differential Equations, and Advanced Calculus and Numerical Methods

UNIT-I

Mathematical Formulation: Law of conservation of mass in mixing tank system, Equilibrium batch still and Single stage extraction. Law of conservation of energy: Flow of heat from a fin and related numerical problems. **07 Hrs**

UNIT-II

Mathematical Formulation of Complex Problems: Mass transfer with the reaction for gas-liquid contact, Heat transfer through multiwall cylinders and spheres, Heat transfer in a jacketed vessel, Rate expression for series and parallel homogeneous 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. **10 Hrs**

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.

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. **10 Hrs**

Solution of Partial Differential Equations: Solution for heat conduction equation, solution for Laplace's equation using finite difference method.

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. **06 Hrs**

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, 2nd edition, Academic Press Inc., 1977.

Reference Books:

1. Rose L.M. Applications of Mathematical Modelling to Process Development and Design, 1st edition, John Wiley and Sons, 1974.
2. Ahuja Pradeep, "Introduction to Numerical Methods in Chemical Engineering", 1st edition, PHI publication, 2013.

E-Books:

1. Ahuja Pradeep, "Introduction to Numerical Methods in Chemical Engineering", https://www.amazon.in/Introduction-Numerical-Methods-Chemical-Engineering-ebook/dp/B00K7YK5H2.
2. Kenneth J bears, "Numerical Methods for Chemical Engineering", https://www.cambridge.org/core/books/numerical-methods-for-chemical-engineering/0E8FDD0E2265EDE9F728FFEDD18F0695.

MOOCs and Online Courses:

1. https://archive.nptel.ac.in/noc/courses/noc20/SEM2/noc20-ge20/
2. https://ocw.mit.edu/courses/10-34-numerical-methods-applied-to-chemical-engineering-fall-2015/video_galleries/class-videos/

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Apply the principles of conversation laws to formulate chemical engineering problems.	PO2	2
CO2	Develop and solve ordinary differential equations of chemical engineering problems.	PO3	3
CO3	Formulate and evaluate partial differential equations of chemical engineering problems.	PO3	2
CO4	Formulate and solve complex engineering problems using Laplace transforms.	PO2	2
CO5	Apply appropriate modern tools to predict the solution for complex engineering problems.	PO5	1

Assessment:

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

Assessment Pattern:

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

Course Title	Optimization of Chemical Processes				
Course Code	23CH5PELA3	Credits	03	L – T – P	3-0-0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Fluid Mechanics, Heat Transfer, Mass Transfer, and Transform Calculus, Fourier Series and Numerical Techniques.

SYLLABUS:

UNIT-I

Introduction and Problem Formulation: Scope and hierarchy of optimization, essential features of optimization problems, procedure for solving optimization problems, and obstacles to optimization. **07 Hrs**

Economic Optimization: Economic objective functions, time value of money, measures of profitability, and related problems.

UNIT-II

Optimization Theory and Methods: Continuity of functions, NLP problem statement, convexity, and its applications. Optimizing a function of one variable, scanning and bracketing procedures, Newton & quasi-Newton methods for one dimensional and multidimensional. Polynomial approximation methods. **06 Hrs**

UNIT-III

Linear Programming and Applications: Geometry of linear programs, basic linear programming, simplex algorithm, barrier method, sensitivity analysis, linear mixed integer programs. **06 Hrs**

Mixed Integer Programming: Problem formulation, Branch-and-Bound methods, and problems on MINLP.

UNIT-IV

Heat Transfer and Energy Conservation: Optimum recovery of waste heat, optimum shell and tube heat exchanger design, optimization of heat exchanger networks, optimization of multistage evaporators, optimization of liquid-liquid extraction processes, optimal design, and operation of staged distillation columns. **10 Hrs**

UNIT-V

Fluid Flow Systems: Optimal pipe diameter, minimum work of gas compression, economic operation of fixed bed filter, optimal design of gas transmission network, optimal design, and operation of chemical reactors. **10 Hrs**

Textbooks:

1. T. F. Edger and D. M. Himmelblau, "Optimization of Chemical Processes", 2nd Edition, Mc. Graw Hill, 2001.
2. Ravindran, K. M. Ragsdell, and G. V. Reklaitis, "Engineering Optimization: Methods and Applications", 2nd Edition, John Wiley & Sons, 2006.

Reference Books:

1. Dominic C. Y. Foo, "Recent Advances in Sustainable Process Design and Optimization", World Scientific, 2012.
2. Kalyanmoy Deb, "Optimization for Engineering Design: Algorithms and Examples", 2nd Edition, PHI Publishers, 2012.

E-Books:

1. Ioannis K. Kookos, "Practical Chemical Process Optimization with MATLAB® and GAMS®", Springer, 2022, https://link.springer.com/book/10.1007/978-3-031-11298-0.
2. Frank (Xin X.) Zhu, "Energy and Process Optimization for the Process Industries", Wiley, 2013, https://onlinelibrary.wiley.com/doi/book/10.1002/9781118782507.

MOOCs and ONLINE COURSES:

1. Optimization in Chemical Engineering, NPTEL Swayam Course, By Prof. Debasis Sarkar, IIT Kharagpur, https://onlinecourses.nptel.ac.in/noc23_ch22/preview.

SEE Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Apply the knowledge of mathematics in arriving at optimum conditions.	PO2	3

CO2	Realize the need for optimization as a part of process industries for sustainable development.	PO7	2
CO3	Solve the developed objective function using different mathematical approximation and optimization tools.	PO2	3
CO4	Relate the optimal conditions to optimize the different operations by utilizing available resources.	PO6	2

Assessment:

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

Assessment Pattern:

Component	Theory (100%)			Total Marks
	Test 1	Test 2	AAT	
Max. Marks	40	40	20	100
Reduced CIE	20	20	10	50

Course Title	Research Methodology and IPR				
Course Code	23CH5AERMI	Credits	02	L – T – P	2-0-0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

Unit 1

Meaning and sources of research problem, Objectives and Characteristics of research; Errors in selecting research problem; Research methods versus; Methodology; Types of research; Criteria of good research; Developing a research plan. **6 Hrs**

Unit 2

Investigations of a research problem; Selecting the problem - Necessity of defining the problem; Data Collection-analysis; Importance of literature review in defining a problem; Survey of literature; Necessary instrumentations. **5 Hrs**

Unit 3

How to write paper: Conference articles; poster preparation; thesis report writing, inclusion of references; journal reviewing; process, journal selection process, filling. Journal template, developing effective research proposal-plagiarism-research ethics. **5 Hrs**

Unit 4

Nature of Intellectual property: IPRs; Invention and Creativity; Importance and Protection of Intellectual Property Rights (IPRs): Procedure for grant of patents and patenting under PCT-types of patents; technological research and innovation-international cooperation on IP. **5 Hrs**

Unit 5

A brief summary of Patents; Copyrights; Trademarks, patent rights; Licensing and transfer of technology; patent databases; case studies on IPR; Geographical indications; new developments in IPR; Protection of IPR rights **5 Hrs**

Textbooks:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, An introduction to Research Methodology, RBSA Publishers, U.K., 2002.

2. Subbarau N R, Handbook of Intellectual property law and practice, S Viswanathan Printers and Publishing Private Limited, 1998.

Reference Books:

1. Kothari, C.R., **Research Methodology: Methods and Techniques**. New Age International. 418p, 1990.
2. Anderson, T. W., **An Introduction to Multivariate Statistical Analysis**, Wiley Eastern Pvt., Ltd., New Delhi.
3. Sinha, S.C. & Dhiman, A.K., **Research Methodology**, ESS Publications. Vol. 1 and Vol. 2, 2002.

E-Books:

1. Ioannis K. Kookos, "Practical Chemical Process Optimization with MATLAB® and GAMS®", Springer, 2022, https://link.springer.com/book/10.1007/978-3-031-11298-0.
2. Frank (Xin X.) Zhu, "Energy and Process Optimization for the Process Industries", Wiley, 2013, https://onlinelibrary.wiley.com/doi/book/10.1002/9781118782507.

MOOC's and Online Courses:

1. Optimization in Chemical Engineering, NPTEL Swayam Course, By Prof. Debasis Sarkar, IIT Kharagpur, https://onlinecourses.nptel.ac.in/noc23_ch22/preview.

SEE Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Apply the knowledge of basic science principle for formulating and designing a research plan	PO2	2
CO2	Design and develop effective reports to communicate effectively with society at large	PO10	3
CO3	Apply the ethical principles to comprehend the importance of intellectual property rights and copyrights.	PO8	2

CO4	Recognize the need of technological changes and new developments for protecting the copyrights and IPR rights	PO12	2

Assessment:

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

Assessment Pattern:

Component	Theory (100%)			Total Marks
	Test 1	Test 2	AAT	
Max. Marks	40	40	20	100
Reduced CIE	20	20	10	50

Course Title	Project Based on Modern Simulation Tools				
Course Code	23CH5PCPW1	Credits	02	L – T – P	0– 0 – 2
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITE: Core subjects from the preceding semesters.

A group of students will be assigned/select one case study or an analytical problem, which they need to solve under the supervision of a guide using modern IT tools or Artificial Intelligence and Machine Learning (AI&ML) models. The project is to be assigned at the beginning of the fifth semester. The project group should complete the literature survey & execute the project. They should submit the synopsis at the end of the beginning of the semester. The project work with a report should be completed by the end of the fifth semester. This project will be evaluated by a committee constituted by the HoD for internal assessment.

Course Outcomes:

Course Outcomes		Programme Outcomes	Levels
CO1	Select a suitable case study or an analytical problem amongst the various options available through a literature survey	PO4	2
CO2	Apply the modern Engineering and IT tools for prediction and modelling the identified engineering problem	PO5	3
CO3	Identify a challenge related to process industries and/or the society with or without multidisciplinary facets	PO6	2
CO4	Demonstrate the need for sustainability for an optimal process	PO7	2
CO5	Develop the ability to function effectively as an individual, and as a member or leader in diverse teams	PO9	2
CO6	Make effective presentations and communicate effectively on the activities carried during the project work with the engineering community and with society at large	PO10	3

Assessment:

Continuous Internal Assessments		Marks 100% (Weightage 50%)	Assessment
Practical Component	Presentation 1	40%	Committee constituted by HOD
	Presentation 2	40%	
	Report	20%	
Semester End Examination – Presentation and write-up (Weightage 50%)			

Assessment Pattern:

Component	Presentation 1	Presentation 2	Report	Total Marks
Max. Marks	40	40	20	100
Reduced CIE	20	20	10	50

Course Title	National Service Scheme -3				
Course Code	23NCMC5NS3	Credits	00	L – T – P	0 – 0 – 1
Non-Credit Mandatory Course		SEE			P/NP

Course Title	Yoga-3				
Course Code	23NCMC5YG3	Credits	00	L – T – P	0 – 0 – 1
Non-Credit Mandatory Course		SEE		P/NP	

Course Objectives:

- Promoting positive health, prevention of stress related health problems and rehabilitation through Yoga.
- Integral approach of Yoga Therapy to common ailments.
- Imparting skills in them to introduce Yoga for health to general public and Yoga for total personality development of students in Colleges and Universities.
- Invoke scientific attitude and team spirit to channelize their energies in to creative and constructive endeavours.
- To enable them to establish Yoga Therapy centres in the service of common man.

