HINDUSTHAN

EDUCATIONAL AND CHARITABLE TRUST

HICET

HINDUSTHAN
COLLEGE OF ENGINEERING AND TECHNOLOGY

(An Autonomous Institution)

Coimbatore – 641032

DEPARTMENT OF CHEMICAL ENGINEERING

2019 REGULATIONS

HindusthanCollegeofEngineering andTechnology

(AnAutonomousInstitution, Affiliatedto AnnaUniversity,Chennai
ApprovedbyAICTE,NewDelhi&AccreditedbyNAACwith'A'Grade)
ValleyCampus,PollachiHighways,Coimbatore,Tamilnadu.

DETAILS OF CHANGES CARRIED OUT IN CURRICULUM & SYLLABUS

CBCS PATTERN

UNDERGRADUATE PROGRAMMES

B.TECH. CHEMICAL ENGINEERING (UG)

REGULATION-2019

SEMESTER I

S.No.	Course Code	Course Title	Category	L	T	P	C	CIA	ESE	TOTAL
THEORY										
1	19HE1101	Technical English	HS	2	1	0	3	25	75	100
2	19MA1102	Calculus and Linear Algebra	BS	3	1	0	4	25	75	100
THEORY WITH LAB COMPONENT										
3	19PH1151	Applied Physics	BS	2	0	2	3	50	50	100
4	19CY1151	Chemistry for Engineers	BS	2	0	2	3	50	50	100
5	19CS1151	Python Programming and Practices	ES	2	0	2	3	50	50	100
6	19ME1152	Engineering Drawing	ES	1	0	4	3	50	50	100
PRACTICAL										
7	19HE1001	Language Competency Enhancement Course-I	HS	0	0	2	1	0	100	100
MANDATORY COURSES										
8	19HE1072	**Career Guidance Level** – I Personality, Aptitude and Career Development	EEC	2	0	0	0	100	0	100
		Total :		14	2	12	20	350	450	800

As Per AICTE Norms 3 Weeks Induction Programme is Added in The First Semester as an Audit Course

SEMESTER II

S.No.	Course Code	Course Title	Category	L	T	P	C	CIA	ESE	TOTAL
THEORY										
1	19HE2101	Business English for Engineers	HS	2	1	0	3	25	75	100
2	19MA2101	Differential Equations and Complex Variables	BS	3	1	0	4	25	75	100
3	19EE2103	Basics of Electrical and Electronics Engineering	ES	3	0	0	3	25	75	100
4	19CH2101	Principles of Chemical Engineering	ES	3	0	0	3	25	75	100
THEORY WITH LAB COMPONENT										
5	19PH2151	Material Science	BS	2	0	2	3	50	50	100
6	19CY2151	Environmental Studies	BS	2	0	2	3	50	50	100
PRACTICAL										
7	19ME2001	Engineering Practices	ES	0	0	4	2	50	50	100
8	19HE2001	Language Competency Enhancement Course-II	HS	0	0	2	1	0	100	100
MANDATORY COURSES										
9	19HE2072	**Career Guidance Level – II** Personality, Aptitude and Career Development	EEC	2	0	0	0	100	0	100
10	19HE2073	Entrepreneurship & Innovation	EEC	1	0	0	0	100	0	100
			Total :	18	2	10	22	450	550	1000

SEMESTER III

S.No	Course Code	Course Title	Category	L	T	P	C	CIA	ESE	TOTAL
THEORY										
1	19MA3103	Fourier Analysis and Numerical Methods	BS	3	1	0	4	25	75	100
2	19CH3201	Chemical Process Calculations	PC	3	1	0	4	25	75	100
3	19CH3202	Fluid Mechanics for Chemical Engineers	PC	3	0	0	3	25	75	100
4	19CH3203	Chemical Engineering Thermodynamics – I	PC	3	0	0	3	25	75	100
THEORY WITH LAB COMPONENT										
5	19CH3251	Analytical Instruments for Analysis	PC	2	0	2	3	50	50	100
PRACTICAL										
6	19CH3001	Fluid Mechanics Lab	PC	0	0	3	1.5	50	50	100
7	19CH3002	Chemical Analysis Lab	PC	0	0	3	1.5	50	50	100
MANDATORY COURSES										
8	19MC3191	Indian Constitution	AC	2	0	0	0	100	0	100
9	19HE3072	**Career Guidance Level – III** Personality, Aptitude and Career Development	EEC	2	0	0	0	100	0	100
10	19HE3073	Leadership Management Skills	EEC	1	0	0	0	100	0	100
			Total	19	2	8	20	550	450	1000

SEMESTER IV

S.No	Course Code	Course Title	Category	L	T	P	C	CIA	ESE	TOTAL
THEORY										
1	19CH4201	Process Heat Transfer	PC	3	1	0	4	25	75	100
2	19CH4202	Mass Transfer – I	PC	3	0	0	3	25	75	100
3	19CH4203	Chemical Engineering Thermodynamics - II	PC	3	0	0	3	25	75	100
THEORY WITH LAB COMPONENT										
4	19CH4251	Mechanical Operations	PC	3	0	2	4	50	50	100
5	19MA4153	Applied Probability Statistics	BS	3	0	2	4	50	50	100
PRACTICAL										
6	19CH4001	Heat Transfer Lab	PC	0	0	3	1.5	50	50	100
7	19CH4002	Petrochemical Analysis Lab	PC	0	0	3	1.5	50	50	100
MANDATORY COURSES										
8	19AC4191	Essence of Indian tradition knowledge/Value Education	AC	2	0	0	0	100	0	100
9	19HE4072	**Career Guidance Level – IV** Personality, Aptitude and Career Development	EEC	2	0	0	0	100	0	100
10	19HE4073	Ideation Skills	EEC	2	0	0	0	100	0	100
			Total	21	1	10	21	575	425	1000

SEMESTER V

S.No.	Course Code	Course Title	Category	L	T	P	C	CIA	ESE	TOTAL
THEORY										
1	19CH5201	Chemical Reaction Engineering – I	PC	3	1	0	4	25	75	100
2	19CH5202	Mass Transfer – II	PC	3	1	0	4	25	75	100
3	19CH5203	Process Instrumentation Dynamics and Control	PC	3	1	0	4	25	75	100
4	19CH5204	Safety in Chemical Industries	PC	3	0	0	3	25	75	100
5	19CH53XX	**Professional Elective -I**	PE	3	0	0	3	25	75	100
THEORY WITH LAB COMPONENT										
6	19CH5251	Water Treatment and Solid Waste Management	PC	2	0	2	3	50	50	100
PRACTICALS										
7	19CH5001	Mass Transfer Lab	PC	0	0	3	1.5	50	50	100
8	19CH5002	Process Control Lab	PC	0	0	3	1.5	50	50	100
MANDATORY COURSES										
9	19HE5071	Soft Skills - I	EEC	1	0	0	1	100	0	100
10	19HE5072	Design Thinking	EEC	1	0	0	1	100	0	100
			Total	19	3	8	26	475	525	1000

SEMESTER VI

S.No.	Course Code	Course Title	Category	L	T	P	C	CIA	ESE	TOTAL
		THEORY								
1	19CH6201	Chemical Reaction Engineering– II	PC	3	1	0	4	25	75	100
2	19CH6202	Chemical Process Industries	PC	3	0	0	3	25	75	100
3	19CH6181	Professional Ethics in Engineering	HS	3	0	0	3	25	75	100
4	19CH63XX	**Professional Elective - II**	PE	3	0	0	3	25	75	100
5	19XX64XX	**Open Elective– I**	OE	3	0	0	3	25	75	100
		THEORY WITH LAB COMPONENTS								
6	19CH6251	Fluidization Engineering	PC	2	0	2	3	50	50	100
		PRACTICALS								
7	19CH6001	Chemical Reaction Engineering Lab	PC	0	0	4	2	50	50	100
		MANDATORY COURSES								
8	19CH6701	Internship/Industrial Training/Skill Development Course (Minimum 3 weeks)	EEC	-	-	-	1	100	0	100
9	19HE6071	Soft Skills - II	EEC	1	0	0	1	100	0	100
10	19HE6072	Intellectual Property Rights (IPR)	EEC	1	0	0	1	100	0	100
			Total	19	1	6	24	525	475	1000

SEMESTER VII

S.No.	Course Code	Course Title	Category	L	T	P	C	CIA	ESE	TOTAL
		THEORY								
1	19CH7201	Process Economics and Engineering Management	PC	3	0	0	3	25	75	100
2	19CH7202	Process Equipment Design	PC	3	1	0	4	25	75	100
3	19CH73XX	**Professional Elective-III**	PE	3	0	0	3	25	75	100
4	19XX74XX	**Open Elective – II**	OE	3	0	0	3	25	75	100
		PRACTICALS								
5	19CH7001	Design and Simulation Lab	PC	0	0	3	1.5	50	50	100
6	19CH7003	Computational Fluid Dynamics Lab	PC	0	0	3	1.5	50	50	100
		PROJECT WORK								
7	19CH7901	Project Work – Phase I	EEC	0	0	4	2	50	50	100
			Total	12	1	10	18	250	450	700

SEMESTER VIII

S.No.	Course Code	Course Title	Category	L	T	P	C	CIA	ESE	TOTAL
THEORY										
1	19CH83XX	**Professional Elective –IV**	PE	3	0	0	3	25	75	100
2	19CH83XX	**Professional Elective- V**	PE	3	0	0	3	25	75	100
PROJECT WORK										
3	19CH8901	Project Work – Phase II	EEC	0	0	16	8	100	100	200
			Total	6	0	16	14	150	250	400

TOTAL NO OF CREDITS: 165

LIST OF PROFESSIONAL ELECTIVES

S.No.	Course Code	Course Title	Category	L	T	P	C	CIA	ESE	TOTAL
PROFESSIONAL ELECTIVE I										
1	19CH5301	Energy Technology	PE	3	0	0	3	25	75	100
2	19CH5302	Petroleum Technology	PE	3	0	0	3	25	75	100
3	19CH5303	Electrochemical Engineering	PE	3	0	0	3	25	75	100
4	19CH5304	Polymer Technology	PE	3	0	0	3	25	75	100
5	19CH5305	Food Technology	PE	3	0	0	3	25	75	100
PROFESSIONAL ELECTIVE II										
1	19CH6301	Petroleum Exploration and Exploitation Techniques	PE	3	0	0	3	25	75	100
2	19CH6302	Enzyme Engineering	PE	3	0	0	3	25	75	100
3	19CH6303	Fundamentals of Nano science	PE	3	0	0	3	25	75	100
4	19CH6304	Corrosion Science and Engineering	PE	3	0	0	3	25	75	100
5	19CH6305	Piping and Instrumentation	PE	3	0	0	3	25	75	100
6	19CH6306	Sugar Technology	PE	3	0	0	3	25	75	100
PROFESSIONAL ELECTIVE III										
1	19CH7301	Natural Gas Engineering	PE	3	0	0	3	25	75	100
2	19CH7302	Pulp and Paper Technology	PE	3	0	0	3	25	75	100
3	19CH7303	Transport Phenomena	PE	3	0	0	3	25	75	100
4	19CH7304	Multicomponent Distillation	PE	3	0	0	3	25	75	100
5	19CH7305	Chemical Process Optimization	PE	3	0	0	3	25	75	100
6	19CH7306	Fundamentals of rubber testing compounds	PE	3	0	0	3	25	75	100
7	19CH7307	Chemical Manufacturing Plant Operation	PE	3	0	0	3	25	75	100
8	19CH7308	Chemical storage and Handling Operation	PE	3	0	0	3	25	75	100
9	19CH7309	Chemical Effluent treatment plant Operation	PE	3	0	0	3	25	75	100
10	19CH7310	Analytical Instruments Operation	PE	3	0	0	3	25	75	100
PROFESSIONAL ELECTIVE IV										
1	19CH8301	Industrial Management	PE	3	0	0	3	25	75	100
2	19CH8302	Sugar Technology	PE	3	0	0	3	25	75	100
3	19CH8303	Total Quality Management	PE	3	0	0	3	25	75	100
4	19CH8304	Foundation Skills in Integrated Product Development	PE	3	0	0	3	25	75	100
5	19CH8305	Supply Chain Management	PE	3	0	0	3	25	75	100

