FACULTY OF ENGINEERING

DEGREE OF BACHELOR OF TECHNOLOGY IN CHEMICAL ENGINEERING

DEPARTMENT OF CHEMICAL ENGINEERING

(REGULAR PROGRAMME)

CURRICULUM

2020-21

KARPAGAM ACADEMY OF HIGHER EDUCATION

FACULTY OF ENGINEERING

Department of Chemical Engineering

(Deemed to be University)

Established Under Section 3 of UGC Act 1956)

Pollachi Main Road, Eachanari Post, Coimbatore- 641 021, India.

PROGRAM OUTCOMES (POs)

On successful completion of the programme,

PO1	a	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
PO2	b	**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	c	**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	d	**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	e	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	f	**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	g	**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	h	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
PO9	i	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings
PO10	j	**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	k	**Project management and finance:** Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments
PO12	l	**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

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1	Graduates will apply knowledge in physics, chemistry and biology in the field of transfer processes for effective separation and purification of petrochemicals, pharmaceuticals and health care products
PSO2	Graduates will automate and control processes by applying mathematics, process control, instrumentation, simulation and process modeling

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO 1	Graduates pursue profession in chemical & allied engineering
PEO 2	Graduates will pursue higher education & research

MAPPING:

PEO \PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	a	b	c	d	e	f	G	h	i	j	k	l		
PEO1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PEO2	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓

KARPAGAM ACADEMY OF HIGHER EDUCATION

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Established Under Section 3 of UGC Act 1956)

FACULTY OF ENGINEERING

B.Tech (CHEMICAL ENGINEERING)

COURSE OF STUDY AND SCHEME OF EXAMINATION (2020 BATCH ONWARDS)

Course code	Name of the course	Category	Objectives and outcomes		Instruction hours / week			Credit(s)	Maximum Marks			Page No.
			PEOs	POs	L	T	P		CIA	ESE	Total	
SEMESTER I												
20BTCC101	English	HS	1,2	i,j,l	2	0	2	3	40	60	100	10
20BTCC102	Mathematics-I	BS	1,2	a,b,c,d,e	3	1	0	4	40	60	100	12
20BTCC103	Engineering Physics	BS	1,2	a,b,c,d,e,l	3	1	3	5	40	60	100	15
20BTCE104	Engineering Chemistry-I	BS	1,2	a,b,c,d,e,f,g,l	3	1	0	4	40	60	100	19
20BTCE105	Python Programming	ES	1,2	a,b,c,d,e	2	0	2	3	40	60	100	21
20BTCE106	Engineering Graphics and Design	ES	1,2	a,b,c,d,e,f	1	0	4	3	40	60	100	25
SEMESTER TOTAL					**14**	**3**	**11**	**22**	**240**	**360**	**600**	
SEMESTER II												
20BTCC201	Communicative English	HS	1,2	i,j,l	2	0	2	3	40	60	100	27
20BTCC202	Mathematics-II	BS	1,2	a,b,c,d,e	3	1	0	4	40	60	100	29
20BTCE203	Engineering Chemistry-II	BS	1,2	a,b,c,d,e,f,g,l	3	1	0	4	40	60	100	32
20BTCE204	Biology	BS	1,2	a,b,c,d,e,f,g,l	3	0	0	3	40	60	100	34
20BTCE205	Basic Electrical and Electronics Engineering	ES	1,2	a,b,c,d,e,f	3	1	2	5	40	60	100	36
20BTCE211	Workshop Practices	ES	1,2	a,b,c,d,e,f	0	0	4	2	40	60	100	39
20BTCE212	Engineering Chemistry lab	BS	1,2	a,b,c,d,e,f,g	0	0	4	2	40	60	100	41
SEMESTER TOTAL					**14**	**3**	**12**	**23**	**280**	**420**	**700**	
PROGRAM TOTAL (I Year)					**28**	**6**	**23**	**45**	**520**	**780**	**1300**	

Course code	Name of the course	Category	Objectives and outcomes		Instruction hours / week			Credit(s)	Maximum Marks			Page No.
			PEOs	POs	L	T	P		CIA	ESE	Total	
SEMESTER III												
20BTCE301	Mathematics III	BS	1,2	a,b,c,d,e	3	1	0	4	40	60	100	43
20BTCE302	Fluid Mechanics	PC	1,2	a,b,c,d,e,f	3	0	0	3	40	60	100	46
20BTCE303	Chemical Process Calculations	PC	1,2	a,b,c,d,e,f	3	1	0	4	40	60	100	48
20BTCE304	Mechanical Operations	PC	1,2	a,b,c,d,e,f	3	0	0	3	40	60	100	50
20BTCE305	Chemical Engineering Thermodynamics	PC	1,2	a,b,c,d,e,f,l	3	1	0	4	40	60	100	52
20BTCE311	Fluid Mechanics lab	PC	1,2	a,b,c,d,e,f	0	0	3	1.5	40	60	100	54
20BTCE312	Technical Analysis Lab	PC	1,2	a,b,c,d,e,f	0	0	3	1.5	40	60	100	55
20BTCE351	Value added course	MC	1,2	a,b,c,d,e,f,i,l	2	0	0	0	100	0	100	154
SEMESTER TOTAL					**17**	**3**	**6**	**21**	**380**	**420**	**800**	
SEMESTER IV												
20BTCE401	Heat Transfer	PC	1,2	a,b,c,d,e,f,l	3	0	0	3	40	60	100	57
20BTCE402	Mass Transfer I	PC	1,2	a,b,c,d,e,f,l	3	0	0	3	40	60	100	59
20BTCE403	Chemical Technology	PC	1,2	a,c,e,f,l	3	0	0	3	40	60	100	61
20BTCE404	Materials Technology	PC	1,2	a,c,e,f,l	3	0	0	3	40	60	100	63
20BTCE405	Universal Human values-II Understanding Harmony	HS	1,2	f,g,h,i,j,l	2	1	0	3	40	60	100	65
20BTCE406	Environmental Studies	BS	1,2	c,f,g,l	3	0	0	3	40	60	100	68
20BTCE411	Numerical Methods in Chemical Engineering	PC	1,2	a,b,c,d,e,f	2	0	2	3	40	60	100	71
20BTCE412	Mechanical Operations Lab	PC	1,2	a,b,c,d,e,f	0	0	4	2	40	60	100	74
20BTCE451	Value added course	MC	1,2	a,b,c,d,e,f,i,l	2	0	0	0	100	0	100	154
20BTCE461	Internship I	MC	1,2	a,b,c,d,e,f,g,h,i,j,k	0	0	0	0	100	0	100	--
SEMESTER TOTAL					**21**	**1**	**6**	**23**	**520**	**480**	**1000**	
PROGRAM TOTAL (II Year)					**38**	**4**	**12**	**44**	**900**	**900**	**1800**	

Course code	Name of the course	Category	Objectives and outcomes		Instruction hours / week			Credit(s)	Maximum Marks			Page No.
			PEOs	POs	L	T	P		CIA	ESE	Total	
SEMESTER V												
20BTCE501	Chemical Reaction Engineering – I	PC	1,2	a,b,c,d,e,f	3	0	0	3	40	60	100	75
20BTCE502	Mass Transfer-II	PC	1,2	a,b,c,d,e,f	3	0	0	3	40	60	100	77
20BTCE503	Professional Ethics in Engineering	HS	1,2	a,c,f,g,h	3	0	0	3	40	60	100	79
20BTCE504	Principles of Management	HS	1,2	f,g,h,i,j,k,l	3	0	0	3	40	60	100	81
20BTCE5PE--	Professional Core Elective – I	CE	1,2	a,b,c,d,e,f	3	0	0	3	40	60	100	102-109
--------	Open Elective-I	OE	1,2	a,b,c,d,e,f,l	3	0	0	3	40	60	100	134-153
20BTCE511	Heat Transfer Laboratory	PC	1,2	a,b,c,d,e,f	0	0	3	1.5	40	60	100	83
20BTCE512	Mass Transfer Laboratory	PC	1,2	a,b,c,d,e,f	0	0	3	1.5	40	60	100	84
20BTCE513	Constitution of India	HS	1,2	f,g,h,i,j,k,l	1	0	0	0	100	0	100	--
20BTCE551	Value added course	MC	1,2	a,b,c,d,e,f,i,l	2	0	0	0	100	0	100	154
SEMESTER TOTAL					**21**	**0**	**6**	**21**	**520**	**480**	**1000**	
SEMESTER VI												
20BTCE601	Chemical Reaction Engineering – II	PC	1,2	a,b,c,d,e,f	3	0	0	3	40	60	100	85
20BTCE602	Process Economics	PC	1,2	a,b,c,f,k	3	0	0	3	40	60	100	87
20BTCE603	Process Dynamics and Control	PC	1,2	a,b,c,d,e,f	3	1	0	4	40	60	100	89
20BTCE6PE--	Professional Core Elective – II	PE	1,2	a,b,c,d,e,f	3	0	0	3	40	60	100	110-117
--------	Open Elective – II	OE	1,2	a,b,c,d,e,f,l	3	0	0	3	40	60	100	134-153
20BTCE611	Process Equipment Design & Drawing	PC	1,2	a,b,c,d,e,f	2	0	2	3	40	60	100	91
20BTCE612	Chemical Reaction Engineering Laboratory	PC	1,2	a,b,c,d,e,f	0	0	4	2	40	60	100	94
20BTCE661	Mini Project	MC	1,2	a,b,c,d,e,f,g,h,i,j,k	0	0	2	1	100	0	100	--
20BTCE662	Internship II	MC	1,2	a,b,c,d,e,f,g,h,i,j,k	0	0	0	0	100	0	100	--
SEMESTER TOTAL					**17**	**1**	**8**	**22**	**480**	**420**	**900**	
PROGRAM TOTAL (III Year)					**38**	**1**	**14**	**43**	**1000**	**900**	**1900**	

Course code	Name of the course	Category	Objectives and outcomes		Instruction hours / week			Credit(s)	Maximum Marks			Page No.
			PEOs	POs	L	T	P		CIA	ESE	Total	
SEMESTER VII												
20BTCE701	Transport Phenomena	PC	1,2	a,b,c,d,e,f	3	1	0	4	40	60	100	96
20BTCE7PE--	Professional Core Elective-3	PE	1,2	a,b,c,d,e,f	3	0	0	3	40	60	100	118-133
20BTCE7PE--	Professional Core Elective-4	PE	1,2	a,b,c,d,e,f	3	0	0	3	40	60	100	118-133
--------	Open Elective-3	OE	1,2	a,b,c,d,e,f,l	3	0	0	3	40	60	100	134-153
--------	Open Elective-4	OE	1,2	a,b,c,d,e,f,l	3	0	0	3	40	60	100	134-153
20BTCE711	Simulation Lab	PC	1,2	a,b,c,d,e,f,l	0	0	3	1.5	40	60	100	98
20BTCE712	Process control Lab	PC	1,2	a,b,c,d,e,f	0	0	3	1.5	40	60	100	100
20BTCE771	Project Stage-I	PW	1,2	a,b,c,d,e,f,g,h,i,j,k	0	0	6	2	40	60	100	--
SEMESTER TOTAL					**15**	**1**	**12**	**21**	**320**	**480**	**800**	
SEMESTER VIII												
20BTCE881	Project Stage-II	PW	1,2	a,b,c,d,e,f,g,h,i,j,k	0	0	30	12	120	180	300	101
SEMESTER TOTAL					**0**	**0**	**30**	**12**	**120**	**180**	**300**	
PROGRAM TOTAL (IV Year)					**15**	**1**	**42**	**33**	**440**	**660**	**1100**	
PROGRAM TOTAL					**119**	**12**	**91**	**165**	**2860**	**3240**	**6100**	

TOTAL CREDITS = 165

LIST OF PROFESSIONAL CORE ELECTIVES

PROFESSIONAL CORE ELECTIVE-I

Course code	Name of the course	Category	Objectives and out comes		Instruction hours / week			Credit(s)	Maximum Marks			Page No,
			PEOs	POs	L	T	P		CIA	ESE	Total	
SEMESTER V												
20BTCE5PE01	Fertilizer Technology	PE	1,2	a,b,e,f,g	3	0	0	3	40	60	100	102
20BTCE5PE02	Polymer Technology	PE	1,2	a,b,e,f,g	3	0	0	3	40	60	100	104
20BTCE5PE03	Nanotechnology	PE	1,2	a,b,e,f,g	3	0	0	3	40	60	100	106
20BTCE5PE04	Petroleum Refining Engineering	PE	1,2	a,b,e,f,g	3	0	0	3	40	60	100	108

PROFESSIONAL CORE ELECTIVE II

Course code	Name of the course	Category	Objectives and out comes		Instruction hours / week			Credit(s)	Maximum Marks			Page No.
			PEOs	Pos	L	T	P		CIA	ESE	Total	
SEMESTER VI												
20BTCE6PE01	Fluidization Engineering	PE	1,2	a,b,c,d,e	3	0	0	3	40	60	100	110
20BTCE6PE02	Biochemical Engineering	PE	1,2	a,b,c,d,e,f,g	3	0	0	3	40	60	100	112
20BTCE6PE03	Instrumental Methods of Analysis	PE	1,2	a,b,c,d,e	3	0	0	3	40	60	100	114
20BTCE6PE04	Corrosive Engineering	PE	1,2	a,b,e,f,g	3	0	0	3	40	60	100	116

PROFESSIONAL CORE ELECTIVE III & IV

Course code	Name of the course	Category	Objectives and out comes		Instruction hours / week			Credit(s)	Maximum Marks			Page No.
			PEOs	POs	L	T	P		CIA	ESE	Total	
SEMESTER VII												
20BTCE7PE01	Computational Fluid Dynamics	PE	1,2	a,b,c,d,e	3	0	0	3	40	60	100	118
20BTCE7PE02	Modern Separation Techniques	PE	1,2	a,b,c,d,e	3	0	0	3	40	60	100	120
20BTCE7PE03	Process Modelling and Simulation	PE	1,2	a,b,c,d,e	3	0	0	3	40	60	100	122
20BTCE7PE04	Process Optimization	PE	1,2	a,b,c,d,e	3	0	0	3	40	60	100	124
20BTCE7PE05	Energy Technology	PE	1,2	a,b,c,d,e,f,g	3	0	0	3	40	60	100	126
20BTCE7PE06	Water Conservation and Management	PE	1,2	a,b,c,d,e,f,g,k	3	0	0	3	40	60	100	128
20BTCE7PE07	Process Safety and Hazardous Engineering	PE	1,2	a,b,c,d,e,f,g	3	0	0	3	40	60	100	130
20BTCE7PE08	Pollution control in Process Industries	PE	1,2	a,b,c,d,e,f,g	3	0	0	3	40	60	100	132

LIST OF OPEN ELECTIVES

COURSE OFFERED BY OTHER DEPARTMENT

Course code	Name of the course	Category	Objectives and outcomes		Instruction hours / week			Credit(s)	Maximum Marks			Page No.
			PEOs	POs	L	T	P		CIA	ESE	Total	
SCIENCE AND HUMANITIES												
20BTSHOE01	Solid Waste Management	OE	1,2	a,b,c,d,e,f,g	3	0	0	3	40	60	100	134
20BTSHOE02	Green Chemistry	OE	1,2	a,b,c,d,e,f,g	3	0	0	3	40	60	100	136
20BTSHOE03	Applied Electrochemistry	OE	1,2	a,b,c,d,e,f,g	3	0	0	3	40	60	100	138
BIOTECHNOLOGY												
20BTBTOE01	Bioreactor Design	OE	1,2	a,b,c,d,e,f,g	3	0	0	3	40	60	100	140
20BTBTOE02	Food Processing and Preservation	OE	1,2	a,b,c,d,e,f,g	3	0	0	3	40	60	100	142
ELECTRONICS AND COMMUNICATION ENGINEERING												
20BEECOE01	Neural Networks and Its Applications	OE	1,2	a,b,c,d,e	3	0	0	3	40	60	100	144
FOOD TECHNOLOGY												
20BTFTOE03	Ready to Eat Foods	OE	1,2	a,b,c,d,e,f,g	3	0	0	3	40	60	100	146
20BTFTOE04	Agricultural Waste and Byproducts Utilization	OE	1,2	a,b,c,d,e,f,g	3	0	0	3	40	60	100	148
MECHANICAL ENGINEERING												
20BEMEOE01	Computer Aided Design	OE	1,2	a,b,c,d,e	3	0	0	3	40	60	100	150
20BEMEOE02	Industrial Safety And Environment	OE	1,2	a,b,c,d,e,f,g	3	0	0	3	40	60	100	152

Semester-I

20BTCC101	**ENGLISH**	**4H-3C**

Instruction Hours/week: L:2 T:0 P:2 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Enable students to attain fluency and accuracy to inculcate proficiency in professional communication to meet the growing demand in the field of Global communication.
- Help students acquire their ability to speak effectively in real life situations.
- Inculcate the habit of reading and to develop their effective reading skills.
- Ensure that students use dictionary to improve their active and passive vocabulary.
- Enable students to improve their lexical, grammatical and communicative competence.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Use English language for communication: verbal & non –verbal.
- Enrich comprehension and acquisition of speaking & writing ability.
- Gain confidence in using English language in real life situations.
- Improve word power: lexical, grammatical and communication competence.
- Guide the students to write business letters and other forms of technical writing.
- Enable students to prepare for oral communication in formal contexts.

UNIT I BASIC WRITING SKILLS

Sentence Structures - Use of phrases and clauses in sentences - Importance of proper punctuation - Creating coherence- Organizing principles of paragraphs in documents - Techniques for writing precisely

UNIT 1I VOCABULARY BUILDING

The concept of Word Formation - Root words from foreign languages and their use in English - Acquaintance, with prefixes and suffixes from foreign languages in English to form derivatives. - Synonyms, antonyms, and standard abbreviations.

UNIT III GRAMMAR AND USAGE

Subject-verb agreement - Noun-pronoun agreement - Misplaced modifiers – Articles – Prepositions – Redundancies - Clichés

UNIT IV LISTENING AND READING SKILLS

Note taking- viewing model interviews – listening to informal conversations – improving listening / reading comprehension – reading model prose / poems – reading exercise

UNIT V WRITING PRACTICES

Comprehension - Précis Writing - Essay Writing Listening Comprehension - Common Everyday Situations: Conversations and Dialogues - Communication at Workplace – Interviews - Formal Presentations

Note: Students shall have hands on training in improving listening skill in the language laboratory @ 2 periods per each unit.

Total: 60 hours

SUGGESTED READINGS:

1. Sangeeta Sharma, Meenakshi Raman, .(2015),Technical Communication: Principles And Practice, 2nd Edition, OUP, New Delhi.
2. Sanjay Kumar and PushpLata, (2011), Communication Skills ,Oxford University Press.
3. Liz Hamp - Lyons and Ben Heasly, (2006), Study Writing, Cambridge University Press
4. F.T. Wood., (2007), Remedial English Grammar, Macmillan.
5. Michael Swan, (1995). Practical English Usage, OUP.

Semester-I

20BTCC102	**MATHEMATICS -I**	**4H-4C**

Instruction Hours/week: L:3 T:1 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Develop the use of matrix algebra techniques that is needed by engineers for practical applications.
- Understand geometrical aspects of curvature and elegant application of differential calculus which are needed in engineering applications.
- Make the student acquire sound knowledge of techniques in solving ordinary differential equations that model engineering problems.
- Familiarize the student with functions of several variables this is the foundation for many branches of engineering.
- Introduce sequence and series which is central to many applications in engineering?
- Apply differentiation to solve maxima and minima problems which is a foundation course which mainly deals with a single variable.

COURSE OUTCOME (COs)

Upon completion of the course, students will be able to

- Solve the rank, Eigen values and eigenvectors, diagonalization of a matrix, Symmetric matrices and the students will be able to use matrix algebra techniques for practical applications.
- Have basic knowledge and understanding in one field of materials, differential calculus
- Solve simple standard examples using the ideas of differential equations.
- Apply various techniques to solve Partial Differential Equations
- Develop the tool of power series for learning advanced Engineering Mathematics.
- Apply the knowledge acquired to solve various engineering problems.

UNIT I MATRICES

Introduction - Characteristic equation – Eigenvalues and Eigenvectors of a real matrix – Properties – Cayley-Hamilton theorem (excluding proof) – Orthogonal transformation of a symmetric matrix to diagonal form – Quadratic forms – Reduction to canonical form through orthogonal reduction. Simple problems using Scilab.

UNIT II DIFFERENTIAL CALCULUS

Overview of Derivatives - Curvature in Cartesian co-ordinates – Centre and radius of curvature – Circle of curvature – Evolutes – Envelopes- Evolutes as Envelope of normals

UNIT III DIFFERENTIAL EQUATIONS

Linear Differential equations of second and higher order with constant coefficients – Homogeneous equation of Euler's and Legendre's type – Method of variation parameters.

UNIT IV FUNCTIONS OF SEVERAL VARIABLES

Partial derivatives- Homogeneous functions and Euler's theorem - Total derivative - Differentiation of implicit functions - Jacobians -Partial differentiation of implicit functions- Taylor's series for functions of two variables- Errors and approximations - Maxima and minima of functions of two variables- Lagrange's method of undetermined multipliers.

UNIT V SEQUENCES AND SERIES

Sequences: Definition and examples – **Series:** Types and Convergence – Series of positive terms – Tests of convergence: Comparison test, Integral test and D'Alembert's ratio test – Alternating series – Leibnitz's test – Series of positive and negative terms – Absolute and conditional convergence.

Total: 60 hours

SUGGESTED READINGS:

1. Grewal B.S., (2014), Higher Engineering Mathematics, 43rd Edition, Khanna Publishers, New Delhi.
2. Erwin Kreyszig, (2016), Advanced Engineering Mathematics, 10th Edition, John Wiley, India.
3. Bali N.P. and Manish Goyal, (2014), A text book of Engineering Mathematics, Laxmi Publications, New Delhi, India.
4. Veerarajan T**,** (2008), Engineering Mathematics for first year,Tata McGraw-Hill, New Delhi,.
5. Ramana B.V**,** (2010), Higher Engineering Mathematics, 11th Reprint, Tata McGraw Hill New Delhi.
6. Hemamalini. P.T**,** (2014), Engineering Mathematics**,** McGraw Hill Education (India) Private Limited, New Delhi.
7. Thomas G.B and. Finney R.L**,** (2002), Calculus and Analytic geometry, 9th Edition,Pearson**,**.
8. Michale D. Greenberg, (2011), Advanced Engineering Mathematics, 2nd Edition, Books Pearson Education, First Indian reprint.
9. Peter V. O'Neil, (2012), Advanced Engineering Mathematics, 7th Edition, Cengage learning.
10. Gilbert Strang, (2009), Introduction to Linear Algebra, 4th Edition, Wellesley-Cambridge Press.

WEBSITES

1. www.efunda.com
2. www.mathcentre.ac.uk
3. www.intmath.com/matrices-determinants
4. www. Intmath.com/calculus/calculus-intro.php

Semester-I

20BTCC103 **ENGINEERING PHYSICS (Theory and Lab)** **7H-5C**

Instruction Hours/week: L:3 T:1 P:3 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

(1) THOERY
COURSE OBJECTIVES

The goal of the course is for the students to

- Inculcate the basics of properties of matter and its applications.
- Study the basics of laser and optical fiber with appropriate applications.
- Disseminate the fundamentals of thermal physics and their applications.
- Introduce the concepts of quantum mechanics for diverse applications.
- Impart the basic knowledge of crystal and its various crystal structures.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Identify the elastic nature of materials.
- Infer the characteristics of laser for various engineering applications.
- Extend the knowledge on optical fiber for communication purposes.
- Illustrate the thermal properties of materials through various methods.
- Develop the idea of quantum mechanics through applications.
- Identify the different atomic arrangements of crystals ad its defects.

UNIT I PROPERTIES OF MATTER AND SOUND

Elasticity – basic definitions, stress - strain diagram - factors affecting elastic modulus and tensile strength – Poisson's ratio – Twisting couple - Torsion pendulum- bending of beams – bending moment – young's modulus – cantilever method, uniform and non-uniform bending – I- shaped girders.

Loudness, decibel, echo, reverberation, Sabine's formula, Ultrasonic – Production, Industrial and medical applications.

UNIT II LIGHT, LASER AND FIBER OPTICS

Light – interference – reflection, refraction – Air wedge - LASER- Principle – characteristics -

emission and absorption process - Einstein's coefficients derivation. Types of LASER - Nd:YAG, CO_2, Semiconductor LASER- Applications of LASER in industry and medicine.

Fiber optics: Total internal reflection – modes of propagation of light in optical fibers – numerical aperture and acceptance angle – types of optical fibers (Material, refractive index and mode) – fiber optical communication system (block diagram) - Fiber optic sensors: pressure and displacement.

UNIT III THERMAL PHYSICS

Introduction– thermal expansion of solids and liquids – expansion joints – bimetallic strips – Mode of heat transfer - heat conductions in solids – thermal conductivity – derivation, Phonons - Forbe's and Lee's disc method: theory and experiment – conduction through compound media (series and parallel) – thermal insulation – applications: heat exchangers, refrigerators, ovens and solar water heaters.

UNIT IV QUANTUM PHYSICS

Merits of quantum theory, Demerits of classical theory – Black body radiation, Photo electric effect – Compton scattering: experimental description, dual nature of matter and radiation – de Broglie wavelength, uncertainty principle – Schrödinger's wave equation – time dependent and time independent equations – particle in one dimensional box- physical significance of wave function, Scanning Electron Microscope, Transmission Electron Microscope.

UNIT V CRYSTAL PHYSICS

Crystalline materials – types - unit cell, primitive cell, intercepts, interfacial angle - crystal systems, Bravais lattices, Miller indices – determination of inter-planar distances - Coordination number and packing factor for SC, BCC, FCC, HCP structures-crystal imperfections: point defect, line defect, surface and volume defect. Crystal growth techniques: Czochralski and Bridgman method.

Total: 60 hours

SUGGESTED READINGS:

1. Bhattacharya D.K. & Poonam T., Engineering Physics, Oxford University Press, 2015.
2. Gaur R.K. and Gupta S.L, Engineering Physics, Dhanpat Rai Publications, 2012.
3. Pandey .B.K. & Chaturvedi .S, Engineering Physics, Cengage Learning India, 2012.
4. Halliday.D., Resnick R. & Walker. J, Principles of Physics, Wiley, 2015.
5. Charles Kittel, Kittel's Introduction to Solid State Physics, Wiley India Edition, 2019.
6. P.M. Mathews, K.Venkatesan, A text book of Quantum Mechanics, 2/e, Mc Graw Hill Education, 2017.
7. Laser Fundamentals, William T Silfvast, Cambridge Univ Press. 2012.
8. Fiber Optics and Optoelectronics, R P Khare, Oxford, 2012.
9. Daniel V.Schroeder, An Introduction to Thermal Physics, Pearson, 2014.

10. D.S. Mathur, Elements of properties of matter, S.Chand, 2010.

JOURNALS

1. Nature Physics.
2. Journal of Applied Mechanics (ASME).
3. Ultrasonics and sonochemistry (Elsevier).
4. Journal of Light wave Technology (IEEE).
5. Optics and Laser Technology (Elsevier).
6. Applied Thermal Engineering (Elsevier).
7. Physical Review B (American Physical Society).

WEBLINKS

1. https://nptel.ac.in/courses/122/103/122103011/
2. https://nptel.ac.in/courses/113/104/113104081/
3. http://hyperphysics.phy-astr.gsu.edu/hbase/optmod/lascon.html

(II) Laboratory

COURSE OBJECTIVES

The goal of the course is for the students to

- Learn the basic concepts in physics relevant to different branches of Engineering and Technology.