Teaching-Learning Process (General Instructions)
These are sample Strategies; which teachers can use to accelerate the attainment of the various course outcomes.

- Teachers shall adopt suitable pedagogy for effective teaching - learning process. The pedagogy shall involve the combination of different methodologies which suit modern technological tools and software to meet the present requirements of the Global employment market.
  (i) Direct instructional method (Low /Old Technology),
  (ii) Flipped classrooms (High/advanced Technological tools),
  (iii) Blended learning (combination of both),
  (iv) Enquiry and evaluation-based learning,
  (v) Personalized learning,
  (vi) Problems based learning through discussion,
  (vii) Following the method of expeditionary learning Tools and techniques,

Apart from conventional lecture methods, various types of innovative teaching techniques through videos, animation films may be adapted so that the delivered lesson can progress the students in theoretical applied and practical skills in teaching of the concepts of Health and Wellness in general.

Module-1

Introduction and Trends of Yoga

- Meaning, Definition, and Importance of Yoga
- History and Philosophical Aspects of Yoga
- Need for and Importance of Yoga in Modern World

Teaching Learning process	Chalk and talk method, PowerPoint presentation and YouTube videos, Animation videos methods. Creating real-time stations in classroom discussions. Giving activities & assignments.

Module-2

Means of Yogic Practices

- Introduction to Prayer and Its Importance
- Concept of Asana, Types and Benefits of Asana
- Concept of Pranayama, types, and benefits of Pranayama
- Concept and types of Mudras and Bandha
- Concept of Meditation and its benefits

Teaching Learning process	Chalk and talk method, PowerPoint presentation and YouTube videos, Animation videos methods. Creating real-time stations in classroom discussions. Giving activities & assignments.

Module-3

Meaning, techniques, precautions & effects of the following

- Classification of Asanas - Meditative Asanas – Relaxative Asanas – Cultural Asanas. - safety measure and precautions while performing asanas.
- Pranayama – different phases in Pranayama practices: Puraka (Inhalation), Kumbhaka (Retention) and Recaka (Exhalation), - safety measures and precautions while performing pranayama.
- Meditation - Its techniques & benefits.
- Practicing methods and benefits of Kriyas, Bandha and Mudra.

Teaching Learning process	Chalk and talk method, PowerPoint presentation and YouTube videos, Animation videos methods. Creating real-time stations in classroom discussions. Giving activities & assignments & Practical sessions.

Module-4

Application of Yoga

- Yoga for Health and Wellness
- Yoga for Aged Population
- Yoga for Otherly able population
- Yoga for Elite Sports Persons

Teaching Learning process	Chalk and talk method, PowerPoint presentation and YouTube videos, Animation videos methods. Creating real-time stations in classroom discussions. Giving activities & assignments.

Module-5

Yoga and Stress Management:

- Concept of Stress according to Yoga
- Stress Management and Relaxation Techniques
- Postural deformities and corrective measures

- Yoga and development of social qualities of personality - Co-operation - Simplicity - Tolerance - Social adjustments - Yoga and personal efficiency. Improvement of personal efficiency through yoga

Teaching Learning process: Chalk and talk method, Demonstration and assessment method, PowerPoint presentation and YouTube videos, Animation videos methods. Creating real-time stations in classroom discussions. Giving activities & assignments.

Course outcome (Course Skill Set)

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

1. Demonstrate an understanding of anatomy and physiology as it applies to the intentional integration of breath, postures, and movement within the practice of yoga
2. Identify asana specific to their desired health benefits and create a yoga practice
3. Apply their understanding of yogic text and principles to their daily lives and yoga practice

Books:

1. Yoga – A Healthy Way of Living" by NCERT
2. Iyengar, BKS., (2003). The Art of Yoga. New Delhi: Harper Collins Publishers.
3. Nagendra, H.R., and Nagarathana, R., (2004). Yoga perspective in stress management. Bangalore: Swami Vivekananda Yoga Prakashana.

Activity-based Learning (suggested Activities in Class)/ Practical Based learning.

- Asanas practice session, Contents related activities (Activity-based discussions)
- For active participation of students, instruct the students to prepare Flowcharts and Handouts
- Organizing Group wise discussions and Health issues-based activities.
- Quizzes and Discussions
- Seminars and assignments

Course Title	Physical Education-3				
Course Code	23NCMC5PE3	Credits	00	L – T – P	0 – 0 – 0
Non-Credit Mandatory Course		SEE		P/NP	

Module-1

Engineering Technology in Sports:

Introduction to Sports Technology, Technological innovations in sports, Use of technology in performance enhancement and analysis, Computer applications in sports

Module-2

Fitness and Healthy Lifestyle:

- Health and Safety in Daily Life at Work- Balance diet
- Yogic practice
- Aerobic Dance/Zumba

Module-3

Sports Training

- Meaning, definition, aim and objectives of sports training.
- Principles, Characteristics of sports training.
- Basic skills and techniques of the Sports/Game. (Each student shall involve in minimum 02 games).

Module-4

Ethics in Sports:

Ethics in Sports - Nature, Characteristics and Needs, Ethical practices in the field of Sports, Code of Conduct, Ethical Value System - Distributive Justice, Individual freedom of Choice, Professional Codes. Their application in the field of sports, Sports as a Profession - Conflict between organization demand, Individual needs and professional ideal, Conflicts the Sports Managers encounter, Social and Ethical - responsibilities of different Sports Association, Clubs, Manager, Coach and Sports Persons, Morale of Sportsmen- Role of Organizations I Association and Sports Manager in the area.

Module-5

Fundamental Exercise

Head, Neck and Facial Exercises, Shoulder and Chest Exercises, Abdominal, Hip and Trunk Exercises, Upper arm, lower Arm, Wrist and Finger Exercises, Thigh, Knee, Calf, Ankle and Finger Exercises

Course outcome

1. Understand fundamental concepts of physical education and sports.
2. Apply in advanced sports technology with personal accountability, integrity and social responsibility for outcome and through dynamic work-teams that uses resources efficiently.
3. Acquire fundamental theory, training methods and sports pedagogy.
4. Create a wider base of personnel to pursue various sport related careers.

Books:

1. Managing Sporting Events- Jerry Solomon (Human kinetics)
2. Managing Sports Organizations- Ruben Acosta Hernandez
3. Contemporary Sports management- Janet. B. Parks & Jerome Quarter man
4. (Publishers Human Kinetics)
5. Bompa T. (1999). Periodization- Theory and Methodology of Training (4th ed). Champaign, Illinois: Human Kinetics.
6. Singh H (1999). Science of Sports Training. New Delhi. DVS Publication.
7. Uppal AK (1999). Sports Training. New Delhi. Friends Publication
8. Franz K. F. et. al., Editor, Routledge Handbook of Sports Technology and Engineering (Routledge, 2013)
9. Steve Hake, Editor, The Engineering of Sport (CRC Press, 1996)
10. Dixon, Sharon. The science and engineering of sport surfaces. Routledge, 2015.
11. Franz K. F. et. al., Editor the Impact of Technology on Sports II (CRC Press, 2007)
12. John Mongilo, (2001), "Nano Technology 101 "New York: Green wood publishing group.
13. Magdalinski, Tara. Sport, technology, and the body: The nature of performance. Routledge, 2009.

Activity-based Learning (suggested Activities in Class)/ Practical Based learning

- Contents and Practical related activities (Activity-based Skills practice/discussions)
- For active participation of students, instruct the students to prepare Flowcharts and Handouts
- Organizing Group wise discussions and Health issues-based activities
- Quizzes and discussions
- Seminars and assignments

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

Teachers shall adopt suitable pedagogy for effective teaching - learning process. The pedagogy shall involve the combination of different methodologies which suit modern technological tools and software to meet the present requirements of the Global employment market.

- Direct instructional method (Low /Old Technology),
- Flipped classrooms (High/advanced Technological tools),
- Blended learning (combination of both),
- Enquiry and evaluation-based learning,
- Personalized learning,
- Problems based learning through discussion,

Following the method of expeditionary learning Tools and techniques,

Apart from conventional lecture methods, various types of innovative teaching techniques through videos, animation films may be adapted so that the delivered lesson can progress the students in theoretical applied and practical skills in teaching of the concepts of Health and Wellness in general.

SIXTH SEMESTER

Course Title	Chemical Reaction Engineering-II				
Course Code	23CH6PCCR2	Credits	03	L – T – P	2– 1 – 0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Chemical Reaction Engineering-I, Process Engineering Thermodynamics-I, Process Engineering Thermodynamics-II, Transform Calculus, Fourier Series and Numerical Techniques.

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. **03+2T =07 Hrs**

UNIT-II

Non-Catalytic Systems: Introduction to Fluid-Fluid reactions, Kinetics for straight mass transfer without reaction, Kinetics for direct mass transfer with the reaction for all types of reactions, the significance of Hatta Number and related problems on fluid-fluid reactions. **04+3T =10Hrs**

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 a combination of resistances and related problems.

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. **02+2T =06 Hrs**

UNIT-IV

Deactivation: Deactivating catalyst, Mechanism, rate & performance equation. **04+3T 10 Hrs**

Solid Catalyzed Reactions: Rate equation for surface kinetics, heterogeneous systems, Pore diffusion resistance combined with surface kinetics, Thiele modulus and enhancement factor.

UNIT-V

Performance Equation for Different Reaction Systems: Performance equations for reactors containing porous catalyst particles, Experimental methods for finding rates, Packed bed catalytic reactors & reactors with suspended solid catalyst. **02+2T = 06 Hrs**

Gas-Liquid Reactors: Trickle Bed, Slurry reactors. Three-phase fluidized bed.

Textbooks:

1. Octave Levenspeil, Chemical Reaction Engineering, 3rd Edition, John Wiley & Sons, 2001.
2. H. Scott Fogler, Elements of Chemical Reaction Engineering. 3rd Edition Prentice Hall, 2001.