		PROFESSIONAL ELECTIVE V								
1	19CH8306	Process Plant Utilities	PE	3	0	0	3	25	75	100
2	19CH8307	Fermentation Technology	PE	3	0	0	3	25	75	100
3	19CH8308	Frontiers of Chemical Technology	PE	3	0	0	3	25	75	100
4	19CH8309	Industrial Nanotechnology	PE	3	0	0	3	25	75	100
5	19CH8310	Drugs and Pharmaceutical Technology	PE	3	0	0	3	25	75	100
6	19CH8311	Membrane Separation Process	PE	3	0	0	3	25	75	100

		LIST OF OPEN ELECTIVES								
		CHEMICAL ENGINEERING								
S.No.	Course Code	Course Title	Category	L	T	P	C	CIA	ESE	TOTAL
1	19CH6401	Waste to Energy Conversion	OE	3	0	0	3	25	75	100
2	19CH7401	Biomass Conversion and Biorefinery	OE	3	0	0	3	25	75	100
		LIFE SKILL COURSES								
3	19LSZ401	General Studies for Competitive Examinations	OE	3	0	0	3	25	75	100
4	19LSZ402	Human Rights, Women's Rights and Gender Equality	OE	3	0	0	3	25	75	100
5	19LSZ403	Indian Ethos and Human Values	OE	3	0	0	3	25	75	100
6	19LSZ404	Indian Constitution and Political System	OE	3	0	0	3	25	75	100
7	19LSZ405	Yoga for Human Excellence	OE	3	0	0	3	25	75	100

(Note: Z Stands for semester, students can't choose twice the course)

ADDITIONAL CREDIT COURSE FOR CHEMICAL ENGINEERING

S.No	Course Code	Course Title	Category	Duration	Assessment	Credit
1.	19VACH01	Industrial Automation	VA	30 hrs	Internal	1
2.	19VACH02	Bulk Solid Handling for Chemical Engineers	VA	30 hrs	Internal	1
3.	19VACH03	Fundamentals of AI and it's Chemometric Applications	VA	30 hrs	Internal	1
4.	19VACH04	Introduction to Chemical Engineering MATLAB	VA	30 hrs	Internal	1
5.	19VACH05	IOT- Basics and Application in Unit Operations	VA	30 hrs	Internal	1

CREDIT DISTRIBUTION

Semester	I	II	III	IV	V	VI	VII	VIII	Total
Credits	20	22	20	21	26	24	18	14	**165**

* Student can earn extra credit 35 over and above the total credits

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COIMBATORE - 641 032.

B.TECH. CHEMICAL ENGINEERING
SYLLABI (I to VIII SEMESTERS)

Programme	Course Code	Name of the Course	L	T	P	C
B.E/B.Tech	19HE1101	**TECHNICAL ENGLISH** (COMMON TO ALL BRANCHES)	2	1	0	3

Course Objective

- ✓ To facilitate students to communicate effectively with coherence.
- ✓ To train the learners in descriptive communication.
- ✓ To introduce professional communication.
- ✓ To enhance knowledge and to provide the information on corporate environment.
- ✓ To equip the trainers with the necessary skills on critical thinking.

Unit	Description	Instructional Hours
I	**Listening and Speaking** – Opening a conversation, maintaining coherence, turn taking, closing a conversation (excuse, general wishes, positive comments and thanks) **Reading** –Reading articles from newspaper, Reading comprehension **Writing** Chart analysis, process description, Writing instructions **Grammar and Vocabulary**-Tenses, Regular and irregular verb, technical vocabulary.	9
II	**Listening and Speaking**- listening to product description, equipment & work place (purpose, appearance, function) **Reading**- Reading technical articles **Writing**- Letter phrases, writing personal letters, **Grammar and Vocabulary**-articles, Cause & effect, Prepositions.	9
III	**Listening and Speaking**- - listening to announcements **Reading**- Reading about technical inventions, research and development **Writing**- Letter inviting a candidate for interview, Job application and resume preparation **Grammar and Vocabulary**- Homophones and Homonyms.	9
IV	**Listening and Speaking**- - Practice telephone skills and telephone etiquette (listening and responding, asking questions).**Reading**- Reading short texts and memos **Writing**- invitation letters, accepting an invitation and declining an invitation **Grammar and Vocabulary**- Modal verbs, Collocation, Conditionals, Subject verb agreement and Pronoun-Antecedent agreement.	9
V	**Listening and Speaking**- listening to technical group discussions and participating in GDs **Reading**- reading biographical writing - **Writing**- Proposal writing, Writing definitions, **Grammar and Vocabulary**- Abbreviation and Acronym, Prefixes & suffixes, phrasal verbs.	9

Total Instructional Hours   45

Course Outcome

CO1- Trained to maintain coherence and communicate effectively.
CO2- Practiced to create and interpret descriptive communication.
CO3- Introduced to gain information of the professional world.
CO4- acquired various types of communication and etiquette.
CO5- Taught to improve interpersonal and intrapersonal skills.

TEXT BOOKS:
T1- Norman Whitby, "Business Benchmark-Pre-intermediate to Intermediate", Cambridge University Press, 2016.
T2- Raymond Murphy, "Essential English Grammar", Cambridge University Press, 2019.

REFERENCE BOOKS :
R1- Meenakshi Raman and Sangeetha Sharma. "Technical Communication- Principles and Practice", Oxford University Press, 2009.
R2- Raymond Murphy, "English Grammar in Use"- 4th editionCambridge University Press, 2004.
R3- Kamalesh Sadanan "A Foundation Course for the Speakers of Tamil-Part-I &II", Orient Blackswan, 2010.

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19HE1101 - Technical English

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1.0	1.0	1.0	1.0	-	-	-	-	2.0	3.0	1.0	2.0	-	-
CO2	2.0	2.0	1.0	1.0	-	-	-	-	2.0	3.0	1.0	2.0	-	-
CO3	-	1.0	1.0	1.0	-	-	-	-	2.0	3.0	1.0	2.0	-	-
CO4	-	2.0	1.0	1.0	-	-	-	-	2.0	3.0	1.0	2.0	-	-
CO5	-	1.0	1.0	1.0	-	-	-	-	2.0	3.0	1.0	3.0	-	-
AVG	1.5	1.4	1.0	1.0	-	-	-	-	2.0	3.0	1.0	2.2	-	-

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Programme/sem	Course Code	Name of the Course	L	T	P	C
B.E./B.Tech/ I	19MA1102	**CALCULUS AND LINEAR ALGEBRA**	3	1	0	4

Course Objective
1. Remember the concept of differentiation.
2. Evaluate the functions of several variables which are needed in many branches of engineering.
3. Illustrate the concept of double integrals.
4. Understand the concept of triple integrals.
5. Develop the skill to use matrix algebra techniques that is needed by engineers for practical Applications

Unit	Description	Instructional Hours
I	**DIFFERENTIAL CALCULUS** Rolle's Theorem – Lagrange's Mean Value Theorem- Maxima and Minima – Taylor's and Maclaurin's Theorem	12
II	**MULTIVARIATE CALCULUS (DIFFERENTIATION)** Totalderivatives - Jacobians – Maxima, M inima and Saddle points - Lagrange's method of undeterminedmultipliers – Gradient, divergence, curl and derivatives	12
III	**DOUBLE INTEGRATION** DoubleintegralsinCartesiancoordinates– Area enclosed by the plane curves (excluding surface area)– Green's Theorem (Simple Application) - Stoke's Theorem – Simple Application involving cubes and rectangular parellopiped.	12
IV	**TRIPLE INTEGRATION** Tripleintegrals in Cartesian co-ordinates – Volume of solids (Sphere, Ellipsoid, Tetrahedron) using Cartesian co-ordinates. Gauss Divergence Theorem – Simple Application involving cubes and rectangular parellopiped.	12
V	**MATRICES** Eigen valuesand Eigen vectors – PropertiesofEigen values andEigen vectors (without proof) - Cayley - Hamilton Theorem (excluding proof) - Reduction of a quadratic form to canonical form by orthogonal transformation.	12
	Total Instructional Hours	60

Course Outcome
CO1: Apply the concept of differentiation in any curve.
CO2: Identify the maximum and minimum values of surfaces.
CO3: Apply double integrals to compute area of plane curves.
CO4: Evaluation of triple integrals to compute volume of solids.
CO5: Calculate Eigen values and Eigen vectors for a matrix which are used to determine the natural frequencies (or Eigen frequencies) of vibration and the shapes of these vibrational modes.

TEXT BOOKS:

T1 - Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India Private Ltd., New Delhi, 2018.

T2 - Veerarajan T, "Engineering Mathematics ", McGraw Hill Education(India) Pvt Ltd, New Delhi, 2016.

REFERENCE BOOKS :

R1- Thomas & Finney " Calculus and Analytic Geometry" , Sixth Edition,,Narosa Publishing House, New Delhi.

R2 – Weir,M.D and Joel Hass, ' Thomas Calculus" 12th Edition,Pearson India 2016.R3 - Grewal B.S, "Higher Engineering Mathematics", 42nd Edition, Khanna Publications, Delhi, 2012.

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19MA1102 - Calculus and Linear Algebra

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.0	3.0	3.0	3.0	2.0	2.0	2.0	-	-	1.0	2.0	2.0	2.0	2.0
CO2	3.0	3.0	3.0	3.0	2.0	2.0	2.0	-	-	1.0	2.0	2.0	2.0	2.0
CO3	3.0	3.0	3.0	3.0	2.0	2.0	2.0	-	-	1.0	2.0	2.0	2.0	3.0
CO4	3.0	3.0	3.0	3.0	2.0	2.0	2.0	-	-	1.0	2.0	2.0	1.0	2.0
CO5	3.0	3.0	3.0	3.0	3.0	2.0	2.0	-	-	1.0	2.0	2.0	2.0	1.0
AVG	3.0	3.0	3.0	3.0	2.2	2.0	2.0	-	-	1.0	2.0	2.0	1.8	2.0

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Programme/sem	Course Code	Name of the Course	L	T	P	C
B.E./B.Tech/ I	19PH1151	APPLIED PHYSICS (Common to all branches)	2	0	2	3

Course Objective	1. Enhance the fundamental knowledge in properties of matter
	2. Analysis the oscillatory motions of particles
	3. Extend the knowledge about wave optics
	4. Gain knowledge about laser and their applications
	5. Conversant with principles of optical fiber, types and applications of optical fiber

Unit	Description	Instructional Hours
I	**PROPERTIES OF MATTER** Elasticity – Hooke's law – Stress-strain diagram - Poisson's ratio – Bending moment – Depression of a cantilever – Derivation of Young's modulus of the material of the beam by Uniform bending theory and experiment.	6
	Determination of Young's modulus by uniform bending method	3
II	**OSCILLATONS** Translation motion –Vibration motion – Simple Harmonic motion – Differential Equation of SHM and its solution – Damped harmonic oscillation - Torsion stress and deformations – Torsion pendulum: theory and experiment.	6
	Determination of Rigidity modulus – Torsion pendulum	3
III	**WAVE OPTICS** Conditions for sustained Interference – air wedge and it's applications - Diffraction of light – Fraunhofer diffraction at single slit –Diffraction grating – Rayleigh's criterion of resolution power - resolving power of grating.	6
	Determination of wavelength of mercury spectrum – spectrometer grating	3
	Determination of thickness of a thin wire – Air wedge method	3
IV	**LASER AND APPLICATIONS**	6
	Spontaneous emission and stimulated emission – Population inversion – Pumping methods – Derivation of Einstein's coefficients (A&B) – Type of lasers – Nd:YAG laser and CO_2 laser- Laser Applications – Holography – Construction and reconstruction of images.	
	Determination of Wavelength and particl size using Laser	3
V	**FIBER OPTICS AND APPLICATIONS** Principle and propagation of light through optical fibers – Derivation of numerical aperture and acceptance angle – Classification of optical fibers (based on refractive index, modes and materials) – Fiber optical communication link – Fiber optic sensors – Temperature and displacement sensors.	6
	Total Instructional Hours	45

Course Outcome	After completion of the course the learner will be able to
	CO1: Illustrate the fundamental properties of matter
	CO2: Discuss the Oscillatory motions of particles
	CO3: Analyze the wavelength of different colors
	CO4: Understand the advanced technology of LASER in the field of Engineering
	CO5: Develop the technology of fiber optical communication in engineering field

TEXT BOOKS: T1 - Rajendran V, Applied Physics, Tata McGraw Hill Publishing Company Limited, New Delhi, 2017.
T2- Gaur R.K. and Gupta S.L., Engineering Physics, 8th edition, Dhanpat Rai Publications (P) Ltd., New Delhi, 2015.
REFERENCE BOOKS:
R1 - Arthur Beiser "Concepts of Modern Physics" Tata McGraw Hill, New Delhi – 2015
R2 - M.N Avadhanulu and PG Kshirsagar "A Text Book of Engineering physics" S. Chand and Company ltd., New Delhi 2016
R3 - Dr. G. Senthilkumar "Engineering Physics – I" VRB publishers Pvt Ltd., 2016

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19PH1151 - Applied Physics

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.0	2.0	2.0	1.0	1.0	1.0	2.0	-	-	-	-	-	-	-
CO2	3.0	3.0	1.0	1.0	1.0	1.0	2.0	-	-	-	-	-	-	-
CO3	3.0	2.0	1.0	2.0	2.0	1.0	2.0	-	-	-	-	-	-	-
CO4	3.0	2.0	1.0	2.0	3.0	1.0	2.0	-	-	-	-	-	-	-
CO5	3.0	3.0	1.0	3.0	2.0	1.0	2.0	-	-	-	-	-	-	-
AVG	3.0	2.4	1.2	1.8	1.8	1.0	2.0	-	-	-	-	-	-	-

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Programme/sem	Course Code	Name of the Course	L	T	P	C
B.E./B.Tech	19CY1151	**CHEMISTRY FOR ENGINEERS (COMMON TO ALL BRANCHES)**	2	0	2	3

Course Objective	
	1. The boiler feed water requirements, related problems and water treatment techniques.
	2. The principles of polymer chemistry and engineering applications of polymers and composites.
	3. The principles of electrochemistry and with the mechanism of corrosion and its control.
	4. The principles and generation of energy in batteries, nuclear reactors, solar cells, wind mills and fuel cells.
	5. The important concepts of spectroscopy and its applications.