COURSE OUTCOME (COs)

Upon completion of the course, students will be able to

- Familiarize the properties of material and basic concepts in physics.

LIST OF EXPERIMENTS – PHYSICS (Any 10 Experiments)

1. Torsional pendulum – Determination of rigidity modulus of wire and moment of inertia of disc
2. Uniform bending (or) Non-uniform Bending – Determination of young's modulus.
3. Viscosity of liquids-Determination of co-efficient of viscosity of a liquid by Poiseuille's flow .

4. Ultrasonic interferometer – determination of the velocity of sound and compressibility of liquids.
5. Laser- Determination of the wave length of the laser using grating, Acceptance angle of optical fiber.
6. Spectrometer- Determination of wavelength using grating.
7. Air wedge – Determination of thickness of a thin sheet/wire.
8. Lee's disc – Determination of thermal conductivity.
9. Determination of Band gap of a semiconductor.
10. Potentiometer – Determination of thermo emf of a thermo couple.
11. Characteristics of photo diode.
12. Particle size determination using LASER.

Total: 45 hours

Semester-I

20BTCE104	**ENGINEERING CHEMISTRY –I**	**4H-4C**

Instruction Hours/week: L:3 T:1 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Understand the terminologies of quantum theory of chemical systems.
- Study about various chemical bonding
- Understand the stereochemistry of molecules.
- Understand the thermodynamic functions.
- Comprehend the basic organic chemistry and to synthesis simple drug.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Appreciate quantum theory of chemical systems.
- Appreciate aliphatic chemistry
- Describe the concepts of stereochemistry
- Write simple mechanisms
- Synthesis of organic molecules
- Integrate the chemical principles in the projects undertaken in field of engineering and technology

UNIT I INTRODUCTION TO QUANTUM THEORY FOR CHEMICAL SYSTEMS

Schrodinger equation, Applications to Hydrogen atom, Atomic orbitals, many electron atoms

UNIT II CHEMICAL BONDING IN MOLECULES

MO theory, Structure, bonding and energy levels of bonding and shapes of many atom molecules, Coordination Chemistry, Electronic spectra and magnetic properties of complexes with relevance to bio-inorganic chemistry, organometallic chemistry

UNIT III INTRODUCTION TO STEREOCHEMISTRY

Stereo descriptors – R, S, E, Z. Enantiomers and Diastereomers. Racemates and their resolution. Conformations of cyclic and acyclic systems.

UNIT IV REACTIVITY OF ORGANIC MOLECULES

Factors influencing acidity, basicity, and nucleophilicity of molecules, kinetic vs. thermodynamic control of reactions

UNIT V STRATEGIES FOR SYNTHESIS OF ORGANIC COMPOUNDS

Reactive intermediates substitution, elimination, rearrangement, kinetic and thermodynamic aspects, role of solvents

Total: 60 hours

SUGGESTED READINGS:

1. B. H. Mahan, (2010), University chemistry, Pearson Education,
2. K. P. C. Volhardt and N. E. Schore, 5th Edition, Organic Chemistry: Structure and Function, W.H. Freeman, (2014)
3. B. L. Tembe, (2009), Kamaluddin and M. S. Krishnan, Engineering Chemistry (NPTEL Web-book)
4. Robert Neilson Boyd, Saibal Kanti Robert Thornton Morrison, Organic Chemistry, Pearson;7 edition
5. Michael B. Smith & Jerry March,,(2006)Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Wiely..
6. Arun Bahl and BS Bahl, (2014) AdvancedOrganic Chemistry, S Chand.

Semester-I

20BTCE105 **PYTHON PROGRAMMING** **4H-3C**

(Theory and Lab)

Instruction Hours/week: L:2 T:0 P:2 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

(i) THEORY

COURSE OBJECTIVES

The goal of the course is for the students to

- Describe the core syntax and semantics of Python programming language.
- Discover the need for working with the strings and functions.
- Illustrate the process of structuring the data using lists, dictionaries, tuples and sets.
- Indicate the use of regular expressions and built-in functions to navigate the file system.
- Infer the Object-oriented Programming concepts in Python.
- Students will solve problems, explore real-world software development challenges, and create practical and contemporary applications.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Explain various operators used in python.
- Apply the string handling functions to solve the given problem
- Describe Object oriented concepts with python
- Use image processing techniques in python programming to solve a given problem
- Discuss the functions of networking in python
- Solve a given analogy

UNIT I INTRODUCTION

Installing Python; basic syntax, interactive shell, editing, saving, and running a script variables, assignments; immutable variables; numerical types; arithmetic operators and expressions; comments in the program; understanding error messages;

UNIT II CONDITIONAL STATEMENT & STRING HANDLING

Conditions, Boolean logic, logical operators; ranges; Control statements: if-else, loops (for, while); short-circuit (lazy) evaluation – Manipulating files and directories, os and sys modules; text files: reading/writing text and numbers from/to a file; creating and reading a formatted file (csv or tab-separated). String manipulations: subscript operator, indexing, slicing a string; strings and number system: converting strings to numbers and vice versa. Binary, octal, hexadecimal numbers.

UNIT III OBJECT ORIENTED PROGRAMMING WITH PYTHON

Classes and OOP: classes, objects, attributes and methods; defining classes; design with classes, data modeling; persistent storage of objects – OOP, continued: inheritance, polymorphism, operator overloading; abstract classes; exception handling, try block

UNIT IV IMAGE PROCESSINGWITH PYTHON

Design with functions: hiding redundancy, complexity; arguments and return values; formal vs actual arguments, named arguments. Program structure and design. Recursive functions Simple Graphics and Image Processing: "turtle" module; simple 2d drawing – colors, shapes; digital images, image file formats, image processing Simple image manipulations with 'image' module (convert to b/w, rayscale, blur, etc).

UNIT V NETWORKINGWITH PYTHON

Multithreading, Networks, and Client/Server Programming; introduction to HTML, interacting with remote HTML server, running html-based queries, downloading pages; CGI programming, programming a simple CGI form.

Total: 30 hours

SUGGESTED READINGS:

1. Shroff ,"Learning Python: Powerful Object-Oriented Programming: 5th Edition, Fifth edition (24 July 2013)
2. Timothy A. Budd 'Exploring Python' – TATA McGRAW-HILL Edition - 2011
3. Vamsi Kurama , "Python Programming: A Modern Approach", Pearson Education, 2018.
4. "Python Essential Reference". Addison-Wesley Professional; 4 edition (July 19, 2009) by David M.Baezly
5. "Python Cookbook" O'Reilly Media; 3rd edition (June 1, 2013) by David M. Baezly.

6. Guido Van Rossum, Fred . L. Drake 'Introduction to Python' – Network Theory Limited – March 2011

7. Alex Martelli 'Python in a Nutshell' - O'Reilly - 2nd Edition, 2006

WEBSITES:

1. https://www.codecademy.com/learn/python

2. www.learnpython.org/

(II) LABORATORY

PYTHON PROGRAMMING

COURSE OBJECTIVES

The goal of the course is for the students to

- Write, test, and debug simple Python programs.
- Implement Python programs with conditionals and loops.
- Use functions for structuring Python programs.
- Represent compound data using Python lists, tuples, and dictionaries.
- Read and write data from/to files in Python.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to:

- Write, test, and debug simple Python programs.
- Implement Python programs with conditionals and loops.
- Develop Python programs step-wise by defining functions and calling them.
- Use Python lists, tuples, dictionaries for representing compound data.
- Read and write data from/to files in Python.

LIST OF EXPERIMENTS:

1. Compute the GCD of two numbers.
2. Find the square root of a number (Newton's method)
3. Exponentiation (power of a number)
4. Find the maximum of a list of numbers
5. Linear search and Binary search
6. Selection sort, Insertion sort

7. Merge sort
8. First n prime numbers
9. Multiply matrices
10. Programs that take command line arguments (word count)
11. Find the most frequent words in a text read from a file
12. Simulate elliptical orbits in Pygame
13. Simulate bouncing ball in Pygame

Total: 30 hours

Semester-I

20BTCE106 **ENGINEERING GRAPHICS AND DESIGN** **5H-3C**

Instruction Hours/week: L:1 T:0 P:4 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Prepare the students to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- Prepare the students to communicate effectively and to use the techniques, skills, and modern engineering tools necessary for engineering practice

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Understand the engineering drawing and its place in society.
- Expose the visualization of engineering drawing and engineering graphics standards.
- Expose the engineering communication.

UNIT I INTRODUCTION

Principles of Engineering Graphics and their significance, usage of Drawing instruments, lettering, Bureau of Indian Standards (BIS), Layout of drawing sheets, sizes of drawing sheets, different types of lines used in drawing practice geometric constructions, principles of dimensioning– linear, angular, aligned system, unidirectional system, parallel dimensioning, chain dimensioning, location dimension and size dimension. Reducing Scale, Enlarging Scale, Plain Scale, Diagonal Scale and Vernier Scale. Conic sections including the Ellipse, Parabola and Hyperbola (eccentricity method only); Cycloid, Epicycloid, Hypocycloid and Involute.

UNIT II FREE HAND SKETCHING

Representation of Three-Dimensional objects – General principles of orthographic projection – Need for importance of multiple views and their placement – First angle projection – layout views – Developing visualization skills through free hand sketching of multiple views from pictorial views of objects.

UNIT III INTRODUCTION TO COMPUTER GRAPHICS – 2D

Overview of Computer Graphics, listing the computer technologies that impact on graphical communication, Demonstrating knowledge of the theory of CAD software [such as: The Menu System, Toolbars, Drawing Area, Dialog boxes and windows, Shortcut menus ,The Command Line (where applicable), Select and erase objects.; Isometric Views of lines, Planes, Simple and compound Solids]; consisting of set up of the drawing page and the printer, including scale settings, Setting up of units and drawing limits; ISO and ANSI standards for coordinate dimensioning and tolerancing; Orthographic constraints, Snap to objects manually and automatically; Producing drawings by using various coordinate input entry methods to draw straight lines, Annotations, layering & other functions.

UNIT IV PROJECTION OF POINTS, LINES AND PLANE SURFACES

Projection of points and straight lines located in the first quadrant inclined to both planes– Determination of true lengths and true inclinations. Projection of polygonal surface and circular lamina inclined to both reference planes

UNIT V ISOMETRIC PROJECTIONS

Principles of Isometric projection – Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple solids, truncated prisms, pyramids, cylinders and cones; Conversion of Isometric Views to Orthographic Views and Vice-versa

Total: 75 hours

SUGGESTED READINGS:

1. Venugopal K and Prabhu Raja V, (2015), Engineering Graphics, New Age International Publishers.
2. C M Agrawal and Basant Agrawal, (2012), Engineering Graphics, Tata McGraw Hill, New Delhi.
3. James D. Bethune, (2019), Engineering Graphics with AutoCAD, Macromedia Press.
4. Narayana, K.L. & P Kannaiah, (2010), Text book on Engineering Drawing, Scitech Publishers.
5. Shah, M.B. & Rana B.C., (2010), Engineering Drawing and Computer Graphics, Pearson Education.
6. Bhatt N.D., Panchal V.M. & Ingle P.R, (2014), Engineering Drawing, Charotar Publishing House.

Semester-II

20BTCC201	**COMMUNICATIVE ENGLISH**	**4H-3C**

Instruction Hours/week: L:2 T:0 P:2 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Help students acquire their ability to speak effectively in real life situations.
- Enable students to communicate in effective way without any barriers.
- Inculcate the habit of listening and to develop their effective listening skills.
- Ensure that students use different aids in order to attain effective communication.
- Enable students to improve their group behavior and presentation skill.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Enrich comprehension and acquisition of listening, speaking & writing ability.
- Gain confidence in using English language and develop leadership qualities.
- Guide the students to effectively manage the team as a team player.
- Develop the students Interpersonal and Interview skills.
- Use English language for communication: verbal & non –verbal
- Enable students to prepare for oral communication in formal contexts.

UNIT I COMMUNICATION SKILLS

Communication Skills: Introduction, Definition, The Importance of Communication

The Communication Process – Source, Message, Encoding, Channel, Decoding Receiver, Feedback, Context

Barriers to Communication: Physiological Barriers, Physical Barriers, Cultural Barriers, Language Barriers, Gender Barriers, Interpersonal Barriers, Psychological Barriers, Emotional Barriers

Perspectives in Communication: Introduction, Visual Perception, Language, Other factors affecting our perspective-Past Experiences, Prejudices, Feelings, Environment

UNIT 1I ELEMENTS OF COMMUNICATION

Introduction, Face to Face Communication- Tone of Voice, Body Language (Non-verbal communication), Verbal Communication, Physical Communication.

Communication Styles: Introduction, The Communication Styles Matrix with example for each - Direct Communication Style, Spirited Communication Style, Systematic Communication Style, Considerate Communication Style.

UNIT III BASIC LISTENING SKILLS

Introduction, Self-Awareness, Active Listening, Becoming an Active Listener, Listening in Difficult Situations.

Effective Written Communication: Introduction, When and When Not to Use Written Communication-Complexity of the Topic, Amount of Discussion's Required, Shades of Meaning, Formal Communication.

Writing Effectively: Subject Lines, Put the Main Point First, Know Your Audience

Organization of the Message.

UNIT IV INTERVIEW SKILLS AND GIVING PRESENTATIONS

Purpose of an interview, Do's and Don'ts of an interview- Dealing with Fears, planning your Presentation, Structuring Your Presentation, Delivering Your Presentation, Techniques of Delivery.

UNIT V WRITING PRACTICES

Group Discussion: Introduction, Communication skills in group discussion, Do's and Don'ts of group discussion

Note: Students shall have hands on training in improving Speaking skill in the language laboratory @ 2 periods per each unit.

Total: 60 hours

SUGGESTED READINGS:

1. SanjayKumar, Pushpalata, (2011), Communication skills, 1st Edition Oxford Press.
2. Konarnira, (2011), Communication Skills for professionals, 2nd Edition New arrivals.
3. John Adair, 4th Edition, (2009), . Effective communication, 1st Edition Cengage Learning India pvt.ltd
4. Butter Field, (2011), Soft skill for everyone, Macmillan

Semester-II

20BTCC202	**MATHEMATICS -II**	**4H-4C**

Instruction Hours/week: L:3 T:1 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Acquaint the student with mathematical tools needed in evaluating multiple integrals and their usage.
- Calculate and establish identities connecting these quantities, to evaluate line, surface and volume integrals in simple coordinate systems and to use Gauss, Stokes and Greens theorems to simplify calculations of integrals and prove simple results.
- Enable the students to apply the knowledge of Mathematics in various Engineering fields by making them to identify the functions in engineering problems as analytic function and their study as a function of a complex variables.
- Develop an understanding of the standard techniques of complex variable theory so as to enable the student to apply them with confidence, to specify some difficult integration that appear in applications can be solved by complex integration in application areas such as fluid dynamics and flow of the electric current.
- Use Laplace transforms efficiently for solving the problems that occur in various branches of engineering disciplines.

COURSE OUTCOMES (COs)

Upon completion of the course the students will be able

- apply integration to compute multiple integrals, area, volume, integrals in polar and Cartesian coordinates, in addition to change of order and vector integration.
- Acquaint the student with the concepts of vector calculus, needed for problems in all Engineering disciplines
- Find the Analytic functions using the Cauchy Riemann equations and they will learn mapping properties of elementary functions and mapping properties of some special transcendental functions.
- Understand relations between conformal mappings and quadratic differentials and how geometric structures are changing under conformal mappings.

- Evaluate complex integrals using the Cauchy integral formula and the residue Theorem and to appreciate how complex methods can be used to prove some important theoretical results.
- Evaluate Laplace transform and inverse transform of simple functions, properties, various related theorems and application to differential equations with constant coefficients

UNIT I MULTIPLE INTEGRALS

Double integral – Cartesian coordinates – Polar coordinates – Area as double integrals -Change of order of integration – Triple integration in Cartesian co-ordinates

UNIT II VECTOR CALCULUS

Gradient, Divergence and Curl – Directional derivative – Irrotational and Solenoidal vector fields – Vector integration – Green's theorem, Gauss divergence theorem and Stoke's theorems (Statement Only)- Surfaces: hemisphere and rectangular parallelopipeds.

UNIT III ANALYTIC FUNCTIONS

Analytic functions - Cauchy-Riemann equations in Cartesian and polar forms – Sufficient condition for an analytic function (Statement Only) - Properties of analytic functions – Constructions of an analytic function - Conformal mapping: w = z+a, az, 1/z and bilinear transformation.

UNIT IV COMPLEX INTEGRATION

Complex Integration - Cauchy's integral theorem and integral formula (Statement Only) – Taylor series and Laurent series - Residues – Cauchy's residue theorem (Statement Only) - Applications of Residue theorem to evaluate real integrals around unit circle and semi circle (excluding poles on the real axis).

UNIT V LAPLACE TRANSFORM

Transforms of elementary functions – Basic properties – Transforms of derivatives and integrals – Initial and final value theorems. Inverse Laplace transforms – Convolution theorem (statement only) – Solution of Ordinary Differential Equations with constant coefficients using Laplace transforms – Transform of periodic functions.

Total: 60 hours

SUGGESTED READINGS:

1. Grewal, B.S., (2014), Higher Engineering Mathematics Khanna Publishers, New Delhi, 43rd Edition.
2. Kreyszig Erwin, (2016), Advanced Engineering Mathematics , John Wiley and Sons, 10th Edition, New Delhi.

3. Bali N. P and Manish Goyal, (2011), A Text book of Engineering Mathematics, Eighth Edition, Laxmi Publications Pvt Ltd.
4. Ramana B.V, (2008), Higher Engineering Mathematics, Tata McGraw Hill Publishing Company, New Delhi.
5. Kandasamy. P, Thilagavathy. K, Gunavathy. K., (2008), Engineering Mathematics, S Chand & Co. Ltd, New Delhi.
6. Hemamalini. P.T**,** (2014), Engineering Mathematics**,** McGraw Hill Education (India) Private Limited, New Delhi.
7. Venkataraman, M. K., (2005), Engineering Mathematics, The National Publishing Company, Chennai.
8. Dass, H.K., and Er. Rajnish Verma, (2011), Higher Engineering Mathematics, S. Chand Private Ltd.
9. Glyn James, (2012), Advanced Modern Engineering Mathematics, 3rd Edition, Pearson Education,
10. Peter V. O'Neil, (2012), Advanced Engineering Mathematics, 7th Edition, Cengage learning.
11. Sastry.S.S, (2014), Engineering Mathematics''. Vol.I&II, PHI Learning Pvt. Ltd, 4th Edition, New Delhi.
12. Wylie, R.C. and Barrett. L.C., (2012), Advanced Engineering Mathematics, Tata McGraw Hill Education Pvt. Ltd, 6th Edition, New Delhi.
13. Narayanan. S, Manicavachagam pillay.T.K and Ramaniah, (2002),Advanced Mathematics for Engineering Students, Viswanathan S.(Printers and Publishers) Pvt. Ltd. Chennai.

WEBSITES:

1. www.intmath.com
2. www.efunda.com
3. www.mathcentre.ac.uk
4. www.sosmath.com/diffeq/laplace/basic/basic.html

Semester-II

20BTCE203	**ENGINEERING CHEMISTRY-II**	**4H-4C**

Instruction Hours/week: L:3 T:1 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Understand the basic chemical reactions.
- Understand the mechanism of chemical reactions.
- Understand the mechanism of lubricants.
- Study about the nature of oils and fat.
- Understand about the dye pigments

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Apply the various unit process
- Extend the principles of reaction mechanisms
- Apply the knowledge on chemical reactions
- Analyses the effect of pigments
- Integrate the chemical principles in the projects undertaken in field of engineering and technology

UNIT I UNIT PROCESSES

Nitration, Sulphonation, Halogenation, Esterification, Amination, Saponification and Hydrogenation – Role of the above unit processes in such industries as petroleum, drugs, pharmaceuticals and organic synthesis.

UNIT II REACTION MECHANISMS

Free radical, substitutions, electrophilic, addition, aromatic electrophilic substitutions, nucleophilic additions, condensation reactions, nucleophilic substitutions in aliphatic and aromatic compounds, cyclo-additions, rearrangements-Beckmann and Fries rearrangement reactions.

UNIT III OILS, FATS, SOAPS & LUBRICANTS

Chemical constitution, Chemical analysis of oils and fats – acid, saponification and iodine values, Definitions, determinations and significance. Definition, mechanism of lubrication, preparation of petrolubes, desirable characteristics – viscosity, viscosity index, carbon residue, oxidation stability, flash and fire points, cloud and pour points, aniline point. Semisolid lubricant – greases, preparation of sodium, lithium, calcium and axle greases and uses, consistency test and drop point test. Solid lubricants – graphite and molybdenum disulphide.

UNIT IV CHEMICALS AND AUXILIARIES

Preparation, properties and uses of bleaching powder, sodium hypochlorite, hydrogen peroxide, chlorine dioxide. Estimation of available chlorine in hypochlorite bleach liquor. Determination of strength of hydrogen peroxide.

UNIT V COLORANTS

Theory of color and constitution: chromophore and auxochrome, classification of dyes based on application. Chemistry and synthesis of azo dye (Methyl red, Methyl orange and Congo red).

Total: 60 hours

SUGGESTED READINGS:

1 Dhara S. S (2016), A Text Book of Engineering Chemistry, S. Chand & Co. Ltd., NewDelhi
2 Jain. P.C and Monica Jain (2012), Engineering Chemistry, DhanpetRai& Sons, New Delhi
3 ShikhaAgarwal (2015), Engineering Chemistry-Fundamentals and Applications, CambridgeUniversity Press, Delhi
4 W.L. McCabe, J.C. Smith and P. Harriot (2005), Unit Operations of Chemical Engineering,7Edition, McGraw Hill Education
5 B.K. Sharma(2011), Industrial chemistry, Krishna Prakashan Media (P) Ltd, Meerut
6 Shore J (2002), Colourants and Auxiliaries: Volume II Auxiliaries, Wood head Publishing Ltd
7 Shenai V. A(1995), Chemistry of Dyes and Principles of Dyeing, Sevak Publications, Mumbai
8 Trotman E. R(1994), Dyeing and Chemical Technology of Textile Fibres, B.I Publishing Pvt. Ltd, New Delhi

Semester-II

20BTCE204	**BIOLOGY**	**3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Understand the basics of biology such as cell structure and functions
- Understand the inheritance & evolution, basic concepts of genetics and microbiology
- Introduce students to the principles of Microbiology to emphasize structure and biochemical aspects of various microbes.
- Solve the problems in microbial infection and their control

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Students will get insight into biology as a science, outlining the diversity, organization and fundamental principles of living systems.
- Recognize the comparison of prokaryotic and eukaryotic cell structures.
- Define the characteristics of living things
- Understand the patterns of Inheritance

UNIT I BASICS

Diversity of life, prokaryotes and eukaryotes, basic cell constituents and Macromolecules , Comparison of Prokaryotic and Eukaryotic Cell Structures, Patterns of Inheritance, Fundamentals of Life Origins, Biochemical Cycles, The Role of Chemistry in Biology

UNIT II BIOCHEMISTRY

Metabolism (Catabolism and Anabolism) and Bioenergetics Structure and properties of Carbohydrates (mono, di, oligo & polysaccharides) Proteoglycans, glucosaminoglycans. mutarotation, glycosidic bond, reactions of monosaccharides, reducing sugars. Starch, glycogen, cellulose and chitin. Proteoglycans, glycosaminoglycans. Hyaluronic acid, chondroitin sulfate

UNIT III GENETICS

Basic principles of Mendel, molecular genetics, structure and function of genes and chromosomes, Transcription and Translation, gene expression and regulation. Transformation, Transduction, Conjugation – mapping, fine structure mapping in merozygotes plasmids and episomes

UNIT IV CELL BIOLOGY

Macromolecules, membranes, organelles, cytoskeleton, signaling, cell division, differentiation, motility. Prokaryotic, Eukaryotic cells, Sub-cellular organelles and functions. Principles of membrane organization membrane proteins, cytoskeletal proteins. Extra cellular matrix, cell-cell junctions.

UNIT V MICROBIOLOGY

host-microbe interactions, physiology, ecology, diversity, and virology Basics of microbial existence; history of microbiology, classification and nomenclature of microorganisms, microscopic examination of microorganisms, light and electron microscopy;principles of different staining techniques like gram staining, acid fast, capsular staining, flagellar staining

Total: 45 hours

SUGGESTED READING:

1. Presscott, S.C. and Cecil G. Dunn, "Industrial Microbiology", Agrobios (India), 2005.
2. Strickberger, M.W., "Genetics", 3rd Edition, Prentice Hall of India, New Delhi, 2008
3. K.G.Ramawat & Shaily Goyal, Comprehensive Biotechnology, 2009, S.Chand publications
4. Page, M.I. and Andrew Williams "Organic and Bio-organic Mechanisms". Pearson, 2010
5. Lodish, Harvey etal., "Molecular Cell Biology", 7th Edition, W.H.Freeman, 2005
6. Biology NPTEL https://nptel.ac.in/courses/122103039/

Semester-II

20BTCE205 BASIC ELECTRICAL & ELECTRONICS ENGINEERING 6H-5C

(Theory and Lab)

Instruction Hours/week: L:3 T:1 P:2 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

(1) THOERY

COURSE OBJECTIVES

The goal of the course is for the students to

- Impart the basic knowledge about the Electric circuits.
- Understand the concept of Electro Mechanical Energy Conversion and Transformers.
- Understand the working of Semiconductor devices and Measuring Instruments.
- Impart the basic knowledge of Digital Circuits.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Attributing the electric circuits with DC and AC excitation by applying various circuit laws.
- Attributing the magnetic circuits and transformer.
- Reproduce the two port networks.
- Evaluate the various digital circuits in real time applications.
- Analysis various semiconductor devices in real time applications.
- Reproduce the Measuring Instruments.

UNIT I DC CIRCUITS

Electrical circuit elements (R, L and C), voltage and current sources, Kirchoff current and voltage laws, analysis of simple circuits with dc excitation. Superposition, Thevenin and Norton Theorems.

UNIT II AC CIRCUITS

Representation of sinusoidal waveforms, peak and rms values, phasor representation, real power, reactive power, apparent power, power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel), resonance. Three phase balanced circuits, voltage and current relations in star and delta connections.

UNIT III ELECTRICAL MACHINES AND TRANSFORMER

Construction and working of a three-phase and Single-phase induction motor. Construction, working and speed control of DC motor. Magnetic materials, BH characteristics, Construction and working principle of ideal and practical transformer.

UNIT IV SEMICONDUCTOR DEVICES AND DIGITAL ELECTRONICS

Bipolar Junction Transistor – Characteristics. Introduction to operational Amplifier –Model– Applications. Number systems – binary codes - logic gates - Boolean algebra, laws & theorems

UNIT V MEASURING INSTRUMENTS AND ELECTRICAL INSTALLATION

Principle, construction, and operation of moving coil and moving iron meters-Measurement of Power. Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, RCCB, MCCB. Earthing. Types of Batteries and its application in Electric Vehicle, Important Characteristics for Batteries. Elementary calculations for energy consumption and battery back up

Total: 60 hours

SUGGESTED READINGS:

1. S.K.Bhattacharya, "Basic Electrical Engineering", Pearson, 2019.
2. E. Hughes, "Electrical and Electronics Technology", Pearson, 2010.
3. P. Kothari and I. J. Nagrath, "Basic Electrical Engineering", Tata McGraw Hill, 2010.
4. VN Mittle and Arvind Mittal,(2006) ,Basic Electrical Engineeering, McGraw Hill.
5. A.Sudhaka and Shyammohan S Palli,(2013), Circuits and Networks, McGraw Hill.
6. R.Muthusubramanian and S.Salivahanan,(2014),Basic Electrical and Electronics Engineering, McGraw Hill.