Reference Books:

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

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 Dora Swamy: https://www.crcpress.com/Chemical-Reaction-Engineering-Beyond-the-Fundamentals/Doraiswamy-Uner/9781439831229.

MOOCs and Online Courses:

1. https://nptel.ac.in/courses/103/101/103101141/#

SEE Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Apply knowledge of material balance to formulate the design equations for non-ideal systems.	PO3	2
CO2	Interpret the performance of non-ideal systems in comparison with ideal systems.	PO4	2
CO3	Develop rate expression for different reaction mechanisms using suitable models for catalytic, non-catalytic and catalytic deactivation reactions with an understanding of their limitations	PO3	3
CO4	Formulate the design equation for heterogeneous reaction systems and porous catalytic reactions in combination with diffusion mechanisms.	PO3	2

Assessment:

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

Assessment Pattern:

Component	Theory (100%)			Total Marks
	Test 1	Test 2	AAT	
Max. Marks	40	40	20	100
Reduced CIE	20	20	10	50

Course Title	Economics in Engineering				
Course Code	23CH6PCEIE	Credits	02	L – T – P	2– 0 – 0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Mathematical calculation skills.

UNIT-I

Introduction: Engineering Economics – An overview, relationship between engineering and economics, scope of engineering economics. **04 Hrs**

Process Design Development: Economics in the overall plant, plant location and layout – Factors affecting plant design and layout, economics of Plant location and layout.

UNIT-II

Estimating Component: Components of costs such as direct material cost, direct labour cost, fixed, Overheads, factory costs, administrative – Overheads, first cost, marginal cost, selling price, estimation for simple components. **04 Hrs**

UNIT-III

Interest: Simple and compound interest, nominal and effective interest, continuous interest, interest formulae and their application, time value of money and numerical. **06 Hrs**

Comparison Methods for Rate of Interest: Present worth, future worth & annual Equivalent method of comparison, revenue and cash dominated cash flow diagram.

UNIT-IV

Depreciation: Depreciation – Introduction, causes of depreciation, Methods of Depreciation - Straight Line method, Unit of Production Method, Double Declining Balance Method, Sum of Years Digits Method /Sinking Fund Method and Numerical. Relationship between Depreciation and Taxes, Numerical problems. **06 Hrs**

UNIT-V

Financial Statements & Breakeven Analysis: Importance of financial statements, compilation of financial statements including balance sheet, income statement, and profit and loss statement. numerical problems. determination of break-even point, BEP in terms of quantity, sales value, and percentage of capacity, break-even chart, and numerical. **04 Hrs**

Textbooks:

1. M.S. Peters and K. D. Timmerhaus, "Plant Design and Economics for Chemical Engineers", 5th Edition, McGraw Hill, 2017.
2. R Paneerselvam, "Engineering Economics", Prentice Hall India Learning Private Limited, 2nd Edition, 2013.

Reference Books:

1. James Riggs. "Engineering Economics", McGraw Hill Education, 4th edition, 2004.
2. Prof. M.N. Vyas, "Management of Chemical Projects, Design and Economics", Atlantic Publishers and Distributors Pvt Ltd, 2020.

E-Books:

1. Sasmita Mishra, "Engineering Economics and Costing", PHI Publishers, 2nd Edition, 2011.
2. V.V. Mahajani and S.M. Mokashi, "Chemical Project Economics", Laxmi Publications Private Limited; 2nd Edition, 2016.

MOOCs and ONLINE COURSES:

1. Plant Design and Economics, NPTEL Swayam Course, By Prof. Debasis Sarkar, IIT Kharagpur, https://archive.nptel.ac.in/courses/103/105/103105166/.

SEE Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Understand the basics of fixed and working capital in an industrial set up and the cost accounting principles of product costing.	PO10	2
CO2	Distinguish between various types of interests and their application in Engineering Economics.	PO2	3

CO3	Identify and comprehend the appropriate method of depreciation in industrial process	PO2	3
CO4	Infer on a macroscopic level the minute economics of process engineering design and plant technology.	PO11	2

Assessment:

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

Assessment Pattern:

Component	Theory (100%)			Total Marks
	Test 1	Test 2	AAT	
Max. Marks	40	40	20	100
Reduced CIE	20	20	10	50

Course Title	Process Control Engineering				
Course Code	23CH6PCPCE	Credits	04	L – T – P	3– 0 – 1
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Engineering Maths

SYLLABUS:

UNIT-I

First Order Systems: Transfer functions of the thermometer, level in a tank, mixing tank, stirred tank reactor, response of first order systems for various input forcing functions, linearization, and first order systems in series. **10 Hrs**

UNIT-II

Second Order Systems: Characteristics of manometer and damped vibrator, Transfer function of second order system, Response to step and impulse forcing functions, terms associated with the response to a step input, transportation lag. **10 Hrs**

UNIT-III

Closed Loop System: Basic components of a control system, Servo and regulator control, negative and positive feedback, development of block diagram of a control system, controllers- P, I, D, PID and On-Off modes. **07 Hrs**

UNIT-IV

Closed Loop Response: Closed loop transfer functions, transient response of servo and regulator control systems with various controller modes and their characteristics. **07 Hrs**

UNIT-V

Stability: Stability of linear control systems, Routh Test, Frequency Response, Bode diagrams. **Root Locus:** Rules for plotting and problems **05 Hrs**

LABORATORY COMPONENT

1. Determination of time constant for Thermometer
2. Single Tank-Step Response & Impulse Response
3. Non-Interacting Tanks-Step Response & Impulse Response
4. Interacting Tanks-Step Response & Impulse Response
5. Response of a second-order system (U- Tube Manometer)
6. Pressure Vessel
7. Valve characteristics
8. Levels Control-P controller, PI controller, PD controller, PID controller

9. Flow Control-P controller, PI controller, PD controller, PID controller
10. Temperature Control-P controller, PI controller, PD controller, PID controller
11. Pressure Control-P controller, PI controller, PD controller, PID controller

Textbook:

1. Donald R. Coughanowr & Steven E. LeBlanc, Process Systems Analysis and Control, 3rd Edition (Indian Edition), McGrawHill Education.
2. Instrumentation and Process Control, D.C. Sikdar, 1st Edition, Khanna Publishing House, 2019

Reference Books:

1. George Stephanopoulos, Chemical Process Control-An Introduction to Theory & Practice, (Indian Edition) Pearson, 2015.
2. Coulson& Richardson, Chemical Engineering Vol 3, 3rd Edition-Pergamon Press, 1998.

E-Books:

1. http://www.ourmumbaicity.com/E-Books:
2. http://www.leka.lt/sites/default/files/dokumentai/process-control.pdf

MOOC's and Online Courses:

1. https://nptel.ac.in/courses/103/106/103106148/
2. https://nptel.ac.in/courses/103/105/103105064/
3. https://www.mooc-list.com/
4. http://elearning.vtu.ac.in/06IT64.html

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Develop the transfer function of simple first-order systems, first-order systems in series, and second-order systems.	PO2	3
CO2	Predict the response of first and second-order systems	PO2	3

CO3	Describe the components of a control system, develop its closed loop transfer function and predict the control action of P, PI, PD and PID controllers.	PO4	2
CO4	Comment on the stability of control systems using Root Locus Method, Frequency Response Method and perform rudimentary controller tuning.	PO4	2
CO5	Conduct experiments in a team and draw inferences.	PO9	2
CO6	Engage in individual/peer learning and communicate effectively.	PO10	2

Assessment:

Continuous Internal Assessment		Marks 100% (Weightage 50%)	Assessment
Theory Component	Three Internals (Best of Two)	40%	Course Instructor
	Quiz (One Quiz or AAT)	10%	
Laboratory Component	Laboratory Component	50%	
Semester End Examination (Written Examination for Three Hours)			

Assessment Pattern:

Component	Theory (50%)			Practical (50%)		Total Marks
	Test 1	Test 2	Quiz/AAT	Records & Performances	Lab Test	
Max. Marks	20	20	10	30	20	100
Reduced CIE	10	10	5	15	10	50

Course Title	Process Modelling and Simulation				
Course Code	23CH6PCPMS	Credits	03	L – T – P	2– 0 – 1
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Chemical reaction engineering, Heat transfer, Mass transfer, Thermodynamics and Numerical techniques

SYLLABUS:

UNIT-I

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 the degree of freedom analysis, Concept of equilibrium and kinetics. **05 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 **06 Hrs**

UNIT-III

Models of Heat Transfer Equipment: Steady state heat conduction through a Hollow Cylindrical pipe, Unsteady state steam heating of a liquid, Cooling of tanks, Heat transfer through extended surface, and related problems. **05 Hrs**

UNIT-IV

Models of Separation Processes: Development of detailed mathematical models for a single-component vaporizer, multicomponent flash drum, ideal binary distillation column, and multicomponent non-ideal distillation column. Activity coefficient model (Wilson, NRTL, UNIQUAC, UNIFAC), equation of state models (RK, SRK, PR). **05 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. **05 Hrs**

LABORATORY COMPONENT

Simulation Using *UniSim*® Simulation Software

1. Simulation of flash drum for binary mixture
2. Simulation of distillation column
3. Simulation of absorption column
4. Simulation of heat exchanger
5. Simulation of two stage compression system
6. Simulation of refrigeration gas plant
7. Simulation of conversion reactor
8. Simulation of equilibrium reactor

9. Simulation of CSTR
10. Simulation of plug flow reactor

Textbooks:

1. William. L Luyben, "Process Modeling Simulation and Control for Chemical Engineering", 2nd Edition., McGraw Hill, 1990.
2. B. V. Babu, "Process Plant Simulation", Oxford University Press, 2004.

REFERENECE-Books:

1. R.W. Gaikwad & Dr. Dhirendra, "Process Modelling and Simulation", Denett & Co., 2006
2. Amiya K. Jana, "Chemical Process Modelling and Computer Simulation", PHI Learning Pvt. Ltd., 2011.
3. Pradeep Ahuja, "Introduction to Numerical Methods in Chemical Engineering", PHI Learning Pvt. Ltd., 2010.

E-Books:

1. Chemical Process Technology and Simulation by Srikumar Koyikkal, ISBN-13: 978-8120347090
2. Enes Kadic, Theodore J. Heindel, "An Introduction to Bioreactor Hydrodynamics and Gas-Liquid Mass Transfer", Willey, April 2014.