Unit	Description	Instructional Hours
I	**WATER TECHNOLOGY** Hard water and soft water- Disadvantages of hard water- Hardness: types of hardness, simple calculations, estimation of hardness of water – EDTA method – Boiler troubles - Conditioning methods of hard water – External conditioning - demineralization process - desalination: definition, reverse osmosis – Potable water treatment – breakpoint chlorination. **Estimation of total, permanent and temporary hardness of water by EDTA**	6 +3=9
II	**POLYMER & COMPOSITES** polymerization – addition and condensation polymerization – mechanism of free radical addition polymerization – copolymers – plastics: classification – thermoplastics and thermosetting plastics, preparation, properties and uses of commercial plastics – PVC, Bakelite – moulding of plastics (extrusion and compression); Composites: definition, types of composites – polymer matrix composites (PMC) –FRP	6
III	**ELECTROCHEMISTRY AND CORROSION** Electrochemical cells – reversible and irreversible cells - EMF- Single electrode potential – Nernst equation (derivation only) – Conductometric titrations. Chemical corrosion – Pilling – Bedworth rule – electrochemical corrosion – different types –galvanic corrosion – differential aeration corrosion – corrosion control – sacrificial anode and impressed cathodic current methods - protective coatings – paints – constituents and functions. **Conductometric titration of strong acid vs strong base (HCl vs NaOH). Conductometric precipitation titration using BaCl₂ and Na₂SO₄. Estimation of Ferrous iron by Potentiometry.**	6+9 =15
IV	**ENERGY SOURCES AND STORAGE DEVICES** Introduction- nuclear energy- nuclear fission- controlled nuclear fission- nuclear fusion differences between nuclear fission and fusion- nuclear chain reactions- nuclear reactor power generator- classification of nuclear reactor- light water reactor- breeder reactor. Batteries and fuel cells: Types of batteries- alkaline battery- lead storage battery- lithium battery- fuel cell H_2 -O_2 fuel cell applications.	6
V	**ANALYTICAL TECHNIQUES** Beer-Lambert's law – UV-visible spectroscopy and IR spectroscopy – principle – instrumentation (block diagram only) – flame photometry – principle – instrumentation (block diagram only) – estimation of sodium by flame photometry – atomic absorption spectroscopy – principles – instrumentation (block diagram only) – estimation of nickel by atomic absorption spectroscopy. **Determination of iron content of the water sample using spectrophotometer.(1,10 phenanthroline / thiocyanate method).**	6+3
	Total Instructional Hours	**45**

Course Outcome	
	CO1: Differentiate hard and soft water and to solve the related problems on water purification and its significance in industries and daily life
	CO2: Acquire the basic knowledge of polymers, composites and FRP and their significance.
	CO3: Develop knowledge on the basic principles of electrochemistry and understand the causes of corrosion, its consequences to minimize corrosion to improve industrial design.
	CO4: Develop knowledge about the renewable energy resources and batteries along with the need of new materials to improve energy storage capabilities.
	CO5: Identify the structure and characteristics of unknown/new compound with the help of spectroscopy.

TEXT BOOKS
T1 - P. N. Madudeswaran and B.Jeyagowri, "Engineering Chemistry" Tata McGraw-Hill Pub.Co.Ltd,Chennai
T2 - P.C.Jain and Monica Jain, "Engineering Chemistry" Dhanpat Rai Pub, Co., New Delhi (2018).
REFERENCES
R1 - B.Sivasankar "Engineering Chemistry" Tata McGraw-Hill Pub.Co.Ltd, New Delhi (2012).
R2 - S.S.Dara "A Text book of Engineering Chemistry" S.Chand & Co. Ltd., New Delhi (2017).

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19CY1151 - Chemistry for Engineers

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.0	2.0	2.0	2.0	2.0	1.0	1.0	-	-	-	-	1.0	-	-
CO2	3.0	2.0	2.0	2.0	2.0	1.0	1.0	-	-	-	-	1.0	-	-
CO3	3.0	2.0	2.0	2.0	2.0	1.0	1.0	-	-	-	-	1.0	-	-
CO4	3.0	2.0	2.0	2.0	2.0	1.0	1.0	-	-	-	-	1.0	-	-
CO5	3.0	2.0	2.0	2.0	2.0	1.0	1.0	-	-	-	-	1.0	-	-
AVG	3.0	2.0	2.0	2.0	2.0	1.0	1.0	-	-	-	-	1.0	-	-

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Programme	Course Code	Name of the Course	L	T	P	C
B.Tech	19CS1151	**PYTHON PROGRAMMING AND PRACTICES**	2	0	2	3

Course Objectives	
	• To know the basics of algorithmic problem solving.
	• To read and write simple Python programs.
	• To develop Python programs with conditionals and loops and to define Python functions and call them.
	• To use Python data structures – lists, tuples, dictionaries.
	• To do input/output with files in Python.

UNIT	DESCRIPTION	INSTRUCTIONAL HOURS
I	**ALGORITHMIC PROBLEM SOLVING**	9
	Algorithms, building blocks of algorithms (statements, state, control flow, functions), notation(pseudo code, flow chart, programming language), algorithmic problem solving, simple strategiesfor developing algorithms (iteration, recursion). Illustrative problems: find minimum in a list, insert acard in a list of sorted cards, guess an integer number in a range, Towers of Hanoi.	
II	**DATA, EXPRESSIONS, STATEMENTS**	7+2
	Python interpreter and interactive mode; values and types: int, float, boolean, string, and list;variables, expressions, statements, tuple assignment, precedence of operators, comments;modules and functions, function definition and use, flow of execution, parameters and arguments. **Illustrative programs: exchange the values of two variables, circulate the values of n variables, distance between two points.**	
III	**CONTROL FLOW, FUNCTIONS**	5+4
	Conditionals: Boolean values and operators, conditional (if), alternative (if-else), chained conditional (if-elif-else); Iteration: state, while, for, break, continue, pass; Fruitful functions: returnvalues, parameters, local and global scope, function composition, recursion; Strings: string slices, immutability, string functions and methods, string module; Lists as arrays. **Illustrative programs: square root, gcd, exponentiation, sum an array of numbers, linear search, binary search.**	
IV	**LISTS, TUPLES, DICTIONARIES**	3+6
	Lists: list operations, list slices, list methods, list loop, mutability, aliasing, cloning lists, listparameters; Tuples: tuple assignment, tuple as return value; Dictionaries: operations andmethods; advanced list processing - list comprehension; **Illustrative programs: selection sort, insertion sort, merge sort, histogram.**	
V	**FILES, MODULES, PACKAGES**	5+4
	Files and exception: text files, reading and writing files, format operator; command line arguments,errors and exceptions, handling exceptions, modules, packages. **Illustrative programs: word count, copying file contents.**	
	Total Instructional Hours	45

Course Outcomes	Upon completion of the course, students can be able to
	CO1: Develop algorithmic solutions to simple computational problems.
	CO2: Read, write, execute by hand simple Python programs.
	CO3: Structure simple Python programs for solving problems and decompose a Python program into functions.
	CO4: Represent compound data using Python lists, tuples, dictionaries.
	CO5: Read and write data from/to files in Python Programs.

TEXT BOOKS:

1. Guido van Rossum and Fred L. Drake Jr, An Introduction to Python – Revised andupdated for Python 3.6.2, Shroff Publishers, First edition (2017).
2. S. Annadurai, S.Shankar, I.Jasmine, M.Revathi, Fundamentals of Python Programming, Mc-Graw Hill Education (India) Private Ltd, 2019.

REFERENCE BOOKS:

1. Charles Dierbach, ―Introduction to Computer Science using Python: A ComputationalProblem-Solving Focus, Wiley India Edition, 2013.
2. Timothy A. Budd, ―Exploring Python‖, Mc-Graw Hill Education (India) Private Ltd., 2015.

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19CS1151 - Python Programming and Practices

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1.0	2.0	3.0	-	1.0	1.0	-	1.0	1.0	1.0	1.0	1.0	2.0	1.0
CO2	1.0	2.0	3.0	-	1.0	1.0	-	1.0	1.0	1.0	1.0	1.0	2.0	1.0
CO3	1.0	2.0	3.0	-	1.0	1.0	-	1.0	1.0	1.0	1.0	1.0	2.0	1.0
CO4	1.0	2.0	3.0	-	1.0	1.0	-	1.0	1.0	1.0	1.0	1.0	2.0	1.0
CO5	1.0	2.0	3.0	-	1.0	1.0	-	1.0	1.0	1.0	1.0	1.0	2.0	1.0
AVG	1.0	2.0	3.0	-	1.0	1.0	-	1.0	1.0	1.0	1.0	1.0	2.0	1.0

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Programme	Course Code	Name of the Course	L	T	P	C
B.Tech	19ME1152	**ENGINEERING DRAWING**	1	0	4	3

Course Objectives	• To gain the knowledge of Engineer's language of expressing complete details about objects and construction of conics and special curves. • To learn about the orthogonal projections of straight lines and planes. • To acquire the knowledge of projections of simple solid objects in plan and elevation. • To learn about the projection of sections of solids and development of surfaces. • To study the isometric projections of different objects.

UNIT	DESCRIPTION	INSTRUCTIONAL HOURS
I	**UNIT I PLANE CURVES** Importance of engineering drawing; drafting instruments; drawing sheets – layout and folding; Lettering and dimensioning, BIS standards, scales. Geometrical constructions, Engineering Curves Conic sections – Construction of ellipse, parabola and hyperbola by eccentricity method. Construction of cycloids and involutes of square and circle – Drawing of tangents and normal to the above curves.	12
II	**UNIT II PROJECTIONS OF POINTS, LINES AND PLANE SURFACES** Introduction to Orthographic projections- Projection of points. Projection of straight lines inclined to both the planes, Determination of true lengths and true inclinations by rotating line method. Projection of planes (polygonal and circular surfaces) inclined to both the planes by rotating object method (First angle projections only).	12
III	**UNIT III PROJECTIONS OF SOLIDS** Projection of simple solids like prisms, pyramids, cylinder and cone when the axis is perpendicular and inclined to one plane by rotating object method.	12
IV	**UNIT IV SECTION OF SOLIDS AND DEVELOPMENT OF SURFACES** Sectioning of simple solids with their axis in vertical position when the cutting plane is inclined to one of the principal planes and perpendicular to the other – Obtaining true shape of section. Development of lateral surfaces of simple and sectioned solids – Prisms, pyramids, cylinder and cone. Development of lateral surfaces of truncated solids.	12
V	**UNIT V ISOMETRIC AND ORTHOGRAPHIC PROJECTIONS** Isometric views and projections simple and truncated solids such as - Prisms, pyramids, cylinders, cones- combination of two solid objects in simple vertical positions. Free hand sketching of multiple views from a pictorial drawing. Basics of drafting using AutoCAD software.	12

Total Instructional Hours   60

Course Outcomes	**Upon completion of the course, students can be able to** CO1: Understand and interpret the engineering drawings in order to visualize the objects and draw the conics and special curves. CO2: Draw the orthogonal projections of straight lines and planes. CO3: Interpret the projections of simple solid objects in plan and elevation. CO4: Draw the projections of section of solids and development of surfaces of solids. CO5: Draw the isometric projections and the perspective views of different objects.