WEBSITES:

1. www. nptel.ac.in.
2. encyclopedia-magnetica.com/doku.php/coenergy.
3. https://en.wikibooks.org/wiki/electronics/measuring instruments.

(II) LABORATORY

COURSE OBJECTIVES

The goal of the course is for the students to

- Impart the basic knowledge about the DC and AC Electric circuits.
- Understand the working of DC Machines and Energy Meter.
- Impart the knowledge of Logical digital circuits and their differences.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Understand and analyze basic electric and magnetic circuits.
- Understand and analyze the working principles of DC Machines and Energy Meter.
- Verify the truth table of Logic Gates.

List of Experiments

1. Experimental verification of electrical circuit problems using Ohms law
2. Experimental verification of electrical circuit problems using Kirchoff's Voltage law.
3. Experimental verification of electrical circuit problems using Kirchoff's Current law.
4. Measurement of electrical quantities – voltage, current, power & power factor in R load.
5. Measurement of energy using single phase energy meter.
6. Speed control of DC Shunt Motor.
7. Verification of truth table of Logic Gates.

Total: 30 hours

Semester-II

20BTCE211	**WORKSHOP PRACTICES**	**4H-2C**

Instruction Hours/week: L:0 T:0 P:4 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Prepare to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- Prepare to communicate effectively and to use the techniques, skills, and modern engineering tools necessary for engineering practice

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Upon completion of this course, the students will gain knowledge of the different manufacturing processes which are commonly employed in the industry, to fabricate components using different materials.
- Students will be able to fabricate components with their own hands.
- They will also get practical knowledge of the dimensional accuracies and dimensional tolerances possible with different manufacturing processes.
- By assembling different components, they will be able to produce small devices of their interest.

(i) Lectures & videos:

Detailed contents

1. Manufacturing Methods- casting, forming, machining, joining, advanced manufacturing methods
2. CNC machining, Additive manufacturing
3. Fitting operations & power tools
4. Electrical &Electronics
5. Carpentry
6. Plastic molding, glass cutting
7. Metal casting

8. Welding

(ii) Workshop Practice:

1. Machine shop
2. Fitting shop
3. Carpentry
4. Electrical & Electronics
5. Welding shop
6. Casting
7. Plumbing Exercises

Total: 60 hours

SUGGESTED READINGS:

1. Gowri S, Jeyapoovan, T.,Engineering Practices Lab Manual, 5th edition, Vikas Publishing House Pvt. Ltd, Chennai. 2017.
2. Bawa, H.S, Workshop Practice, 2nd edition, Tata McGraw – Hill Publishing Company Limited, New Delhi, 2009.
3. Choudhry S K, Elements of workshop technology, Vol 2, 13th edition, Indian book distributing company, Kolkatta, 2010.
4. D K Singh, Manufacturing Technology, 2nd edition, Pearson Education, 2008.
5. Kalpakjian S., Steven S. Schmid, Manufacturing Engineering and Technology, 4th edition,Pearson Education India Edition, 2001.
6. Roy A. Lindberg, Processes and Materials of Manufacture, 4th edition, Prentice Hall India, 1997.
7. Rao P.N., Manufacturing Technology, Vol. I and Vol. II, 4th edition, Tata McGrawHill House, 2018.

Semester-II

20BTCE212 **ENGINEERING CHEMISTRY LABORATORY** **4H-2C**

Instruction Hours/week: L:0 T:0 P:4 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Comprehend the basic organic chemistry
- Synthesis simple drug
- Provide practical knowledge of quantitative analysis of materials by classical and instrumental methods for developing experimental skills in building technical competence.

COURSE OUTCOMES (COS)

Upon completion of the course, students will be able to

- List steps for identifying simple organic compounds
- Use different analytical instruments
- Identify reaction rate parameters

About 10 experiments to illustrate the concepts learnt in Engineering Chemistry-I, Engineering Chemistry-II

Suitable number of experiments from the following categories:

1. Identification of an organic compounds through group detection, physical constants (m.p and b.p)
2. Synthesis of organic compounds involving reactions such as hydrogenation, oxidation, esterification, etc.
3. Use of analytical instruments for characterization and identification of compounds
4. Measurements of kinetics of simple reactions
5. Determination of surface tension and viscosity
6. Determination of Sodium Carbonate and Sodium Hydrogen Carbonate in a mixture using volumetric titration

7. Determination of Ca / Mg using complexometric titration
8. Determination of chloride content of water
9. Determination of Dissolved oxygen in water / waste water
10. Determination of the rate constant of a reaction
11. Conductometry - Determination of cell constant and conductance of solutions
12. pH Metry – Determination of Acid / Base
13. Potentiometry - determination of redox potentials and emfs
14. Saponification/acid value of an oil
15. Determination of the partition coefficient of a substance between two immiscible liquids
16. Effect of Adsorption of chemicals by charcoal
17. Use of the capillary viscometers to demonstrate of the isoelectric point as the pH of minimum viscosity for gelatin sols and/or coagulation of the white part of egg.
18. Synthesis of organic compounds involving reactions such as hydrogenation, oxidation, esterification, etc.

Total: 60 hours

Semester-III

20BTCE301	**MATHEMATICS -III**	**4H-4C**

Instruction Hours/week: L:3 T:1 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Introduce the basic concepts of PDE for solving standard partial differential equations.
- Introduce Fourier series analysis which is central to many applications in Engineering apart from its use in solving boundary value problems.
- Acquaint the student with Fourier series techniques in solving heat flow problems used in various situations.
- Acquaint the student with Fourier transform techniques used in wide variety of situations.
- Introduce the effective mathematical tools for the solutions of partial differential equations that model several physical processes and to develop Z transform techniques for discrete time systems.

COURSE OUTCOME (COs)

Upon completion of the course, students will be able to

- Apply the basic concepts of fluid mechanics and to solve dimensional analysis problems.
- Solve the given standard partial differential equations.
- Solve differential equations using Fourier series analysis which plays a vital role in engineering applications.
- Appreciate the physical significance of Fourier series techniques in solving one and two dimensional heat flow problems and one dimensional wave equations.
- Apply the mathematical principles of transforms and partial differential equations would provide them the ability to formulate and solve some of the physical problems of Engineering.
- Use the effective mathematical tools for the solutions of partial differential equations by using Z transform techniques for discrete time systems.
- Equip themselves in the transform techniques and solve partial differential equations

UNIT I PARTIAL DIFFERENTIAL EQUATIONS

Formation of partial differential equations – Singular integrals - Solutions of standard types of first order partial differential equations - Lagrange's linear equation - Linear partial differential equations of second and higher order with constant coefficients of both homogeneous and non homogeneous types.

UNIT II FOURIER SERIES

Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series – Half range cosine series – Complex form of Fourier series – Parseval's identity – Harmonic analysis.

UNIT III APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS

Classification of PDE – Method of separation of variables - Fourier Series Solutions of one dimensional wave equation – One dimensional equation of heat conduction – Steady state solution of two dimensional equation of heat conduction.

UNIT IV FOURIER TRANSFORMS

Statement of Fourier integral theorem – Fourier transform pair – Fourier sine and cosine transforms – Properties – Transforms of simple functions – Convolution theorem – Parseval's identity.

UNIT V Z - TRANSFORMS AND DIFFERENCE EQUATIONS

Z-transforms - Elementary properties – Inverse Z-transform (using partial fraction and residues) – Initial and final value theorems - Convolution theorem - Formation of difference equations – Solution of difference equations using Z - transform.

Total: 60 hours

SUGGESTED READINGS

1. Grewal B.S., "Higher Engineering Mathematics", 43rd Edition, Khanna Publishers, New Delhi, 2014.
2. Dass, H.K., and Er. Rajnish Verma," Higher Engineering Mathematics", S. Chand Private Ltd., 2011.
3. Vasishtha A.K , Gupta R K, Integral Transforms, Krishna Prakashan Media, 2016.
4. Bali. N.P and Manish Goyal, "A Textbook of Engineering Mathematics", 9th Edition, Laxmi Publications Pvt. Ltd, 2014.
5. Erwin Kreyszig, "Advanced Engineering Mathematics ", 10th Edition, John Wiley, India, 2016.
6. James, G., "Advanced Modern Engineering Mathematics", 5th Edition, Pearson Education, 2012.

7. Ramana. B.V., "Higher Engineering Mathematics", McGraw Hill Education Pvt. Ltd, New Delhi, 2016.
8. Wylie, R.C. and Barrett, L.C., “Advanced Engineering Mathematics “Tata McGraw Hill Education Pvt. Ltd, 6th Edition, New Delhi, 2012.
9. Glyn James, “Advanced Modern Engineering Mathematics”, Pearson Education, New Delhi, 2007.
10. Peter V. O’Neil,” Advanced Engineering Mathematics”, 7th Edition, Cengage learning, 2012.

WEBSITES

1. www.sosmath.com
2. http://mathworld.wolfram.com/FourierSeries.html
3. http://www.math.umn.edu/~olver/pdn.html
4. http://www.facstaff.bucknell.edu/mastascu/econtrolhtml/sampled/sampled.html
5. www. nptel.ac.in

Semester-III

20BTCE302	**FLUID MECHANICS**	**3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Understand the mechanics of fluids (fluid statics and fluid dynamics), relevant to Chemical Engineering operations.
- Introduce fundamental aspects of fluid flow behavior
- Develop steady state mechanical energy balance equation for fluid flow systems
- Estimate the pressure drop in fluid flow systems and measurement of flow rates

COURSE OUTCOME (COs)

Upon completion of the course, students will be able to

- Apply the basic concepts of fluid mechanics and to solve dimensional analysis problems.
- Solve problems related to mass, momentum and energy balances in fluid flow..
- Design fluid flow reactors and solve problems on fluid flow measurements.
- Estimate the pump efficiency, head developed and pressure drop.

UNIT I BASIC CONCEPTS

Definition of a fluid – Shear stress in a moving fluid – Compressible and incompressible fluids – Newtonian and non Newtonian fluids - continuum concept of a fluid - properties of fluids - viscosity - compressibility - bulk modulus. Statics of fluid systems-pressure - variation of pressure vertically in a fluid under gravity -General equation for the variation of pressure due to gravity in a static fluid - manometers: U-tube, differential and inclined manometers. Dimensional analysis and its applications in fluid flow.

UNIT II FLUID DYNAMICS

Fluid flow - basic concepts - Reynolds experiment - laminar and turbulent flows - nature of turbulence. Basic concepts of Boundary layer. Equation of continuity and its applications - momentum equations - Euler's equation of motion -Bernoulli's theorem and its applications

UNIT III INCOMPRESSIBLE FLUID FLOW

Flow in conduits -Shear stress distribution in a cylindrical tube -Friction factor-Fanning's equation -Applications -Laminar flow in pipes -Hagen Poiseuille equation -Velocity distribution for laminar and turbulent flows -Losses due to sudden expansion and sudden contraction -Losses in pipe fittings.

UNIT IV FLUIDISED AND PACKED BEDS

Flow through packed beds - Ergun equation and Kozeny - Carman equation. Equation for one dimensional motion - Fluidisation- Mechanism of fluidisation - Types of fluidization- Pressure drop in fluidized beds - Minimum fluidisation velocity.

UNIT V HYDRAULIC PUMPS AND PIPE FITTINGS

Pipes, Fittings and valves - Pumps, Fans, Compressors and Blowers – Positive displacement pumps - Centrifugal pumps - NPSH and cavitation - Pump calculations - Constant and variable head flow meters.

Total: 45 hours

SUGGESTED READINGS

1. McCabe. W.L.,Smith. J C., Harriot. P.,Unit operations of Chemical Engineering, McGraw Hill, Seventh Edition, 2017
2. Douglas.J.F.,Gasiorek. J.M., Swaffielf. J.A., Fluid Mechanics, Sixth Edition, 2011.
3. Hughes. F., John A Brighton and Nicholas Winowich, Schaum's Outline of Fluid Dynamics, Third Edition 2009.
4. Ranald.V.Giles, Cheng Liu and Jack Evett, Schaum's outline of Fluid Mechanics and Hydraulics, Fourth Edition 2010.
5. Sulzer Pumps Ltd, Centrifugal pump Handbook, Third edition, Winterthur, Switzerland, 2010
6. Fluid Mechanics: https://nptel.ac.in/courses/103104043/

Semester-III

20BTCE303	**CHEMICAL PROCESS CALCULATIONS**	**4H-4C**

Instruction Hours/week: L:3 T:1 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Understand the fundamental concepts and calculations of process calculation
- Perform mass balance calculations on existing processes (involving single and multiple units).
- Use basic, applied chemistry/ thermodynamics in material balance calculations.
- Understand the various heats and their calculations related to chemical reactions.
- Understand the fuels and combustion calculation, proximate and ultimate analysis

COURSE OUTCOME (COs)

Upon completion of the course, students will be able to

- Apply the principles of dimensional homogeneity to convert one form of unit to other equivalent forms and apply fundamental gas laws to solve ideal gas problems.
- Calculate the composition of a mixture in terms of mole fractions from a given composition expressed in terms of mass fractions or vice versa.
- Compute the concentration, degree of saturation and dew point of vapor -gas mixture at the given temperature and pressure using humidity chart.
- Formulate steady state material balance for the unit operations such as distillation, evaporation, mixing, extraction, drying and crystallization processes with recycle, by-pass and purge.
- Practice the combined steady state material and Energy balance for simple processes like distillation, evaporation and combustion.

UNIT I MASS RELATIONS AND IDEAL GASES

Units and dimensions: Basic and derived units - Different ways of expressing units and quantities, Conversion of units. Properties of pure substances - Ideal gas laws. Mole fractions and partial pressures - Application of Dalton's and Amagat's law.

UNIT II HUMIDITY AND SATURATION

Definition of dry, wet bulb temperature - relative and percentage saturation, Dew point - humid heat, adiabatic saturation curve - Humidity Charts. Solubility and Crystallization - Recovery of crystals from solutions by crystallization - Calculations based on material balance. Henry's laws. Concept of Vapour pressure, Raoult's law and its applications, vapour pressure plots and effect of temperature on vapour pressure.

UNIT III MATERIAL BALANCE WITH CHEMICAL REACTIONS

Concept of limiting and excess reactants, Concepts of tie elements, recycle, by-pass and purge. Batch, stage-wise and continuous operations. Principles of Stoichiometry, Concept of limiting, excess reactants and inerts, fractional and percentage conversion, fractional yield and percentage yield, selectivity, related problems.

UNIT IV MATERIAL BALANCE WITHOUT CHEMICAL REACTIONS

Drying, mixing and evaporation, Elementary treatment of material balances involving bypass, recycle and purging, Psychometric, Humidification and dehumidification. Material balance in systems without chemical reactions, Material balance in systems with Recycle

UNIT V ENERGY BALANCE

Definition of Heat capacity and Specific heat, Heat capacity of gases as a function of temperature, Mean heat capacity, heat capacity of mixture of gases. Heat capacities of solids and liquids - Kopp's rule and Trouton's rule. Standard heat of reaction, formation and combustion, Hess's law of heat summation and its application to determine heat of reaction, heat of neutralization, heat of mixing.

Total: 60 hours

SUGGESTED READINGS

1. Bhatt, B.I. and Thakore, S.B., Stoichiometry, Fifth Edition, Tata-McGraw Hill, New Delhi, 2010.
2. Narayanan. K.V. and Lakshmikutty.B., Stoichiometry and Process Calculations, Second Edition, Prentice-Hall of India, New Delhi, 2016.
3. David M. Himmelblau, Basic Principles and Calculations in Chemical Engineering, Eighth Edition, Prentice -Hall of India, New Delhi, 2012.
4. Hougen, O.A., Watson, R.M. and Ragatz, R.A., Chemical Process Principles - Part I, Second Edition, John Wiley (ISE), 2016.
5. Chemical Process Calculations https://nptel.ac.in/courses/103/103/103103165/

Semester-III

20BTCE304 **MECHANICAL OPERATIONS** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Impart the basic concepts of mechanical operations
- Develop an understanding of size analysis, size reduction, and solid handling
- Understand mechanical separation methods such as filtration, sedimentation, transportation of solids and associated equipment used for achieving these methods
- Expose to basic theory, calculations, and machinery
- Involved in various solid handling operations

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Characterize particles and perform size reduction and size analysis of particles
- Identify conveyors & storage vessels for particular applications
- Explain the principle, construction and operation of various classification equipments
- Apply the principles of agitation and mixing
- Evaluate the parameters of filtration

UNIT I PROPERTIES OF PARTICULATE SOLID AND SIZE REDUCTION

Forces employed for size reduction of solids. Types of crushers, grinders and disintegrators for coarse, intermediate, fine and ultrafine grinding. Cutting machines. Size reduction operation - Power requirements - Laws of comminution. Open and closed circuit grinding. Industrial applications of size reduction equipment's. Shape factor of particulate solids. Standard sieves and sieve scales. Differential and cumulative analysis - Plotting of sieve analysis data. Specific surface area determination - Calculation of particle size from sieve analysis data. Industrial screening equipment's. Screen effectiveness.

UNIT II MIXING AND AGITATION

Types of Mixers and mixing equipments for liquids, pastes, rubber and plastic materials and for dry powders. Power consumption in mixers. Equipment for blending and kneading, dispersion, power for agitation, correlations. Properties, handling and mixing of particulate solids: Characterization of solid particles, properties of particulate masses, storage of solids and mixing of solids, types of mixers, mixers for non-cohesive solids and mixers for cohesive solids. Criteria for mixing of Solids - Mixing Index – Scale up of agitator design.

UNIT III SIZE SEPARATION BY SETTLING ANDSEDIMENTATIONMETHODS

Drag on spherical and non-spherical particles, Terminal settling velocity under laminar and turbulent conditions (Stokes' law and Newton's law). Size separation by settling methods - Free settling and Hindered settling. Equipments - Settling chambers, classifiers, jigging and Tabling. Theory of Sedimentation. Types of Thickeners - Batch and Continuous. Applications of batch sedimentation tests for design of continuous thickeners.

UNIT IV FILTRATION AND CENTRIFUGAL SEPARATION

Batch and continuous filtration equipments. Theories of filtration and washing. Compressibility of filter cakes. Filter media and Filter aids. Industrial filtration practice. Centrifugal filtration, Centrifugal settling, Centrifugal sedimentation and centrifugal clarification.

UNIT V TRANSPORTATION, STORAGE AND RECOVERY OF FINE PARTICLE

Mechanical and pneumatic conveying equipment's. Storage of solids - Angle of repose and angle of internal friction. Pressures in bins - Janssen equation. Gas cleaning methods - Cyclone separators, Bag filters, Scrubbers and electrostatic precipitators. Dense Media Separation (DMS), Flotation process -Separation by Magnetic and Impingement methods.

Total: 45 hours

SUGGESTED READINGS

1. McCabe. W.L., Smith. J. C., Harriot. P.,Unit Operations of Chemical Engineering, Seventh Edition, McGraw-Hill, New York, 2017.
2. Badger. W.L., Banchero. J.T., Introduction to Chemical Engineering, McGraw Hill (ISE), 2007.
3. Perry. R. H., Green. D. W., Perry's Chemical Engineer's Handbook, Eighth Edition, McGraw- Hill, New York, 2007.
4. Narayanan. C.M., Bhattacharyya. B.C., Mechanical Operation for Chemical Engineers (Incorporating Computer Aided Analysis), Khanna Publisher, Third Edition, 2005
5. Mechanical Operations https://nptel.ac.in/courses/103/103/103103155/

Semester-III

20BTCE305 CHEMICAL ENGINEERING THERMODYNAMICS 4H-4C

Instruction Hours/week: L:3 T:1 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Learn PVT behaviour of fluids, laws of thermodynamics
- Understand the nature and role of the following thermodynamic properties of matter :internal energy, enthalpy, entropy, temperature, pressure and specific volume
- Access thermodynamic property data from appropriate sources
- Chart thermodynamic processes on appropriate thermodynamic diagrams, such as a temperature-entropy or pressure-volume diagram
- Recognize and understand the different forms of energy and restrictions imposed by the first law of thermodynamics on conversion from one form to another

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Apply thermodynamic concepts and the laws of thermodynamics to various systems and processes
- Resolve thermodynamic competence of different energy associated processes
- Gauge the properties of ideal and real mixtures based on thermodynamic ethics
- Establish changes in the properties of fluids undergoing changes in temperature and volume
- Explain the effects of Compression at different work environment

UNIT I LAWS OF THERMODYNAMICS

Laws of Thermodynamics Laws of Thermodynamics: Basic concepts; Zeroth l aw; First Law - applications to non-flow and flow processes; Second Law - heat engines, Carnot cycle and theorem, Entropy calculations; Third Law of thermodynamics.

UNIT II PROPERTIES OF REAL GASES AND THERMODYNAMICS FORMULATIONS

Properties of Real Gases and Thermodynamics Formulations: PVT behaviour of fluids - compressibility factor, two- and three-parameter theorems of corresponding states; Equation of states- Virial, Vander Waals, Redlich-Kwong and Peng-Robinson equations; Basic energy relations; Maxwell relations.

UNIT III PROPERTIES OF SOLUTIONS

Partial molar properties; chemical potential; fugacity and activity coefficients; Gibbs -Duhem equation; enthalpy , entropy and Gibbs free energy changes in mixing of ideal solution.

UNIT IV PHASE EQUILIBRIA

Phase equilibrium and stability; criteria for equilibrium between phases in single and multi - component non-reacting systems; vapor-liquid equilibrium of binary ideal and non-ideal solutions; azeotropes; Raoult‘s l aw and Henry‘s law; P-x- y and T-x- y diagrams using Antoine equations.

UNIT V CHEMICAL REACTION EQUILIBRIA 12

Criteria of equilibrium; standard free energy change and react ion equilibrium constant; effect of temperature and pressure on reaction equilibrium constant; homogeneous chemical reactions - thermodynamic analysis and prediction of equilibrium compositions.

Total: 60 hours

SUGGESTED READINGS

1. J.M. Smith, H.C. Van Ness and M.M. Abbott, “Introduction to Chemical Engineering Thermodynamics”, 8th edition, McGraw-Hill International Edition, 2019
2. S.Sandler, “Chemical, Biochemical and Engineering Thermodynamics”, 4th edition, Wiley, India. 2006
3.
4. K.V. Narayanan, A Textbook of Chemical Engineering Thermodynamics, Prentice Hall India, 2004
5. Y.V.C.Rao, “Chemical Engineering Thermodynamics”, University Press, Hyderabad, 2007.
6. Pradeep Ahuja, Chemical Engineering Thermodynamics, PHI Learning Ltd, 2009
7. Thermodynamics https://nptel.ac.in/courses/103/104/103104151/

Semester-III

20BTCE311	**FLUID MECHANICS LABORATORY**	**3H-1.5C**

Instruction Hours/week: L:0 T:0 P:3 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Compare the results of analytical models introduced in lecture to the actual behavior of real fluid flows;
- Discuss and practice standard measurement techniques of fluid mechanics and their applications;
- Work on small design projects.
- Compare the results of analytical models introduced in lecture to the actual behavior of real fluid flows

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Identify, name, and characterize flow patterns and regimes.
- Understand basic units of measurement, convert units, and appreciate their magnitudes.
- Utilize basic measurement techniques of fluid mechanics.
- Discuss the differences among measurement techniques

LIST OF EXPERIMENTS

1. Viscosity measurement of non Newtonian
2. Calibration of constant and variable head meters
3. Calibration of weirs and notches
4. Open drum orifice and draining time
5. Flow through straight pipe
6. Flow through annular pipe
7. Flow through helical coil and spiral coil
8. Losses in pipe fittings and valves
9. Characteristic curves of pumps
10. Hydrodynamics of fluidized bed
11. Drag coefficient of solid particle

Total: 45 hours

Semester-III

20BTCE312	**TECHNICAL ANALYSIS LABORATORY**	**3H-1.5C**

Instruction Hours/week: L:0 T:0 P:3 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Learn basic principles involved in analysis and synthesis of different organic derivatives
- Impart practical training on the analysis of fine chemicals, environment samples and quality assay of commercial products
- Provide an adequate mastery of analytical methods used for the determination of industrial raw materials and finished products quality

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Analyze organic chemicals
- Analyze inorganic chemicals
- Analyze ores and alloys

LIST OF EXPERIMENTS

1. Soap Analysis
    a) Estimation of total fatty acid
    b) Estimation of percentage alkali content
2. Oil Analysis
    a) Estimation of free acid
    b) Determination of Saponification value
    c) Determination of iodine value
3. Cement Analysis
    a) Estimation of Silica content
    b) Estimation of mixed oxide content
    c) Estimation of calcium oxide content
    d) Estimation of calcium oxide by rapid method

4. Analysis of Bleaching Powder
    a) Estimation of available chlorine
5. Analysis of fuels
    a). Flash point
    b}. Fire point
    c}. Cloud point
    d). Pour point
    e). Aniline point.
6. Determination of the molecular weight of the polymer by viscometry.
7. Calorimetric measurements
8. Conductivity measurement of an electrolyte solution
9. pH Measurements
10. Determination of dissolved oxygen in water
11. Determination of total nitrogen and ammoniacal nitrogen
12. Determination of SS, TDS, and VSS of a wastewater sample
13. Study of analytical instruments: Spectrophotometer, pH meter, Gas Chromatograph, High Performance Liquid Chromatograph (HPLC), FTIR, Total Organic Carbon Analyser (TOC).

Total: 45 hours

Semester-IV

20BTCE401 **HEAT TRANSFER** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Understand the basic concepts of Heat Transfer
- Learn mechanisms of conduction, convection and radiation.
- Analyze the performance of heat exchange equipment's & evaporators.
- Study components subjected to thermal loading.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Understands the concepts of heat transfer.
- Design and Rating of Heat exchangers with and without Phase Change
- Operate heat exchangers in parallel & counter current flow directions.
- Evaluate the effect of heat transfer in boiling and evaporators.

UNIT I CONDUCTION

Importance of heat transfer in Chemical Engineering operations - Modes of heat transfer - Fourier's law of heat conduction - one dimensional steady state heat conduction equation for flat plate, hollow cylinder, - Heat conduction through a series of resistances- effect of temperature on thermal conductivity; Combined Conduction- Convection Heat transfer, Critical radius of insulation, Heat transfer in extended surfaces

UNIT II CONVECTION

Concepts of heat transfer by convection - Natural and forced convection, Dimensional analysis in heat transfer, Correlations for the calculation of heat transfer coefficients, heat transfer coefficient for flow through a pipe, flow through a non circular conduit, Concepts of thermal boundary layer, Von karmaan Integral & energy Equation for flow past flat plate, Heat transfer by natural convection.

UNIT III HEAT EXCHANGERS

Parallel and counter flow heat exchangers - Log mean temperature difference - Single pass and multipass heat exchangers; plate heat exchangers; use of correction factor charts; heat exchangers effectiveness; number of transfer unit - Chart for different configurations - Fouling factors - Design of various types of heat exchangers and condensers.

UNIT IV CONDENSATION AND BOILING

Heat transfer to fluids with phase change - heat transfer from condensing vapours, drop wise and film wise condensation, Nusselt equation for vertical and horizontal tubes, condensation of superheated vapours, effect of non-condensable gases on rate of condensation. Heat transfer to boiling liquids - mechanism of boiling, nucleate boiling and film boiling.