MOOC's and Online Courses:

1. http://nptel.ac.in/courses/103107096/
2. http://www.myopencourses.com/subject/process-modelling-and-simulation-1

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Comprehend the fundamental laws and thermodynamic principles required for formulating a mathematical model.	PO2	2
CO2	Apply the fundamental laws using engineering concepts to build mathematical models for processes.	PO3	3

CO3	Analyze and pursue suitable shell balance approach to build models for complex chemical processes.	PO4	3
CO4	Conduct simulation experiments individually using UNISIM simulation software.	PO5	3
CO5	Report the observations, and calculations, and derive valid conclusions.	PO10	2
CO6	Recognize the need for learning simulation tools in the context of technological change.	PO12	2

Assessment:

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

Assessment Pattern:

Component	Theory (50%)			Practical (50%)		Total Marks
	Test 1	Test 2	Quiz/AAT	Records & Performances	Lab Test	
Max. Marks	20	20	10	30	20	100
Reduced CIE	10	10	5	15	10	50

Course Title	Interfacial Phenomena				
Course Code	23CH6PELB1	Credits	03	L – T – P	3– 0 – 0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Chemical Reaction Engineering-I, Calculus and Differential Equations, and Advanced Calculus and Numerical Methods

UNIT-I

Introduction: Concept of colloids and interface, surface tension, equivalence in the concepts of surface energy and surface tension, and measurement of surface and interfacial tension using capillary rise method, drop weight method, du Nouy ring method, Wilhelmey method, maximum bubble pressure method, and spinning drop method. Numerical on-surface tension and interfacial tension measurement. **09 Hrs**

UNIT-II

Excess Pressure: Generalized equation for excess pressure across a curved surface: Young-Laplace equation and its application, Kelvin equation, and its application: Capillary condensation, supersaturation, and nucleation. Numerical on Young-Laplace and Kelvin's equation. **07 Hrs**

UNIT-III

Wetting: Work of adhesion, cohesion, criteria for spreading of liquids, the kinetics of spreading, and Young's equation. **09 Hrs**

Emulsions: General properties, factors determining emulsion stability, ageing and inversions of emulsions, hydrophobic-lipophilic balance.

UNIT-IV

Charged Interfaces: The concept of electrical double layer, models of electrostatic double layer, electrokinetic Phenomena: electrophoresis, electro-osmosis, and its industrial applications. Only theoretical aspects. **07 Hrs**

UNIT-V

Surfactants: Introduction, classification and properties of surfactants, surfactant self-assembly, and thermodynamic aspects. **07 Hrs**

Surfactant-Based Separations: Liquid membrane permeation, foam separations, micellar separations, soil remediation.

Textbooks:

1. Pallab Ghosh, Colloids and Interface Science, 1st edition, Prentice Hall Publications, 2009.
2. Clarence A. Miller, and P. Neogi, "Interfacial Phenomena: Equilibrium and Dynamic Effects", 2nd edition, 2019.

REFERENCE-Books:

1. A.W. Adamson, Physical chemistry of surfaces, 6th edition, John Wiley, 1997.
2. Duncan J. Shaw, Butter worth Heinemann, Introduction to colloid and surface chemistry, 4th edition.

E-Books:

1. http://www.freebookcentre.net/chemistry-books-download/An-Introduction-to-Surface-Chemistry.html
2. https://archive.org/details/introductiontosu017148mbp

MOOCs and Online Courses:

1. Interfacial Engineering https://archive.nptel.ac.in/courses/103/102/103102016/
2. Interfacial Fluid Mechanics https://onlinecourses.nptel.ac.in/noc22_me127/preview

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Apply relevant correlations to find the properties of colloids	PO2	1
CO2	Apply the basics of interfacial phenomena to calculate the surface and interfacial tension	PO2	2
CO3	Identify the types of surfactants and their important attributes that affect the properties of emulsions	PO2	3
CO4	Understand and apply the concepts in interfacial phenomena for environmental applications	PO7	2
CO5	Communicate the concepts of colloids and interfacial phenomena through PowerPoint presentation	PO10	2

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%	
Semester End Examination (Written Examination for Three Hours)			

Assessment Pattern:

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

Course Title	Petroleum Refining				
Course Code	23CH6PELB2	Credits	03	L – T – P	3– 0 – 0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Engineering Chemistry, Materials chemistry and applications

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. **06 Hrs**

UNIT-II

Products - Properties And Test Methods: Crude Distillation, Products from crude; Gasoline: ASTM Distillation, Reid Vapor Pressure Analysis, Octane Number, Oxidation stability, Additives; Kerosene: Flash point, Fire point, Smoke Point, Burning Quality; Diesel Fuels: Classification, Pour Point, Aniline Point, Viscosity, Additives for diesel; Lube Oils: Categories, Carbon Residue: Conradson Residue, Rams bottom Method and Bitumen: Softening Point, Penetration Index. **07 Hrs**

UNIT-III

Crude Pre-treatment: Pumping of crude oil, Dehydration of crude: Chemical, gravity, centrifugal, electrical de-salter. **10 Hrs**

Treatment Techniques: Types of impurities present, Sweetening operations for gases: Ethanolamine Treatment, Stretford Operation; Treatment of gasoline: Catalytic desulphurization; and Treatment of kerosene: Liquid SO_2 extraction of aromatics.

UNIT-IV

Catalytic Cracking: Catalytic cracking: Carbonium ion chemistry, catalysts, reaction variables; Fluid catalytic cracking - Texaco, ESSO, Kellog; Naphtha cracking; and Hydrocracking: Chemistry, catalysts, reaction conditions. **10 Hrs**

Catalytic Reforming: Chemistry, Reaction variables, catalysts, feedstock requirements.

UNIT-V

Thermal Processes: Thermal cracking: Chemistry, theory, properties of cracked materials and factors influencing the properties of cracked materials, Visbreaking, Dubb's two coil cracking. **06 Hrs**

Coking: Types of coking processes, Dubb's two coil coking, delayed coking, fluid coking

Textbooks:

1. Bhaskara Rao, Modern Petroleum Refining Processes Oxford & IBH Publication, 3rd Edition, Reprint, 1999.
2. Nelson, Petroleum Refinery Engineering - McGraw Hill, 4th Edition, Reprint, 1982.

Reference Books:

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

MOOCs and Online Courses:

1. http://nptel.ac.in/courses/103102022/1
2. https://www.mooc-list.com/tags/refining?static=true
3. https://www.class-central.com/subject/engineering

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Possess knowledge of the composition, properties, and evaluation of crude and its fractions	PO1	3
CO2	Ability to describe the properties of products and their test methods	PO2	2
CO3	Identify the pre-treatment and treatment processes for fractions of crude	PO2	3

CO4	Possess introductory knowledge of the technologies for converting crude to valuable products	PO3	2
CO5	Demonstrate the sequence of operations involved in a process	PO2	3
CO6	Acquaint with the environmental impact and the need for sustainability in refining	PO7	2

Assessment:

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

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	Polymer Processing				
Course Code	23CH6PELB3	Credits	03	L – T – P	3-0-0
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 blending and compounding for engineering application, stress – strain behaviour, practical assessment for long term behaviour (any two tests only). **06 Hrs**

UNIT-II

Polymer Extrusion: Principle and operation of single screw extruder, extruder zones, extruder screws, power calculation, co-extrusion, extrusion coating, extrusion film blowing, reactive extrusion, extrusion blow moulding, wire drawing, spinning, extrusion defects. **07 Hrs**

UNIT-III

Injection Moulding: Reciprocating screw injection moulding, single & multiple impression moulds, hot runner moulds, gates, mould clamping force calculation, thermoset and fibre reinforced polymer injection moulding, sandwich moulding, injection blow moulding and reaction injection moulding, defects of injection moulding, comparison of injection moulding and extrusion injection moulding, applications. **10 Hrs**

UNIT-IV

Compression Moulding: Principle and operation, derivation of compression mould thickness and compaction force, applications. **09 Hrs**

Transfer Moulding: Principle and operation, types of moulds, applications.

Calendaring: Principles and operation, derivation of film thickness of product and pressure required, gauge control during calendaring, applications.

UNIT-V

Thermoforming: Principle and operation, vacuum & pressure forming, derivation of thermoformed product thickness, applications. **07 Hrs**

Rotational Moulding: Principle and operation, time required for rotational moulding, applications.

Textbooks:

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

Reference Books:

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

E-Books:

1. https: //www. overdrive. com/media/105670/principles-of-polymer-processing.
2. https: //www. crcpress. com/Polymer-Processing-and-Characterization/Thomas-Ponnamma-Zachariah/9781926895154.

MOOCs and ONLINE COURSES:

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

SEE Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Possess knowledge of the principles of melt processing for thermoplastics.	PO 1	1
CO2	Demonstrate knowledge of polymer extrusion processes and defects.	PO 2	2
CO3	Understand injection moulding techniques principles and applications.	PO 2	2
CO4	Comprehend compression moulding, transfer moulding, calendaring, thermoforming and rotational moulding principles and applications.	PO 2	3

Assessment:

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

Assessment Pattern:

Component	Theory (100%)			Total Marks
	Test 1	Test 2	AAT	
Max. Marks	40	40	20	100
Reduced CIE	20	20	10	50

Course Title	Open Elective - NPTEL MOOC Online Course				
Course Code	25MC6OECHX	Credits	03	L – T – P	3-0-0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

Course Code	Name of the MOOC course
25MC6OECH1	Characterization of Polymers, Elastomers and Composites
25MC6OECH2	Polymeric Biomaterials: Structure, Properties, Function and Performance
25MC6OECH3	Introduction to Operations Research
25MC6OECH4	Cryogenic Hydrogen Technology
25MC6OECH5	Agricultural Economics

Course Title	Pre-Final Project Work				
Course Code	23CH6PCPPW	Credits	02	L – T – P	0-0-2
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

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

Course Outcomes:

Course Outcomes		Program Outcomes	Levels
CO1	Perform an extensive literature survey to understand the changes in technological trends	PO4	2
CO2	Identify a feasible method to carry out the project work by considering professional ethics of engineering practice	PO8	3
CO3	To formulate one or more methodological approach to carry out the experiments to find a feasible solution for societal and environmental problems.	PO6	3
CO4	Communicate and present/publish effectively the methodological planned to carry out the project work.	PO10	3
CO5	Develop multidisciplinary skills to work as an individual and as a member or leader in diverse team	PO9	2
CO6	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	PO12	1

Assessment:

Continuous Internal Assessments		Marks 100% (Weightage 50%)	Assessment
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
Semester End Examination (Presentation)		Marks 100 (Weightage 50%)	

Assessment Pattern:

Component	Presentation 1	Presentation 2	Report	Total Marks
Max. Marks	40	40	20	100
Reduced CIE	20	20	10	50

Course Title	Project Management and Finance				
Course Code	23CH6AEPMF	Credits	02	L – T – P	2-0-0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Economics in Engineering, Statistics and Probability

SYLLABUS:

UNIT-I

Concept of Project Management: Concept of a project, characterization of a project, project life cycle phases, concept of project management and functional management, tools and techniques for project management, roles and responsibilities of project manager, project management as a profession. **04 Hrs**

UNIT-II

Project Analysis, Selection and Financing: Resource allocation – Project initiation and need of resource allocation, Feasibility analysis - market, demand, and technical analysis. **04 Hrs**

Financing Arrangements: capital costs, working capital, and operating costs. Source of financing, financial institutions.