1. K.Venugopal, V.Prabu Raja, "Engineering Drawing, AutoCAD, Building Drawings", 5th edition New Age International Publishers, New delhi 2016.

REFERENCE BOOKS:

1. BasantAgrawal and C.M.Agrawal, "Engineering Drawing", Tata McGraw Hill Publishing   company Limited,New Delhi 2013.

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Programme	Course Code	Name of the Course	L	T	P	C
B.E/B.Tech	19HE1001	LANGUAGE COMPETENCY ENHANCEMENT COURSE- I	0	0	2	1

Course Objective
- ✓ To enhance student language competency
- ✓ To train the students in LSRW skills
- ✓ To develop student communication skills
- ✓ To empower the trainee in business writing skills.
- ✓ To train the students to react to different professional situations

Unit	Description	Instructional Hours
I	**Listening** Listening to technical group discussions and participating in GDs. listening to TED talks. Listen to Interviews & mock interview. Listening short texts and memos.	3
II	**Reading** Reading articles from newspaper, magazine. Reading comprehension. Reading about technical inventions, research and development. Reading short texts and memos.	3
III	**Writing** E-mail writing: Create and send email writing (to enquire about some details, to convey important message to all, to place an order, to share your joy and sad moment). Reply for an email writing.	3
IV	**Speaking** To present a seminar in a specific topic (what is important while choosing or deciding something to do). To respond or answer for general questions (answer for your personal details, about your family, education, your hobbies, your aim etc.,).	3
V	**Speaking** Participate in discussion or interactions (agree or disagree express your statement with a valid reason, involve in discussion to express your perspective on a particular topics).	3

Total Instructional Hours   15

Course Outcome
CO1- Trained to maintain coherence and communicate effectively.
CO2- Practiced to create and interpret descriptive communication.
CO3- Introduced to gain information of the professional world.
CO4- acquired various types of communication and etiquette.
CO5- Taught to improve interpersonal and intrapersonal skills.

TEXT BOOKS:
T1- Norman Whitby, "Business Benchmark-Pre-intermediate to Intermediate",Cambridge University Press, 2016.
T2-Raymond Murphy, "Essential English Grammar", Cambridge University Press, 2019.

REFERENCE BOOKS :
R1- Meenakshi Raman and Sangeetha Sharma. "Technical Communication-Principles and Practice", Oxford University Press, 2009.

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Programme/sem	Course Code	Name of the Course	L	T	P	C
B.E./B.Tech/ II	19HE1901	**BUSINESS ENGLISH FOR ENGINEERS** (COMMON TO ALL BRANCHES)	2	1	0	3

Course Objective

1. Introduce business communication.
2. Train to respond different professional situations.
3. Make the learners familiar with the managerial skills
4. Empower the trainee in business writing skills.
5. Educate to interpret and expertisedifferent business content.

Unit	Description	Instructional Hours
I	**Listening and Speaking** – listening and discussing about programme and conference arrangement **Reading** –reading auto biographies of successful personalities **Writing** Formal & informal email writing, Recommendations **Grammar and Vocabulary**- Business vocabulary, Adjectives & adverbs.	9
II	**Listening and Speaking**- listening to TED talks **Reading**-Making and interpretation of posters**Writing**- Business letters: letters giving good and bad news, Thank you letter, Congratulating someone on a success"**Grammar and Vocabulary**- Active & passive voice, Spotting errors (Tenses, Preposition, Articles).	9
III	**Listening and Speaking**-travel arrangements and experience **Reading**- travel reviews **Writing**- Business letters (Placing an order, making clarification & complaint letters). **Grammar and Vocabulary**- Direct and Indirect speech.	9
IV	**Listening and Speaking**- Role play- **Reading**- Sequencing of sentence **Writing**- Business report writing (marketing, investigating) **Grammar and Vocabulary**- Connectors, Gerund & infinitive.	9
V	**Listening and Speaking**- Listen to Interviews & mock interview **Reading**- Reading short stories, reading profile of a company - **Writing**- Descriptive writing (describing one's own experience) **Grammar and Vocabulary**- Editing a passage(punctuation, spelling& number rules).	9

	Total Instructional Hours	**45**

Course Outcome

CO1- To know different modes of business communication
CO2- To understand managerial techniques.CO3- To apply the rules of grammar and vocabulary in effective business communication.
CO4-To analyse and interpret business documents.
CO5-To draft business reports

TEXT BOOKS:

T1 - Norman Whitby, "Business Benchmark-Pre-intermediate to Intermediate",Cambridge University Press, 2016.

T2- Ian Wood and Anne Willams. "Pass Cambridge BEC Preliminary", Cengage Learning press 2015.

REFERENCE BOOKS :

R1 -Michael Mc Carthy, "Grammar for Business", Cambridge University Press, 2009.

R2- Bill Mascull, "Business Vocabulary in use: Advanced 2nd Edition", Cambridge University Press, 2009.

R3-Frederick T. Wood, "Remedial English Grammar For Foreign Students", Macmillan publishers, 2001.

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19HE2101 - Business English for Engineers

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1.0	1.0	1.0	1.0	-	-	-	-	2.0	3.0	1.0	2.0	-	-
CO2	2.0	2.0	1.0	1.0	-	-	-	-	2.0	3.0	1.0	2.0	-	-
CO3	-	1.0	1.0	1.0	-	-	-	-	2.0	3.0	1.0	2.0	-	-
CO4	-	2.0	1.0	1.0	-	-	-	-	2.0	3.0	1.0	2.0	-	-
CO5	-	1.0	1.0	1.0	-	-	-	-	2.0	3.0	1.0	3.0	-	-
AVG	1.5	1.4	1.0	1.0	-	-	-	-	2.0	3.0	1.0	2.2	-	-

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Programme/sem	Course Code	Name of the Course	L	T	P	C
B.E./B.Tech/ II	19MA2101	DIFFERENTIAL EQUATIONS AND COMPLEX VARIABLES	3	1	0	4

Course Objective	1. Describe some methods to solve different types of first order differential equations.
	2. Solve ordinary differential equations of certain types using Wronskian technique
	3. Use the effective mathematical tools for the solutions of partial differential equations.
	4. Describe the construction of analytic functions and conformal mapping.
	5. Illustrate Cauchy's integral theorem and calculus of residues

Unit	Description	Instructional Hours
I	**FIRST ORDER ORDINARY DIFFERENTIAL EQUATIONS**	
	Solutions of Equations of the first order and of the first degree – Variable seperable method-Homogeneous equations – Exact differential equations (Excluding non Exact differential Equations) – Linear equations – Equations reducible to the linear form – Bernoulli's equation .	12
II	**ORDINARY DIFFERENTIAL EQUATIONS OF HIGHER ORDER**	
	Second order linear differential equations with constant and variable co-efficients – Cauchy – Euler equations – Cauchy – Legendre equation – Method of variation of paramers. Solution of ODE related to electric circuits, bending of beams.	12
III	**PARTIAL DIFFERENTIAL EQUATIONS**	
	Formation of partial differential equations by the elimination of arbitrary constants and arbitrary functions – Solution of standard types of first order partial differential equations of the form $f(p,q)=0$, Clairaut's type : $z = px+qy +f(p,q)$ – Lagrange's linear equation.	12
IV	**COMPLEX DIFFERENTIATION**	
	Functions of complex variables – Analytic functions – Cauchy's – Riemann's equations and sufficient conditions (excluding proof) – Construction of analytic functions – Milne –Thomson's method – Conformal mapping $w = A+z$, Az, $1/z$ and bilinear transformations.	12
V	**COMPLEX INTEGRATION**	
	Cauchy's integral theorem – Cauchy's integral formula –Taylor's and Laurent's series (statement only) – Residues - Cauchy's Residue theorem.	12
	Total Instructional Hours	60

Course Outcome	CO1: Apply few methods to solve different types of first order differential equations.
	CO2: Develop sound knowledge of techniques in solving ordinary differential equations
	CO3 Solve Partial Differential Equations using various methods.
	CO4: Infer the knowledge of construction of analytic functions and conformal mapping.
	CO5: Evaluate real and complex integrals over suitable closed paths or contours.

TEXT BOOKS:

T1- Ravish R Singh, Mukul Bhatt, "Engineering Mathematics", McGraw Hill education (India) Private Ltd.,Chennai,2017

T2- Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India Private Ltd., New Delhi, 2018.

REFERENCE BOOKS :

R1- Veerarajan T, "Engineering Mathematics", McGraw Hill Education(India) Pvt Ltd, New Delhi, 2016

R2- Grewal B.S, "Higher Engineering Mathematics", 42nd Edition, Khanna Publications, Delhi, 2012.

R3- Peter V. O'Neil, "Advanced Engineering Mathematics", 7th Edition, Cengage learning,2012.

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19MA2101 - Differential Equations and Complex Variables

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.0	3.0	3.0	2.0	2.0	1.0	1.0	-	-	1.0	1.0	2.0	2.0	2.0
CO2	3.0	3.0	3.0	2.0	2.0	1.0	1.0	-	-	1.0	1.0	2.0	2.0	2.0
CO3	3.0	3.0	3.0	3.0	3.0	1.0	1.0	-	-	1.0	1.0	2.0	2.0	2.0
CO4	3.0	3.0	3.0	2.0	2.0	1.0	1.0	-	-	1.0	-	2.0	2.0	2.0
CO5	3.0	3.0	3.0	3.0	3.0	1.0	1.0	-	-	1.0	-	2.0	2.0	2.0
AVG	3.0	3.0	3.0	2.4	2.4	1.0	1.0	-	-	1.0	1.0	2.0	2.0	2.0

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Programme	Course Code	Name of the Course	L	T	P	C
B.Tech	19EE2103	BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING	3	0	0	3

Course Objectives
- To understand the basic laws and apply them in Electrical circuits and understand different measuring instruments.
- To impart knowledge on construction and working of DC and AC machines
- To create awareness on the methods for electrical safety, load protection basics.
- To provide knowledge on the fundamentals of semiconductor devices and their applications.
- To impart knowledge on digital electronics and its principles.

UNIT	DESCRIPTION	INSTRUCTIONAL HOURS
I	**UNIT I: ELECTRICAL CIRCUITS AND MEASUREMENTS** Ohm's Law – Kirchoff's Laws – Steady State Solution of DC Circuits – Introduction to AC Circuits – Waveforms and RMS Value – Power and Power factor – Single Phase circuits - Three Phase Balanced Circuits. Operating Principles of Moving Coil and Moving Iron Instruments - Ammeters and Voltmeters, Dynamometer type Watt meters and Energy meters.	9
II	**UNIT II : ELECTRICAL MACHINES** Construction, Principle of Operation of DC Generators - EMF Equation - Construction, Principle of Operation of DC shunt and series Motors, Single Phase Transformer - EMF Equation, Single phase capacitor start - capacitor run – Construction, Principle of Operation of Three Phase Induction Motor – Applications - (Qualitative Approach only).	9
III	**UNIT III : ELECTRICAL WIRING AND SAFETY** Wiring types and applications: Service mains, meter board and distribution board - Brief discussion on concealed conduit wiring. One way and two way control. Elementary discussion on Circuit protective devices: fuse and Miniature Circuit Breaker (MCB's). Electric shock, precautions against shock, Objectives for Neutral and Earthing, types of earthing; pipe and plate earthing, Residual current circuit breaker.	9
	UNIT IV : SEMICONDUCTOR DEVICES AND APPLICATIONS Characteristics of PN Junction Diode – Zener Diode and its Characteristics – Zener Effect – Half wave and Full wave Rectifiers – Voltage Regulation. Bipolar Junction Transistor (BJT) – CB, CE, CC Configurations and Characteristics – FET – Characteristics.	9
	UNIT V : DIGITAL ELECTRONICS Binary Number System – Logic Gates – Boolean Algebra – Half and Full Adders – Flip-Flops (RS, JK, T & D), A/D and D/A Conversion (Dual Slope, SAR, Binary-weighted and R-2R).	9
	Total Instructional Hours	45

Course Outcomes

Upon completion of the course, students can be able to
CO1: Apply the KVL and KCL in Electrical circuits.
CO2: Explain the constructional features of AC and DC machines.
CO3: Develop awareness on the methods for electrical safety, load protection basics.
CO4: Identify electronics components and use of them to design circuits.
CO5: Develop Combinational and Sequential logic circuits.