UNIT V EVAPORATION AND RADIATION

Theory of evaporation - single effect and multiple effect evaporation - Types of Evaporators - Design calculation for single and multiple effect evaporation. Radiation heat transfer - Emissive power, Black body radiation, Emissivity, Stefen - Boltzman law, Planck's law, radiation between surfaces.

Total: 45 hours

SUGGESTED READINGS

1. Binay K. Dutta., Heat Transfer: Principles and Applications, Fifth Printing, Prentice Hall of India Private Limited, 2006.
2. Holman, J. P., Heat Transfer, Tenth Edition, McGraw Hill, 2017.
3. McCabe W.L., Smith J.C., Harriott. P., Unit Operations of Chemical Engineering, Seventh Edition, McGraw Hill International Student Edition, 2017.
4. Kern, D.Q., Process Heat Transfer, McGraw-Hill India, 2017.
5. Coulson, J.M. and Richardson, J.F., Chemical Engineering, Vol-1, Fourth Edition, Asian Books Private Limited, India, 1999
6. Heat Transfer https://nptel.ac.in/courses/103/101/103101137/

Semester-IV

20BTCE402	**MASS TRANSFER - I**	**3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Learn about the diffusion and interphase mass transfer.
- Introduce the most important separation equipment's in the process industries.
- Analyse vapour liquid equilibrium data for different fluids.
- Know about the concepts of number and height transfer units.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Calculate interphase and different mass transfer coefficients.
- Select driers for different drying processes.
- Design and operatee absorption and distillation columns.
- Be aware of recent developments in mass transfer operation.

UNIT I DIFFUSION IN FLUIDS

Molecular diffusion and eddy diffusion. Steady state molecular diffusion in fluids at rest and in laminar flow. Molecular diffusion in gases, steady state diffusion of gas A through non-diffusing gas B, steady state equivocal counter diffusion. Effective diffusivity, steady state diffusion in multicomponent mixtures. Measurement of diffusivity Molecular diffusion in liquids.

UNIT II INTERPHASE MASS TRANSFER

Mass transfer coefficients, F and K type mass transfer coefficients, Relation between mass transfer coefficients, Film theory, Penetration theory, Danckwerts surface renewal theory. Two film theory. Wetted wall towers. Equilibrium stage modelling: equilibrium curve and operating line .Analogy between momentum, heat and mass transfer.

UNIT III ABSORPTION

Equilibrium solubility of gases in liquids. Choice of solvents for absorption. Single component absorption. Operating and equilibrium lines for absorber and stripper. Minimum liquid - gas ratio for absorption. Countercurrent multistage operation, one component transferred continuous

contact equipment, absorption of one component in packed tower, overall coefficients, Concept of NTU and HTU - graphical, analytical methods and overall height of transfer units. Hydrodynamic consideration. Tower packings and packed tower.

UNIT IV DISTILLATION

Vapor - Liquid - Equilibrium (VLE). Ideal solutions and Raoult's law, non-ideal solutions and Henry's law, relative volatility, azeotropes - minimum and maximum boiling. Flash distillation, differential distillation - Rayleigh's equation, steam distillation.

UNIT V EQUIPMENT FOR CONTINUOUS DISTILLATION

Plate columns, packed columns. Determination of number of theoretical plates using McCabe - Thiele and Ponchon - Savarit methods. Location of feed plate. Reflux ratio - minimum reflux, optimum reflux, total reflux. Plate efficiency - overall and Murphree efficiencies. Azeotropic and extractive distillations.

Total: 45 hours

SUGGESTED READINGS

1. McCabe W. L., Smith J.C., and Harriott P., Unit Operations of chemical Engineering, seventh Edition, McGraw Hill (ISE), 2017.
2. Treybal R.E., Mass Transfer Operations, Third Edition, McGraw Hill (ISE), 2017.
3. Coulson J.M., Richardson J.F., Backhurst J.R Harker J.M., Coulson and Richardson's., Chemical Engineering, Vol II, 6th Edition, Butter Worth Heinemann, Oxford, 2013.
4. B.K. Dutta, Principles of Mass Transfer and Separation Processes, Prentice Hall India Learning Private Limited (2009)
5. Alan S. Foust, Leonard A Wenzel, Curlis W. Clump, Louis Maus, L.Bryce Andersen., Principles of Unit operations, second ed, John Wiley and Sons, 2015.
6. Mass Transfer https://nptel.ac.in/courses/103/103/103103145/

Semester-IV

20BTCE403	**CHEMICAL TECHNOLOGY**	**3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Impart knowledge about unit process and unit operations in various industries
- Develop understanding of manufacturing process flow drawing for the manufacturing chemical
- Processes, its applications and major engineering problems encountered in the process
- Classify the chemical process industry into industrial categories of base, intermediate end-products and specialty chemicals manufacturers

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Understand the various unit operations and processes with their symbols.
- Understand the various chemical reactions involved in the process
- Know to draw the process Flow sheet and understand the major engineering problems encountered in the processes
- Learn manufacturing processes of organic and Inorganic Chemicals and its applications.

UNIT I INTRODUCTION TO CHEMICAL PROCESS INDUSTRIES

Introduction to chemical processing; symbolic representation of different unit operations and unit processes to build a flow sheet ; Production of pulp and paper, Manufacture of sugar, starch and starch derivatives, Manufacture of leather from hides and skins, Manufacture of Glue and Gelatin, Materials for handling, storage and transportation

UNIT II ALKALI INDUSTRIES

Alkalies and Acids: Chlor - alkali Industries: Manufacture of Soda ash, Manufacture of caustic soda and chlorine - common salt. Sulphur and Sulphuric acid: Mining of sulphur and manufacture of sulphuric acid, Manufacture of hydrochloric acid.

UNIT III CEMENT, SOAPS, PAINTS AND GLASS INDUSTRIES

Cement -Types and Manufacture of Portland cement, , Refining of edible oils and fats, fatty acids, Manufacture of Soaps and detergents ;Manufacture of paints and Varnishes – Pigments Manufacture of pigments such as White lead, Zinc oxide and Titanium dioxide, Raw materials for Glass Industries.Production of glass by tank furnace - shaping and forming of articles from glass.

UNIT IV NATURAL AND SYNTHETIC FIBRES

Natural and synthetic fibres- Manufacture of nylon 6,6 and nylon 6 fibres, viscose rayon and polyester fibres; Nature, types, composition and uses of glass -its manufacture, melting, shaping, annealing and finishing operations; Basic principles of polymerization reactions: stepwise and chain polymerization, general polymerization systems: bulk, solution, suspension and emulsion polymerisation.

UNIT V FERTILIZERS

Fertilizers: Nitrogen Fertilizers; Synthetic ammonia, nitric acid, Ammonium nitrate, Ammonium sulphate, Urea, Phosphorous Fertilizers: Phosphate rock, phosphoric acid, super phosphate and Triple Super phosphate, Ammonium phosphates, Sodium phosphates, Nitro phosphate & Phosphate esters, Mixed fertilizers (NPK Mixtures)

Total: 45 hours

SUGGESTED READINGS

1. Dryden's Outlines of Chemical Technology, Edited by M. Gopala Rao, M. Sittig, Affiliated East-West Press Ltd (2010)
2. G.T. Austin, Shreve's Chemical Process Industries, Mc Graw Hill.(2017)
3. Moulin, J.A., M. Makkee, and Diepen, A.V., Chemical Process Technology, Wiley, May 2013
4. Srikumar Koyikkal,"Chemical Process Technology and Simulation", PHI Learning Ltd (2013)
5. Chemical Process Industries https://nptel.ac.in/courses/103/106/103106109/

Semester-IV

20BTCE404 **MATERIALS TECHNOLOGY** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Understand the structure property relationship of the materials.
- Familiarize treatment, testing and applications of metals and non-metallic materials.
- Identify suitable materials for various engineering applications.
- Outline the properties and applications of smart materials and nano and bio materials

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Comprehend the criterion for selection of materials for chemical process industries.
- Select materials for high temperature and Sour service and gain knowledge of modern engineering materials.
- Qualitatively derive a material's Young's modulus from a potential energy curve
- Describe a polymer's elastic behavior above and below the glass transition.

UNIT I NATURE OF MATERIALS

Selection process of engineering materials (General aspects), Chemical and physical properties of materials, chemical structure, Micro and macro structure, corrosion resistance, chemical Reactivity. Mechanical properties, stress, strain, strength, hardness, malleability, ductility, elasticity, plasticity, toughness, thermal stability. Types of deformation: Plastic, viscous; plastic deformation of single crystal, poly crystalline metals, slip, twinning, dislocations, viscoelasticity, creeps in metals, amorphous materials.

UNIT II METALLURGY

Extractive Metallurgy: Hydro, pyro and electro metallurgy, refining of metals. Powder Metallurgy: methods of production of metal powder, mixing of metal powders, compaction of powders-applications. Extraction process of Iron: manufacture of pig iron, blast furnace operations, chemistry of reactions. Manufacture of cast iron, varieties of cast iron, effect of impurities. Production of steel ,Bessemer process ,open-hearth process ,L D methods.

Classification of steel, effect of impurities. Heat treatment process: annealing, hardening, tempering, normalizing and gas carburizing. Fe-Carbon phase diagram.

UNIT III COMPOSITES AND ADHESIVES

Polymer composites: Introduction, Types of composites, particle reinforced, fiber reinforced, structural composites, examples. Matrix materials, reinforcement materials-, Kevlar, Polyamides, Fibers, glass, carbon fibers, ceramics and metals. Technical applications.

UNIT IV BIOMATERIALS

Classification of bio-materials (based on tissue response) ,Comparison of properties of some common biomaterials , Metallic implant materials (stainless steel, cobalt-based and titanium-based alloys) , Polymeric implant materials (Polyamides, polypropylene, Acrylic resins and Hydro gels),Tissue replacement implants, Soft and hard tissue replacements, Skin implants, Tissue engineering, Biomaterials for organ replacement (Bone substitutes), Biosensor.

UNIT V MODERN ENGINEERING MATERIALS

Smart materials , Shape memory alloys, Electrostatics, Irreversible Marten sites, Domain Walls, Nature of Shape Memory, Shape Memory Alloy Materials, Ferromagnetic Shape Memory Alloys, Relation to Shape Memory Alloys, Actuator and Sensor Materials Chromic materials (Thermo, Photo and Electro), Rheological fluids, Metallic glasses.

Total: 45 hours

SUGGESTED READINGS

1. Thiruvadigal .J.D , Ponnusamy, Sudha.D and Krishnamohan.M ,Materials Sciences , II Edition ,Vibrant Publication,Chennai,2013
2. Rajendran.V, Materials Science, III Edition, Tata McGraw hill, New Delhi, 2011
3. Khanna.O.P, A textbook of material science and metallurgy, IV Edition, Danpat raj Publications, 1999
4. Rajput.R.K, a Textbook of Material Science and Engineering, III Edition, S.K.Kataria & Sons, Delhi, 2003
5. Agarwal.C.V, Chemistry of Engineering materials, IV Edition, Tata McCraw Hill, 1997
6. William F.Smith, Foundation of materials science and Engineering , II Edition ,Tata McCraw Hill,1998
7. Properties of Materials https://nptel.ac.in/courses/113/104/113104096/

20BTCE405 UNIVERSAL HUMAN VALUES II UNDERSTANDING HARMONY 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Distinguish between values and skills, and understand the need, basic guidelines, content and process of value education.
- Initiate a process of dialog within themselves to know what they 'really want to be' in their life and profession
- Understand the meaning of happiness and prosperity for a human being.
- Understand harmony at all the levels of human living, and live accordingly.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Understand the significance of value inputs in a classroom and start applying them in their life and profession
- Distinguish between values and skills, happiness and accumulation of physical facilities, the Self and the Body, Intention and Competence of an individual, etc.
- Understand the value of harmonious relationship based on trust and respect in their life and profession
- Understand the role of a human being in ensuring harmony in society and nature.

UNIT I COURSE INTRODUCTION - NEED, BASIC GUIDELINES, CONTENT AND PROCESS FOR VALUE EDUCATION

Understanding the need, basic guidelines, content and process for Value Education, Self-Exploration–what is it? - its content and process; 'Natural Acceptance' and Experiential Validation- as the mechanism for self-exploration, Continuous Happiness and Prosperity- A look at basic Human Aspirations, Right understanding, Relationship and Physical Facilities- the basic requirements for fulfillment of aspirations of every human being with their correct priority, Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario, Method to fulfill the above human aspirations: understanding and living in harmony at various levels

UNIT II UNDERSTANDING HARMONY IN THE HUMAN BEING - HARMONY IN MYSELF

Understanding human being as a co-existence of the sentient 'I' and the material 'Body', Understanding the needs of Self ('I') and 'Body' - Sukh and Suvidha, Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer), Understanding the characteristics and activities of 'I' and harmony in 'I' , Understanding the harmony of I with the Body: Sanyam and Swasthya; correct appraisal of Physical needs, meaning of Prosperity in detail, Programs to ensure Sanyam and Swasthya

UNIT III UNDERSTANDING HARMONY IN THE FAMILY AND SOCIETY-HARMONY IN HUMAN-HUMAN RELATIONSHIP

Understanding harmony in the Family- the basic unit of human interaction, Understanding values in human-human relationship; meaning of Nyaya and program for its fulfillment to ensure Ubhay-tripti; Trust (Vishwas) and Respect (Samman) as the foundational values of relationship, Understanding the meaning of Vishwas; Difference between intention and competence, Understanding the meaning of Samman, Difference between respect and differentiation; the other salient values in relationship, Understanding the harmony in the society (society being an extension of family): Samadhan, Samridhi, Abhay, Sah-astitva as comprehensive Human Goals, Visualizing a universal harmonious order in society- Undivided Society (AkhandSamaj), Universal Order (*SarvabhaumVyawastha*)- from family to world family!

UNIT IV UNDERSTANDING HARMONY IN THE NATURE AND EXISTENCE - WHOLE EXISTENCE AS CO-EXISTENCE

Understanding the harmony in the Nature, Interconnectedness and mutual fulfillment among the four orders of nature- recyclability and self-regulation in nature, Understanding Existence as Co-existence (Sah-astitva) of mutually interacting units in all-pervasive space, Holistic perception of harmony at all levels of existence

UNIT V IMPLICATIONS OF THE ABOVE HOLISTIC UNDERSTANDING OF HARMONY ON PROFESSIONAL ETHICS

Natural acceptance of human values, Definitiveness of Ethical Human Conduct, Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order, Competence in Professional Ethics: a) Ability to utilize the professional competence for augmenting universal human order, b) Ability to identify the scope and characteristics of people-friendly and eco-friendly production systems, technologies and management models, Case studies of typical holistic technologies, management models and production systems, Strategy for transition from the present state to Universal Human Order: a) At the level of individual: as socially and ecologically responsible engineers, technologists and managers b) At the level of society: as mutually enriching institutions and organizations

Total: 45 hours

SUGGESTED READINGS

1. R R Gaur, R Sangal, G P Bagaria, 2009, A Foundation Course in Human Values and Professional Ethics.
2. Ivan Illich, 1974, Energy & Equity, The Trinity Press, Worcester, and Harper Collins, USA
3. E.F. Schumacher, 1973, Small is Beautiful: a study of economics as if people mattered, Blond & Briggs, Britain.
4. Sussan George, 1976, How the Other Half Dies, Penguin Press. Reprinted 1986, 1991
5. Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, William W. Behrens III, 1972, Limits to Growth – Club of Rome's report, Universe Books.
6. A Nagraj, 1998, Jeevan Vidya Ek Parichay, Divya Path Sansthan, Amarkan
7. tak.
8. P L Dhar, RR Gaur, 1990, Science and Humanism, Commonwealth Publishers.
9. A N Tripathy, 2003, Human Values, New Age International PublisherSubhasPalekar, 2000, How to practice Natural Farming, Pracheen (Vaidik) KrishiTantraShodh, Amravati.
10. E G Seebauer & Robert L. Berry, 2000, Fundamentals of Ethics for Scientists & Engineers , Oxford University Press
11. M Govindrajran, S Natrajan & V.S. Senthil Kumar, Engineering Ethics (including Human Values), Eastern Economy Edition, Prentice Hall of India Ltd.
12. B P Banerjee, 2005, Foundations of Ethics and Management, Excel Books.
13. B L Bajpai, 2004, Indian Ethos and Modern Management, New Royal Book Co., Lucknow. Reprinted 2008.

20BTCE406 **ENVIRONMENTAL STUDIES** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Understand the concept of ecosystem and biodiversity.
- Educate the ways and means of the environment.
- Create the awareness about environmental problems among people.
- Develop an attitude of concern for the environment.
- Motivate public to participate in environment protection and improvement.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Master core concepts and methods from ecological and physical sciences and their application in environmental problem solving.
- Master core concepts and methods from economic, political, and social analysis as they pertain to the design and evaluation of environmental policies and institutions.
- Appreciate the ethical, cross-cultural, and historical context of environmental issues and the links between human and natural systems.
- Understand the transnational character of environmental problems and ways of addressing them, including interactions across local to global scales.
- Apply systems concepts and methodologies to analyze and understand interactions between social and environmental processes.
- Reflect critically about their roles and identities as citizens, consumers and environmental actors in a complex, interconnected world.

UNIT I INTRODUCTION - ENVIRONMENTAL STUDIES & ECOSYSTEMS

Environment Definition, Scope and importance; Ecosystem, Structure and functions of ecosystem. Energy flow, Food chains and food webs, Ecological succession. Classification of ecosystem. Forest ecosystem, Grassland Ecosystem, Desert ecosystem, Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries).

UNIT II NATURAL RESOURCES - RENEWABLE AND NON-RENEWABLE RESOURCES

Natural resources - Renewable and Non – Renewable resources. Land resources and land use change, Land degradation, soil erosion and desertification. Forest resources - Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations. Water resources - Use and over-exploitation of surface and ground water, floods, droughts, conflicts over water. Use of alternate energy sources, growing energy needs, case studies. Role of an individual in conservation of natural resources. Equitable use of resources for sustainable lifestyles.

UNIT III BIODIVERSITY AND ITS CONSERVATION

Levels of biological diversity - genetic, species and ecosystem diversity. Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value. Bio-geographical classification of India. Biodiversity patterns (global, National and local levels). Hot-spots of biodiversity. India as a mega-diversity nation. Endangered and endemic species of India. Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts. Conservation of biodiversity: in-situ and ex-situ conservation of biodiversity.

UNIT IV ENVIRONMENTAL POLLUTION

Definition, causes, effects and control measures of Air pollution, Water pollution, Soil pollution, Noise pollution. Nuclear hazards and human health risks. Solid waste management and control measures of urban, industrial and e-wastes. Role of an individual in prevention of pollution. Case studies.

UNIT V SOCIAL ISSUES AND THE ENVIRONMENT

Concept of sustainability and sustainable development. Water conservation - Rain water harvesting, watershed management. Climate change, global warming, ozone layer depletion, acid rain and its impacts on human communities and agriculture. Environment Laws (Environment Protection Act, Air Act, Water Act, Wildlife Protection Act, Forest Conservation Act). International agreements (Montreal and Kyoto protocols). Resettlement and rehabilitation of project affected persons. Disaster management (floods, earthquake, cyclones and landslides). Environmental Movements (Chipko, Silent valley, Bishnois of Rajasthan). Environmental ethics: Role of Indian and other religions and cultures in environmental conservation. Environmental communication and public awareness, case studies (e.g., CNG vehicles in Delhi). Human population growth: Impacts on environment, human health and welfare.

Total: 45 hours

SUGGESTED READINGS

1. Anonymous. 2004. A text book for Environmental Studies, University Grants Commission and Bharat Vidypeeth Institute of Environmental Education Research, New Delhi.
2. Anubha Kaushik., and Kaushik, C.P. 2004. Perspectives in Environmental Studies. New Age International Pvt. Ltd. Publications, New Delhi.
3. Arvind Kumar. 2004. A Textbook of Environmental Science. APH Publishing Corporation, New Delhi.
4. Daniel, B. Botkin., and Edward, A. Keller. 1995. Environmental Science John Wiley and Sons, Inc., New York.
5. Mishra, D.D. 2010. Fundamental Concepts in Environmental Studies. S.Chand & Company Pvt. Ltd., New Delhi.
6. Odum, E.P., Odum, H.T. and Andrews, J. 1971. Fundamentals of Ecology. Philadelphia: Saunders.
7. Rajagopalan, R. 2016. Environmental Studies: From Crisis to Cure, Oxford University Press.
8. Sing, J.S., Sing. S.P. and Gupta, S.R. 2014. Ecology, Environmental Science and Conservation. S. Chand & Publishing Company, New Delhi.
9. Singh, M.P., Singh, B.S., and Soma, S. Dey. 2004. Conservation of Biodiversity and Natural Resources. Daya Publishing House, New Delhi.
10. Tripathy. S.N., and Sunakar Panda. (2004). Fundamentals of Environmental Studies (2nd ed.). Vrianda Publications Private Ltd, New Delhi.
11. Verma, P.S., and Agarwal V.K. 2001. Environmental Biology (Principles of Ecology). S. Chand and Company Ltd, New Delhi.
12. Uberoi, N.K. 2005. Environmental Studies. Excel Books Publications, New Delhi.
13. Introduction to Environmental Engineering and Science https://nptel.ac.in/courses/127/105/127105018/

Semester-IV

20BTCE411 NUMERICAL METHODS IN CHEMICAL ENGINEERING 4H-3C

Instruction Hours/week: L:2 T:0 P:2 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- The objective of this course is to familiarize the students with statistical techniques.
- It aims to equip the students with standard concepts and tools at an intermediate to advanced level that will serve them well towards tackling various problems in the discipline.
- To introduce students to numerical methods used to solve engineering problems, in particular chemical engineering problems, using numerical methods and computer programming.
- Fundamentals of numerical methods/algorithms to solve systems of different mathematical equations (e.g. linear/ non-linear algebraic equations, ordinary /partial differential equations), will be introduced.
- The course would enable students to write their own computer programs using programming languages like C and commercial software like Matlab.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Solve chemical engineering problems involving Linear and non-linear equations.
- Hands-on experience will be provided to apply these computer programs to solve problems in different areas of chemical engineering e.g. fluid flow, heat and mass transfer, chemical reaction engineering etc.
- Acquire skills in handling situations involving linear/ non-linear algebraic equations, ordinary /partial differential equations
- Solving actual chemical engineering problems through computer programming and coding.
- Solve ordinary and partial differential equations using programming languages like C and software's like MATLAB.
- Student will understand procedure-oriented MATLAB concepts. Student will be capable of writing C and MATLAB programs efficiently.

LIST OF EXPERIMENTS

1. Solution of non-linear equation
   - i) Newton – Raphson Method
   - ii) Bisection method
   - iii) Iterative method by reducing the equation to the form $x= f(x)$

2. Solution of algebraic simultaneous equations
   - i) Gauss elimination method
   - ii) Gauss Seidel method

3. Interpolation and Approximation
   - i) Newton's Divided Difference Interpolation Method for unequal intervals
   - ii) Newton's Forward and Backward Interpolation Method for equal intervals

   Newton's forward and Backward Interpolation Method for equal intervals

4. Numerical integration
   - iii) Gauss 2 point and 3 point formulae
   - iv) Trapezoidal method
   - v) Simpson's 1/3 rule

5. Solution of initial value problems governed by ODE

   - i) Euler's method
   - ii) Modified Euler's method
   - iii) Runge - Kutta 4th order method
   - iv) Runge - Kutta 4th order method for solving system of ODEs

6. Solution of BVP governed by PDE

   - i) Laplace Equation
   - ii) One – dimensional heat equation
     - a) Explicit method : Bender – Schmidt's method
     - b) Implicit method : Crank - Nicolson's method
   - iii) One dimensional wave equation- Implicit method

Total: 60 hours

SUGGESTED TEXT BOOKS

1. Gupta, S. K., "Numerical Methods for Engineers, New Academic Science, 2012.
2. S.C. Chapra & R.P. Canale, "Numerical Methods for Engineers with Personal Computer Applications", McGraw Hill Book Company, 1985.
3. R.L. Burden & J. D. Faires, "Numerical Analysis", 7th Ed., Brooks Coles, 2000.
4. Atkinson, K. E., "An Introduction to Numerical Analysis", John Wiley & Sons, 1978.

5. Press, W. H. et al., "Numerical Recipes in C: The Art of Scientific Computing, 3rd Edition, Cambridge University Press, 2007.
6. P. Kandasamy, K. Thilagavathy, K. Gunavathy (2008), Numerical Methods, S.Chand Ltd.
7. Curtis F. Gerald and Patrick O. Wheatley, Applied Numerical Analysis, Pearson Education, South Asia ,2009.
8. Steven C. Chapra, Raymond P. Canale, Numerical Methods for Engineers, McGraw - Hill Pub. Co. Ltd, 2014.
9. S R K Iyengar and R K Jain, Numerical Methods, New Age Interantional (P), Ltd, New Delhi, 2015.
10. T. Veerarajan and T Ramachandran, Numerical Methods, Tata McGraw - Hill Pub. Co. Ltd, 2013.
11. Jain M.K., Iyengar S.R.K and Jain R.K., "Numerical Methods for Engineering and Scientific Computation (Fourth Edition)", New Age International (P) Ltd., New Delhi, 2010.
12. Gerald C.F., Wheatley P.O., Applied Numerical Analysis (Fifth Edition), Addison – Wesley, Singapore, 1998
13. Sastry, S.S., "Introductory Methods of Reference Numerical Analysis (Seventh Edition)", Prentice Hall of India, New Delhi, 2009.
14. Grewal B.S., Grewal J.S., "Numerical Methods in Engineering and Science", Seventh Edition, Khanna Publishers, New Delhi, 2005.
15. S.S.Sastry, Introductory Methods of Numerical Analysis, PHI Pvt Ltd , Fifth Edition, New Delhi (2012)

WEBSITES:

1. www.nr.com
2. www.numerical-methods.com
3. www.math.ucsb.edu
4. www.mathworks.com

B.Tech Chemical Engineering		2020-2021
		Semester-IV
20BTCE412	MECHANICAL OPERATIONS LAB	4H-2C

Instruction Hours/week: L:0 T:0 P:4 **Marks:** Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Apply the concepts of mechanical operations in physical separation processes.
- Conduct experiments to solve complex engineering problems effectively as an individual or team work.
- Perform the size reduction process using various mechanical operation equipments.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Operate the mechanical size reduction and separation equipments
- Estimate the performance and energy requirement for milling and crushing operations.
- Separate the material according to different particle sizes using Screening, Leaf filter and sedimentation processes.

EXPERIMENTS

1. Ball Mill
2. Roll Crusher
3. Sedimentation
4. Filtration
5. Air Classifier
6. Plate and Frame Filter Press
7. Screen Effectiveness
8. Hammer Mill
9. Jaw Crusher
10. Leaf filter

Total: 60 hours

Semester-V

20BTCE501 **CHEMICAL REACTION ENGINEERING - I** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Understand the order and rate for different types reactions
- Impart knowledge on different types and dynamics of chemical reactors.
- Design the chemical reactors under isothermal and non-isothermal conditions
- Optimize the sequence of reactors in series for improving the conversion of the reactions.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Apply the principles of reaction kinetics and formulate rate equations and analyze the batch reactor data
- Select the reactor for the desired reaction and its design
- Predict reactor performance when the temperature is not uniform within the reactor
- Develop skills to choose the right reactor among single, multiple, recycle reactor etc. schemes.