UNIT-III

Project Budgeting: Capital budgeting - definition, significance, limitations. Cost of capital – definition, significance, importance in capital budgeting decisions. Measurement of cost of capital – cost of debt and equity. **04 Hrs**

UNIT-IV

Risk Analysis and Performance Evaluation: Concept of time value of money, venture capital and cash flow. Risk analysis in capital decisions, project appraisal criteria. Termination & closeout responsibilities, performance indicators, project evaluation methods, post audit: phases & types, audits and audit reports, agencies for post audit. **7 Hrs**

UNIT-V

Project Scheduling: Project scheduling techniques - Work breakdown structure, Bar chart, GANT chart, project evaluation and review technique, critical path method, crashing. Problems based on PERT and CPM. **7 Hrs**

Inventory management – definition, importance, and types (ABC analysis, VED analysis, Economic order equity, EOD).

Textbooks:

1. Prassanna Chandra, "Projects", Tata McGraw Hill, 8th edition., 2014.
2. Sadhan Choudhury, "Project Management": Tata McGraw-Hill Education, 1988

Reference-Books

1. J. K. Sharma, "Operation Research" MacMillan, 4th edition., 2009.
2. Entrepreneurship Development, Colombo Plan Staff College for Technical Education, Tata Mc Graw Hill, 1998.

E-Books:

1. Principles of Project Finance by E.R. Yescombe, 1st 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 and Online Courses:

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

SEE Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Programme Outcomes	Levels
CO1	Demonstrate knowledge of management principles and recognize the responsibilities as a member and team leader.	PO9	2
CO2	Analyse the project's overall viability and communicate effectively.	PO10	2
CO3	Apply and critically evaluate theories of financial statements and related analysis.	PO11	3
CO4	Analyse and interpret the project activity network using project scheduling techniques.	PO4	3

Assessment:

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

Assessment Pattern:

Component	Theory (100%)			Total Marks
	Test 1	Test 2	AAT	
Max. Marks	40	40	20	100
Reduced CIE	20	20	10	50

Course Title	National Service Scheme -4				
Course Code	23NCMC6NS4	Credits	00	L – T – P	0 – 0 – 0
Non-Credit Mandatory Course		SEE			P/NP

Course Title	Yoga-4				
Course Code	23NCMC6YG4	Credits	00	L – T – P	0 – 0 – 0
Non-Credit Mandatory Course		SEE		P/NP	

Course Objectives:

- Promoting positive health, prevention of stress related health problems and rehabilitation through Yoga.
- Integral approach of Yoga Therapy to common ailments.
- Imparting skills in them to introduce Yoga for health to general public and Yoga for total personality development of students in Colleges and Universities.
- Invoke scientific attitude and team spirit to channelize their energies in to creative and constructive endeavours.
- To enable them to establish Yoga Therapy centres in the service of common man.

Teaching-Learning Process (General Instructions)
These are sample Strategies; which teachers can use to accelerate the attainment of the various course outcomes.

- Teachers shall adopt suitable pedagogy for effective teaching - learning process. The pedagogy shall involve the combination of different methodologies which suit modern technological tools and software to meet the present requirements of the Global employment market.
  (i) Direct instructional method (Low /Old Technology),
  (ii) Flipped classrooms (High/advanced Technological tools),
  (iii) Blended learning (combination of both),
  (iv) Enquiry and evaluation-based learning,
  (v) Personalized learning,
  (vi) Problems based learning through discussion,
  (vii) Following the method of expeditionary learning Tools and techniques,

Apart from conventional lecture methods, various types of innovative teaching techniques through videos, animation films may be adapted so that the delivered lesson can progress the students in theoretical applied and practical skills in teaching of the concepts of Health and Wellness in general.

Module-1

Introduction and Trends of Yoga

- Meaning, Definition, and Importance of Yoga
- History and Philosophical Aspects of Yoga
- Need for and Importance of Yoga in Modern World

Teaching Learning process	Chalk and talk method, PowerPoint presentation and YouTube videos, Animation videos methods. Creating real-time stations in classroom discussions. Giving activities & assignments.

Module-2

Means of Yogic Practices

- Introduction to Prayer and Its Importance
- Concept of Asana, Types and Benefits of Asana
- Concept of Pranayama, types, and benefits of Pranayama
- Concept and types of Mudras and Bandha
- Concept of Meditation and its benefits

Teaching Learning process	Chalk and talk method, PowerPoint presentation and YouTube videos, Animation videos methods. Creating real-time stations in classroom discussions. Giving activities & assignments.

Module-3

Meaning, techniques, precautions & effects of the following

- Classification of Asanas - Meditative Asanas – Relaxative Asanas – Cultural Asanas. - safety measure and precautions while performing asanas.
- Pranayama – different phases in Pranayama practices: Puraka (Inhalation), Kumbhaka (Retention) and Recaka (Exhalation), - safety measures and precautions while performing pranayama.
- Meditation - Its techniques & benefits.
- Practicing methods and benefits of Kriyas, Bandha and Mudra.

Teaching Learning process	Chalk and talk method, PowerPoint presentation and YouTube videos, Animation videos methods. Creating real-time stations in classroom discussions. Giving activities & assignments & Practical sessions.

Module-4

Application of Yoga

- Yoga for Health and Wellness
- Yoga for Aged Population
- Yoga for Otherly able population
- Yoga for Elite Sports Persons

Teaching Learning process	Chalk and talk method, PowerPoint presentation and YouTube videos, Animation videos methods. Creating real-time stations in classroom discussions. Giving activities & assignments.

Module-5

Yoga and Stress Management:

- Concept of Stress according to Yoga
- Stress Management and Relaxation Techniques
- Postural deformities and corrective measures

- Yoga and development of Social qualities of personality - Co-operation - Simplicity - Tolerance - Social adjustments - Yoga and personal efficiency. Improvement of personal efficiency through yoga

Teaching Learning process	Chalk and talk method, Demonstration and assessment method, PowerPoint presentation and YouTube videos, Animation videos methods. Creating real-time stations in classroom discussions. Giving activities & assignments.

Course outcome (Course Skill Set)

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

1. Demonstrate an understanding of anatomy and physiology as it applies to the intentional integration of breath, postures, and movement within the practice of yoga
2. Identify asana specific to their desired health benefits and create a yoga practice
3. Apply their understanding of yogic text and principles to their daily lives and yoga Practice

Books:

1. Yoga – A Healthy Way of Living" by NCERT
2. Iyengar, BKS., (2003). The Art of Yoga. New Delhi: Harper Collins Publishers.
3. Nagendra, H.R., and Nagarathana, R., (2004). Yoga perspective in stress management. Bangalore: Swami Vivekananda Yoga Prakashana.

Activity-based Learning (suggested Activities in Class)/ Practical Based learning.

- Asanas practice session, Contents related activities (Activity-based discussions)
- For active participation of students, instruct the students to prepare Flowcharts and Handouts
- Organizing Group wise discussions and Health issues-based activities.
- Quizzes and Discussions
- Seminars and assignments

Course Title	Physical Education-4				
Course Code	23NCMC6PE4	Credits	00	L – T – P	0 – 0 – 0
Non-Credit Mandatory Course		SEE		P/NP	

Module-1

Engineering Technology in Sports:

Introduction to Sports Technology, Technological innovations in sports, Use of technology in performance enhancement and analysis, Computer applications in sports

Module-2

Fitness and Healthy Lifestyle:

- Health and Safety in Daily Life at Work- Balance diet
- Yogic practice
- Aerobic Dance/Zumba

Module-3

Sports Training

- Meaning, definition, aim and objectives of sports training.
- Principles, Characteristics of sports training.
- Basic skills and techniques of the Sports/Game. (Each student shall involve in minimum 02 games).

Module-4

Ethics in Sports:

Ethics in Sports - Nature, Characteristics and Needs, Ethical practices in the field of Sports, Code of Conduct, Ethical Value System - Distributive Justice, Individual freedom of Choice, Professional Codes. Their application in the field of sports, Sports as a Profession - Conflict between organization demand, Individual needs and professional ideal, Conflicts the Sports Managers encounter, Social and Ethical - responsibilities of different Sports Association, Clubs, Manager, Coach and Sports Persons, Morale of Sportsmen- Role of Organizations I Association and Sports Manager in the area.

Module-5

Fundamental Exercise

Head, Neck and Facial Exercises, Shoulder and Chest Exercises, Abdominal, Hip and Trunk Exercises, Upper arm, lower Arm, Wrist and Finger Exercises, Thigh, Knee, Calf, Ankle and Finger Exercises

Course outcome

9. Understand fundamental concepts of physical education and sports.
10. Apply in advanced sports technology with personal accountability, integrity and social responsibility for outcome and through dynamic work-teams that uses resources efficiently.
11. Acquire fundamental theory, training methods and sports pedagogy.

12. Create a wider base of personnel to pursue various sport related careers.

Books:

1. Managing Sporting Events- Jerry Solomon (Human kinetics)
2. Managing Sports Organizations- Ruben Acosta Hernandez
3. Contemporary Sports management- Janet. B. Parks & Jerome Quarter man (Publishers Human Kinetics)
4. Bompa T. (1999). Periodization- Theory and Methodology of Training (4th ed). Champaign, Illinois: Human Kinetics.
5. Singh H (1999). Science of Sports Training. New Delhi. DVS Publication.
6. Uppal AK (1999). Sports Training. New Delhi. Friends Publication
7. Franz K. F. et. al., Editor, Routledge Handbook of Sports Technology and Engineering (Routledge, 2013)
8. Steve Hake, Editor, The Engineering of Sport (CRC Press, 1996)
9. Dixon, Sharon. The science and engineering of sport surfaces. Routledge, 2015.
10. Franz K. F. et. al., Editor the Impact of Technology on Sports II (CRC Press, 2007)
11. John Mongilo, (2001), "Nano Technology 101 "New York: Green wood publishing group.
12. Magdalinski, Tara. Sport, technology, and the body: The nature of performance. Routledge, 2009.