TEXT BOOKS:
1. Muthusubramanian R, Salivahanan S and Muraleedharan K A, "Basic Electrical, Electronics and Computer Engineering", Tata McGraw Hill, Eighteenth Reprint, 2014.
2. Mittle N., "Basic Electrical Engineering", Tata McGraw Hill Edition, New Delhi, 1990.

REFERENCES BOOKS:
1. Premkumar N, "Basic Electrical and Electronics Engineering", Anuradha Publishers, 2018.
2. Mehta V K, "Principles of Electronics", S.Chand& Company Ltd, 1994.
3. Nagsarkar T K and Sukhija M S, "Basics of Electrical Engineering", Oxford press 2005.

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19EE2103 - Basics of Electrical and Electronics Engineering

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.0	2.0	2.0	2.0	2.0	1.0	1.0	-	-	-	1.0	2.0	3.0	2.0
CO2	3.0	3.0	3.0	2.0	2.0	1.0	1.0	-	-	-	1.0	2.0	3.0	2.0
CO3	3.0	3.0	3.0	2.0	2.0	1.0	1.0	-	-	-	1.0	2.0	3.0	2.0
CO4	3.0	3.0	3.0	2.0	2.0	1.0	1.0	-	-	-	1.0	2.0	3.0	2.0
CO5	3.0	3.0	3.0	2.0	2.0	1.0	1.0	-	-	-	1.0	2.0	2.0	3.0
AVG	3.0	2.8	2.8	2.0	2.0	1.0	1.0	-	-	-	1.0	2.0	2.8	2.2

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Programme	Course Code	Name of the Course	L	T	P	C
B.Tech	19CH2101	**PRINCIPLES OF CHEMICAL ENGINEERING**	3	0	0	3

Course Objectives	Students should be able to
	1. Understand the overall view of the chemical reactions and chemical engineering.
	2. Examine the scientific laws in chemical kinetics
	3. Illustrate the role of computers in chemical industry.

UNIT	DESCRIPTION	INSTRUCTIONAL HOURS
I	**HISTORY**: Chemistry, Chemical Engineering and Chemical Technology; Chemical process industries: History and their role in Society; Role of Chemical Engineer; History and Personalities of Chemical Engineering; Greatest achievements of Chemical Engineering. Role of Mathematics, Physics, Chemistry and Biology.	9
II	**SCIENTIFIC LAWS IN CHEMICAL KINETICS:** Thermodynamics and Fluid mechanics; Arrhenius equation, Avogadro's law, Boltzmann equation, Boyle's law, Carnot's theorem, Charles's law, Dalton's law, Darcy's law, Fick's law of diffusion, Fourier's law, Gibbs–Helmholtz equation, Graham's law, Henry's law, Hess's law, Helmholtz free energy, Stefan–Boltzmann law, Stokes's law- Definition.	9
III	**INTRODUCTION** - Law of conservation of matter, Chemical equations **and** chemical reactions. Reactants **to** products -balancing the chemical reaction, coefficients, stoichiometry. Types of Chemical Reactions; Chemical reactions – Classifications and definations; Combination reactions, Decomposition **reac**tions, Combustion reactions, Oxidation reactions, Reduction reactions - examples.	9
IV	**QUANTITIES IN CHEMICAL REACTIONS**: Introduction – Mole, atomic and molar masses, mole – mass, mole-mole, mass-mass conversion and relationships in chemical reactions-basic problems. Energy and Chemical Processes; Introduction -Energy and its Units, Heat, Phase Changes, Bond Energies and Chemical Reactions, Energy of Biochemical Reactions.	9
V	**ROLE OF COMPUTER IN CHEMICAL ENGINEERING:** Chemical Engineering Software. Role of Chemical Engineers in the area of Food, Medical, Energy, Environmental, Biochemical, Electronics etc. Paradigm shifts in Chemical Engineering; Range of scales in Chemical Engineering; Opportunities for Chemical Engineers; Future of Chemical Engineering.	9
	Total Instructional Hours	**45**

Upon completion of the course, students can be able to

Course Outcomes		
	CO1:	Understand the role of chemical engineers.
	CO2:	Understand the scientific and governing laws in chemical engineering.
	CO3:	Understand about the various chemical reactions in the processes.
	CO4:	Understand the measurement of quantities and energy in process.
	CO5:	Understand the demand of chemical engineers, opportunities and future.

TEXT BOOKS:
1. Salil K. Ghosal, Siddhartha Datta "Introduction to Chemical Engineering" Tata McGraw-Hill Education.
2. Introduction to chemical engineering, S. Pushpavanam, PHI Learning Pvt. Ltd.,-2012.
3. Dryden, C.E., "Outlines of Chemicals Technology", Edited and Revised by GopalaRao, M. and M.Sittig, 2nd Edition, Affiliated East-West press,1993.
4. The Language of Chemistry or Chemical Equations, by G.D. Tuli, P.L. Soni, EPH (Eurasia Publishing House)

REFERENCEBOOKS:
1. Finlayson, B. A., Introduction to Chemical Engineering Computing, John Wiley & Sons, New Jersey,2006.
2. McCabe, W.L., Smith, J. C. and Harriot, P. "Unit operations in Chemical Engineering", McGraw Hill, 7th Edition,2001.

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19CH2101 - Principles of Chemical Engineering

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2.0	-	2.0	-	-	2.0	2.0	-	-	-	-	-	2.0	2.0
CO2	3.0	-	-	2.0	-	-	-	-	-	-	-	-	3.0	2.0
CO3	3.0	-	-	2.0	-	-	-	-	-	-	-	-	3.0	2.0
CO4	3.0	-	-	2.0	-	-	-	-	-	-	-	-	3.0	3.0
CO5	2.0	1.0	2.0	1.0	3.0	-	2.0	-	-	-	-	3.0	-	2.0
AVG	2.6	1.0	2.0	1.75	3.0	2.0	2.0	-	-	-	-	3.0	2.75	2.2

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Programme/sem	Course Code	Name of the Course **Material Science**	L	T	P	C
B.E./B.Tech/ II	**19PH2151**	**(Common to all Branches)**	2	0	2	3

Course Objective	1. Acquire fundamental knowledge of semiconducting materials which is related to the 2. engineering program 3. Extend the knowledge about the magnetic materials 4. Explore the behavior of super conducting materials 5. Gain knowledge about Crystal systems 6. Understand the importance of ultrasonic waves

Unit	Description	Instructional Hours
I	**SEMICONDUCTING MATERIALS** Introduction – Intrinsic semiconductor – Compound and elemental semiconductor - direct and indirect band gap of semiconductors. Carrier concentration derivation – Fermi level – Variation of Fermi level with temperature – electrical conductivity – band gap determination. Optical properties of semiconductor – Light through optical fiber(Qualitative). Determination of band gap of a semiconductor Determination of acceptance angle and numerical aperature in an optical fiber	6 3 3
II	**MAGNETIC MATERIALS** Origin of magnetic moment – Bohr magneton – comparison of Dia, Para and Ferro magnetism – Domain theory – Hysteresis – soft and hard magnetic materials – anti ferromagnetic materials – Ferrites and its applications. B – H curve by Magnetic hysteresis experiment	6 3
III	**PERCONDUCTING MATERIALS** Superconductivity : properties(Messiner effect, effect of magnetic field, effect of current and isotope effects) – Type I and Type II superconductors – High Tc superconductors – Applications of superconductors –Cryotron and magnetic levitation.	6
IV	**CRYSTAL PHYSICS** Crystal systems - Bravais lattice - Lattice planes - Miller indices - Interplanar spacing in cubic lattice - Atomic radius, Coordination number and Packing factor for SC, BCC and FCC crystal structures.	6
V	**ULTRASONICS** Production – Magnetostrictive generator – Piezoelectric generator – Determination of velocity using acoustic grating – Cavitations – Viscous force – co-efficient of viscosity. Industrial applications – Drilling and welding – Non destructive testing – Ultrasonic pulse echo system. Determination of velocity of sound and compressibility of liquid – Ultrasonic wave Determination of Coefficient of viscosity of a liquid –Poiseuille's method	6 3 3
	Total Instructional Hours	**45**

Course Outcome	CO1: Understand the purpose of acceptor or donor levels and the band gap of a semiconductor CO2: Interpret the basic idea behind the process of magnetism and its applications in everyday CO3: Discuss the behavior of super conducting materials CO4: Illustrate the types and importance of crystal systems CO5: Evaluate the production of ultrasonics and its applications in NDT

TEXT BOOKS:

T1 - Rajendran V, Applied Physics, Tata McGraw Hill Publishing Company Limited, New Delhi, 2017.

T2- Gaur R.K. and Gupta S.L., Engineering Physics, 8th edition, Dhanpat Rai Publications (P) Ltd., New Delhi, 2015.

REFERENCE BOOKS:

R1 - Arthur Beiser "Concepts of Modern Physics" Tata McGraw Hill, New Delhi – 2015

R2 - M.N Avadhanulu and PG Kshirsagar "A Text Book of Engineering physics" S. Chand and Company ltd., New Delhi 2016

R3 - Dr. G. Senthilkumar "Engineering Physics – II" VRB publishers Pvt Ltd., 2016

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19PH2151 - Material Science

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.0	2.0	1.0	1.0	1.0	1.0	-	-	-	-	-	-	-	-
CO2	3.0	3.0	1.0	1.0	2.0	-	-	-	-	-	-	-	-	-
CO3	3.0	2.0	1.0	2.0	2.0	-	-	-	-	-	-	-	-	-
CO4	3.0	3.0	1.0	2.0	2.0	1.0	-	-	-	-	-	-	-	-
CO5	3.0	2.0	2.0	3.0	2.0	1.0	2.0	-	-	-	-	-	-	-
AVG	3.0	2.4	1.2	1.8	1.8	1.0	2.0	-	-	-	-	-	-	-

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Programme/sem	Course Code	Name of the Course	L	T	P	C
B.E./B.Tech/ II	19CY2151	ENVIRONMENTAL STUDIES (COMMON TO ALL BRANCHES)	2	0	2	3

Course Objective
1. The importance of environmental education, ecosystem and biodiversity.
2. The knowledge about environmental pollution – sources, effects and control measures of environmental pollution.
3. The natural resources, exploitation and its conservation
4. Scientific, technological, economic and political solutions to environmental problems.
5. An awareness of the national and international concern for environment and its protection.

Unit	Description	Instructional Hours
I	**ENVIRONMENT, ECOSYSTEMS AND BIODIVERSITY** Main objectives and scope of environmental studies-Importance of environment – need for public awareness - concept of an ecosystem – structure and function of an ecosystem – food chain, food web and ecological pyramids - energy flow in the ecosystem – ecological succession processes - Introduction, types, characteristic features, structure and function of the forest and ponds ecosystem – Introduction to biodiversity definition: types and value of biodiversity – hot-spots of biodiversity – threats to biodiversity– endangered and endemic species of India – conservation of biodiversity: In-situ and ex-situ conservation of biodiversity.	6
II	**NATURAL RESOURCES** Renewable and Non renewable resources - Forest resources: Use and over-exploitation, deforestation, timber extraction, mining, dams and their effects on forests and tribal people - Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture – Energy resources: Renewable and non renewable energy sources – Solar energy and wind energy - role of an individual in conservation of natural resources.	6+9=15
III	**ENVIRONMENTAL POLLUTION** Definition – causes, effects and control measures of: Air pollution- Water pollution – Water quality parameters- Soil pollution - Noise pollution- Nuclear hazards – role of an individual in prevention of pollution. **Determination of Dissolved Oxygen in sewage water by Winkler's method. Estimation of alkalinity of water sample by indicator method. Determination of chloride content of water sample by argentometric method.**	6
IV	**SOCIAL ISSUES AND THE ENVIRONMENT** From unsustainable to sustainable development – urban problems related to energy- environmental ethics: Issues and possible solutions – 12 Principles of green chemistry- Municipal solid waste management. Global issues – Climatic change, acid rain, greenhouse effect and ozone layer depletion – Disaster Management – Tsunami and cyclones. **Determination of pH in beverages.**	6+3=9
V	**HUMAN POPULATION AND THE ENVIRONMENT** Population growth, variation among nations – population explosion – family welfare programme – environment and human health – effect of heavy metals – human rights – value education – HIV / AIDS – women and child welfare –Environmental impact analysis (EIA)- GIS-remote sensing-role of information technology in environment and human health. **Estimation of heavy metal ion (copper) in effluents by EDTA.**	6+3=9

Total Instructional Hours   **45**

Course Outcome
CO1: Realise the importance of ecosystem and biodiversity for maintaining ecological balance.
CO2: Understand the causes of environmental pollution and hazards due to manmade activities.
CO3: Develop an understanding of different natural resources including renewable resources.
CO4: Demonstrate an appreciation for need for sustainable development and understand the various social issues and solutions to solve the issues.
CO5: Gain knowledge about the importance of women and child education and know about the existing technology to protect environment

TEXT BOOKS:

T1- S.Annadurai and P.N. Magudeswaran, "Environmental studies", Cengage Learning India Pvt.Ltd, Delhi, 2020
T2 – Anubha Kaushik and C. P. Kaushik, "Perspectives in Environmental studies", Sixth edition, New Age International Publishers, New Delhi, 2019.