UNIT I KINETICS OF HOMOGENEOUS REACTIONS

Classification of reactions, Rate equations of elementary and non-elementary reactions, variables affecting the rate of reaction, Reaction rate constant, Reaction order and molecularity, Reversible reactions, non-elementary reactions; Concentration dependent term of rate equation, Temperature dependent term of rate equation, Predictability of reaction rate from theory Relationship between equilibrium and specific rate constants–Relationship among Arrhenius theory, Collision theory and Transition state theory

UNIT II INTERPRETATION OF BATCH REACTOR DATA

Constant volume batch reactor, Variable volume batch reactor, Integral and differential methods of kinetic analysis, empirical reactions of nth order, irreversible reactions in series and parallel, Analysis of total pressure data obtained in a constant-volume system, First and second order reversible reactions, Reactions of shifting order, Biochemical Reaction systems (Enzymatic reactions) Method of half-lives–Method of initial rates

UNIT III ISOTHERMAL REACTOR DESIGN

Ideal reactors for a single reaction - Ideal batch reactor, Steady-state mixed flow reactor, Steady-state plug flow reactors; Design for single reactions - Size comparison of single reactors, Multiple reactor systems, Recycle reactor, Autocatalytic reactions Semi-batch reactor–Pressure drop in reactors

UNIT IV NON-ISOTHERMAL REACTOR SYSTEM

Non-isothermal homogeneous reactor systems, adiabatic reactors, rates of heat exchanges for different reactors, design for constant rate input and constant heat transfer coefficient, operation of batch and continuous reactors, optimum temperature progression.

UNIT V DESIGN FOR MULTIPLE REACTIONS AND TEMPERATURE & PRESSURE EFFECTS

Introduction to design of parallel reactions, Qualitative and quantitative discussion on product distribution, Contacting patterns, Reactor Size and arrangement, Selectivity & Yield Reversible first order reaction, First order followed by zero order reaction, Zero order followed by first order reaction Non-isothermal operation of reactors: Optimum temperature progression; Adiabatic and non-adiabatic batch, mixed flow and plug flow reactors; Exothermic reactions in mixed flow reactors Non-isothermal continuous flow reactors

Total: 45 hours

SUGGESTED READINGS

1. Levenspiel O ,Chemical Reaction Engineering, Wiley Eastern Ltd, III Edition, 2006
2. Smith, J.M , Chemical Engineering Kinetics, McGraw Hill , Third Edition,2015
3. Fogler .H.S, Elements of Chemical Reaction Engineering, Prentice Hall of India Ltd, Fourth Edition,2015
4. Froment .G.F & K. B. Bischoff, Chemical Reactor Analysis and design ,John Wiley and sons, Third Edition,2010
5. Smith J.M, VanNess H.C., & Abbot M.C , Introduction to Chemical Engineering Thermodynamics, McGraw Hill, Eight Edition,2019
6. Chemical Reaction Engineering I https://nptel.ac.in/courses/103/103/103103153/

Semester-V

20BTCE502	**MASS TRANSFER - II**	**3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Learn the techniques of extraction, adsorption, ion exchange, humidification, drying and crystallization.
- Understand the contact methods of liquid – gas, liquid – liquid and gas – gas operations.
- Analyze and select suitable equipment's for required mass transfer processes.
- Emphasize the impact of principles on the design steps of equipment and result in specific requirements for quality and capacity

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Determine the number of stages and recovery efficiency for solid-liquid and liquid-liquid separation processes.
- Calculate the quantity of adsorbent required for stage-wise operations and illustrate the types of adsorption, adsorption isotherms and ion-exchange process.
- Identify the properties of air-water system using psychrometric chart and review the operational features of cooling towers.
- Analyze the applications of dryers and calculate the time of drying from rate of drying curve

UNIT I EXTRACTION

Application of liquid-liquid extraction, Liquid-liquid equilibria, general features of triangular co-ordinate systems, Choice of solvent for extraction, Number of stages, Minimum solvent rate, Solid-liquid extraction, Typical industrial applications, Factors affecting leaching – agitation, particle size, temperature and solvent properties, Leaching by percolation moving bed leaching and shank's system, Operation of stage wise and differential contact extractors.

UNIT II ADSORPTION AND ION EXCHANGE

Types of adsorption - physical adsorption and chemical adsorption, factors influencing adsorption, nature of adsorbents, Industrial adsorbents, Freundlich adsorption isotherm and its

application, Adsorption operation - single stage, crosscurrent and countercurrent operations, Recovery of solvent vapours, Principles of ion exchange - techniques and applications - equilibria rate of ion exchange.

UNIT III HUMIDIFICATION

Humidification operation of air-water system, Wet bulb temperature and Measurement of humidity, Adiabatic saturation curves and Psychometric chart, Methods of humidification and dehumidification, Lewis relation, Design of cooling towers, Types of cooling towers .

UNIT IV DRYING

Theory and mechanism of drying. Batch drying, drying tests, drying curve, time of drying. Mechanism of moisture movement, drying rate during constant rate period, unsaturated surface drying, drying with internal diffusion. Continuous drying operations and equipment. Classification of dryers. Application of dryers in process industries

UNIT V CRYSTALLIZATION

Principles of Crystallisation – Purity of product, Equilibria and yield, Enthalpy balance, Factors governing nucleation and crystal growth, theory of crystallization. Batch and continuous crystallizers. Performance and applications of industrial crystallizers – Super saturation by Cooling, Evaporation, Evaporation and Cooling.

Total: 45 hours

SUGGESTED READINGS

1. McCabe W. L., Smith J.C., and Harriott P., Unit Operations of chemical Engineering, seventh Edition, McGraw Hill (ISE), 2017.
2. Treybal R.E., Mass Transfer Operations, Third Edition, McGraw Hill (ISE), 2017.
3. Coulson J.M., Richardson J.F., Backhurst J.R Harker J.M., Coulson and Richardson's., Chemical Engineering, Vol II, 6th Edition, Butter Worth Heinemann, Oxford, 2013.
4. B.K. Dutta, Principles of Mass Transfer and Separation Processes, Prentice Hall India Learning Private Limited (2009)
5. Alan S. Foust, Leonard A Wenzel, Curlis W. Clump, Louis Maus, L.Bryce Andersen., Principles of Unit operations, second ed, John Wiley and Sons, 2015.
6. Mass Transfer Operations II https://nptel.ac.in/courses/103/103/103103154/

Semester-V

20BTCE503 PROFESSIONAL ETHICS IN ENGINEERING 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Be aware on the concepts of Engineering Ethics and Human Values
- Instill Moral and Social Values in their professional activities
- Understand the social issues in local, national and global scale.
- Know the intellectual property rights, professional rights and occupational crime.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Apply ethics, integrity and other values with aptitude in the society.
- Discuss the ethical issues and solve the conflicts related to engineering in different paradigms.
- Realize the roles, responsibilities and social issues in the local, national and global scales.
- Emerge as a socially responsible engineer to deliver innovative products using entrepreneurship, startup and incubation.

UNIT I HUMAN VALUES

Morals, values and Ethics – Integrity – Work ethic – Service learning – Civic virtue – Respect for others – Living peacefully – Caring – Sharing – Honesty – Courage – Valuing time – Cooperation – Commitment – Empathy – Self confidence – Character – Spirituality – Introduction to Yoga and meditation for professional excellence and stress management.

UNIT II ENGINEERING ETHICS

Senses of 'Engineering Ethics' – Variety of moral issues – Types of inquiry – Moral dilemmas – Moral Autonomy – Kohlberg's theory – Gilligan's theory – Consensus and Controversy – Models of professional roles - Theories about right action – Self-interest – Customs and Religion – Uses of Ethical Theories.

UNIT III ENGINEERING AS SOCIAL EXPERIMENTATION

Engineering as Experimentation – Engineers as responsible Experimenters – Codes of Ethics – A Balanced Outlook on Law – Gender sensitivity issues – Protecting the rights of vulnerable sections using modern technologies – Innovation - Entrepreneurship – Startup – Incubation.

UNIT IV SAFETY, RESPONSIBILITIES AND RIGHTS

Safety and Risk – Assessment of Safety and Risk – Risk Benefit Analysis and Reducing Risk - Respect for Authority – Collective Bargaining – Confidentiality – Conflicts of Interest – Occupational Crime – Professional Rights – Employee Rights – Intellectual Property Rights (IPR) – Discrimination.

UNIT V LOCAL, NATIONAL AND GLOBAL ISSUES

Multinational Corporations – Environmental Ethics – Computer Ethics – Weapons Development – Engineers as Managers – Consulting Engineers – Engineers as Expert Witnesses and Advisors – Moral Leadership –Code of Conduct – Corporate Social Responsibility.

Total: 45 hours

SUGGESTED READINGS:

1. Mike W. Martin and Roland Schinzinger, "Ethics in Engineering", Tata McGraw Hill, New Delhi, 2003.
2. Govindarajan M, Natarajan S, Senthil Kumar V. S, "Engineering Ethics", Prentice Hall of India, NewDelhi, 2004.
3. Charles B. Fleddermann, "Engineering Ethics", Pearson Prentice Hall, New Jersey, 2004.
4. Charles E. Harris, Michael S. Pritchard and Michael J. Rabins, "Engineering Ethics – Concepts andCases", Cengage Learning, 2009.
5. John R Boatright, "Ethics and the Conduct of Business", Pearson Education, New Delhi, 2003
6. Edmund G Seebauer and Robert L Barry, "Fundamentals of Ethics for Scientists and Engineers",Oxford University Press, Oxford, 2001.
7. Ethics in Engineering Practice https://nptel.ac.in/courses/110/105/110105097/

20BTCE504 **PRINCIPLES OF MANAGEMENT** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Sketch the Evolution of Management.
- Extract the functions and principles of management.
- Learn the application of the principles in an organization.
- Study the various HR related activities.
- Analyze the position of self and company goals towards business.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Have clear understanding of managerial functions like planning, organizing, staffing, leading & controlling
- Have same basic knowledge on international aspect of management.
- Understand management concept of organizing.
- Understand management concept of directing.
- Understand management concept of controlling.

UNIT I INTRODUCTION TO MANAGEMENT AND ORGANIZATIONS

Definition of Management – Science or Art – Manager Vs Entrepreneur- types of managers- managerial roles and skills – Evolution of Management –Scientific, human relations , system and contingency approaches– Types of Business organization- Sole proprietorship, partnership, company-public and private sector enterprises- Organization culture and Environment – Current trends and issues in Management.

UNIT II PLANNING

Nature and purpose of planning – Planning process – Types of planning – Objectives – Setting objectives – Policies – Planning premises – Strategic Management – Planning Tools and Techniques – Decision making steps and process.

UNIT III ORGANISING

Nature and purpose – Formal and informal organization – Organization chart – Organization structure – Types – Line and staff authority – Departmentalization – delegation of authority – Centralization and decentralization – Job Design - Human Resource Management – HR

Planning, Recruitment, selection, Training and Development, Performance Management , Career planning and management.

UNIT IV DIRECTING

Foundations of individual and group behaviour– Motivation – Motivation theories – Motivational techniques – Job satisfaction – Job enrichment – Leadership – types and theories of leadership – Communication – Process of communication – Barrier in communication – Effective communication – Communication and IT.

UNIT V CONTROLLING

System and process of controlling – Budgetary and non - Budgetary control techniques – Use of computers and IT in Management control – Productivity problems and management – Control and performance – Direct and preventive control – Reporting

Total: 45 hours

SUGGESTED READINGS

1. Harold Koontz and Heinz Weihrich "Essentials of management" Tata McGraw Hill,1998.
2. Stephen P. Robbins and Mary Coulter, " Management", Prentice Hall (India)Pvt. Ltd., 10th Edition, 2009.
3. Robert Kreitner and MamataMohapatra, " Management", Biztantra, 2008.
4. Stephen A. Robbins and David A. Decenzo and Mary Coulter, "Fundamentals of Management" Pearson Education, 7th Edition, 2011.
5. Prasanna Chandra Fundamentals of Financial Management Tata McGraw Hill, New Delhi. 2007
6. Financial Management https://nptel.ac.in/courses/110/107/110107144/

Semester-V

20BTCE511	**HEAT TRANSFER LABORATORY**	**3H-1.5C**

Instruction Hours/week: L:0 T:0 P:3 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Develop sound practical knowledge on different types of heat transfer equipments
- Estimate the heat transfer rate and heat transfer co-efficient
- Collect and analyses the heat transfer data practically.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Collect quality raw data from any heat transfer operation and to compare observed with predicted performance.
- Apply the concepts of heat transfer, fluid dynamics and thermodynamics to the design and operation of heat transfer experiments..
- Determine the heat transfer co-efficient and effectiveness of heat exchangers from experimentally observed data.

LIST OF EXPERIMENTS:

1. Heat Transfer through Composite Wall
2. Transient Heat Conduction
3. Heat Transfer in a Shell and Tube Heat Exchanger
4. Heat Transfer through Packed Bed
5. Heat Transfer in a Double Pipe Heat Exchanger
6. Heat Transfer in a Vertical Condenser
7. Heat Transfer in a Horizontal Condenser
8. Heat Transfer in Helical Coils
9. Heat Transfer with Natural Convection
10. Heat Transfer by Radiation

Total: 45 hours

Semester-V

20BTCE512	**MASS TRANSFER LABORATORY**	**3H-1.5C**

Instruction Hours/week: L:0 T:0 P:3 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Select the equipment's for required mass transfer operations.
- Collect and analyses the mass transfer data practically
- Calculate the mass transfer rate and mass transfer coefficients

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Determine the diffusivity practically and compare the results with the empirical correlations.
- Evaluate the performance/calculate the parameters in different distillation processes
- Estimate the drying characteristics and the parameters in leaching and extraction operations

LIST OF EXPERIMENTS

1. Measurement of Diffusion coefficient
2. Determination of HETP in Random packing
3. Wetted wall column
4. Ternary Liquid-liquid Equilibrium
5. Counter current & crosscurrent leaching
6. Extraction in packed and plate columns
7. Steam distillation
8. Simple distillation
9. Vapor- Liquid Equilibrium
10. Drying rate measurements

Total: 45 hours

Semester-VI

20BTCE601 **CHEMICAL REACTION ENGINEERING - II** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Learn the gas-solid catalytic, non-catalytic reactors and gas-liquid reactors.
- Distinguish between various RTD curves (Resonance Time Distribution).
- Understand the ideal reactor concepts and heterogeneous reactors.
- Understand the basics of catalysis and industrial catalytic reactors such as gas-solid reactors.

COURSE OUTCOMES (COs)

Upon the completion of the course, the students will be able to

- Predict the conversion from a non - ideal reactor using tracer information
- Develop rate laws for heterogeneous reactions
- Design tower for gas liquid operations with and without chemical reaction
- Design reactors for non-catalytic and catalytic reactions

UNIT I BASICS OF NON-IDEAL FLOW

Non-ideal flow, Residence time distribution (Importance and interpretation of RTD curve, E, F and C curves and relationship between them in reactor), Statistical Interpretation, RTD measurement, Conversion in non-ideal flow reactors, Diagonizing reactor ills, Dispersion model, Tanks-in-series model Micro fluid–Macro fluid–Early mixing–Late mixing

UNIT II HETEROGENEOUS REACTIONS AND SOLID CATALYSIS

Heterogeneous processes, Rate equations for heterogeneous reactions, adsorption isotherm and rates of adsorption, desorption and surface reaction, concept of rate controlling steps and analysis of rate equation. Classification and preparation of catalysts, Promoters and inhibitors, Catalyst characterization: Surface area and pore size distribution, Poisoning of catalysts Temkin isotherm-Redlich-Peterson isotherm

UNIT III SOLID CATALYZED REACTIONS

Characteristics of catalyzed reaction, Mechanism, Pore diffusion resistance combined with surface kinetics, Single cylindrical pore with first order reaction, Effectiveness factor, Porous catalyst particles, Heat effects during reaction, Performance equation for reactors containing porous catalyst particles, Experimental methods for finding rates, Deactivation of catalysts and mechanism - the rate and performance equations Fixed Bed Reactors - Fluidized Bed Reactors

UNIT IV FLUID--PARTICLE REACTIONS

Selection of kinetic model, shrinking core model for spherical particles of unchanging size: Diffusion through gas film controls, Diffusion through ash layer controls, Chemical reaction controls; Rate of reaction for shrinking spherical particles: Chemical reaction controls, Diffusion through gas film controls, SCM for cylindrical particles of unchanging size, determination of rate controlling step Conversion-time expression for non-spherical particles

UNIT V MULTIPHASE REACTORS

Two-film theory, Hatta number - General design models, simplifications to design models, instantaneous, fast and slow reactions, solid catalyzed reactions, resistances in series chemical engineering and chemical technology approximation - Selection of gas-liquid contactors

Total: 45 hours

SUGGESTED READINGS

1. Levenspiel O ,Chemical Reaction Engineering, Wiley Eastern Ltd, III Edition, 2006
2. Smith, J.M , Chemical Engineering Kinetics, McGraw Hill , Third Edition,2015
3. Fogler .H.S, Elements of Chemical Reaction Engineering, Prentice Hall of India Ltd, Fourth Edition,2015
4. Froment .G.F & K. B. Bischoff, Chemical Reactor Analysis and design ,John Wiley and sons, Third Edition,2010
5. Smith J.M, VanNess H.C., & Abbot M.C , Introduction to Chemical Engineering Thermodynamics, McGraw Hill, Eight Edition,2019
6. CRE II https://nptel.ac.in/courses/103/101/103101141/

Semester-VI

20BTCE602	**PROCESS ECOOMICS**	**3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Analyse cost/revenue data and carry out make economic analyses in the decision making process
- Justify or reject alternatives/projects on an economic basis
- Basic concepts in engineering economics
- Make economic analyses in the decision making process

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Practice various depreciation methods and its uses in industries for the recovery of plant cost Assess the various financial ratios by taking the real time data's of the industries and comment the stability of the financial statements
- Specify the economic balance in batch, cyclic and continuous operations and study the optimum conditions of operating variables.
- Outline the various management principles and organization types practiced in the organizations
- Discuss the production planning control methods in industries and also role of control charts in production for the quality control.

UNIT I INTEREST AND PLANT COST

Time value of money - equivalence, Depreciation, Depletion, estimation of capital cost, Capital requirement for complete plant, cost indices, capital recovery and its real time problems.

UNIT II COST ANALYSIS AND BREAK EVEN ANALYSIS

Cost analysis - Basic cost concepts – FC, VC, TC, MC – Cost output in the short and long run. Depreciation - meaning – Causes – Methods of computing Depreciation (simple problems in Straight Line Method, Written down Vale Method). Meaning – Break Even Analysis - Managerial uses of BEA.

UNIT III PROJECT PROFITABILITY AND FINANCIAL RATIOS

Estimation of project profitability, Investment alternatives, income statement and financial ratios, balance sheet preparation-case studies and problems.

UNIT IV ECONOMIC BALANCE IN EQUIPMENTS

Essentials of economic balance, economic balance in batch operations, cyclic operations, economic balance for insulation, evaporation, heat transfer equipment's and its applications.

UNIT V PRODUCTION PLANNING CONTROL

Work measurement techniques, motion study, principles of time study, elements of production control, forecasting, planning, routing, scheduling, dispatching, inventory and control, role of control charts in production and quality control.

Total: 45 hours

SUGGESTED READINGS

1. Max Peters, Klaus Timmerhaus, Ronald West, plant design and economics for chemical Engineers, Fifth Edition, McGraw Hill (ISE), 2003.
2. Ahuja K.K, Industrial management, khanna publishsers, New Delhi, 2004.
3. H.E. Schwyer, Process Engineering Economics, McGraw Hill Book, New York, 2007
4. FC Jelen, JH Black, Cost and Optimization Engineering, Second Edition, McGraw-Hill., New York, 2009.
5. Robin Smith, Chemical Process Design and Integration, Second edition, John Wiley & Sons, United States, 2016.
6. Process economics https://nptel.ac.in/courses/103/103/103103039/

Semester-VI

20BTCE603	**PROCESS DYNAMICS AND CONTROL**	**4H-4C**

Instruction Hours/week: L:3 T:1 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Understand dynamic modeling of physical process.
- Understand the elements and techniques involved in process dynamics and control.
- Design various control schemes and to apply the control system in various Processes.
- Convert the model to a form amenable to get solution

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Explain the basic principles and elements of a process control system including digital controls
- Find the response of a first order, second order system to an input function
- Predict the closed loop transfer function and its response with controllers like P, PI, PD and PID
- Identify the stability of a control system by Routh test, Root locus and Bode criterion along with system tuning

UNIT I INTRODUCTION TO CHEMICAL PROCESS CONTROL

Introduction to Chemical Process Control, Mathematical description of chemical processes, Formulating Process Models, Laplace Transforms, Properties of Laplace Transforms, Solution of ODE using Laplace Transforms, Standard input forcing functions, State – Space representation, transform domain models, Impulse response models, Inter relationship between process model forms

UNIT II OPEN-LOOP SYSTEMS

Open-loop systems, first order systems and their transient response for standard input functions, first order systems in series, linearization and its application in process control, second order systems and their dynamics; transportation lag, FOPDT Model, Skogestaad's rule for FOPDT and SOPDT, Lead- Lag systems

UNIT III CLOSED LOOP CONTROL SYSTEMS

Closed loop control systems, development of block diagram for feed-back control systems, servo and regulatory problems, transfer function for controllers and final control element, principles of pneumatic and electronic controllers, control valves, transient response of closed-loop control systems and their stability, Root locus diagram.

UNIT IV STABILITY

Introduction to frequency response of closed-loop systems, control system design by frequency response techniques, Bode diagram, stability criterion, tuning of controller settings, Nyquist Stability Criterion

UNIT V INTRODUCTION TO ADVANCED CONTROL SYSTEMS

Introduction to advanced control systems, cascade control, feed forward control, Controllers for Inverse response Smith predictor controller, control of distillation towers and heat exchangers, introduction to computer control of chemical processes.

Total: 60 hours

SUGGESTED READINGS

1. D. R. Coughnowr, Process System Analysis and Control, 3rd Ed., McGraw-Hill Inc., 2013
2. G.Stephanopoulos, Chemical Process Control: An Introduction to Theory & Practice, PHI, 1983
3. W. B.Bequette, Process Control: Modeling, Design and Simulation, Prentice Hall, 1998
4. D.Seborg, T.F. Edgar Duncan, A. Mellichamp, Process Dynamics and Control,3 rd Ed., John Wiley & Sons, Inc, 2010
5. B.Roffel, B.Betlem, Process Dynamics and Control: Modeling for Control & Prediction, John Wiley & Sons, 2006
6. N.E. Battikha,The Condensed Handbook of Measurement and Control, 3rdEd.,ISA, 2006
7. Chemical Process Control https://nptel.ac.in/courses/103/101/103101142/

Semester-VI

20BTCE611 **PROCESS EQUIPMENT DESIGN & DRAWING** **4H-3C**

Instruction Hours/week: L:2 T:0 P:2 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Learn design of the equipments that are used in process industries.
- Select appropriate equipment for the process
- Understand standard specifications like BIS (Bureau of Indian Standards) and ASTM.
- Understand various design parameters

COURSE OUTCOMES (COs)

Upon completion of the course, students are able to

- Design equipments for the specified requirement as per standard codes.
- Design shell and tube heat exchangers by considering standard codes and compute the design parameters of distillation columns and evaporators
- Integrate the knowledge acquired from core chemical engineering subjects for design of chemical process equipments
- Address the process equipment problems and provide suitable alternate solutions.

UNIT I INTRODUCTION TO CHEMICAL ENGINEERING DESIGN

Design of cylindrical and spherical shell under internal and external pressures; Selection and design of flat Plate, torisperical, ellipsoidal, and conical closures, compensations of openings.

UNIT II PRESSURE VESSELS

Tall vertical & horizontal vessels: Pressure dead weight, wind, earthquake and eccentric loads and induced stresses; combined stresses, Vessel supports; design of skirt, lug, and saddle supports.

UNIT III DOUBLE PIPE HEAT EXCHANGERS

Design of Heat Transfer Equipment: Design of Heat Transfer Equipment double pipe heat exchangers ; counter flow and parallel flow.

UNIT IV HEAT TRANSFER EQUIPMENTS

Design of Heat Transfer Equipment's: Shell and tube heat exchangers, condensers- tubular horizontal and tubular vertical, evaporators- single effect and multiple effects, crystallizers.

UNIT V MASS TRANSFER EQUIPMENTS

Design of Mass Transfer Equipment's: Design and Drawing of mass transfer equipment's such as distillation columns, absorption columns, dryers.

SUGGESTED READINGS

1. R. H. Perry, "Chemical Engineers' Handbook", 7th Edn., McGraw Hill , NewYork, 1998. R. K. Sinnott, "Chemical Engineering Design", Coulson and Richardson's Chemical Engineering Series, Volume-6, Fourth Edition, Butterwoth-Heinemann, Elsevier, NewDelhi, 2005.
2. L. E. Brownell and E.H. Young, "Process Equipment Design - Vessel Design", Wiley Eastern Edn. New York, 2008.
3. B.C. Bhattacharyya, "Introduction to Chemical Equipment Design Mechanical Aspects", CBS Publishers & Distributors, New Delhi.
4. D.Q.Kerm "Process Heat Transfer", Tata McGraw Hill Edn., 2004.
5. Robin Smith, "Chemical Process Design and Integration", Eighth Edition, Wiley India (P) Ltd., NewDelhi, 2006.
6. V. V.Mahajani and S. B. Umarjii, "Joshi's Process Equipment Design", 4th Edn., Mac Millan Publishers India Limited, NewDelhi, 2009.
7. Equipment Design https://nptel.ac.in/courses/103/107/103107143/

LABORATORY

COURSE OBJECTIVES

The goal of the course is for the students to

- Understand the basic of design of heat transfer equipment.
- Analyze the design of mass transfer equipment.
- Know the basics of construction and design of high-pressure vessels.
- Create flow diagrams and different equipment inspection methods.

COURSE OUTCOMES (COs)

Upon completion of the course students are able to

- Design and draw heat exchanger and evaporator.
- Fix parameters for designing distillation and absorption columns.
- Construct and analyze high pressure vessels design.
- Explain different flow sheet presentation and equipment inspection methods

EXPERIMENTS

1. P&ID symbols and drawings
2. Mechanical design of pressure vessels
3. Double pipe heat exchangers
4. Shell and Tube heat exchangers
5. Design of Condensers
6. Design of Evaporators
7. Design of Distillation columns

Total: 60 hours

Semester-VI

20BTCE612 CHEMICAL REACTION ENGINEERING LABORATORY 4H-2C

Instruction Hours/week: L:0 T:0 P:4 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Impart knowledge of design of reactors
- Provide experience on analysis of process control and reaction engineering.
- Analyze experimental data for steady state and unsteady state and compare to theoretical principles.
- Conduct experiments to solve complex problems effectively.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Calculate the reaction kinetics of various reactors used for manufacturing of chemicals in industries.
- Determine the order and rate constant of the rate equations for Batch, Mixed, Plug flow reactor.
- Evaluate the performance of combined Mixed and Plug flow reactor System.
- Conduct residence time distribution studies to develop various curve for Mixed, Plug flow reactor and packed bed reactor.