Activity-based Learning (suggested Activities in Class)/ Practical Based learning

- Contents and Practical related activities (Activity-based Skills practice/discussions)
- For active participation of students, instruct the students to prepare Flowcharts and Handouts
- Organizing Group wise discussions and Health issues-based activities
- Quizzes and discussions
- Seminars and assignments

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Teachers shall adopt suitable pedagogy for effective teaching - learning process. The pedagogy shall involve the combination of different methodologies which suit modern technological tools and software to meet the present requirements of the Global employment market.
    (i) Direct instructional method (Low /Old Technology),
    (ii) Flipped classrooms (High/advanced Technological tools),
    (iii) Blended learning (combination of both),
    (iv) Enquiry and evaluation-based learning,
    (v) Personalized learning,
    (vi) Problems based learning through discussion,

(vii) Following the method of expeditionary learning Tools and techniques,

- Apart from conventional lecture methods, various types of innovative teaching techniques through videos, animation films may be adapted so that the delivered lesson can progress the students in theoretical applied and practical skills in teaching of the concepts of Health and Wellness in general.

SEVENTH SEMESTER

Course Title	Process Equipment Design				
Course Code	25CH7PCPED	Credits	03	L – T – P	2-1-0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Transport Phenomena, Fluid Mechanics, Heat Transfer and Mass Transfer

SYLLABUS:

The detailed process design of the chemical engineering equipment is taught. The use of standard cod E-BOOKS and 7th Edition Perry's Chemical Engineering Handbook is to be learnt. The drawing of the respective chemical equipment shall include a sectional front view, dimensioning, and writing of the part list.

UNIT-I

Introduction: General design procedure, classification of chemical equipment, Pressure vessel codes, pressure vessel design-thickness based on internal pressure. Vessel enclosures-types and flanges-types and classification. **07+2T =09 h**

Mechanical design of process equipment:

Calculation of vessel thickness, and shell thickness based on internal & external pressure, nozzle dimensions and vessel enclosures. Numerical problems.

UNIT-II

Design of heat transfer equipment: **11+4T =15h**

Double pipe heat exchanger (DPHE): determination of liquid properties, LMTD, individual and overall heat transfer coefficient, area of heat transfer, and number of pipes.

Mechanical design: number of bends and pressure drop. Drawing of sectional front view of DPHE.

Shell and tube heat exchanger (STHE): determination of liquid properties, LMTD, individual and overall heat transfer coefficient, area of heat transfer, number of pipes, and shell diameter.

Mechanical design: details of STHE using IS 4503 code and pressure drop. Drawing of sectional front view of STHE.

Design of mass transfer equipment: **11+4T =15h**

Single effect evaporator: material and energy balance, number of tubes, diameter of down-comer, and diameter of evaporator. Drawing of sectional front view of evaporator.

Bubble cap distillation column: material balance, number of stages, length, diameter of column based on enriching and exhausting sections, and plate and bubble cap specifications.

Drawing of sectional front view of distillation column.

Textbooks:

1. Donald Q. Kern, Process Heat Transfer, McGraw Hill, 1997.
2. Robert E Treybal, Mass Transfer Operations, McGraw Hill, 1981.
3. V V Mahajani & S B Umarji, "Joshi's Process Equipment Design" – Trinity Press, Delhi, India 4th edition, 2014.

REFERENCE-Books:

1. R. H. Perry and D. W. Green, Chemical Engineering Handbook, 7th edition, McGraw Hill, 1998.
2. J. M. Coulson and J. F. Richardson, Chemical Engineering, Vol. 6, Pergamon Press, 1993.
3. Specifications for shell and tube heat exchangers, IS 4503-1967, BIS, New Delhi, 1967.
4. Code for unfired pressure vessels, IS 2825-1969, BIS, New Delhi, 1969.
5. S. D. Dawande, "Process Design of Equipment", Vol. 1, Central Techno Publications. 3rd edition, 2003.

E-Books:

1. S. D. Dawande, Process Design of Equipment, Vol. 2, 3rd edition, Central Techno Publications, 2003.
2. R. H. Perry and D. W. Green, Chemical Engineering Handbook, 7th edition, McGraw Hill, 1998.

MOOCs and Online Courses:

1. https://archive.nptel.ac.in/courses/103/107/103107207/
2. https://onlinecourses.nptel.ac.in/noc21_ch18/preview
3. https://onlinecourses.nptel.ac.in/noc21_ch52/preview

Question Paper Pattern:

1. The overall question paper pattern is to have four questions from all the units.
2. The student should answer one question from each unit.
3. Unit I will have two main questions of 20 marks each.
4. Unit II will have two full design problems for 80 marks each question selecting one heat transfer equipment and one mass transfer equipment. The student to answer anyone design problem. 15 Marks should be for drawing component.

5. Perry's Chemical Engineering Handbook, Steam Tables and IS Code 4503 for heat exchangers shall be allowed in the examination as reference.

Course Outcomes:

Course Outcomes		Programme Outcomes	Levels
CO1	Identify the data from the literature, handbooks, and code-Books:	PO2	3
CO2	Design the heat and mass transfer equipment with respect to diameter and height	PO4	3
CO3	Identify and design the accessories for heat and mass transfer equipment	PO4	2
CO4	Draft the equipment as per the calculations	PO2	2

Assessment:

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

Assessment Pattern:

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

Course Title	Biochemical Engineering				
Course Code	25CH7PCBCE	Credits	03	L – T – P	3-0-0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Biology for Engineers, Transport Phenomena and Chemical Reaction Engineering

SYLLABUS:

UNIT-I

INTRODUCTION: Bioprocess engineering and technology. Role of Chemical engineer in bioprocess industry, Classification of microorganisms based on structure, reproduction cycle, and engineering applications, Methods of enzyme production and purification. **06 hrs**

UNIT-II

PROTEINS & ENZYMES: Proteins: Types and Structure; Enzyme commission's nomenclature of enzymes, Nucleic acids- Formation & biological function, DNA structure and importance for life. **11 hrs**

KINETIC MODELS AND EQUATIONS OF ENZYME ACTION: Michaelis-Menten rate Equation-Steady state and equilibrium state, Effect of temperature, and pH on the rates of enzyme-catalyzed reactions. Experimental determination of rate parameters by: Lineweaver-Burk, Eadie-Hofstee, and Hanes-Woolf Plots.

UNIT-III

ENZYME INHIBITION: Kinetics of inhibition reactions- Competitive, non-competitive, uncompetitive, substrate and product inhibitions, Determination of kinetic parameters for various inhibitions. **11 hrs**
Inhibition Constants and Immobilization: Evaluation of inhibition Constant-Dixon method, Enzyme Immobilization-Methods of enzyme immobilization and various applications.

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. **06 hrs**

UNIT-V

FERMENTATION TECHNOLOGY: Operation and maintenance of typical aseptic aerobic fermentation processes, Sterilization of bioprocess equipment, alternate bioreactor configurations **05 hrs**

DOWNSTREAM PROCESSING: Cell disruption, Affinity chromatography, Freeze drying.

Textbooks:

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

Reference Books:

1. Biochemical Engineering by James Lee, Prentice Hall, University of Michigan, 1992.
2. Microbiology Concept and Application by Pelczer, 5th edition, McGraw Hill, 2001.
3. E-Books:
4. Biochemical Engineering and Biotechnology by Ghasem Najafpour Ghasem Najafpour, eBook ISBN: 9780080468020.
5. Biochemical Engineering by Shigeo Katoh, ISBN: 978-3-527-33804-7.

MOOC's and Online Courses:

1. https://ocw.mit.edu/courses/biological-engineering
2. http://www.online.colostate.edu/degrees/biomedical-engineering

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Programme Outcomes	Levels
CO1	Infer the industrial application of microbes in bioprocess engineering.	PO8	2
CO2	Infer the importance of biopolymers in technology development.	PO2	2
CO3	Analyze the mechanisms and effect of parameters on enzymatic reactions.	PO4	2
CO4	Establish kinetic expressions through experiential results	PO4	3
CO5	Apply and analyze inhibition and immobilization concepts with kinetics of enzyme catalyzed reaction.	PO4	3
CO6	Select bioreactors for application and perform the analytical techniques in downstream processing.	PO7	1

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%	
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	Food Engineering				
Course Code	23CH7PELC1	Credits	03	L – T – P	3-0-0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Engineering Chemistry and Technical Chemistry

SYLLABUS:

UNIT-I

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. **06 Hrs**

UNIT-II

Food Contamination and Adulteration: Types of adulterants and contaminants, Intentional adulterants, Metallic contamination, Incidental adulterants, Nature and effects, food laws and standards, Food Safety and Standards Authority of India (FSSAI), Hazard Analysis and Critical Control Points (HACCP). **06 Hrs**

Food Processing and Preservation: Food deterioration – causes, aims and objectives of preservation and processing. Types of food preservation

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; Z-value, numerical; batch & continuous retorts for thermal processing, Numerical **10 Hrs**

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 Planck's equation & Nagaoka's equation, Numerical

Non-thermal preservation: Cold sterilization: Gamma irradiation; Microwave & Ohmic heating, Pulsed Electric Field, High Pressure Processing **07Hrs**

Extrusion Processes: Introduction to extrusion, basic principles, extrusion systems, cold extrusion, extrusion cooking, single screw extruders, twin-screw extruders.

UNIT-V

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. **10 Hrs**

Packaging Concepts: Introduction to packaging, food protection, product containment, commutation, convenience, mass transfer in packaging materials, the permeability of packaging material to fixed gases, innovations in food packaging, passive packaging, active packaging, intelligent packaging, food packaging, and product shelf-life. Advances in aseptic processing and packaging, nutrition labeling.

Textbooks:

1. Introduction to Food Engineering, R. Paul Singh and Dennis R. Elsevier Science & Technology, 5th edition, ISBN: 9780123985309, 2013.

Reference Books:

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

E-Books:

1. Food Engineering 1, Gustavo V. Barbosa-Canovas & Pablo Juliano
2. http://www.eolss.net/ebooklib/ebookcontents/e5-10-themecontents.pdf
3. Food Processing, Carl J. Schaschke: http://bookboon.com/en/food-processing-ebook

MOOC's and 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

SEE Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Programme Outcomes	Levels
CO1	Identify sources of contaminants, adulterants, and hazard analysis to ensure the safe food processing.	PO7	3
CO2	Comprehend the engineering solutions involved in the packaging improvements for sustainable development of food industry.	PO7	2
CO3	Understand and infer the impact of nutritional properties of food on societal and health.	PO6	2
CO4	Discern different technological changes and recent advancements involved in food preservation	PO12	1

Assessment:

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

Assessment Pattern:

Component	Theory (100%)			Total Marks
	Test 1	Test 2	AAT	
Max. Marks	40	40	20	100
Reduced CIE	20	20	10	50

Course Title	Nanomaterials and Characterization				
Course Code	23CH7PELC2	Credits	03	L – T – P	3-0-0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Engineering chemistry, Analytical instruments, Thermodynamics.