REFERENCES:

R1 – Erach Bharucha, "Textbook of environmental studies" University Press (I) Pvt.ltd, Hyderabad, 2015
R2 - G.Tyler Miller, Jr and Scott E. Spoolman"Environmental Science" Thirteenth Edition, Cengage Learning, 2010.
R3 - Gilbert M. Masters and Wendell P. Ela "Introduction to Environmental Engineering and Science", 3rd edition, Pearson Education, 2013.

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Programme	Course Code	Name of the Course	L	T	P	C
B.Tech	19ME2001	**ENGINEERING PRACTICES LAB**	0	0	4	2

Course Objectives	• To provide exposure to the students with hands on experience on various basic engineering practices in Civil, Mechanical and Electrical Engineering.

S.No.   **DESCRIPTION**
GROUP A (CIVIL & MECHANICAL)

1. Preparation of Single pipe line and Double pipe line connection by using valves, taps, couplings, unions, reducers and elbows.

2. Arrangement of bricks using English bond for 1brick thick wall and 11/2 brick thick wall for right angle corner junction.

3. Arrangement of bricks using English bond for 1brick thick wall and 11/2 brick thick wall for T junction.

4. Preparation of arc welding of Butt joints, Lap joints and Tee joints. structures.

5. Practice on sheet metal Models– Trays and funnels

6. Hands-on-exercise in wood work, joints by sawing, planning and cutting.

7. Practice on simple step turning, taper turning and drilling.

8. Demonstration on Smithy operation.

9. Demonstration on Foundry operation.

10. Demonstration on Power tools.

S.No.   **DESCRIPTION**
GROUP B (ELECTRICAL)

1. Residential house wiring using switches, fuse, indicator, lamp and energy meter.

2. Fluorescent lamp wiring.

3. Stair case wiring.

4. Measurement of Electrical quantities – voltage, current, power & power factor in single phase circuits.

5. Measurement of energy using single phase energy meter.

6. Soldering practice using general purpose PCB.

7. Measurement of Time, Frequency and Peak Value of an Alternating Quantity using CRO and Function Generator.

8. Study of Energy Efficient Equipment's and Measuring Instruments.

Total Instructional Hours   45

Upon completion of the course, students can be able to

Course Outcomes	• Fabricate wooden components and pipe connections including plumbing works. • Fabricate simple weld joints. • Fabricate different electrical wiring circuits and understand the AC Circuits.

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Programme	Course Code	Name of the Course	L	T	P	C
B.E/B.Tech	19HE2001	**LANGUAGE COMPETENCY ENHANCEMENT COURSE- II** (COMMON TO ALL BRANCHES)	0	0	2	1

Course Objective	✓ To introduce to business communication. ✓ To train the students to react to different professional situations. ✓ To make the learnerfamiliar with the managerial skills ✓ To empower the trainee in business writing skills. ✓ To learn to interpret and expertise different content.

Unit	Description	Instructional Hours
I	**Listening and Speaking** – listening and discussing about programme and conference arrangement **Reading** –reading auto biographies of successful personalities **Writing** Formal & informal email writing, Recommendations **Grammar and Vocabulary**- Business vocabulary, Adjectives & adverbs.	3
II	**Listening and Speaking**- listening to TED talks **Reading**-Making and interpretation of posters**Writing**- Business letters: letters giving good and bad news, Thank you letter, Congratulating someone on a success" **Grammar and Vocabulary**- Active & passive voice, Spotting errors (Tenses, Preposition, Articles).	3
III	**Listening and Speaking**-travel arrangements and experience **Reading**- travel reviews **Writing**- Business letters (Placing an order, making clarification & complaint letters). **Grammar and Vocabulary**- Direct and Indirect speech.	3
IV	**Listening and Speaking**- Role play- **Reading**- Sequencing of sentence **Writing**- Business report writing (marketing, investigating) **Grammar and Vocabulary**- Connectors, Gerund & infinitive.	3
V	**Listening and Speaking**- Listen to Interviews & mock interview **Reading**- Reading short stories, reading profile of a company - **Writing**- Descriptive writing (describing one's own experience) **Grammar and Vocabulary**- Editing a passage(punctuation, spelling& number rules).	3
	Total Instructional Hours	15

Course Outcome	CO1- Introduced to different modes and types of business communication. CO2- Practiced to face and react to various professional situations efficiently. CO3- learnt to practice managerial skills. CO4- Familiarized with proper guidance to business writing. CO5- Trained to analyze and respond to different types of communication.

TEXT BOOKS:

T1 - Norman Whitby, "Business Benchmark-Pre-intermediate to Intermediate",Cambridge University Press, 2016.

T2- Ian Wood and Anne Willams. "Pass Cambridge BEC Preliminary", Cengage Learning press 2015.

REFERENCE BOOKS :

R1 -Michael Mc Carthy, "Grammar for Business", Cambridge University Press, 2009.

R2- Bill Mascull, "Business Vocabulary in use: Advanced 2nd Edition", Cambridge University Press, 2009.

R3-Frederick T. Wood, "Remedial English Grammar For Foreign Students", Macmillan publishers, 2001.

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Programme	Course Code	Name of the Course	L	T	P	C
B.Tech	19MA3103	FOURIER ANALYSIS AND NUMERICAL METHODS	3	1	0	4

Course Objectives
- Introduce Fourier series analysis which is central to many applications in Engineering.
- Solve boundary value problems by applying Fourier series.
- Apply Fourier transform techniques used in wide variety of situations.
- Apply various methods to solve numerical differentiation and numerical integration.
- Explain the numerical solution of ordinary differential equations as most of the engineering problems are expressed in the form of differential equations.

UNIT	DESCRIPTION	INSTRUCTIONAL HOURS
I	**FOURIER SERIES** Introduction:Dirichlet's conditions- General Fourier Series – Odd and Even Functions – Half range sine and cosine series –Change of Interval - Parseval's Identity - Harmonic analysis.	12
II	**BOUNDARY VALUE PROBLEMS** Classification – solution of one dimensional wave equation – one dimensional heat equation –Fourier series solution in Cartesian coordinates.	12
III	**FOURIER TRANSFORMS** Fourier Transform Pair - Fourier sine and cosine transforms – Properties - Transforms of Simple functions – Convolution Theorem – Parseval's identity.	12
IV	**INTERPOLATION, NUMERICAL DIFFERENTIATION AND INTEGRATION** Interpolation: Newton's forward and backward difference formulae – Newton's divided difference formula and Lagrangian interpolation for unequal intervals. Differentiation: Newton's forward and backward interpolation formulae for equal intervals – Newton's divided difference formula for unequal intervals. Numerical integration: Trapezoidal and Simpson's 1/3 and 3/8 rules.	12
V	**INITIAL VALUE PROBLEMS FOR ORDINARY DIFFERENTIAL EQUATIONS** Single step methods: Taylor's series method – Modified Euler's method for first order equation – Fourth order Runge- kutta method for solving first order equations – Multi step method: Milne's predictor and corrector method.	12
	Total Instructional Hours	60

Upon completion of the course, students can be able to

Course Outcomes

CO1: Understand the function in terms of sine and cosine terms in Fourier series and also to get knowledge in Fourier transforms.

CO2: Demonstrate the application of Fourier series in solving the heat and wave equations.

CO3: Illustrate the mathematical principles on Fourier transforms and able to solve some of the Physical problems of engineering.

CO4: Apply the concepts of interpolation, numerical differentiation andintegration.

CO5: Examine the concept of solving ordinary differential equations using single and multi step methods.

TEXT BOOKS:
1. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India Private Ltd., New Delhi, 2018.
2. Grewal.B.S. " Higher Engineering Mathematics", 44th Edition, Khanna Publications, New Delhi, 2012.

REFERENCE BOOKS:
1. Kreyszig.E. "Advanced Engineering Mathematics", Eight Edition, John Wiley & sons (Asia) ltd 2010.
2. Veerarajan. T.,"Transforms and Partial Differential Equations", Tata McGraw Hill Education Pvt. Ltd., Second reprint, New Delhi, 2012.
3. S.K.Gupta, Numerical Methods for Engineers", New Age International Pvt.Ltd Publishers,2015.

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19MA3103 - Fourier Analysis and Numerical Methods

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.0	3.0	3.0	2.0	2.0	1.0	1.0	-	-	1.0	2.0	2.0	2.0	2.0
CO2	3.0	3.0	3.0	2.0	2.0	1.0	1.0	-	-	1.0	2.0	2.0	2.0	2.0
CO3	3.0	3.0	3.0	3.0	2.0	1.0	1.0	-	-	1.0	2.0	2.0	3.0	2.0
CO4	3.0	3.0	3.0	3.0	3.0	1.0	2.0	-	-	1.0	2.0	2.0	3.0	2.0
CO5	3.0	3.0	3.0	3.0	3.0	1.0	2.0	-	-	1.0	3.0	2.0	3.0	2.0
AVG	3.0	3.0	3.0	2.6	2.4	1.0	1.4	-	-	1.0	2.2	2.0	2.6	2.0

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Programme	Course Code	Name of the Course	L	T	P	C
B.Tech	19CH3201	**CHEMICAL PROCESS CALCULATIONS**	3	1	0	4

The student should be able to

Course Objectives

Formulate material balances to solve for compositions and flow rates of process streams

Incorporate single and multiple reactions into unit operations within chemical processes

Perform material and energy balance calculations in various systems

UNIT	DESCRIPTION	INSTRUCTIONAL HOURS
I	**Units & Dimensions** – Unit Conversion; Process variables and Properties; Stoichiometric Equations, Degrees of freedom.	12
II	**Introduction to material balances** - Material balance problems for single units, multiple units – Distillation, Humidification, Adsorption & Stripping, Extraction & Leaching, Crystallization, Psychrometry, Drying, Evaporation; Stoichiometry and Chemical reaction equations; Material balance for processes involving reaction; Bypass, Purging, Recycle operations.	12
III	**Ideal gases, Real gases,** Single component two phase systems, Multiple component phase systems, Phase rule, Phase equilibria, Combustion processes – Flue gas analysis, Ultimate and Proximate analyses of coal.	12
IV	**Energy balances**, Conservation of Energy processes without reaction, Heat capacity, Energy balances with chemical reaction, Efficiency applications.	12
V	**Application of energy balances;** Unsteady state material and energy balances; Solving material and energy balances using process simulators.	12

Total Instructional Hours 45 + 15 = 60

Upon completion of the course, students can be able to

Course Outcomes

CO1: Remember the units, unit's conversion and degrees of freedom.

CO2: Calculate the reactor systems and perform material and energy balances for process flow sheets by applying degree of freedom.

CO3: Apply the calculations associated with gases in two phase systems, in combustion processes.

CO4: Inspect the energy balance and heat capacity calculations.

CO5: Identify the simulation of steady-state and unsteady state processes using process simulators.

TEXT BOOKS:
1. David M. Himmelblau, "Basic Principles and Calculations in Chemical Engineering", 8thEdition, Prentice Hall of India, New Delhi, 2012.
2. Bhatt B.I. and Vora S.M., "Stoichiometry", 2nd Edition, Tata McGraw Hill, New Delhi,2004.