EXPERIMENTS

1. Kinetic Studies in Batch Reactor-I
2. Kinetic Studies in Batch Reactor-II
3. Performance Characteristics of Semi-Batch Reactor-I
4. Performance Characteristics of Semi-Batch Reactor-II
5. Performance Characteristics of Mixed Flow Reactor
6. Performance Characteristics of Plug Flow Reactor
7. Adiabatic Reactor
8. Residence Time Distribution Studies in Plug Flow Reactor

9. Residence Time Distribution Studies in Mixed Flow Reactor
10. Performance Characteristics of Tubular Reactor
11. Performance Studies of Mixed Flow Reactor in Series
12. Determination of Activation Energy

Total: 60 hours

Semester-VII

20BTCE701 **TRANSPOART PHENOMENA** **4H-4C**

Instruction Hours/week: L:3 T:1 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Understand the importance of transport phenomena and the applications of conservation law in heat, momentum and mass transfer.
- Analyze mass, momentum and energy transport at molecular, microscopic and macroscopic level.
- Determine velocity, temperature and concentration profiles using various boundary conditions.
- Learn different types of fluids, their flow characteristics and mechanism of fluids in motion under different conditions.
- Analyze different mathematical models applied to actual situations.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Develop mathematical models to determine transfer fluxes and velocity, temperature and concentration distribution for flow channels, heat sources and systems involving diffusion and reactions.
- Establish the analogy between the transport processes of heat, momentum and mass transfer.
- Determine the interrelationship between the molecular, microscopic and macroscopic descriptions of transport processes and compare the various coordinate systems to formulate equations of change.
- Apply the equation of change for different coordinate systems and solve of momentum, mass and heat transport problems.
- Develop shell energy balance, shell momentum balance and shell mass balance for various systems and apply equation of change to solve problems.

UNIT I MOMENTUM TRANSPORT

Viscosity, temperature and pressure effect on viscosity of gases and liquids, Newton's law, mechanism of momentum transport, shell momentum balance method, Shear stress and velocity distributions in falling film, circular tube, annulus, slit.

UNIT II ENERGY TRANSPORT

Thermal conductivity, temperature and pressure effect on thermal conductivity of gases and liquids, Fourier's law, mechanism of energy transport, shell energy balance method, Energy flux and temperature distribution in solids and laminar flow with electrical, nuclear, viscous, chemical heat source, heat conduction through composite walls, cylinders, spheres, fins, slits.

UNIT III MASS TRANSPORT

Diffusivity, temperature and pressure effect on diffusivity, Fick's law, mechanism of mass transport, shell mass balance method, Mass flux and concentration distribution in solids and in laminar flow: stagnant gas film, heterogeneous and homogeneous chemical reaction systems, falling film, porous catalyst.

UNIT IV EQUATIONS OF CHANGE AND THEIR APPLICATIONS

Momentum: Equations of continuity, motion and mechanical energy (Isothermal), Energy: Equation of energy (non-isothermal). Mass: Equations of change (multi-component), equations of continuity for each species, equation of energy (multi-component). Solutions of momentum, heat and mass transfer problems discussed under shell balance by applications of equation of change, dimensional analysis of equations of change.

UNIT V TRANSPORT IN TURBULENT FLOWS AND ANALOGIES

Comparison of laminar and turbulent flows, time-smoothed equations of change, empirical expressions. Comparison of laminar and turbulent hydrodynamics, thermal and concentration boundary layer and their thicknesses. Development and applications of analogies between momentum, heat and mass transfer.

Total: 60 hours

SUGGESTED READINGS

1. Byron R. Bird, Warren E Stewart , Transport Phenomena ,John Wiley & Sons, New York,2002
2. Brodkey, R. S., and Hershey, H. C., "Transport Phenomena", McGraw-Hill, 1988
3. SissomL.E, & Pitts .D.R , Elements of Transport Phenomena, McGraw Hill,1972
4. Welty J.R.,Wicks.C.E., Wilson.R.E., Fundamentals of momentum , heat and mass transfer, John Wiley & Sons,2007
5. Transport Phenomena https://nptel.ac.in/courses/103/105/103105128/

Semester-VII

20BTCE711 **SIMULATION LABORATORY** **3H-1.5C**

Instruction Hours/week: L:0 T:0 P:3 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Familiarize MATLAB as simulation tool
- Use MATLAB to solve chemical engineering problems
- Solve the developed process models of chemical engineering
- Develop a solution for chemical engineering design problems using ASPEN PLUS

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Identify MATLAB as a simulating tool to solve chemical engineering problems
- Solve steady state chemical engineering problems using MATLAB
- Use the commercial simulation tools like ASPEN PLUS
- Simulate basic Heat transfer and Mass transfer equipment

LIST OF EXPERIMENTS

The following experiments are to be solved in MATLAB

1. Gravity Flow tank.

2. Three CSTRs in series – open loop

3. Three CSTRs in series – closed loop

4. Non isothermal CSTR

5. Binary Distillation column

6. Heat Exchanger

7. Isothermal Batch reactor.

8. Interacting & Non interacting system-two tank liquid level

The following experiments are to be solved in ASPEN PLUS

9. T-xy,P-xy diagrams of a Binary mixture

10. Ideal reactor – CSTR, Batch, Plug flow

11. Distillation column

12. Heat exchanger

Total: 45 hours

Semester-VII

20BTCE712 **PROCESS CONTROL LABORATORY** **3H-1.5C**

Instruction Hours/week: L:0 T:0 P:3 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Get knowledge on the development and use of right type of control dynamics for process control under different operative conditions.
- Impart knowledge about the elements and techniques involved in process dynamics and control.
- Know the tuning procedures and advanced control techniques.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Determine experimentally the methods of controlling the processes including measurements using process simulation techniques.
- Evaluate the suitable controllers for different chemical process.
- Analyze and asses the control system into stability.

LIST OF EXPERIMENTS

1. Single capacity liquid level process
2. Two capacity liquid level process without interaction
3. Two capacity liquid level process with interaction
4. Time constant of a thermocouple
5. Two capacity liquid level process without interaction
6. Two capacity liquid level process with interaction
7. Computer controlled level process analyser
8. Computer controlled flow process analyser
9. Computer controlled pressure process analyser
10. Computer controlled temperature process analyser

Total: 45 hours

Semester-VIII

20BTCE811	**PROJECT PHASE-II**	**30H-12C**

Instruction Hours/week: L:0 T:0 P:30 **Marks:** Internal**:120** External**:180**Total**:300**

COURSE OBJECTIVES

The goal of the course is for the students to

- Develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.
- Train the students in preparing project reports and to face reviews and viva voce examination.

The students in a group of 3 to 4 works on a topic approved by the head of the department under the guidance of a faculty member and prepare a comprehensive project report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews.

The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.

20BTCE5PE01 **FERTILIZER TECHNOLOGY** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Impart the basic concepts of fertilizer technology.
- Develop understanding about unit process and operations in various chemical industries.
- Learn manufacturing processes of organic and Inorganic Fertilizers and its applications.
- Introduce the bio and bio based fertilizers to minimize the negative impacts of synthetic fertilizers in agriculture.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Understand the role of chemical engineers in fertilizer industries and develop block diagrams and flow charts for manufacture of different chemicals
- Comprehend the unit operations/ processes in nitrogen, phosphorous, potassium and sulphur based fertilizer industries
- Apply knowledge in the manufacture of plant nutrients, agrichemicals and fertilizers.
- Incorporate principles of chemical engineering in innovating novel fertilizers to bring in sustainability in agriculture.

UNIT I NITROGEN FERTILIZERS

Nitrogenous Fertilizers - Methods of production of Ammonia and Urea. Nitric acid, Ammonium sulphate, Ammonium Nitrate, Calcium Ammonium Nitrate, Ammonium Chloride - Their methods of production, characteristics, storage and handling specifications.

UNIT II PHOSPHATIC FERTILIZERS

Raw materials, phosphate rock, Sulphur pyrites -Process for the production of Sulphuric and Phosphoric acids. Ground phosphate rock, bone meal. Single Super Phosphate, Triple Super phosphate -Methods of production, characteristics and specifications.

UNIT III POTASSIC FERTILIZERS

Potassium chloride, Potassium sulphate, Potassium schoenite - Methods of production, specification, characteristics. Complex Fertilizers, NPK Fertilizers, Mono ammonium phosphate, Di-ammonium phosphate, Nitro phosphate Methods of production.

UNIT IV COMPLEX AND NPK FERTILISERS

Methods of production of ammonium phosphate, sulphate di-ammonium phosphate, nitro phosphates, urea, ammonium phosphate, mono-ammonium phosphate and various grades of NPK fertilizers produced in the country

UNIT V MISCELLANEOUS FERTILISERS

Mixed fertilizers and granulated mixtures; secondary nutrients and micro nutrients; fluid fertilizers, controlled release fertilizers, controlled release fertilizers. Manufacturing of NPK, Ammonium Sulphate Phosphate (ASP), Calcium Ammonium Nitrate (CAN), Bio-fertilizers, Types of Bio-fertilizers, Nitrogen-fixing bio-fertilizers, Phosphate-solubilizing bio-fertilizers, Preparation of a bio-fertilizers

Total: 45 hours

SUGGESTED READINGS:

1. Gopala Rao M., Marshall Sittig, Dryden's Outlines of Chemical Technology, Third Edition, WEP East-West Press, New Delhi, 2010.
2. George T. Austin., Shreve's Chemical Process Industries, Fifth Edition, McGraw Hill Professional, 2012
3. Vincent Sauchelli, The Chemistry and Technology of Fertilizers, Reinhold Pub. Corp., 2000
4. Editorial Committee - FAI Seminar on Fertilizer in India in the Seventies (Proceedings), The Fertilizer Association of India, New Delhi, 1973.
5. Nptel Course: Fertilizer Engineering: nptel.ac.in/courses/103/107/103107086/

Semester-V

20BTCE5PE02 **POLYMER TECHNOLOGY** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Gain knowledge about mechanism of polymer process and its application
- Understand the mechanism of polymerization, various techniques of polymerization
- Analyze the characterization of polymers by molecular weight, reactions and degradation of polymers.
- Impart knowledge on mould making techniques such as metal cutting, metal erosion, metal deposition, metal displacement and mould polishing

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Understand the fundamentals of polymers and mechanism of polymerization techniques.
- Apply the mechanism and effectiveness of polymerization in making finished materials.
- Understand the knowledge of developing new formulations and products from elastomers
- Understand the manufacture and properties of application oriented industrial polymers.

UNIT I GENERAL ASPECTS OF POLYMERS

Classification of polymers- natural and synthetic, thermoplastic and thermosetting. Types and mechanism of polymerization: addition (free radical, cationic, anionic and living); condensation and copolymerization, Functionality-degree of polymerization. Techniques of polymerization: Bulk, emulsion, solution and suspension.

UNIT II MIXING AND MOULDING DEVICES

Additives and Mixing process, different types of mixing devices, Types of moulds – ejector system – ejection techniques – mould cooling – CAD / CAM, Extrusion Moulding, Injection Moulding, Special Moulding Techniques.

UNIT III ELASTOMERS AND APPLICATION ORIENTED POLYMERS

Natural Rubber, Styrene – butadiene, Polyisopropane – Neoprene, Silicone rubber, Thermoplastic elastomers, Resins – PVC, Silicon Oil and resins, fibrous Polymers – Nylon 66, Polyacrylonitrile.

UNIT IV PROPERTIES OF POLYMER MATERIALS

Molecular weight-weight average, mechanical properties, thermal properties, electrical properties, rheological properties, and optical properties.

UNIT V POLYMER COMPOSITES

Fibrous and Laminated Composites - Hybrid Composites - Matrix Resins - Unsaturated Polyester - Vinyl Ester - Epoxy- Phenol Formaldehyde - Urea Formaldehyde, Catalysts, Fillers, Reinforcements, Additives for Composites.

Total: 45 hours

SUGGESTED READINGS

1. Birley, Haworth, Batchelor, Physics of Plastics – Processing Properties and Materials Engineering, Hamer Publication, 1992.
2. F.W. Billmayer, Text Book of Polymer Science, 3rd edition, John Wiley and sons, New York, 2002.
3. Richard G. Griskey, Polymer Process Engineering, Chapman and Hall, 1995.
4. Vishu Shah, Hand book of Plastics Testing and Failure Analysis, 3rd Edition, John-Willey &Sons, New York, 2007.
5. Science and Technology of Polymers: https://nptel.ac.in/courses/113105028/

Semester-V

20BTCE5PE03	**NANOTECHNOLOGY**	**3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Understand the basic concepts of Nanotechnology
- Learn mechanisms of Nanofabrication using Photolithography
- Analyze the performance of 0D, 1D, 2D, 3D nanomaterials.
- Study components subjected to Nanomaterials characterization.

COURSE OUTCOMES (COs)

Upon completing of the course students will be able to:

- Learn about the background on Nanoscience
- Understand the synthesis of nanomaterials and their application
- Impact of nanomaterials on environment
- Apply their learned knowledge to develop Nanomaterial's.

UNIT I INTRODUCTION

Background and Definition of Nanotechnology. Why Nano? Applications in Different Fields, Chemical Approaches to Nanostructured Materials, Molecular Switches and Logic Gates, Solid State Devices.

UNIT II CARBON NANOTUBES

Carbon Nanotubes - Structure of Carbon Nanotubes, Synthesis of Carbon Nanotubes, Growth Mechanisms of Carbon Nanotubes, Properties of Carbon Nanotubes, Carbon Nanotube-Based Nano-Objects, Applications of Carbon Nanotubes, Nano wires – Synthesis, Characterization and Physical Properties of Nanowires, Applications.

UNIT III NANOFABRICATION TECHNIQUES

Basic Microfabrication Techniques, MEMS Fabrication Techniques, Nanofabrication Techniques, Stamping techniques- High Resolution Stamps, Microcontact Printing, Nano transfer Printing, Applications.

UNIT IV MEMS and NEMS

Material aspects of NEMS and MEMS – Silicon, Germanium-Based Materials, Metals, GaAs, InP, and Related III-V Materials, MEMS Devices and Applications - Pressure Sensor, Inertial Sensor, Optical MEMS, RF MEMS, NEMS Devices and Applications, Current Challenges and Future Trends.

UNIT V NANO MATERIALS CHARACTERIZATION TECHNOLOGIE

Microscopy-Scanning Tunneling Microscope, Atomic Force Microscope, Scanning Electron Microscopy, Principles of Noncontact Atomic Force Microscope (NC- AFM), Raman Spectroscopy, Thermo Gravimetric Analysis, Digital Scanning Calorimetry, Fourier Transform Infra-Red Spectroscopy and X ray Diffraction

Total: 45 hours

SUGGESTED READINGS

1. Murty, B. S., P. Shankar, Baldev Raj, B. B. Rath, and James Murday. Textbook of nanoscience and nanotechnology. Springer Science & Business Media, 2013.
2. Varghese, P. I., and T. Pradeep. A textbook of nanoscience and nanotechnology. Tata McGraw-Hill Education, 2003.
3. Zhou, Bing, Sophie Hermans, and Gabor A. Somorjai, eds. Nanotechnology in Catalysis Volumes 1 and 2. Vol. 2. Springer Science & Business Media, 2003.
4. Krueger, Anke. Carbon materials and nanotechnology. John Wiley & Sons, 2010.
5. Bhushan, Bharat, ed. Springer handbook of nanotechnology. Springer, 2017.
6. Nptel Course : Nanotechnology : nptel.ac.in/courses/113/106/113106093/

Semester-V

20BTCE5PE04 **PETROLEUM REFINING ENGINEERING** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Understand the formation and composition of petroleum
- Understand the various treatment techniques of petroleum
- Making students familiarize with upgrading process of petroleum products
- Understand Fundamental and methodologies in the petroleum refining processes

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Indicate what crude oils consist of and how crude oils are characterized based on their physical properties
- Classify the processes used in petroleum refining
- Demonstrate how a petroleum refinery works and all refining processes and the resulting refinery products
- Assess implications of changing crude oil feedstocks on refinery configuration and propose strategies to resolve conflicts with degrading crude oil quality and increasingly stringent environmental regulations on petroleum fuels

UNIT I FORMATION AND COMPOSITION OF PETROLEUM

Origin, exploration and production of Petroleum, Types of crudes, composition, characteristics, Products Pattern, Indigenous and imported crudes. Crude heating, primary distillation principles, separation of cuts, gaps / overlaps, stripping. Desalting heat balance in distillation, energy input and recovery, vacuum distillation, types of trays, drawoffs, intermediate product, quality control

UNIT II THERMAL AND CATALYTIC CRACKING

Lube oil and wax processing, solvent extraction, dewaxing desilting, deasphalting, clay contacting, principles operating parameters, feed and product equalities and yields. Types and functions of secondary processing, cracking, thermal cracking and visbreaking, different feed stocks, products, yields and qualities.

UNIT III CATALYTIC REFORMING

Fluid catalytic feed stocks and product yields and qualities. Catalyst and operating parameters. Steam Reforming, Hydrogen, Synthesis gas, cracking of gaseous and liquid feed stocks, olefins, Diolofins, Acetylene and Aromatics and their separation.

UNIT IV ISOMERIZATION, ALKYLATION AND POLYMERIZATION

Isomerization process, Reactions, Effects of process variables. Alkylation process, Feedstocks, reactions, products, catalysts and effect of process variables. Polymerization: Objectives, process, Reactions, catalysts and effect of process variables.

UNIT V ENVIRONMENTAL ISSUES AND NEW TRENDS IN PETROLEUM REFINERY OPERATIONS

Solvent extraction, dewaxing, Additives production from refinery feedstocks. Ecological consideration in petroleum refinery, Waste water treatment, control of air pollution, Alternative energy sources, Biodiesel, Hydrogen energy from biomass.

Total: 45 hours

SUGGESTED READINGS

1. B.K. BhaskaraRao, "Modern Petroleum Refining Processes" Edition 3, Oxford and IBH Publishing Company Pvt. Ltd., New Delhi,2008
2. Jones, D.S.J. and Pujadó, P.R., Handbook of petroleum processing, Springer, The Netherlands, 2006
3. Chaudhuri, Uttam Ray. Fundamentals of petroleum and petrochemical engineering. Crc Press, 2016.
4. Abdel-Aal, Hussein K., and Mohammed A. Alsahlawi, eds. Petroleum economics and engineering. CRC Press, 2013.
5. Petroleum Refinery Engineering: https://nptel.ac.in/courses/103102022/

Semester-VI

20BTCE6PE01 **FLUIDIZATION ENGINEERING** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Understand the fundamental of fluidization.
- Acquainted with the fundamentals of fluidization engineering, different regimes, classification of particles.
- Realize the movement of bubbles mixing in bed.
- Know the mathematical models of Fluidized Bed

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Understand the fluidization behavior.
- Estimate pressure drop, bubble size, void age, heat and mass transfer rates for the fluidized beds
- Write model equations for fluidized beds.
- Design gas-solid fluidized bed reactors.

UNIT I INTRODUCTION

The phenomenon of fluidization; liquid like behaviour of a fluidized bed; Comparison with other contacting methods; Advantages and disadvantages of fluidized beds. Industrial applications of fluidized beds: Coal gasification; gasoline from other petroleum fractions; Gasoline from natural and synthesis gases; Heat exchange; Coating of metal objects with plastics.

UNIT II FLUIDIZATION AND MAPPING OF REGIMES

Drying of solids; FCCU; Fluidized combustion of coal; incineration of solid waste; Activation of carbon; gasification of waste; bio-fluidization. Minimum fluidization velocity; Pressure drop vs. velocity diagram; effect of temperature and pressure on fluidization; Geldart classification of particles; terminal velocity of particles; turbulent fluidization; pneumatic transport of solids; fast fluidization; solid circulation systems;

UNIT III BUBBLING FLUIDIZED BEDS

Voidage diagram; Mapping of regimes of fluidization. Bubbles in dense bed: Single rising bubbles; Davidson model for gas flow at bubbles; Evaluation of models for gas flow at bubbles. Voidage diagram; Mapping of regimes of fluidization. Bubbles in dense bed: Single rising bubbles; Davidson model for gas flow at bubbles; Evaluation of models for gas flow at bubbles.

UNIT IV SPOUTED BED

Experimental findings; Estimation of bed porosities; Physical models: simple two-phase model; K-L model. High velocity Fluidization: Turbulent fluidized bed; Fast fluidization pressure drop in turbulent and fast fluidization. Solids Movement, Mixing, Segregation and staging:; Vertical movement of solids; Horizontal movement of solids; Staging of fluidized beds.

UNIT V HEAT AND MASS TRANSFER IN FLUIDIZED BEDS

Definition, pressure drop-flow diagram, minimum spouting correlation and effect of various parameters on spouting, Heat and mass transfer in fluidized beds: Variables affecting heat transfer rate, heat transfer at the wall of containing vessel, heat transfer to immersed tubes, heat transfer in fixed and fluidized beds, definition and evaluation of mass transfer coefficient.

Total: 45 hours

SUGGESTED READINGS

1. Kaizo Kunii and Octave Levenspiel ,Fluidization engineering, Butterworth-Heinemann Publisher, 2nd. Ed., 1991
2. Liang-Shih Fan, Gas-Liquid-Solid Fluidization Engineering,,Butterworths, 1989
3. MosoonKwauk, Fluidization Idealized and Bubbleless, with Applications, Science Press, 1992
4. Robert H. Perry and Don W. Green, Perrys Chemical Engineers Hand Book, 7th Edition, Mc Graw Hill – International, 1997.
5. Wen-Ching Yang., Handbook of Fluidization and Fluid-Particle Systems, Marcel Dekker Inc, 2003.
6. Fluidization Engineering: https://nptel.ac.in/courses/103/103/103103132/

Semester-VI

20BTCE6PE02 **BIOCHEMICAL ENGINEERING** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Impart the basic concepts of biochemical engineering
- Introduce fundamental concept of Bioprocesses to Chemical Engineers
- Design and construction of unit processes that involve biological organisms or molecules
- Calculate the kinetic parameters of enzymatic reactions and analyze the kinetic parameters for microbial growth.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Understand basics of microbiology to engineer them
- To apply the reaction kinetics to enzyme catalyzed reactions
- Understand mass transport mechanisms in bioprocesses
- Application of chemical concepts in bio-based industries

UNIT I INTRODUCTION TO BIOPROCESS

Overview of traditional and modern application of bioprocesses, unit operations in bioprocesses, Microbiology overview- microbial taxonomy, prokaryotic cell, eukaryotic cell; Introduction to biochemistry- fats, lipids, proteins, carbohydrates, nucleic acids, vitamins.

UNIT II ENZYME TECHNOLOGY

Classification of enzymes, Kinetics of enzyme catalyzed reaction: enzyme substrate complex and enzyme action, types of inhibition, Immobilization-methods, properties, Diffusional limitations, enzyme reactors.

UNIT III KINETICS OF MICROBIAL GROWTH

Stoichiometry of microbial growth and product formation, Medium formulation, operating conditions of suspended and immobilized cells in bioreactors-Batch, fed batch; operation and control of bioreactors.

UNIT IV MASS TRANSFER IN BIOPROCESSES

Stoichiometry of microbial growth and product formation, Medium formulation, operating conditions of suspended and immobilized cells in bioreactors-Batch, fed batch; operation and control of bioreactors.

UNIT V DOWN STREAM PROCESSING

Product recovery: Filtration, sedimentation, centrifugation, cell disruption, extraction, crystallization, drying, Design and analysis of bioreactors.

Total: 45 hours

SUGGESTED READINGS

1. Biochemical engineering fundamentals by J.E.Bailey and D.F.Ollis, 2nd ed, 1986, McGraw Hill.
2. Bioprocess Engineering by Michael L. Shuler and FikretKargi, 2nd edition, Pearson education.
3. Biochemical engineering by James M.Lee – Prentice-Hall-1992.
4. Katoh, Shigeo, Jun-ichi Horiuchi, and Fumitake Yoshida. Biochemical engineering: a textbook for engineers, chemists and biologists. John Wiley & Sons, 2015.
5. Das, Debabrata, and Debayan Das. Biochemical Engineering: An Introductory Textbook. Jenny Stanford Publishing, 2019.
6. Rao, Dubasi Govardhana. Introduction to biochemical engineering. Tata McGraw-Hill Education, 2010.
7. Biochemical Engineering: https://nptel.ac.in/courses/103105054/

Semester-VI

20BTCE6PE03 **INSTRUMENTAL METHODS OF ANALYSIS** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Understand the working principles of different types of instruments and their applications.
- Grasp the principles and applications of UV, Visible, IR Spectroscopy and Photometric titrations
- Familiarize treatment, testing and applications of various spectroscopy.
- Identify suitable chemicals for various engineering applications.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Comprehend the spectroscopy of different elements and compounds.
- Select characterization techniques for different chemicals.
- Be able to do qualitative and qualitative analysis of elements.
- Understand the principles and applications of chromatographic methods.

UNIT I ELECTROMAGNETIC RADIATION

Various ranges, Dual properties, Various energy levels, Interaction of photons with matter, absorbance& transmittance and their relationship, permitted energy levels for the electrons of an atom and simple molecules, classification of instrumental methods based on physical properties

UNIT II MOLECULAR SPECTROSCOPY

Various electronic transitions in organic and inorganic compounds effected by UV, visible and infra-red radiations, excitation by UV and Visible radiations, Woodward-Fischer rules for the calculation of absorption maxima, Effects of auxochromes and effects of conjugation on the absorption maxima; Instrumentation for UV, VISIBLE and IR spectroscopies , Photometric titration, Applications of UV, VISIBLE and IR spectroscopies

UNIT III AAS, NMR SPECTROSCOPY

Atomic Absorption Spectrophotometry: Principle instrumentation and applications, Identification of different heavy metals. Nuclear Magnetic Resonance: Introduction to Nuclear Magnetic Resonance spectroscopy, principle and instrumentation (Proton NMR only). Relaxation, Chemical shift and its causes, reference compounds.

UNIT IV THERMAL METHODS

Thermogravimetry: Instrumentation, factors affecting shapes of thermo grams, and applications, Thermogram of important compounds. Differential Thermal Analysis: Principle, instrumentation and applications. Differences between DSC & DTA. Application of DSC (Inorganic & Polymer samples). TGA - Principle, instrumentation and applications.

UNIT V CHROMATOGRAPHIC METHODS

Classification of chromatographic methods; Column, Thin layer, Paper, Gas, High Performance Liquid Chromatography. Separation of organic compounds by Column and Thin Layer, Mixture of Cu, Co and Ni by Paper Chromatography. Separation of amino acids by Paper Chromatography. Estimation of organic compounds by GC and HPLC.

Total: 45 hours

SUGGESTED READINGS

1. Willard H.H., Merritt I., Dean J.A. and Settle F.A, Instrumental Methods of Analysis, 7thEdition, CBS Publishers, New Delhi, 2004
2. Ewing, Galen W, Instrumental Methods of Chemical Analysis, 7thEdition, McGraw-Hill Company, New Delhi, 2005
3. Skoog D.A. and West D.M, Fundamentals of Analytical Chemistry, 7th Edition, Saunders College Publishing, New York, 2006
4. Banwell. G. C, Fundamentals of Molecular Spectroscopy, Tata McGraw-Hill, New Delhi, 2017
5. Nptel Course: Modern Instrumental Methods of Analysis: nptel.ac.in/courses/103/108/103108100/#

Semester-VI

20BTCE6PE04 **CORROSIVE ENGINEERING** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Understand the corrosion testing and its modern techniques.
- Making familiarize with the economic, environmental, and safety significance of corrosion.
- Learn terms and definitions of basic electrochemistry and electrochemical processes and concepts.
- Understand of Corrosion principles, Electrochemical aspectsand Environmental effects.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Define corrosion and recognize each form of corrosion, corrosion resistance of materials.
- Determine the mechanisms of corrosion reaction including reduction and oxidation reactions, galvanic series, polarization and passivation.
- Recognize the forms of corrosion and its mechanism and conditions for example, fingernail and pitting corrosion.
- Describe the Corrosion Protection techniques, Inhibitors, Coatings, Anodic protection, Cathodic Protection and its related topics.
- Demonstrate the Corrosion monitoring methods.