SYLLABUS:

UNIT-I

Introduction: Nanomaterials and nanotechnology – an overview, an evolutionary perspective, material classes, structure and properties – classes of materials, internal structure of materials. **07 Hrs**

Properties of nanomaterials: Mechanical properties, thermal properties, electrical properties, magnetic properties, optical properties. Special cases – nanotubes, nanocomposites.

UNIT-II

Types of Nanostructures: Quantum wells, Quantum Wires-Carbon Nanotubes, Nanowires, Quantum Dots, Nanoclusters, Nanoparticles- Colloidal nanoparticle crystals, Functionalized nanoparticles. **10 Hrs**

Types of nanomaterials: Properties, limitations and applications - inorganic-based nanomaterials, carbon-based nanomaterials, organic-based nanomaterials, and composite-based nanomaterial.

UNIT-III

Nanomaterial Synthesis: Methods of making 0-D, 1-D, 2-D nanomaterials, Methods of making 3-D nanomaterials, Top down processes, bottom up processes. **06 Hrs**

UNIT-IV

Characterization of nanomaterials: Powder X-ray diffraction, Fourier transform infrared spectroscopy, UV-Vis-NIR spectroscopy, scanning electron microscopy, Energy dispersive spectroscopy Transmission electron microscopy, Raman spectrometry, Thermal gravimetric analysis, X-ray photo electron spectroscopy, and BET surface area analysis. **10 Hrs**

UNIT-V

Applications of Nanomaterials: Chemical sensors and mechanical sensors, drug delivery system. **06 Hrs**

Water remediation: Photocatalytic degradation of toxic dyes, heavy metal removal, and defluorination of water.

Agriculture: Nanoparticles encapsulated fertilizers and biofertilizers.

Food Industry: Food safety, food processing, and food packaging.

Textbooks:

1. Michael F. Ashby, Paulo J. Ferreira, Daniel L. Schodek, Nanomaterials, Nanotechnologies and Design – An introduction for Engineers and Architect, Elsevier, 2009.
2. A.S. Edelstein and R.C. Cammarata, Nanomaterials- Synthesis, Properties and Applications. Institute of Physics Publishing, London, 1998.

Reference Books:

1. Kourosh Kalantar-zadeh and Benjamin Fry, Nanotechnology – Enabled sensors, Springer, 2008.
2. C. N. R. Rao, H.C. mult. Achim Müller, A. K. Cheetham. The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Wiley-VCH Verlag GmbH, 2005.
3. Frank J. Owens and Charles P. Poole Jr. The Physics and Chemistry of NanoSolids, Wiley-Interscience, 2008.

MOOC's and ONLINE COURSES:

1. Nanostructures and Nanomaterials: Characterization and Properties, NPTEL Course by Kantesh Balani, Dr. Anandh Subramaniam, IIT Kanpur, https://nptel.ac.in/courses/118104008
2. Nanotechnology: Applications and Opportunities, course by Dr. Nicholas Xuanlai Fang, Massachusetts Institute of Technology, Cambridge.

SEE Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Programme Outcomes	Levels
CO1	Understand the significance and types of nanomaterials and nano characteristic properties.	PO1	3
CO2	Synthesise the nanomaterials through various synthesis routes.	PO2	3
CO3	Interpret the nanomaterial surface properties using various characterization techniques.	PO2	3
CO4	Use the nanomaterials in various fields.	PO2	2

Assessment:

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

Assessment Pattern:

Component	Theory (100%)			Total Marks
	Test 1	Test 2	AAT	
Max. Marks	40	40	20	100
Reduced CIE	20	20	10	50

Course Title	Recycle and Reuse of Waste Materials for Sustainable Development				
Course Code	23CH7PELC3	Credits	03	L – T – P	3-0-0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Engineering Chemistry and Engineering Physics,

SYLLABUS:

UNIT-I

Current Practice & Future Sustainability: Introduction to waste management and treatment; Incineration, Landfill, Zero pollution and 7Rs rule, Life cycle analysis and extended producer responsibility and Cradle-to-cradle concept**.** **06 Hrs**

UNIT-II

Cleaner Production: Promoting cleaner production, Benefits of cleaner production, Obstacles to cleaner production and solutions, Cleaner production techniques, Cleaner production opportunity assessment, Cleaner production case studies. **10 Hrs**

UNIT-III

Solid Waste Source Reduction & Recycling: Solid Waste Source Reduction; Paper Recycling, Metals Recycling, Plastics Recycling, Glass Container Recycling, Environmental Impacts and benefits of recycling. **10 Hrs**

UNIT-IV

Sustainability of Industrial Waste Management: Cement industry case study; Iron and steel industry case study; Aluminium foundries case study; petroleum sector case study; Integrated sugar industry case study. **07 Hrs**

UNIT-V

Costs & Management of Waste Facilities and Systems: Capital and Operating Costs of Facilities; Lifecycle Cost Analysis, Management Responsibilities, Pre-Consumer and Post-Consumer Recyclable Waste, Markets for Recyclables. **06 Hrs**

Textbooks:

1. Salah M. El-Haggar, Sustainable Industrial Design and Waste Management Cradle-to-cradle for Sustainable Development, 1st Edition, Elsevier Publications, 2007.
2. Charles R. Rhyner, Leander J. Schwartz, Robert B. Wenger, Mary G. Kohrell, Waste management and resource recovery, 1st Edition, CRC Press, 1999.

Reference Books:

1. C. S. Rao, Environmental Pollution Control Engineering, New Age International Publisher, 2011.
2. Richard Ian Stessel, Recycling and Resource Recovery Engineering-Principles of Waste Processing, Springer, 1996.

E-books:

1. Air Pollution by M N Rao and HV N Rao: http://www.avlib.in/ebook/title/air-pollution-mn-rao-and-hvn-rao-.html
2. https://www.free-E-BOOKS.net/ebook/introduction-to-wastewater-treatment

MOOC's and Online Courses:

1. https://sustainabledevelopment.un.org/content/dsd/csd/csd_pdfs/csd-9/learningcentre/presentations/May%209%20am/1%20-%20Learning_Centre_9May_ppt_Mohanty.pdf
2. https://nptel.ac.in/courses/120108005/module6/lecture6.pdf

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Programme Outcomes	Levels
CO1	Identify the appropriate remedial engineering conceptual design to solve the waste management problem.	PO3	2
CO2	Know the responsibility of an individual to engineer the reduction and reuse of waste for societal benefit.	PO6	1
CO3	Acquainted with the knowledge on the environmental impact of waste and know its remedial processes for sustainable development.	PO7	3
CO4	Recognize the economic impact on the cost of production by adopting "Reduce, Recycle and Reuse".	PO11	2
CO5	Implement the concept of process integration to produce value-added products that can be obtained from industrial waste.	PO7	7

CO6	Accustomed to the generation and management of waste with advances in process technology and device new waste management techniques.	PO12	2

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%	
Semester End Examination (Written Examination for Three Hours)			

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	Open Elective				
Course Code	25MC7OECHX	Credits	03	L – T – P	3-0-0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

College Course Code	Name of the course	Course Instructor	Course Link
25MC7OECH1	Technologies for Clean and Renewable Energy Production	Prof. P. Mondal	https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_ch60
25MC7OECH2	Hydrogen Energy: Production, Storage, Transpsporation & Safety	Prof. Pratibha Sharma	https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_ch76
25MC7OECH3	Physics of Renewable Energy Systems	Prof. Amreesh Chandra	https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_ph57

Course Title	Final Project Work				
Course Code	23CH7PCFPW	Credits	07	L – T – P	0– 0–7
CIE	50 marks (50% Weightage)	SEE	50 marks (50% Weightage)		

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 must 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 the 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. Students are encouraged to submit one technical paper at the end of the semester in reputed National/International journals for publications/present the paper in any national or international conference at the end of the semester.

Course Outcomes:

Course Outcomes		Programme Outcomes	Levels
CO1	Design and carry out the experiments/design/theoretical design/ simulations work in team in the predetermined methodology.	PO4	3
CO2	Analyze and interpret the obtained data for optimum solution using suitable Engineering and IT tools.	PO5	3
CO3	Elucidate the short comings and identify the scope for future work	PO12	2
CO4	Effectively communicate the project the results/write effective reports to publicize the deduce solutions.	PO10	2
CO5	Develop ability to function and to work as an individual/ as a member/leader in diverse team	PO9	3
CO6	Understand the essence and need of professional ethics during project documentation	PO8	2

Assessment:

Continuous Internal Assessments		Marks 100% (Weightage 50%)	Assessment
Practical Component	Presentation 1	40%	Committee constituted by HOD
	Presentation 2	40%	
	Report	20%	
Semester End Examination – Presentation and write-up (Weightage 50%)			

Assessment Pattern:

Component	Presentation 1	Presentation 2	Report	Total Marks
Max. Marks	40	40	20	100
Reduced CIE	20	20	10	50

Course Title	INDIAN KNOWLEDGE SYSTEMS				
Course Code	25MA7HSIKL	Credits	01	L – T – P	1– 0–0
CIE	50 marks (100% Weightage)	SEE	50 marks (100% Weightage)		

Course Learning Objectives: The students will be able to

1. To facilitate the students with the concepts of Indian traditional knowledge and to make them understand the Importance of roots of knowledge system.
2. To make the students understand the traditional knowledge and analyze it and apply it to their day-to-day life.

Unit-I 05 Hrs

Introduction to Indian Knowledge Systems (IKS): Overview, Vedic Corpus, Philosophy, Character scope and importance, traditional knowledge vis-a-vis indigenous knowledge, traditional knowledge vs. western knowledge.

Unit – II 05 Hrs

Traditional Knowledge in Humanities and Sciences: Linguistics, Number and measurements- Mathematics, Chemistry, Physics, Art, Astronomy, Astrology, Crafts and Trade in India and Engineering and Technology.

Unit -III 05 Hrs

Traditional Knowledge in Professional domain: Town planning and architecture-Construction, Health, wellness and Psychology-Medicine, Agriculture, Governance and public administration, United Nations Sustainable development goals.

COURSE OUTCOMES (COs):

Course Outcomes		Program Outcomes	Levels
CO1	Provide an overview of the concept of the Indian Knowledge System and its importance.	1, 8, 12	2, 3, 1
CO2	Appreciate the need and importance of protecting traditional knowledge.	6	2
CO3	Recognize the relevance of Traditional knowledge in different domains.	3, 4	2, 2
CO4	Establish the significance of Indian Knowledge systems in the contemporary world.	6, 7	3, 2

Reference Books

1. Introduction to Indian Knowledge System- concepts and applications, B Mahadevan, Vinayak Rajat Bhat, Nagendra Pavana R N, 2022, PHI Learning Private Ltd, ISBN-978-93-91818-21-0.