REFERENCE BOOKS:
1. Hougen O A, Watson K M and Ragatz R A, "Chemical process principles" Part I, 2nd Edition, CBS publishers, 2004.
2. Venkatramani. V, Anatharaman. N and MeeraShariffaBegam" Process Calculations" Printice Hall of India, New Delhi, 2nd Edn, 2011.
3. Felder, R. M. and Rousseau, R. W., "Elementary Principles of Chemical Processes",3rd Edition, John Wiley & Sons, New York, 2005.

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19CH3201 - Chemical Process Calculations

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.0	3.0	3.0	-	-	-	-	-	2.0	-	2.0	3.0	3.0	2.0
CO2	3.0	3.0	3.0	-	-	-	-	-	2.0	-	3.0	3.0	3.0	2.0
CO3	3.0	3.0	3.0	-	-	-	1.0	-	2.0	-	3.0	3.0	3.0	2.0
CO4	3.0	3.0	3.0	2.0	-	2.0	2.0	-	2.0	-	3.0	3.0	3.0	2.0
CO5	3.0	3.0	3.0	3.0	-	2.0	2.0	-	2.0	-	3.0	3.0	3.0	2.0
AVG	3.0	3.0	3.0	2.5	-	2.0	1.67	-	2.0	-	2.8	3.0	3.0	2.0

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Programme	Course Code	Name of the Course	L	T	P	C
B.Tech	19CH3202	**FLUID MECHANICS FOR CHEMICAL ENGINEERS**	3	0	0	3

Course Objectives	**The student should be able to**

Develop an understanding of the fundamental properties of fluids and their behavior in static conditions.

Familiarize students with the principles of fluid flow, including laminar and turbulent flow, flow equations, and flow measurement techniques.

Enable students to understand various flow metering techniques and their applications in fluid transportation.

UNIT	DESCRIPTION	INSTRUCTIONAL HOURS
I	**Fluid Properties and Statics:** Nature of fluids - properties of fluids; Types of fluids- Newtonianand Non-Newtonian fluids, Compressible and incompressible fluids; Introduction-Hydrostatic equilibrium; Pressure measurement – Manometers.	9
II	**Principles of Fluid Flow:** Types of flow – laminar and turbulent flow in pipes and closed channels;Equation of Continuity; shear stress distribution; friction factors; Bernoulli'sequation and applications; Introduction - Boundary layer concept.	9
III	**Flow Past Immersed Bodies:** Drag- types, drag coefficient, friction factor for flow through beds of solids, applications to packed and fluidized beds; packing materials; determination of pressure drop using Ergun equation, Fluidization-types, determination of minimum fluidization velocity and pressure drop; Motion of particles through fluids – calculation of terminal settling velocity.	9
IV	**Metering of Fluids:** Classification and selection of flow meters; variable head and variable area meters: venturi, orifice and rotameters; determination of discharge and discharge coefficient; Pitot tube; Anemometer; Introduction to notches, weirs, turbine, Vortex and Magnetic flow meters.	9
V	**Transportation of Fluids:** Classification of fluid moving machinery; Centrifugal pump- characteristics and applications; elementary principles of Reciprocating, gear, air lift, diaphragm and submersible pumps; Introduction to valves and pipe fittings. **Dimensional analysis:** Basics of dimensional analysis; Rayleigh's method and Buckingham's-π method.	9
	Total Instructional Hours	**45**

Course Outcomes	**Upon completion of the course, students can be able to**

CO1: Elucidate the principles of fluid properties and fluid statics

CO2: Apply the principles of fluid flow problems like pressure drop power and loss coefficient and apply the same in chemical process industries.

CO3: Illustrate the flow behavior of solid and liquid and to demonstrate the understanding of packed and fluidized bed.

CO4: Categorize and select the fluid measuring devices for different application in process industries.

CO5: Examine and select the characteristics of pumps, flow meters and valves for different applications in process industries.

TEXT BOOKS:

1. McCabe W.L., Smith J.C. and Harriot P., — "Unit Operations in Chemical Engineering", 7 th Edition, McGraw Hill International Edition, New York, 2006.
2. Bansal R.K., "Fluid Mechanics & Hydraulic Machines", Laxmi Publications, 2015.

REFERENCE BOOKS:

1. Cengel, Yunus and Cimbala John M, — "Fluid Mechanics Fundamentals and Applications", 2nd Edition, Tata McGraw Hill Publishing Company, New Delhi, 2006.
2. Munson B.R., Young D.F., Okiishi T.H. and Huebsch W.W., — "Fundamentals of Fluid Mechanics", 6th Edition, Wiley India, New Delhi, 2010.
3. Noel de Nevers, "Fluid Mechanics for Chemical Engineers", 3rd Edition, McGrawHill, New York, 2004.

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19CH3202 - Fluid Mechanics for Chemical Engineers

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.0	3.0	2.0	3.0	-	-	-	-	2.0	-	2.0	3.0	3.0	-
CO2	3.0	3.0	2.0	3.0	-	-	-	-	2.0	-	2.0	3.0	3.0	-
CO3	3.0	3.0	3.0	3.0	-	-	-	-	2.0	-	2.0	3.0	3.0	-
CO4	3.0	3.0	2.0	3.0	-	-	-	-	2.0	-	3.0	3.0	3.0	2.0
CO5	3.0	3.0	2.0	3.0	-	-	-	-	2.0	-	3.0	3.0	3.0	2.0
AVG	3.0	3.0	2.2	3.0	-	-	-	-	2.0	-	2.4	3.0	3.0	2.0

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Programme	Course Code	Name of the Course	L	T	P	C
B.Tech	19CH3203	**CHEMICAL ENGINEERING THERMODYNAMICS - I**	3	0	0	3

Course Objectives	**The student should be able to**
	Calculate and analyse the P-V-T behaviour of the gases using various equation of states and compressibility charts.
	Know the first and second law of thermodynamics and will learn to apply these to the solution of chemical engineering problems.
	Assess thermodynamic potential and the concept of Internal energy and enthalpy

UNIT	DESCRIPTION	INSTRUCTIONAL HOURS
I	**Scope of thermodynamics**; Definition of system, control volume, state and path function, equilibrium, reversibility, energy, work and heat. Zeroth law; temperature scales. Joule's experiment, internal energy, first law, energy balance for closed systems, mass and energy balance for open systems.	9
II	**PVT behaviour of fluids**; Mathematical representation of PVT behaviour; generalized compressibility factor correlation; generalized equations of state.	9
III	**Statements of the second law of thermodynamics**, heat engine and refrigerator, Carnot cycle and Carnot theorems, thermodynamic temperature scale, entropy and its calculation, second law of thermodynamics for a control volume. Third law of thermodynamics, entropy from a microscopic point of view.	9
IV	**Thermodynamic potentials** – Internal energy, Enthalpy, Helmholtz free energy, Gibbs free energy; thermodynamic property relations – Maxwell relations - partial derivatives and Jacobian method; residual properties; thermodynamic property tables and diagrams.	9
V	**Duct flow of compressible fluids**, Compression and expansion processes, steam power plant, internal combustion engines, jet and rocket engines.	9

Total Instructional Hours   **45**

Course Outcomes	**Upon completion of the course, students can be able to**
	CO1: Remember the concepts of heat, work and energy.
	CO2: Determine the properties and relationships of thermodynamic fluids.
	CO3: Illustrate the laws thermodynamics and correctly use thermodynamics terminology.
	CO4: Remember the fundamental thermodynamic properties.
	CO5: Examine the basic thermodynamic cycles.

TEXT BOOKS:
1. Smith, J.M., Van Ness, H.C and Abbot M.M "Introduction to Chemical Engineering Thermodynamics ", McGraw Hill Publishers, VI edition, 2003.
2. Narayanan, K.V. A Textbook of Chemical Engineering Thermodynamics Prentice Hall India, 2004.

REFERENCE BOOKS:
1. Kyle, B.G., "Chemical and Process Thermodynamics III Edition", Prentice Hall of India Pvt. Ltd., 3rd edition, 2004.
2. Elliott J.R., Lira, C.T., "Introductory Chemical Engineering Thermodynamics", Prentice Hall, Second Edition, 2011.
3. Rao, Y.V.C., "Chemical Engineering Thermodynamics" Universities Press, 2005.

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19CH3203 - Chemical Engineering Thermodynamics – I

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.0	3.0	2.0	2.0	-	-	-	-	2.0	-	-	3.0	3.0	-
CO2	3.0	3.0	2.0	2.0	-	-	-	-	2.0	-	-	3.0	3.0	-
CO3	3.0	3.0	3.0	3.0	-	-	-	-	2.0	-	2.0	3.0	3.0	2.0
CO4	3.0	3.0	2.0	3.0	-	-	2.0	-	2.0	-	3.0	3.0	3.0	2.0
CO5	3.0	3.0	2.0	2.0	-	-	2.0	-	2.0	-	3.0	3.0	3.0	2.0
AVG	3.0	3.0	2.2	2.4	-	-	2.0	-	2.0	-	2.67	3.0	3.0	2.0

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Programme	Course Code	Name of the Course	L	T	P	C
B.Tech	19CH3251	**ANALYTICAL INSTRUMENTS FOR ANALYSIS**	2	0	2	3

Course Objectives	The student should be able to
	• Develop the ability to select the instruments based on appropriate criteria,
	• Analyze and interpret the experimental data.
	• Examine the working of instruments.

UNIT	DESCRIPTION	INSTRUCTIONAL HOURS
I	**Introduction:** Introduction to classical qualitative and quantitative analysis, classification of instrumental methods, Errors, precision and accuracy of instruments, statistical methods of data handling.	6
II	**Spectroscopy:** Beer"s Law, deviation of Beer"s Law, instrumentation of UV and IR spectroscopy: Monochromatic Source, grating systems and types of detectors, different sampling techniques and application of UV &IRSpectroscopy: **Determination of Pka value of a component usingUV-spectroscopy, Study of Chemical Reaction Kinetics usingUV-System, Determination of wavelength using UV- spectroscopy.**	6+9
III	**Gravimetric analysis:** Principle of Thermogravimetric analyzer (TGA), construction of TGA, principle of bomb Calorimeter (BC), principle of Differential scanning calorimeter (DSC), Instrumentation of TGA and BC, Application of TGA andBCinstruments: **Effect of temperature on viscosity of oils using red woodviscometer.**	6+6
IV	**Gas chromatography:** Introduction, Principle, carrier gas, stationary phase, instrumentation, column detectors (TCD, FID, ECD), qualitative andquantitativeanalysis.	6
V	**High performance liquid chromatography:** Principle, instrumentation, types of columns, sample injection, detectors used like (absorbance, refractive index, and electrochemical measurements), criteria for mobile phase selection and applicationofHPLC.	6
	Total Instructional Hours	45

Course Outcomes	Upon completion of the course, students can be able to
	CO1: Understand qualitative and quantitative analysis
	CO2: Determine the operation and analyze the samples using UV-spectroscopy
	CO3: Examine the principles of gravimetric analysis of samples
	CO4: Choose the particular sample for analyses using gas chromatography
	CO5: Illustrate the sample analyses using HPLC

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

REFERENCE BOOKS:
1. Lloyd R. Snyder, Joseph J. Kirkland, John W. Dolan., "Introduction to Modern Liquid Chromatography"., 3rd Edition, Wiley-Blackwell, scholarlypublishing.
2. H.H. Willard, L.L. Merritt, J.N. Dean and F.A. Settle, "Instrumental methods ofanalysis"., I.B.H. Publishing House, New Delhi.

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19CH3251 - Analytical Instruments for Analysis

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.0	3.0	2.0	3.0	2.0	-	2.0	-	2.0	-	2.0	3.0	3.0	2.0
CO2	3.0	3.0	2.0	3.0	2.0	-	2.0	-	2.0	-	2.0	3.0	3.0	2.0
CO3	3.0	3.0	3.0	3.0	2.0	-	2.0	-	2.0	-	2.0	3.0	3.0	2.0
CO4	3.0	3.0	2.0	3.0	2.0	-	2.0	-	2.0	-	3.0	3.0	3.0	2.0
CO5	3.0	3.0	2.0	3.0	2.0	-	2.0	-	2.0	-	3.0	3.0	3.0	2.0
AVG	3.0	3.0	2.2	3.0	2.0	-	2.0	-	2.0	-	2.4	3.0	3.0	2.0

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Programme	Course Code	Name of the Course	L	T	P	C
B.Tech	19CH3001	**FLUID MECHANICS LAB**	0	0	3	1.5

Course Objectives	• To learn experimentally to calibrate flow meters, find pressure loss for fluid flows and determine pump characteristics.