UNIT I ELECTROCHEMICAL AND THERMODYNAMIC PRINCIPLES

Electrochemical and thermodynamic principles, EMF and galvanic series, merits and demerits; origin of Pourbaix diagram and its importance to iron, aluminum and magnesium metals.

UNIT II ELECTROCHEMICAL BEHAVIOR

Exchange current density, polarization - concentration, activation and resistance, Tafel equation; passivity, electrochemical behavior of active/passive metals, Flade potential, theories of passivity.

UNIT III STRESS CORROSION CRACKING

Nernst equation and electrode potentials of metals, Atmospheric, pitting, dealloying, stress corrosion cracking, intergranular corrosion, corrosion fatigue, fretting corrosion and high temperature oxidation; causes and remedial measures.

UNIT IV TESTING

Purpose of testing, laboratory, semi-plant and field tests, susceptibility tests for IGC, stress corrosion cracking and pitting, sequential procedure for laboratory and on-site corrosion investigations, corrosion auditing and corrosion map of India.

UNIT V CORROSION PREVENTION

Corrosion prevention by design improvements, anodic and cathodic protection, metallic, non-metallic and inorganic coatings, mechanical and chemical methods and various corrosion inhibitors.

Total: 45 hours

SUGGESTED READINGS:

1. Fontana, M.G., "Corrosion Engineering", Tata McGraw-Hill ,2008.
2. Perre R. Roberge," Corrosion engineering: principles and practice", McGraw-Hill 2008.
3. Pierre R. Roberge, "Handbook of corrosion engineering", McGraw-Hill ,2012.
4. Sastri, V.S., Ghali, E. and Elboujdaini, M.," Corrosion prevention and protection: Practical solutions", John Wiley and Sons,2007.
5. Jones, D.A., "Principles and Prevention of Corrosion", Prentice-Hall, 1996.

Semester-VII

20BTCE7PE01 **COMPUTATIONAL FLUID DYNAMICS** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Introduce them to widely used techniques in the numerical solution of fluid flow equations
- Provide them with basic mathematical and numerical concepts of fluid flow and heat transfer problems.
- Get exposed to modern trends in CFD.
- Enhance their skills related to computer design and evaluation in fluid flow, critical thinking and lifelong learning.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Understand the basic principles of mathematics and numerical concepts of fluid dynamics.
- Develop governing equations for a given fluid flow system.
- Apply finite difference method for heat transfer problems.
- Solve computational fluid flow problems using finite volume techniques.

UNIT I GOVERNING EQUATIONS FOR BASIC FLUID FLOW

Introduction to CFD, Basic Philosophy of CFD, Governing equations of fluid dynamics (Mass Equation), Governing equations of fluid dynamics (Newton's Equation), Governing equations of fluid dynamics (Energy Equation).

UNIT II IMPLEMENTATION OF FINITE DIFFERENCE TECHNIQUES IN FLUID FLOW

Incompressible In viscid flows sources, Vortex flow model Transformations and grids, McCormack's method, finite differences, discrimination, consistency, stability, fundamentals of fluid flow modeling.

UNIT III APPLICATION OF FINITE DIFFERENCE TECHNIQUE IN HEAT TRANSFER

Elementary finite difference quotients, implementation aspects of finite difference equations. Finite difference applications in heat conduction and convection- Heat conduction, steady heat conduction in a rectangular geometry.

UNIT IV FINITE VOLUME METHODS & OVERVIEW ON COMMERCIAL PACKAGES

Transient heat conduction Finite difference application in convective heat transfer. Introduction of finite volume methods in computational fluid dynamics, Approximation of surface integrals, volume integrals.

UNIT V ASPECTS OF CFD COMPUTATIONS

Interpolation and differentiation practices, Cell Centered formulation, LAXWendroff time stepping Aspects of CFD computations with commercial packages Like ZN Tutor and Fluent.

Total: 45 hours

SUGGESTED READINGS

1. Versteeg, H.K., and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The finite volume Method", Pearson Education Ltd.Second Edition, 2007.
2. Ghoshdastidar, P.S., "Computer Simulation of flow and heat transfer", Tata McGraw Hill Publishing Company Ltd., 1998.
3. John F. Wendt, John David Anderson ,Computational Fluid Dynamics: An Introduction, , Springer, 2009.
4. Chung, T.J. "Computational Fluid Dynamics", Cambridge University, Press, 2002.
5. ProdipNiyogi, Chakrabarty, S.K., Laha, M.K. "Introduction to Computational Fluid Dynamics", Pearson Education, 2005.
6. Anil W. Date "Introduction to Computational Fluid Dynamics" Cambridge University Press, 2005.
7. Computational Fluid Dynamics: https://nptel.ac.in/courses/112105045/

Semester-VII

20BTCE7PE02 **MODERN SEPARATION TECHNIQUES** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Gain knowledge about advanced separation process.
- Learn possible cases of industrial application
- Learn conceptual design of separation processes and design of equipment involved
- Understand the fundamental principles of separation processes used in analytical chemistry

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Understand the key concepts of conventional and advanced aspects of separation processes, and the selection of separation processes.
- Understand the concepts and develop design equations for membrane separation processes.
- Analyze the separation system for multi-component mixtures, design separation process based on electrical properties.
- Understand and select appropriate separation technique for intended problem.

UNIT I BASICS OF SEPARATION PROCESS

Review of Conventional Processes, Recent advances in Separation Techniques based on size, surface properties, ionic properties and other special characteristics of substances, Process concept, Theory and Equipment used in cross flow Filtration, cross flow Electro Filtration, Surface based solid – liquid separations involving a second liquid.

UNIT II MEMBRANE SEPARATIONS

Types and choice of Membranes, Plate and Frame, tubular, spiral wound and hollow fiber Membrane Reactors and their relative merits, commercial, Pilot Plant and Laboratory Membrane permeators involving Dialysis, Reverse Osmosis, Nano-filtration, Ultra filtration and Micro filtration, Ceramic membranes, Hybrid process and Biological Membranes.

UNIT III SEPARATION BY ADSORPTION TECHNIQUES

Types and choice of Adsorbents, Adsorption Techniques, Dehumidification Techniques, Affinity Chromatography and Immuno Chromatography, Recent Trends in Adsorption.

UNIT IV INORGANIC SEPARATIONS

Controlling factors, Applications, Types of Equipment employed for Electrophoresis, Di electrophoresis, Ion Exchange Chromatography and Electro dialysis, EDR, Bipolar Membranes.

UNIT V OTHER TECHNIQUES

Separation involving Lyophilisation, Pervaporation and Permeation Techniques for solids, liquids and gases, zone melting, Adductive Crystallization, other Separation Processes, Supercritical fluid Extraction, Oil spill Management, Industrial Effluent Treatment by Modern Techniques.

Total: 45 hours

SUGGESTED READINGS

1. Ronald W.Roussel "Handbook of Separation Process Technology", John Wiley, New York, 1987
2. Seader J.D. and Henley E.J., “Separation Process Principles”, 2nd Ed., John Wiley, 2006.
3. Snyder, Lloyd R., Joseph J. Kirkland, and John W. Dolan. Introduction to modern liquid chromatography. John Wiley & Sons, 2011.
4. Escobar, Isabel, and Bart Van der Bruggen, eds. Modern applications in membrane science and technology. American Chemical Society, 2011.
5. Novel Separation Processes: https://nptel.ac.in/courses/103105060/

Semester-VII

20BTCE7PE03 **PROCESS MODELING AND SIMULATION** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Develop steady state and transient models for processes and unit operations
- Understand lumped and distributed parameter models and to seek solution of models using analytic and numerical techniques.
- Construct data driven models and estimate the parameters.
- Give an overview of various methods of process modeling, different computational techniques for simulation.
- Develop process models based on conservation principles and process data

COURSE OUTCOMES (COs)

Upon the completion of the course students are able to

- Apply Computational techniques to solve the process models
- Understand the fundamentals of modeling and their applications in energy equations and phase equilibrium kinetics
- Associate the model with constitutive relations such as phenomenological laws, rate equations, equations of state, property estimation methods
- Create the mathematical models for different unit operations equipments such as stirred tank heaters, Heat exchangers, Evaporators, Reactors, distillation columns
- Analyze the principles of steady state/unsteady state lumped systems and steady state/ unsteady state distributed systems

UNIT I INTRODUCTION

Introduction to modeling and simulation, classification of mathematical models, conservation equations and auxiliary relations.

UNIT II BASIC MODELING

Degree of freedom analysis, single and network of process units, systems yielding linear and nonlinear algebraic equations, flow sheeting – sequential modular and equation oriented

approach, tearing, partitioning and precedence ordering, solution of linear and non-linear algebraic equations using Matrices and Numerical techniques. Error estimates.

UNIT III FLUID FLOW AND REACTION KINETICS

Analysis of liquid level tank, gravity flow tank, jacketed stirred tank heater, reactors, flash and distillation column, solution of ODE initial value problems, matrix differential equations, simulation of closed loop systems – Solution of ODE using Eigen values – Jordan Canonical Form – Stiff equations – Gear's algorithm -Perturbation Methods

UNIT IV STAGED OPERATIONS AND DISTRIBUTED SYSTEMS

Analysis of compressible flow, heat exchanger, packed columns, Monolith Reactor Modeling – Pseudo-homogeneous and Heterogeneous models for catalytic reactors – plug flow reactor, solution of ODE boundary value problems – shooting Method

UNIT V SIMULATION

Analysis laminar flow in pipe, sedimentation, boundary layer flow, conduction, heat exchanger, heat transfer in packed bed, diffusion, packed bed adsorption, plug flow reactor, - hierarchy in model development, classification and solution of partial differential equations – Characteristic curves for parabolic, Elliptic and Hyperbolic equations - Empirical modeling, parameter estimation, population balance and stochastic modelling - Principal Component Analysis

Total: 45 hours

SUGGESTED READINGS

1. Bequette, B.W., "Process Dynamics: Modelling, Analysis and Simulation," Prentice Hall (1998)
2. Himmelblau D.M. and Bischoff K.B., Process Analysis and Simulation, Wiley, 1988
3. Varma A. and Morbidelli M., Mathematical Methods in Chemical Engineering, Oxford University Press, 1997
4. Golub G.H. and van Loan C.F., Matrix Computations, Johns Hopkins University Press, 3rd Edition, 1996

Semester-VII

20BTCE7PE04 **PROCESS OPTIMIZATION** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Introduces the basic concepts in optimization and how to obtain a mathematical representation of the optimization problem.
- Impart optimization techniques using both linear and non-linear programming.
- Learn to frame engineering minima maxima problems in the framework of optimization problems.
- Understand the design experiments and formulate models for chemical processes.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Learn efficient computational procedures to solve optimization problems.
- Cast engineering minima/maxima problems into optimization framework.
- Develop different solution techniques that can be used to actually solve such problems.
- Formulate the optimization problem, and choose appropriate method/solver for solution of the optimization problem.

UNIT I MATHEMATICAL PRELIMINARIES

Linear algebra and matrices -Vector space, Eigen analysis- Elements of probability theory- Elementary multivariable calculus Nature and organization of optimization problems - scope and hierarchy of optimization -typical applications of optimization - essential features of optimization problems- objective function .

UNIT II LINEAR PROGRAMMING

Investment costs and operating costs in objective function - optimizing profitability- constraints - internal and external constraints Formulation of optimization problems -typical examples - nature of functions and their representation - continuous functions -discrete functions - unimodal functions - convex and concave functions

UNIT III UNCONSTRAINED OPTIMIZATION

Necessary and sufficient conditions for optimum of unconstrained functions Simplex method- Introduction to linear programming model - Duality- Karmarkar's method Numerical methods for unconstrained functions - one dimensional search - gradient-free search with fixed step size - gradient search with acceleration

UNIT IV CONSTRAINED OPTIMIZATION

Newton's method -Quasi- Newton method - dichotomous search -fibonacci search - golden-section method – quadratic Interpolation. Conjugate direction and quasi-Newton methods- Gradient-based methods - One-dimensional search methods. Lagrange theorem - FONC, SONC, and SOSC conditions numerical methods for unconstrained multivariable optimization.

UNIT V PROJECTION METHODS

Univariate search - simplex method - Powell's method - method of steepest descent – Fletcher Reeves conjugate - gradient method - Newton's method Linear programming basic concepts in linear programming simplex method two-phase simplex method - nonlinear programming with constraints - equality constraints - method of direct substitution. KKT conditions - Non-linear constrained optimization models.

Total: 45 hours

SUGGESTED READINGS

1. Ravindran, K. M. Ragsdell and G. V. Reklaitis, "Engineering Optimization: Methods andApplications", Wiley India Pvt Ltd. New Delhi, 2006.
2. T.F. Edgar and D.M. Himmelblau," Optimization Techniques for Chemical Engineers",McGraw Hill, New York, 1985.
3. Stainslaw Zak ,An introduction to Optimization by Edwin P K Chong, ,2013
4. K. Deo, "Optimization Techniques", Wiley Eastern, 1995.
5. Edgar T.F. and D. M. Himmelblau, 'Optimization of Chemical Processes', 2nd Edition, McGraw Hill, 2001.
6. Stoecker W. F., Design of Thermal Systems, McGraw-Hill, 3rd Edition, 2011.
7. Singiresu S Rao, 'Engineering Optimization: Theory and Practice', 4th Edition, John Wiley & Sons Ltd., 2009
8. Optimization in Chemical Engineering: https://nptel.ac.in/courses/103105139/

Semester-VII

20BTCEPE05 **ENERGY TECHNOLOGY** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Provide a survey of the most important renewable energy resources,
- Understand the technologies for harnessing these energies from simple to advanced energy systems
- Understanding basic characteristics of renewable sources of energy and technologies for their utilization
- Give review on utilization trends of renewable sources of energy to give review on legislative and regulatory rules related

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Describe the fundamentals and main characteristics of renewable energy sources and their differences compared to fossil fuels.
- Professionals in the various fields of energy engineering
- Compare different renewable energy technologies and choose the most appropriate based on local conditions.
- Develop in-depth technical understanding of energy problems at an advanced level

UNIT I INITRODUCTION

Introduction to energy – Global energy scene – Indian energy scene - Units of energy, conversion factors, general classification of energy, energy crisis, energy alternatives

UNIT II CONVENTIONAL ENERGY SOURCES

Conventional energy resources, Thermal, hydel and nuclear reactors, thermal, hydel and nuclear power plants, efficiency, merits and demerits of the above power plants, combustion processes, fluidized bed combustion.

UNIT III SOLAR ENERGY TECHNOLOGIES

Solar energy, solar thermal systems, flat plate collectors, focusing collectors, solar water heating, solar cooling, solar distillation, solar refrigeration, solar dryers, solar pond, solar thermal power generation, solar energy application in India, energy plantations.

UNIT IV RENEWABLE ENERGY TECHNOLOGIES

Biomass origin - Resources – Biomass estimation. Thermochemical conversion – Biological conversion, Chemical conversion – Hydrolysis & hydrogenation, solvolysis, biocrude, biodiesel power generation gasifier, biogas, integrated gasification. Wind energy, types of windmills, types of wind rotors, Darrieus rotor and Gravian rotor, wind electric power generation, wind power in India, economics of wind farm, ocean wave energy conversion, ocean thermal energy conversion, tidal energy conversion, geothermal energy.

UNIT V ENERGY MANAGEMENT

Energy conservation - Act; Energy management importance, duties and responsibilities; Energy audit – Types methodology, reports, instruments. Benchmalcing and energy performance, material and energy balance, thermal energy management.

Total: 45 hours

SUGGESTED READINGS

1. Sukhatme. S.P., “Solar Energy”, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.
2. Godfrey Boyle, “Renewable Energy, Power for a Sustainable Future”, Oxford University Press, U.K., 1996.
3. Tiwari. G.N., Solar Energy – “Fundamentals Design, Modelling & Applications”, Narosa Publishing House, New Delhi, 2002.
4. Freris. L.L., “Wind Energy Conversion Systems”, Prentice Hall, UK, 1990.
5. Johnson Gary, L. “Wind Energy Systems”, Prentice Hall, New York, 1985
6. David M. Mousdale – “Introduction to Biofuels”, CRC Press, Taylor & Francis Group, USA 2010
7. Chetan Singh Solanki, Solar Photovoltaics, “Fundamentals, Technologies and Applications”, PHI Learning Private Limited, New Delhi, 2009.
8. Technologies for Clean and Renewable Energy Production: http://nptel.ac.in/course/103107157/

Semester-VII

20BTCE7PE06 WATER CONSERVATION AND MANAGEMENT 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Understand wastewater transport system and the theory and design technique for the wastewater treatment process
- Describe the different ways in which water is used, and the quantities used for various purposes
- Distinguish consumptive and non-consumptive uses of water
- Recognize uses of water that are elastic in demand and those uses that are inelastic in demand

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Examine the constituents of waste water and its effects.
- Separate the contaminants from the effluent for treatability.
- Determine the biomass yield and substrate utilization rate for biological treatment process and design of activated sludge process.
- Develop a flow sheet for the waste water treatment from dairy, sugar, pulp and paper, textile and pharmaceutical industries.

UNIT I INTRODUCTION

Introduction: water cycle, water storage, , Importance of water, water requirements (Domestic, Institutional, Industrial, Public and Agriculture). Water availability, water quantification, Water supply scheme: Importance & necessity of water supply scheme. Types of water demands: (Domestic Water Demand, Industrial Demand, Institution and Commercial Demand, Water demand for Public Use and percapita demand). Factors affecting per capita demand (Habit of inhabitants, Public services, Climate, System of supply, Metering of water supply, System of drainage, Industrialization).

UNIT II WATER MANAGEMENT

Water management-water quality, controlling use and quality of water, water flow measurement, water quality control, testing water salinity. Water and water quality standards:, Desirable limits, Permissible limit, PPM, PPB. Drinking Water Specifications: Physical parameters (Color, taste-odor, Turbidity, suspended solids, Temperature. Chemical parameters (TDS Alkalinity, Hardness, salts, acids and alkalis, chlorides, fluorides, proteins, carbohydrates, organics, fats oil & grease, Hazen unit, NTU,BOD, COD, DO, TDS, Trace metals, Heavy metals, tests on quality parameters.

UNIT III WATER AUDIT

Preserving water quality, minimizing evaporation, water sanitation, Water audits. Drinking Water Standards of BIS, International water quality standards, BIS (Bureau of Indian Standards).Safe limits for Electrical Conductivity for Irrigation Water, Guidelines for Evaluation of Quality of Irrigation Water, Effects of water quality parameters of water being used in industries.

UNIT IV WASTE WATER TREATMENT

Waste water in Industry- Home and Agriculture – Various waste water treatment processes – Treatment of Water: Flowchart of water treatment plant, Treatment methods (Theory and Design)- Physico-Chemical treatments: Sedimentation, Coagulation-Flocculation, Settling Tanks, Disinfection Systems: Chemicals- Chlorination and other Disinfection methods, UV, Ozonation, Aeration and Gas transfer; Precipitation; Softening; Adsorption and Ion exchange; Reverse Osmosis Technologies Membrane processes, Ultra Filtration.

UNIT V WATER CONSERVATION

Water conservation in agriculture; Water conservation in process industry; water conservation in construction industry; water conservation in service industry. Water conservation in homes; water conservation in the work place.

Total: 45 hours

SUGGESTED READINGS

1. P.C.Bansil "Water Management in India", Concept Publishing company, New Delhi, First Edition, 2004.
2. G.S.Bridie and J.S.Bridie "Water Supply and Sanitary Engineering", Dhanpat Raj Publishing company (P) Ltd., New Delhi, 7th Edition, 2013
3. Austin G.T., "Shreve's Chemical Process Industries", Fifth Edition, McGraw Hill, 1998.
4. S.C. Rangwala, "Water supply and Sanitary Engineering", Eighteenth Edition, Charotar Publishing House, 2003.
5. Metcalf and Eddy," Wastewater Engineering: Treatment and Reuse", Fifth edition, 2016

Semester-VII

20BTCE7PE07 PROCESS SAFETY AND HAZARDOUS ENGINEERING 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Understand the key principles of process safety and its management.
- Making students familiarize the key factors influencing the basis of process safety.
- Understand the various aspects of Industrial safety.
- Learn the occupational hazards existing in chemical industries.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Evaluate the hazards associated with a process plant and how the risks can be controlled
- Recognize the human, environmental and business consequences of poor process safety.
- Predict the key process safety requirements at each stage in the life cycle of a process plant from conceptual design through to operation, maintenance and modification
- Determine the interdependence of and the need for overall organization process safety management capability
- Analyze how to acquire further knowledge and understanding of process safety management

UNIT I INDUSTRIAL SAFETY MANAGEMENT

Importance of Safety consciousness in Indian Chemical Industries - Development of Industrial Health and Safety, Safety Organization –Polices-Culture -Planning- Promotion – Inspection – Rules- Responsibility – Supervision, Safety Committee – role of safety functionaries, Elements of work place Safety Program, Economic and Social Benefits from Safety Program- Effective Safety Education and Training – Communication at various levels of production and operation, Safety slogans.

UNIT II CHEMICAL PLANT SAFETY

Chemical process Industries - Sitting and Layout of a Chemical plant, Safety in transportation, storage and handling of hazardous chemicals, Chemical process hazards and their control - First degree and second degree hazards. Lines of defense - High pressure - High temperature operations – Case studies, Emergency preparation: On-site and Offsite , Safety

aspects of maintenance in chemical plant -Effective steps to implement safety procedures- Periodic Advice and checking to follow safety procedures and rules- Safe guarding of Machines.

UNIT III ACCIDENT AND THEIR PREVENTION

Ergonomics -Proper selection and replacement of handling equipment -Safe handling and operation of materials and machineries. Definitions, H.W.Henrich, Frank bird & Multiple Causation theories of accident occurrences, Classification, Causes, Costs -Industrial accidents, Principles of Accident prevention, Accident prevention technique – Plant and Chemical job safety analysis, Accident proneness-vocational guidance, Safety performance measurement tools - FR. SR, (FSI), Safe-T-Score.

UNIT IV HAZARD IDENTIFIATION TECHNIQUES

Accident rate per 1000 workers, Disabling injury index, Accident Compensation Statutes, Accident Investigation reporting and Analysis, Case studies. Conditions -Fire triangle, Classification of fires, Common causes of industrial fires, Fire protection systems- prevention- Case studies, Safety in Explosive Safety Appraisal - Risk Assessment -Hazard identification techniques with examples such as FMEA, CMA, Fault Tree Analysis, Preliminary Hazard Analysis (PHA), Hazard and operability (HAZOP) study.

UNIT V INDUSTRIAL HYGIENE AND OCCUPATIONAL HEALTH HAZARDS

Quantitative risk analysis-Out line of methodology, Consequences analysis, Calculation of release rates of liquids under ambient pressure and liquids under pressure, Calculation of dispersion of released gases and vapors and platting of equal concentration contours, Dow (Index) Fire and Explosion Index System of Risk Analysis, Safety Audit. Concepts - Industrial and Occupational health hazards, Housekeeping, human factors and error, stress at work, Personnel protective equipments, Role of trade unions in Industrial safety and health.

Total: 45 hours

SUGGESTED READINGS:

1. Sarma. A M," Safety and Health in Industry", BS Publications,2009.
2. Fulekar. M.H," Industrial Hygiene and Chemical Safety ", I.K International Publishing,2006.
3. Fawcett .H.H, and Wood .W.S," Safety and Accident Prevention in Chemical Operations", John Wiley & sons, 1965.

Semester-VII

20BTCE7PE08 POLLUTION CONTROL IN PROCESS INDUSTRIES 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Impart the basic concepts of environmental engineering.
- Understand the problems of pollution and create awareness.
- Address these issues and conserve the environment in a better way.
- Learn the basic concepts of water treatment technology.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Understand the effects of pollutants to the environment.
- Develop the various treatment technologies for water/wastewater, air effluents and solid waste released from chemical industries.
- Understand the development of various unit operation.
- Analyze the problems of pollution and suggest suitable treatment methodology.

UNIT I INTRODUCTION

Man and Environment, Types of pollution, Pollution control aspects, Pollution monitoring and analysis of pollutant. Impact of man on the environment: an overview, the biosphere, hydrologic cycle and measurement of precipitation, the nutrient cycle, Importance of environment for mankind, pollution of air, water and soil, Environment, Environmental quality and degradation, description of environment setting and procedure for environment impact assessment policies and acts.

UNIT II AIR POLLUTION

Air pollution: Sources and effects - Nature of air pollution classification, properties and sources of pollutants. Acid rain - Greenhouse effect- Ozone depletion - Effects of man, animal, vegetation and material dangers. Equipment for control of air pollution. Measurements of air

pollution. particulate control, control of gaseous pollutants (SOx, NOx, oxides of carbon, hydrocarbon pollutants), Air Quality Management.

UNIT III WATER POLLUTION

Sources and classification and effects of water pollutants. Measurements of COD & COD. Sampling and analysis. Waste water treatment: Design aspects of Preliminary, primary, secondary and tertiary treatment of waste water. Recovery of materials from process effluents. Anaerobic and aerobic Sludge treatment and disposal. Cake filtration and composting. Methods of physio-chemical and biological treatment of industrial effluents from fertilizer, petrochemical, pulp and paper, caustic soda, tanning and sugar industries.

UNIT IV NOISE POLLUTION

Sources of noise pollution. Noise pollution measurements - controlling methods of noise pollution. Effects on human being. Noise control criteria, administrative and engineering controls, acoustical absorptive materials. Hazardous noise exposure, noise measuring instruments and noise pollution control technology. Regulations: ISO 14000, 9000, pollution Acts and Regulations.

UNIT V SOLID WASTE MANAGEMENT

Solid waste management: Sources, classification and microbiology of solid waste., methods of collection, disposal methods. Sources, processing methods, waste disposal methods, energy recovery from solid waste. Solid waste characteristics- Health aspects, methods of collection and disposal, Solid waste processing and recovery - composting. Sanitary land filling, thermal processes, regeneration and recycling. City waste and industrial wastes management

Total: 45 hours

SUGGESTED READINGS:

1. C. S. Rao, “Environmental Pollution Control Engineering”, New Age International Pvt. Ltd., 2003.
2. P. Venugopal Rao, "Text book of Environmental Engineering", PHI, New Delhi 2002.
3. J. P. Sharma, " Comprehensive Environmental Studies", Laxmi Publications, New Delhi 2004.
4. Santhosh Kumar Garg, " Environmental Engineering", (Vol I and II) Khanna Publishers, NewDelhi, 2004

20BTSHOE01 **SOLID WASTE MANAGEMENT** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Make the students toconversant with basics of Solid wastes and its classification.
- Make the student acquire sound knowledge of different treatments of solid wastes.
- Acquaint the student with concepts of waste disposals.
- Develop an understanding of the basic concepts of Hazardous waste managements.
- Acquaint the students with the basics of energy generation from waste materials

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Outline the basic principles of Solid waste and separation of wastes
- Identify the concepts of treatment of solid wastes
- Identify the methods of wastes disposals.
- Examine the level of Hazardousness and its management.
- Examine the possible of the energy production using waste materials.
- Integrate the chemical principles in the projects undertaken in field of engineering and technology

UNIT I SOLID WASTE

Definitions – Sources, Types, Compositions, Properties of Solid Waste – Municipal Solid Waste – Physical, Chemical and Biological Property – Collection – Transfer Stations – Waste Minimization and Recycling of Municipal Waste

UNIT II WASTE TREATMENT

Size Reduction – Aerobic Composting – Incineration – batch type and continuous flow type, Medical/ Pharmaceutical Waste Incineration – Environmental Impacts – Measures of Mitigate Environmental Effects due to Incineration

UNIT III WASTE DISPOSAL

Sanitary Land Fill Method of Solid Waste Disposal – Land Fill Classficaition, Types, Methods &Siting Consideration – Layout & Preliminary Design of Land Fills – Composition,

Characteristics generation, Movement and Control of Landfill Leachate & Gases – Environmental Monitoring System for Land Fill Gases, Waste landfill Remediation

UNIT IV HAZARDOUS WASTE MANAGEMENT

Definition & Identification of Hazardous Waste – Sources and Nature of Hazardous Waste – Impact on Environment – Hazardous Waste Control – Minimization and Recycling -Assessment of Hazardous Waste Sites – Disposal of Hazardous Waste, Underground Storage Tanks Construction, Installation & Closure, Remediaiton, risk assessment.