2. Traditional Knowledge System in India, Amit Jha, 2009, Atlantic Publishers and Distributors, (P) Ltd., ISBN-13: 978-8126912230.

3. Knowledge Traditions and Practices of India, Kapil Kapoor, Avadesh Kumar Singh, Vol. 1, 2005, DK Print World (P) Ltd., ISBN 81-246-0334.

Suggested Web Links:

1. https://www.youtube.com/watch?v=LZP1StpYEPM

2. http://nptel.ac.in/courses/121106003/

3.http://www.iitkgp.ac.in/department/KS;jsessionid=C5042785F727F6EB46CBF432D7683B63 (Centre of Excellence for Indian Knowledge System, IIT Kharagpur)

4. https://www.wipo.int/pressroom/en/briefs/tk_ip.html

5. https://unctad.org/system/files/official-document/ditcted10_en.pdf

6. http://nbaindia.org/uploaded/docs/traditionalknowledge_190707.pdf

7.https://unfoundation.org/what-we-do/issues/sustainable-development-goals/?gclid=EAIaIQobChMInp-Jtb_p8gIVTeN3Ch27LAmPEAAYASAAEgIm1vD_BwE

ASSESSMENT:

ASSESSMENT AND EVALUATION PATTERN		
WEIGHTAGE	**50% (CIE)**	**50%(SEE)**
QUIZZES		
Quiz-I	Each quiz is evaluated for 05 marks adding up to 10 Marks.	*****
Quiz-II		
THEORY COURSE - (Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating)		
Test – I	Each test will be conducted for 25 Marks adding upto 50 marks. Final test marks will be reduced to 20 Marks	*****
Test – II		
EXPERIENTIAL LEARNING	20	*****
Case Study-based Teaching-Learning	--	

Sector wise study & consolidation (viz., Engg. Semiconductor Design, Healthcare & Pharmaceutical, FMCG, Automobile, Aerospace and IT/ ITeS)	--	*****
Video based seminar (4-5 minutes per student)	--	
Maximum Marks for the Theory	---	50 Marks
Practical	--	--
Total Marks for the Course	50	50

EIGHTH SEMESTER

Course Title	Advanced Separation Techniques				
Course Code	23CH8PELD1	Credits	03	L – T – P	3– 0–0
CIE	50 marks (50% Weightage)	SEE	50 marks (50% Weightage)		

PREREQUISITES: Mass Transfer 1, Mass Transfer II, and Interfacial Phenomena

SYLLABUS:

UNIT I

Fundamental Concepts: Basic Separation Techniques, Separations by Phase Addition or Creation, Separations by Barriers, Separations by Solid Agents, Separations by External Field or Gradient, Separation Factor, Selection of Feasible Separations. **06 Hrs**

UNIT II

Membrane Separations: Membrane Materials, Different Membrane Shapes like flat, asymmetric or thin-film composite sheets, tubular, hollow-fiber and monolithic; Membrane Modules like plate-and-frame, spiral-wound, four-leaf, spiral-wound, hollow-fiber, tubular and monolithic; Transport in Porous Membranes, Module Flow Patterns like perfect mixing, counter-current flow, co-current flow and crossflow. **10 Hrs**

Industrial Membrane Separation Processes: Reverse Osmosis, Nanofiltration, Ultrafiltration, Microfiltration, and Dialysis: Physio chemical principles, Process Description and Applications.

UNIT III

Separations by Solid Agents: Adsorption: Industrial Applications, Adsorbents, Equilibrium Considerations, Kinetic and Transport Considerations, Equipment; Chromatography: Industrial Applications, Sorbents for Chromatography, Equilibrium considerations, Equipment. **10 Hrs**

UNIT IV

Ionic Separations: Electro dialysis, Electrophoresis, Ion exchange chromatography: Physio chemical principles, Process Description and Industrial Applications. **07 Hrs**

UNIT V

Other Techniques: Gas Permeation, Pervaporation, Supercritical fluid extraction, **06 Hrs**

Zone Melting: Physio chemical principles, Process Description and Applications.

Textbooks:

1. Separation Process Principles; J. D. Seader, Ernest J. Henley, D. Keith Roper, 3rd edition, John Wiley & Sons, Inc., 2011.
2. Separation Processes, C. J. King, Second Edition, Mc Graw Hill Chemical Engineering Series

Reference Books:

1. Handbook of Separation Process Technology, R.W. Rousseau, John Wiley and Sons
2. Encyclopaedia of Chemical Technology, Kirk-Othmer, Fifth Edition, John Wiley and Sons

E-Books:

1. Separation Process Engineering, Wankat Phillip C, Second Edition, Prentice Hall.

Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Programme Outcomes	Levels
CO1	Apply the knowledge of engineering fundamentals to utilize separation operations in chemical industries.	PO1	1
CO2	Identify membrane processes in terms of materials, modules, mechanisms of transport and industrial applications.	PO2	2
CO3	Apply contextual knowledge for the industrial application of Adsorption and Chromatography techniques.	PO6	2
CO4	Demonstrate the pursuance of sustainable development through electro-dialysis, electrophoresis, and ion-exchange chromatography techniques.	PO7	3
CO5	Illustrate Gas Permeation, Pervaporation, Supercritical fluid extraction, and Zone Melting in terms of Physio chemical principles, Process Description and Applications.	PO7	3
CO6	Differentiate the separation techniques in terms of their relative advantages, disadvantages and applicability in the context of technological changes.	PO12	2

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%	
Semester End Examination (Written Examination for 3 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	Pilot Plant and Scale-Up Studies				
Course Code	23CH8PELD2	Credits	03	L – T – P	3-0-0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

PREREQUISITES: Chemical equipment design, Process Equipment Design, Chemical Reaction Engineering-II, Fluid Mechanics, Mass transfer, and Heat Transfer

SYLLABUS:

UNIT-I

Introduction: Role of pilot plants, Major Factors in Scale–Up, Process development, Process study, Concept of prototypes, models, scale ratios and element. **06 Hrs**

UNIT-II

Principles of Similarity: Geometric similarity, Distorted similarity. Static, Dynamic, Kinematic, Thermal and Chemical similarity with examples, Dimensional Analysis and related problems, Differential equations for Heat, Mass transfer and Chemical processes. **06 Hrs**

UNIT-III

Regime Concept: Introduction, Temperature coefficient, Effect of agitation. Similarity criteria and scale equations for Static, Dynamic, Thermal and Mixed regime concepts. Criteria to decide the regimes. Extended principles of similarity. **07 Hrs**

UNIT-IV

Scale-Up of Mixing Processes: Scale-up criteria conditions and relationships for baffled mixers, immiscible liquids and gas-liquid systems. Scale up relations based on peripheral speed. **10 Hrs**

Scale-Up of Reactors: Scale-up of Stirrer slurry reactor - polymerization unit, Scale-up considerations in Tubular and Continuous Stirrer Tank Reactors

UNIT-V

Scale-Up of Mass Transfer Processes: Continuous Mass Transfer Process: Similarity criteria and Scale-up procedure for Packed towers, Distillation, Absorption, and Extraction units. **10 Hrs**

Scale Up of Fluid Flow Systems & Heat Transfer Systems: Momentum transfer, Natural and Forced convection. Scale up of Heat Transfer Equipment's – Wilson plot method.

Textbooks:

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

Reference Books:

1. Marko Zlokarnik, Scale-up in chemical engineering, Wiley-VCH, 2006
2. Colin Divall, Sean Johnston, Scaling up: The Institution of Chemical Engineers and the rise of a new profession, Springer (2000)

E-Books:

1. P. E. Burke, H. M. S. Patel, Pilot Plants and Scale-up of Chemical Processes, Volume 1, Royal Society of Chemistry, Information Services, 1997.

MOOC's and Online Courses:

1. Scale up Process Operations: https://www.icheme.org/career/training/online-training/scale-up/

SEE Question Paper Pattern:

1. Overall, the question paper pattern will have ten questions
2. Two questions from each unit.
3. Five questions to be answered, selecting one question from each unit.

Course Outcomes:

Course Outcomes		Programme Outcomes	Levels
CO1	Comprehend the concept of Pilot Plant Scale up.	PO2	3
CO2	Recognise the importance of principles of Similarity in scale up process.	PO2	2
CO3	Develop the correlation between various physical quantities involved.	PO4	3
CO4	Scale up Mixing Processes, reactors and separation processes	PO3	2
CO5	Scale up momentum, mass and heat transfer systems	PO3	3

CO6	Identify and conclude engineering limitations allied with the scale up process.	PO6	2

Assessment:

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

Assessment Pattern:

Component	Theory (100%)			Total Marks
	Test 1	Test 2	AAT	
Max. Marks	40	40	20	100
Reduced CIE	20	20	10	50

Course Title	Open Elective				
Course Code	25MC8OECHX	Credits	03	L – T – P	3 – 0 – 0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)		

College Course Code	Name of the course	Course Instructor	Course Link
25MC8OECH1	Chemical Process Safety	Prof. Shishir Sinha, IIT Roorkee	https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_ch72
25MC8OECH2	Industrial Safety Engineering	Prof. Jhareswar Maiti, IIT Kharagpur	https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_mg142

Course Title	**Internship**				
Course Code	**23CH8SRINT**	**Credits**	**06**	**L – T – P**	**0– 0–6**
CIE	**50 marks (50% Weightage)**	**SEE**	**50 marks (50% Weightage)**		

The students are expected to undergo in-plant training in any of the chemical and allied industries or in reputed research laboratories with pilot plant facilities. This shall be for a minimum period of 16- 20 Weeks before the end of the eighth semester. The student should submit a report during the eighth semester, which is evaluated by a committee constituted by the HoD for internal assessment.

Course Outcomes:

Course Outcomes		Programme Outcomes	Levels
CO1	Communicate & report the industrial practices through technical presentations.	PO10	2
CO2	Develop interpersonal relationships and work as a member in diversified areas.	PO9	3
CO3	Understand the need for engineering solutions for sustainability and environmental conservation.	PO7	3
CO4	Understand the essence and need of industrial ethics.	PO8	2
CO5	Know the role of economics and management principles in the success of industrial operations.	PO11	2
CO6	Recognize the changes in industrial practices due to technological changes and engage in lifelong learning.	PO12	2

Assessment:

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

Assessment Pattern:

Component	Presentation 1	Report	Total Marks
Max. Marks	60	40	100
Reduced CIE	30	20	50