UNIT V ENERGY GENERATION FROM WASTE

Thermal conversion Technologies – Pyrolysis systems, Combustion systems, Gasification systems, Environment control systems, Energy recovery systems. Biological & Chemical conversion technologies – Aerobic composting, low solids. Anaerobic digestion, high solids anaerobic digestion, Energy production from biological conversion products, other biological transformation processes. Chemical transformation processes.

Total: 45 hours

SUGGESTED READINGS

1. Dara.S.S,Mishra.D.D (2011) A Text book of Environmental Chemistry and Pollution ControlS.Chand and Company Ltd., New Delhi
2. Naomi B. Klinghoffer and Marco J. Castaldi (2013) Waste to Energy Conversion Technology (Woodhead Publishing Series in Energy) Woodhead Publishing Ltd., Cambridge, UK
3. Frank Kreith, George Tchobanoglous (2002) Hand Book of Solid Waste Management-2nd edition McGraw Hill Publishing Ltd., Newyork
4. Shah, L Kanti (Basics of Solid & Hazardous Waste Management Technology Prentice Hall (P) Ltd.,New Delhi
5. Salvatore Caccavale (2016)A Basic Guide to RCRA: Understanding Solid and Hazardous Waste Management 2 edition American Society of Safety Professionals
6. www.iitk.ac.in/3inetwork/html/reports/IIR2006/Solid_Waste.
7. http://www.unep.or.jp/ietc/ESTdir/Pub/MSW/
8. www.alternative-energy-news.info/technology/garbage-energy/
9. nzic.org.nz/ChemProcesses/environment/

20BTSHOE02 **GREEN CHEMISTRY** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Make the students conversant about the green chemistry
- Make the student acquire sound knowledge of the atom efficient process and synthesis elaborately.
- Acquaint the student with concepts of green technology.
- Develop an understanding of the basic concepts of renewable energy resources.
- Acquaint the students with the basics information on catalysis.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Outline the basic principles of green chemistry
- Examine the different atom efficient process and synthesis elaborately
- Apply the concepts combustion of green technology
- Identify and apply the concepts of renewable energy
- Apply the concepts of green catalysts in the synthesis
- Integrate the chemical principles in the projects undertaken in field of engineering and technology

UNIT I INTRODUCTION TO GREEN CHEMICAL PRINCIPLES

Definition, tools, and twelve principles of green chemistry, solvent-less reactions and reactions in water, microwaves and fluorous solvents, green resolution of racemic mixtures, materials for a sustainable economy, chemistry of longer wear, agrochemicals: problems and green alternate solutions.

UNIT II ATOM EFFICIENT PROCESSES

Atom efficient processes, evaluating chemical reagents according to their yield and atom efficiency, examples of efficient stoichiometric and catalytic processes, atom economy and homogeneous catalysis, halide-free synthesis and alternatives to Strecker synthesis.

UNIT III BIOTECHNOLOGY AND GREEN CHEMISTRY

Bio technology and its applications in environmental protection - Bio informatics-Bio remediation, biological purification of contaminated air. Green chemistry for clean technology-Significance of green chemistry-Basic components of green chemistry, Industrial applications of green chemistry, green fuels-e-green propellants and bio catalysts.

UNIT IV RENEWABLE RESOURCES

Use of renewable materials, evaluating feedstock and starting materials and their origins, toxicity, sustainability and the downstream implications of the choice of feedstock, commodity chemicals from glucose and biomass conversion.

UNIT V CATALYSIS IN GREEN CHEMISTRY

Catalysis, energy requirements and usage, optimization of the reaction by minimizing the energy requirements, examples of efficient catalytic reactions including the use of heterogeneous catalysis, zeolites, oxidation using molecular oxygen.

Total: 45 hours

SUGGESTED READINGS

1. Sanjay K. Sharma, Ackmez Mudhoo (2010)Green Chemistry for Environmental Sustainability CRC Press , London
2. Ahluwalia V. K. and M.Kidwai (2007) New Trends in Green Chemistry 2nd edition Anamaya publishers., New Delhi.
3. Dr. Sunita Ratan (2012) A Textbook of Engineering Chemistry S.K. Kataria and Sons., New Delhi
4. Mukesh Doble. Ken Rollins, Anil Kumar (2007) Green Chemistry and Engineering, 1st edition Academic Press, Elesevier., New Delhi.
5. Desai K. R. (2005) Green Chemistry Himalaya Publishing House, Mumbai.
6. Matlack A. S. (2001) Introduction to Green Chemistry Marcel Dekker: New York
7. http://www.organic-chemistry.org/topics/green-chemistry.shtm
8. http://www.essentialchemicalindustry.org/processes/green-chemistry.html
9. http://www.chm.bris.ac.uk/webprojects2004/vickery/green_solvents.htm
10. http://www.epa.gov/research/greenchemistry/
11. http://www.amazon.in/Green-Chemistry-Catalysis

20BTSHOE03 **APPLIED ELECTROCHEMISTRY** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Make the students conversant with the information on electrochemical material.
- Make the student acquire sound knowledge of conducting polymers.
- Acquaint the student with concepts of Energy storage devices.
- Develop energy storage devices.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Outline the basic principles of chemistry in **electrochemical material**
- Examine the properties of conducting polymers
- Apply the concepts of electrochemistry in storage devices.
- Identify the concepts of storage devices and its applications.
- Apply the suitable materials for the manufacturing of storage devices.
- Integrate the chemical principles in the projects undertaken in field of engineering and technology

UNIT I METAL FINISHING

Fundamental principles, surface preparation-Electroplating of copper, nickel, chromium, zinc and precious metals (gold & silver)- Electroplating for electronic industry- Alloy plating, brass plating- Electro less plating of nickel- anodizing – Electroforming – Electro winning.

UNIT II CONDUCTING POLYMERS AND ELECTROCHEMICALS

Lectro-polymerisation- anodic and cathodic polymerization-effect of reaction parameters on the course of the reaction- Electrochemical preparation of conducting polymers- poly acetylene- Electrolytic production of perchlorates and manganese dioxide- Electro organic chemicals- constant current electrolysis.

UNIT III BATTERIES AND POWER SOURCES-I

Principles of energy conservation- electrochemical energy conservation- thermodynamic reversibility, Gibbs equation. EMF- battery terminology, energy and power density- Properties of anodes, cathodes, electrolytes and separators- Types of electrolytes.

UNIT IV BATTERIES AND POWER SOURCES-II

Primary batteries- Dry Leclanche cells, alkaline primary batteries, Lithium batteries, Lithium ion batteries- construction, characteristics, problems associated with system- Secondary batteries- Lead acid, nickel cadmium- Fuel cells- Introduction, types of fuel cells, advantages.

UNIT V ELECTROCHEMICAL MATERIAL SCIENCE

Solar cells- Preparation of CdS/Cu_2S solar cells by screen printing techniques and their characteristics - Amorphous silicon solar cells - Photo electrochemical cells(PEC) for conversion of light energy to electrical energy - PEC cells based on Cd/Se and Ga/As characteristics.

Total: 45 hours

SUGGESTED READINGS

1. Cynthia G. Zoski (2007) Hand Book of Electrochemistry, Academic Press, Elesevier., UK
2. D.Pletcher and F.C.Walsh, (2012) Industrial Electrochemistry, Chapman and Hall, London
3. Vladimir S. Bagotsky , Alexander M. Skundin , Yurij M. Volfkovich, (2015) Electrochemical Power Sources: Batteries, Fuel Cells, and Supercapacitors, Wiley India Pvt. Ltd
4. Bruno Scrosati (2012) Applications of Electroactive Polymers Chapman & Hall, London
5. K.L. Chopra (2011) Thin Film Devices Application Plenum Press, New York
6. M.M.Baizer (2011) Organic electrochemistry: An introduction and a guide Dekker Inc. New York
7. http://www.anoplate.com/finishes/
8. http://hyperphysics.phy-astr.gsu.edu/hbase/electric/battery.html
9. http://inventors.about.com/od/sstartinventions/a/solar_cell.htm

20BTBTOE01 **BIOREACTOR DESIGN** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Impart basic knowledge in bioprocess Engineering
- Design the bioreactors for various operations.
- Discuss the principle and working of heat transfer equipments.
- Extend the knowledge in principle of heat transfer inside a bioreactor
- Construct the equipments used in mass transfer operations.
- Illustrate the equipments used in separation process.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Summarize the basic concepts in bioprocess Engineering.
- Design the bioreactors for various operations.
- Develop the heat transfer equipments for Bioprocess Engineering.
- Construct the equipments used in mass transfer operations.
- Categorize the equipments used in separation process.
- Describe the applications of bioreactors.

UNIT I INRODUCTION TO BIOPROCESS ENGINEERING

Introduction – Biotechnology and Bioprocess Engineering- Biologists and Engineers Differ in their approach to research-How Biologists and Engineers work Together- Bioprocesses: Regulatory constraints.

UNIT II REACTOR DESIGN

Design of Airlift fermentor, Bubble column reactor and Continuous stirred tank reactor.

UNIT III HEAT TRANSFER EQUIPMENTS

Design of Shell and tube Heat exchanger, Double pipe heat exchanger, long tube vertical evaporator and forced circulation evaporator.

UNIT IV MASS TRANSFER EQUIPMENTS

Design of Bollmann extractor, fractionating column, packed tower and spray tray absorber

UNIT V SEPARATION EQUIPMENTS

Design of plate and frame filter press, leaf filter, rotary drum filter, disc bowl centrifuge, rotary drum drier and Swenson –walker crystallizer.

Total: 45 hours

SUGGESTED READINGS:

1. James Edwin Bailey, David F. Ollis (2015) Biochemical Engineering Fundamentals, Second Edition. McGraw-Hill Education (India) private limited.
2. Don W. Green, Robert H.Perry (2008). Chemical Engineer Hand book. The McGraw-Hill Companies, Inc.
3. Pauline. M. Doran (2015). Bioprocess Engineering Principles Second Edition . Academic Press.

20BTBTOE02 **FOOD PROCESSING AND PRESERVATION** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Discuss the scope and importance of food processing.
- Impart basic knowledge in different food processing methods carried out in the food tech companies.
- Extend the brief knowledge in food conservation operations.
- Explain the methods of food preservation by cooling.
- Tell the concepts of preservation methods for fruits.
- Create deeper understanding on preservation methods for vegetables.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Describe the scope and importance of food processing.
- Outline the various processing methods for foods.
- Extend the knowledge in food conservation operations.
- Describe the methods of food preservation by cooling.
- Summarize the preservation methods for fruits.
- Demonstrate the preservation methods for vegetables.

UNIT I SCOPE AND IMPORTANCE OF FOOD PROCESSING

Properties of food-Physical, thermal, mechanical, sensory. Raw material Preparation - Cleaning, sorting, grading, peeling.

UNIT II PROCESSING METHODS

Heating- Blanching and Pasteurization. Freezing- Dehydration- canning-additives- fermentation- extrusion cooking- hydrostatic pressure cooking- dielectric heating- micro wave processing and aseptic processing – Infra red radiation processing-Concepts and equipment used.

UNIT III - FOOD CONVERSION OPERATIONS

Size reduction – Fibrous foods, dry foods and liquid theory and foods–equipments- membrane separation- filtration- equipment and application.

UNIT IV FOOD PRESERVATION BY COOLING

Refrigeration, Freezing-Theory, freezing time calculation, methods freezing of freezing equipments, freeze drying, freeze concentration, thawing, effect of low temperature on food. Water activity, methods to control water activity.

UNIT V PRESERVATION METHODS FOR FRUITS AND VEGETABLES

Pre processing operations - preservation by reduction of water content: drying / dehydration and concentration – chemical preservation – preservation of vegetables by acidification, preservation with sugar - Heat preservation– Food irradiation- Combined preservation techniques.

Total: 45 hours

SUGGESTED READINGS:

1. R. Paul Singh, Dennis R.Heldman (2014).Introduction to food engineering. Academic press.
2. P.Fellows. (2017). Food processing technology principles and practice, Fourth Edition. Wood head publishing Ltd.
3. Mircea Enachescu Dauthy. (1995). Food and vegetable processing.FAO agricultural services bulletin.
4. M.A. Rao, Syed S.H.Rizvi, Ashim K. Datta. (2014). Engineering properties of foods. CRC press.
5. B. Sivasankar. (2002). Food processing and preservation.PHI learning Pvt.Ltd.

20BEECOE01 **NEURAL NETWORKS AND ITS APPLICATIONS** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Introduce the basic concepts of neural networks and its applications in various domain
- Educate about supervised and unsupervised learning process
- Gain a solid understanding of various neural network model
- Study about annealing technique
- Learn the concepts of Self-Organizing Map (SOM) algorithm
- Understand steps involved in ballistic arm movements.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Understand the basic concepts of neural networks and its applications in various domains
- Gain knowledge about learning process in Neural Networks
- Design using Adaptive Resonance Theory (ART) technique
- Describe steps in annealing process
- Acquire knowledge on SOM concepts
- Explain ballistic arm movements.

UNIT I INTRODUCTION TO NEURAL NETWORKS

Introduction-biological neurons and their artificial models-learning, adaptation and neural network's learning rules-types of neural networks-single layer, multiple layer-feed forward, feedback networks

UNIT II LEARNING PROCESS

Error– correction learning– memory based learning- hebbian learning-competitive learning-Boltzmann learning-supervised and unsupervised learning-adaptation-statistical learning theory.

UNIT III PERCEPTION

Single layer Perception-Adaptive filtering-unconstrained Optimization-Least-mean square algorithm- Leaning Curve-Annealing Technique-perception convergence Theorem-Relationship between perception and Baye's Classifier-Back propagation algorithm

UNIT IV ATTRACTOR NEURAL NETWORK AND ART

Hopfield model-BAM model -BAM Stability-Adaptive BAM -Lyapunov function-effect of gain- Hopfield Design-Application to TSP problem-ART-layer 1-layer 2-orienting subsystem- ART algorithm-ARTMAP.

UNIT-V SELF ORGANIZATION

Self-organizing map-SOM Algorithm-properties of the feature map-LVQ-Hierarchical Vector Quantization. Applications of self-organizing maps: The Neural Phonetic Type Writer Learning Ballistic Arm Movements.

Total: 45 hours

SUGGESTED READINGS

1. SimonHaykin Neural Networks and Learning Machines 3rd Edition Pearson/Prentice Hall 2009
2. SatishKumar Neural Networks: A Classroom Approach TMH 2008
3. Rajasekaran.S, Vijayalakshmi Pai.G.A Neural Networks, Fuzzy Logic and Genetic Algorithms, Synthesis and Applications PHI, New Delhi 2003.
4. LaureneFausett Fundamentals of Neural Networks: Architectures, Algorithms, and Applications Pearson/Prentice Hall 1994
5. Wasserman P.D Neural Computing Theory & Practice Van Nortrand Reinhold 1989.
6. Freeman J.A, S kapura D.M Neural networks, algorithms, applications, and programming techniques Addition Wesley 2005.
7. https://nptel.ac.in/courses/117105084/
8. https://www.geeksforgeeks.org/adaptive-resonance-theory-art/

20BTFTOE03 **READY TO EAT FOODS** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Outline the current status of snack food Industry
- Describe the production, processing and marketing trends of potato and tortilla chips
- Outline the overall processing of popcorn
- Explain the production and processing of fruits involved in snack food preparation
- Summarize the sensory analysis methods and packaging techniques of snack foods

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- List the various manufacturing process in snack food industries
- Acquire knowledge about current production and marketing status of Snack foods
- Elucidate the advantages of Sensory Evaluation
- Packaging technologies in Snack Food Industries
- Demonstrate the equipments involved in the snack production processes
- Use flavorings in the popcorn industries

UNIT I SNACK FOOD INDUSTRY

Introduction-History-Past innovations- Outline of snack food industry- Nutrition-Total Quality Management of Technology-Domestic Snack Food Market-Global Market-Snack Food Association Future Considerations

UNIT II POTATO AND TORTILLA CHIPS PROCESSING

Potato Production- Potato snack Ingredients- Potato Analysis and Composition-Potato chip manufacturing process-Unit Operations-Other value added products from Potato.

Tortilla chips - Raw Materials- Processing steps-Equipment involved-Reconstitution of Dry Maize Flour-Unit operations.

UNIT III POPCORN PROCESSING

Introduction- Raw popcorn selection and preparation-Popping Methods-Home preparation of Popcorn-Equipments-Industrial manufacturing process- Flavorings and Applicators-Popcorn Packaging- Relative Nutrition- Marketing.

UNIT IV FRUIT BASED SNACKS

Introduction-production and processing of fruit crops – fruit purees – fruit powders – canned fruit snacks – alcoholic preservation of fruit snacks – fruit candies – fruit bars – exotic fruits.

UNIT V SENSORY EVALUATION AND PACKAGING

Introduction- Analytical methods-Sensory methods- Sensory Aspect of Processing- Quality properties of Snack Foods and Packaging Materials-Automated Bag- Pouch Packaging-Cartoning Case Packing-Current Issues in Snack Foods Packaging

Total: 45 hours

SUGGESTED READING

1. Lusas, E. W and Rooney, L. W. Snack Foods Processing. CRC Press,1st Edition 2001. (ISBN-13: 978-0367412746)
2. Panda, H. The Complete Technology Book on Snack Foods, National Institute of Industrial Research, Delhi. 2nd Edition 2013. (ISBN-13: 978-9381039243)
3. Sergio O Serna-Saldivar, Industrial Manufacture of Snack Foods, Kennedys Books Ltd. 2008. (ISBN-13: 978-0955808500)

20BTFTOE04 AGRICULTURAL WASTE AND BYPRODUCTS UTILIZATION 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Categorize the types of agricultural wastes
- Outline the production and utilization of biomass
- Explain the various parameters considered to be important in the designing of biogas units
- Discuss the methods employed in the production of alcohol from agricultural wastes / byproducts
- Summarize the overall aspects involved in the production of paperboards and particle boards from agricultural wastes

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- List and classify the types of agricultural wastes
- Collect and generate number of value added products from agricultural wastes
- Recall the techniques involved in the production and utilization of biomass
- Assess the various parameters considered to be important in the designing of biogas units
- Illustrate the various methods employed in the production of alcohol from the byproducts of agricultural wastes
- Choose the appropriate materials to produce paperboards and particle boards from agricultural wastes

UNIT 1 TYPES OF AGRICULTURAL WASTES

Introduction and background of agricultural waste, crop waste, agricultural residues (annual crops), technical terms, rice by-product utilization - rice bran and germ, rice bran oil, economic products from agriculture waste/by-products.

UNIT 2 BIOMASS PRODUCTION AND UTILIZATION

Biomass gasifier, Technology used for the utilization of agricultural wastes: Biomass gasifier, Nimbkar Agricultural Research Institute (NARI) gasifier, rice-husk based gasifier, heat and steam from sugarcane leaf and bagasse.

UNIT 3 BIOGAS DESIGN AND PRODUCTION

Biogas: Definition, composition, history of biogas, production of biogas; types of biogas plant (floating drum type and fixed dome type) and their components (inlet, outlet, stirrer, slanting pipe, digester, gas holder and gas outer pipe), selection and design of biogas plant.

UNIT 4 PRODUCTION OF ALCOHOL FROM WASTE MATERIALS

Production of alcohol from waste materials: Introduction, production methods, cellulolysis (biological approach): pretreatment, cellulolytic processes (Chemical and Enzymatic hydrolysis), microbial fermentation, gasification process (thermochemical approach).

UNIT 5 PRODUCTION OF PAPERBOARDS AND PARTICLEBOARDS FROM AGRICULTURAL WASTE

Production and testing of paperboards and particleboards from agricultural waste: Introduction, history, terminology and classification, raw materials, production steps - pulping, classifications of pulp, bleaching, plies, coating, grades.

Total: 45 hours

SUGGESTED READINGS

1. Efthymia Alexopoulou. Bioenergy and Biomass from Industrial Crops on Marginal Lands. Elsevier, 1st Edition, 2020. (ISBN: 9780128188644)
2. Navanietha Krishnaraj Rathinam, Rajesh Sani. Biovalorisation of Wastes to Renewable Chemicals and Biofuels. Elsevier, 1st Edition, 2019. (ISBN: 9780128179529)
3. Simona Ciuta, Demetra Tsiamis, Marco J. Castaldi. Gasification of Waste Materials. Academic Press, 1st Edition, 2017. (ISBN: 9780128127162)
4. Nicholas E. Korres, Padraig O'Kiely, John A.H. Benzie, Jonathan S. West. Bioenergy Production by Anaerobic Digestion: Using Agricultural Biomass and Organic Wastes. Routledge, 1st Edition, 2013. (ISBN-13: 9780415698405)
5. Albert Howard, Yashwant Wad. The Waste Products of Agriculture. Benediction Classics, 1st Edition, 2011. (ISBN-13: 9781849025454)

20BEMEOE01 **COMPUTER AIDED DESIGN** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Provide an overview of how computers are being used in mechanical component design
- Study about the various computer graphics concepts
- Get basic knowledge on geometric modeling
- Study about the basics of parametric design and object representation
- Get basic knowledge in product design and development.

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Give the overview of the cad systems and its importance
- Explain the ideas and principles behind the computer graphics
- Explain the process involved in graphic transformations
- Understand the operations involved in the geometric modeling.
- Describe the concepts of parametric design
- Understand the basics of the product design and development.

UNIT I OVERVIEW OF CAD SYSTEMS

Conventional and computer aided design processes-advantages and disadvantages. Subsystems of CAD-CAD hardware and software, analytical and graphics packages, CAD workstations. Networking of CAD systems.

UNITII INTERACTIVE COMPUTER GRAPHICS AND GRAPHICS TRANSFORMATIONS

Generative, cognitive and image processing graphics. Static and dynamic data graphics. Transport of graphics data. Graphic standards. Generation of graphic primitives - display transformation in Two- and Three – Dimensional graphics concepts, Graphical input technique, Geometric transformations, Visual Realism, Computer animation, customizing graphics software.

UNIT III GEOMETRIC MODELING

Wireframe, surface, NURBS and solid modeling-applications and advantages. Creating primitive solids, sweeping solids, Boolean operations. Extracting entities from a solid. Filleting of edges of solids. Boundary representation (B-rep) Constructive Solid Geometry (CSG) and Analytical Solid Modeling (ASM)

UNIT IV PARAMETRIC DESIGN AND OBJECT REPRESENTATION

Types of co-ordinate systems. Parametric design - definition and advantages. Parametric representation of analytic and synthetic curves. Parametric representation of surfaces and solids - manipulations.

UNITV PRODUCT DESIGN AND DEVELOPMENT

Automated 2D drafting - basics, mating conditions–Types of translators (IGES, STEP, ACIS and DXF). Mass property calculations.

Total: 45 hours

SUGGESTED READINGS

1. Vera B Anand, Computer Graphics and Geometric Modeling for Engineers,1st edition, John Wiley & Sons, New York,2000
2. Radhakrishnan P and Subramanyan S, CAD/CAM/CIM, 2nd edition, New Age International Pvt. Ltd,2008
3. Ibrahim Zeid, CAD/CAM Theory and Practice,2ndedition,McGraw Hill Inc., New York,2009
4. Barry Hawhes, The CAD/CAM Process,1st edition, Pitman Publishing, London,2007(digital)
5. William M Newman and Robert Sproul, Principles of Interactive Computer Graphics,1stedition,McGraw Hill Inc., New York,2001
6. Rao S S, Optimization Techniques, 1st edition,Wiley Eastern, New Delhi,2006

20BEMEOE02 **INDUSTRIAL SAFETY AND ENVIRONMENT** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of the course is for the students to

- Provide in-depth knowledge on various techniques of non-destructive testing

COURSE OUTCOMES (COs)

Upon completion of the course, students will be able to

- Understand the need and awareness of the safety concepts
- Understand the various safety techniques involved in industrial sector
- Record and investigate the accident zone and prepare reports related toit.
- Conduct basic safety inspections using strategies that they have developed
- Identify and demonstrate working of safety monitoring
- Train about the education and training based on safety

UNIT I CONCEPTS

Evolution of modern safety concept- Safety policy - Safety Organization - line and staff functions for safety- Safety Committee- budgeting for safety.

UNIT II TECHNIQUES

Incident Recall Technique (IRT), disaster control, Job Safety Analysis (JSA), safety survey, safety inspection, safety sampling, Safety Audit.

UNIT III ACCIDENT INVESTIGATION ANDREPORTING

Concept of an accident, reportable and non-reportable accidents, unsafe act and condition – principles of accident prevention, Supervisory role- Role of safety committee – Accident causation models - Cost of accident. Overall accident investigation process - Response to accidents, India reporting requirement, Planning document, Planning matrix, Investigators Kit, functions of investigator, four types of evidences, Records of accidents, accident reports

UNIT IV SAFETY PERFORMANCEMONITORING

Reactive and proactive monitoring techniques - Permanent total disabilities, permanent partial disabilities, temporary total disabilities -Calculation of accident indices, frequency rate, severity rate, frequency severity incidence, incident rate, accident rate, safety "t" score, safety activity rate – problems.

UNIT V SAFETY EDUCATION ANDTRAINING

Importance of training-identification of training needs-training methods – programme, seminars, conferences, competitions – method of promoting safe practice - motivation – communication - role of government agencies and private consulting agencies in safety training – creating awareness, awards, celebrations, safety posters, safety displays, safety pledge, safety incentive scheme, safety campaign – Domestic Safety and Training.

Total: 45 hours

SUGGESTED READINGS

1. Accident Prevention Manual for Industrial Operations, 3rd edition, N.S.C. Chicago,2010(digital).
2. Heinrich H.W. "Industrial Accident Prevention", 2ndedition, Tata McGraw-Hill Company, New York, 1941.
3. Krishnan N.V, Safety Management in Industry, 1st edition, Jaico Publishing House, Bombay,1997.
4. John R Ridley, Safety at Work,3rd edition,Elsevier,2014
5. Roland P. Blake ,Industrial Safety, 2ndedition,Prentice Hall, Inc., New Jersey,1973
6. L M Deshmukh, Industrial safety management,1st edition, TATA McGraw Hill,2005

Semester-III/IV/V

20BTCE351/451/551 **VALUE ADDED COURSE** **2H-0C**

Instruction Hours/week: L:2 T: P:0 **Marks:** Internal**:100** Total**:100**

LIST OF VALUE ADDED COURSES

S.NO	COURSE NAME
1	Recent Trends in Material Characterization
2	Skill Enchantment using Free and Open software tools
3	Statistical Analysis for Experimental Data
4	Natural Gas Engineering
5	Mechanical Aspects of Equipment Design
6	Environmental Quality Monitoring and analysis
7	Chemical Process Instrumentation
8	Catalyst Science and Technology