S.No.	DESCRIPTION
1.	Viscosity measurement of non Newtonian fluids
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.	Pressure drop studies in packed column
11.	Hydrodynamics of fluidized bed
12.	Drag coefficient of solid particle

Total Practical Hours   45

Upon completion of the course, students can be able to

Course Outcomes

- Measure viscosity of non: Newtonian fluids under varying shear rates and flow conditions.
- Calibrate flow measurement devices, including head meters, weirs, and notches, for accurate fluid flow analysis.
- Analyze fluid flow through straight, annular, helical, and spiral pipes, including associated pressure losses.
- Evaluate pressure drops in packed columns and hydrodynamics of fluidized beds for process optimization.
- Determine drag coefficients for solid particles and construct characteristic curves for pump performance.

REFERENCE BOOKS:

- McCabe W.L, Smith, J C and Harriot. P "Unit Operations in Chemical Engineering", McGraw Hill, VII Edition, 2005
- White, F.M., "Fluid Mechanics ", McGraw-Hill Inc., VII Edition, 2011.

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19CH3001 - Fluid Mechanics Lab

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.0	2.0	3.0	2.0	-	-	-	-	2.0	-	-	2.0	3.0	2.0
CO2	3.0	3.0	-	2.0	-	-	-	-	2.0	-	-	2.0	3.0	2.0
CO3	3.0	3.0	3.0	-	-	-	2.0	-	2.0	-	-	2.0	3.0	3.0
CO4	2.0	2.0	-	2.0	-	-	2.0	-	2.0	-	2.0	2.0	3.0	3.0
CO5	2.0	2.0	2.0		-	-	2.0	-	2.0	-	2.0	2.0	3.0	3.0
AVG	2.6	2.4	2.67	2	-	-	2	-	2	-	2	2	3	2.6

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rogramme	Course Code	Name of the Course	L	T	P	C
B.Tech	19CH3002	**CHEMICAL ANALYSIS LAB**	0	0	3	1.5

Course Objectives	• To make the student acquire practical skills in the wet chemical and instrumental methods for quantitative estimation of nitrite in water, cement, oil, coal and Phenol.

S.No.	DESCRIPTION
1.	Determination of Redwood / Saybolt numbers, kinematic viscosity and viscosity index of Lubricating oils.
2.	Determination of flash point, fire point, cloud and pour point of oils.
3.	Determination of acid value and iodine value of oils.
4.	Determination of COD of water samples.
5.	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.
6.	Coal Analysis a. Ultimate analysis of coal b. Proximate analysis of coal.
7.	Soap Analysis a. Estimation of total fatty acid b. Estimation of percentage alkali content.
8.	Estimation of phenol.
9.	Determination of calorific value using bomb calorimeter.
10.	Determination of nitrite in water.

Total Instructional Hours   45

Course Outcomes	**Upon completion of the course, students can be able to** • Develop the ability to handle and work with the equipment like viscometers, flash and fire point apparatus etc., • Measure acid value, iodine value, and phenol content in oils and chemical samples. • Determine COD and nitrite levels in water for environmental and quality assessment • Analyze cement (silica, oxides, calcium) and coal (ultimate and proximate) composition. • Evaluate calorific value of fuels using bomb calorimeter for energy content analysis.

REFERENCE BOOKS:
1. Environmental pollution analysis, S.M.Khopkar, New age international.2011.
2. Manual of environmental analysis, N.C Aery, Ane books.2010.
3. Text book of quantitative chemical analysis, J.Mendham, Pearson education 2008.

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19CH3002 - Chemical Analysis Lab

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.0	3.0	-	-	-	-	-	-	2.0	-	-	2.0	3.0	2.0
CO2	3.0	3.0	-	-	-	-	2.0		2.0	-	-	2.0	3.0	2.0
CO3	3.0	3.0	-	-	-	-	2.0	-	2.0	-	-	2.0	3.0	2.0
CO4	3.0	3.0	-	-	-	-	2.0	-	2.0	-	-	2.0	3.0	2.0
CO5	3.0	3.0	-	-	-	-	2.0	-	2.0	-	-	2.0	3.0	2.0
AVG	3.0	3.0	-	-	-	-	2.0	-	2.0	-	-	2.0	3.0	2.0

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Programme	Course Code	Name of the course	L	T	P	C
B.E. / B.Tech	19AC3191	INDIAN CONSTITUTION	2	0	0	0

COURSE OBJECTIVES

1. Sensitization of student towards self, family (relationship), society and nature.
2. Understanding (or developing clarity) of nature, society and larger systems, on the basis of human relationships and resolved individuals.
3. Strengthening of self reflection.
4. Development of commitment and courage to act.

UNIT	DESCRIPTIVE	INSTRUCTIONAL HOURS

UNIT I : BASIC FEATURES AND FUNDAMENTALE PRINCIPLES 4

Meaning of the constitution law and constitutionalism – Historical perspective of the constitution of India – salient features and characteristics of the constitution of India.

UNIT II : FUNDAMENTAL RIGHTS 4

Scheme of the fundamental rights – fundamental duties and its legislative status – The directive principles of state policy – its importance and implementation - Federal structure and distribution of legislative and financial powers between the union and states.

UNIT III : PARLIAMENTARY FORM OF GOVERNMENT 4

The constitution powers and the status of the president in India. – Amendement of the constitutional powers and procedures – The historical perspective of the constitutional amendment of India – Emergency provisions : National emergency, President rule, Financial emergency.

UNIT IV: LOCAL GOVERNANCE 4

Local self government -constitutional scheme of India – Scheme of fundamental right to equality – scheme of fundamental right to certain freedom under article19 – scope of the right to life and personal liberty under article 19.

UNIT V : INDIAN SOCIETY 4

Constitutional Remedies for citizens – Political Parties and Pressure Groups; Right of Women, Children and Scheduled Castes and Scheduled Tribes and other Weaker Sections.

TOTAL INSTRUCTIONAL HOURS: 20

OUTCOMES:

Upon completion of the course, students will be able to:
1. Rememberthe functions of the Indian government
2. Understand and abide the rules of the Indian constitution.

TEXT BOOKS:
T1. Durga Das Basu, "Introduction to the Constitution of India ", Prentice Hall of India, New Delhi.
T2. R.C.Agarwal, (1997) "Indian Political System", S.Chand and Company, New Delhi.
T3. Maciver and Page, " Society: An Introduction Analysis ", Mac Milan India Ltd., New Delhi.
T4. K.L.Sharma, (1997) "Social Stratification in India: Issues and Themes", Jawaharlal Nehru University, New Delhi.

REFERENCE BOOKS:
R1. Sharma, Brij Kishore, " Introduction to the Constitution of India:, Prentice Hall of India, New Delhi.
R2. U.R.Gahai, "Indian Political System ", New Academic Publishing House, Jalaendhar.
R3. R.N. Sharma, "Indian Social Problems ", Media Promoters and Publishers Pvt. Ltd.

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rogramme	Course Code	Name of the Course	L	T	P	C
BE/BTECH	19HE3073	**Leadership Management Skills**	1	0	0	0

Course Objective`	1. To know about the leadership skills that is to be acquired for success. 2. To become a teamwork expert, real world problem solver, your views will be challenged 3. To gain global perspective and becoming an effective communicator 4. To understand about learning, negotiation and decision making 5: To get first hand information about the skills we possess and to work on improvement.

Module	Description	Instructional Hours
1.	Strategic thinking skills	
2.	Planning and Delivery skills	
3.	People management skills (Delegation)	
4.	Change management and Innovation skills	
5.	Communication skills	
6.	Persuasion and influencing skills	
7.	Learning Agility	
8.	Motivation	
9.	Personality	
10.	Emotions	
11.	Perception	
12.	Negotiation	
13.	Decision making	
14.	Problem solving	
15.	Building trust	
	Total Instructional Hours	**15**

Course Outcome	CO1: To practice essential leadership skills in day to day operations CO2: To work on leadership skills in the study environment CO3: To understand and develop the skills consciously. CO4: To know about the real worth of all the skills for success CO5: To Analyze the real worth of the person and suggestion for improvement

TEXT BOOKS

T1: A REVIEW OF LEADERSHIP THEORY AND COMPETENCY FRAMEWORKS, Bolden, R., Gosling, J., Marturano, A. and Dennison, P.June 2003
T2: LEADING FROM WITHIN: Building Organizational Leadership Capacity-David R. Kolzow, PhD, 2014

REFERENCE BOOKS

R1: Seven habits of highly effective people – Stephen R.Covey
R2: The Art of Business Leadership: Indian Experiences – G.Balasubramaniam
R3: DEVELOPING the LEADER WITHIN YOU-JOHN C. MAXWELL

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Programme	Course Code	Name of the Course	L	T	P	C
B.Tech	19CH4201	**PROCESS HEAT TRANSFER**	3	1	0	4

Course Objectives	The student should be able to
	• Understand the heat transfer by conduction, convection and radiation.
	• Apply the laws of heat conduction, convection and radiation.
	• Examine the types of evaporators and heat exchangers.

UNIT	DESCRIPTION	INSTRUCTIONAL HOURS
I	**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 - Thermal conductivity measurement; effect of temperature on thermal conductivity; Heat transfer in extended surfaces.	12
II	**Concepts of heat transfer by convection** - Natural and forced convection, analogies between transfer of momentum and heat - Reynold's analogy, Prandtl and Coulburn analogy. Dimensional analysis in heat transfer, heat transfer coefficient for flow through a pipe, flow past flat plate, flow through packed beds.	12
III	**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, Heat transfer to boiling liquids - mechanism of boiling, nucleate boiling and film boiling.	12
IV	**Theory of evaporation** - single effect and multiple effect evaporation - Design calculation for single and multiple effect evaporation. Radiation heat transfer - Black body radiation, Emissivity, Stefan - Boltzmann law, Plank's law, radiation between surfaces.	12
V	**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.	12

Total Instructional Hours   45 + 15 = 60

Course Outcomes	Upon completion of the course, students can be able to
	CO1: Recognize the modes of heat transfer and ability to solve conduction based problems.
	CO2: Comprehend the concept of convective heat transfer model using dimensional analysis.
	CO3: Understand the heat transfer process with phase change.
	CO4: Understand the difference between radiation and evaporation and ability to design evaporator.
	CO5: Apprehend the design concepts of heat exchangers.

TEXT BOOKS:

1. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", 7th Edn., McGraw-Hill, 2005.
2. G.K. Roy, Fundamentals of Heat and Mass Transfer, Khanna Publishers, Sixth Edition, 2017.

REFERENCES BOOKS:

1. Coulson, J.M. and Richardson, J.F., "Chemical Engineering " Vol. I, 4th Edn., Asian Books Pvt. Ltd., India, 1998.
2. Kern, D.Q., "Process Heat Transfer ", McGraw-Hill, 1999.
3. Holman, J. P., 'Heat Transfer ', 8th Edn., Tata McGraw Hill, 1997.
4. Coulson, J.M. and Richardson, J.F., "Chemical Engineering" Vol. I and II,4th Edition, Asian Books Pvt. Ltd., India,1998.

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Programme	Course Code	Name of the Course	L	T	P	C

19CH4201 - Process Heat Transfer

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.0	3.0	3.0	3.0	-	-	-	-	2.0	-	-	3.0	3.0	2.0
CO2	3.0	3.0	3.0	3.0	-	-	-	-	2.0	-	-	3.0	3.0	2.0
CO3	3.0	3.0	3.0	3.0	-	-	-	-	2.0	-	-	3.0	3.0	2.0
CO4	3.0	3.0	2.0	3.0	-	-	-	-	2.0	-	-	3.0	3.0	2.0
CO5	3.0	3.0	2.0	3.0	-	-	-	-	2.0	-	-	3.0	3.0	2.0
AVG	3.0	3.0	2.6	3.0	-	-	-	-	2.0	-	-	3.0	3.0	2.0

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Course Objectives	The student should be able to
	• Understand the principles of mass transfer and their application to various unit operations.
	• Determine mass transfer rates under laminar and turbulent conditions.
	• Apply the concept of drying, crystallization in Industries.

UNIT	DESCRIPTION	INSTRUCTIONAL HOURS
I	**DIFFUSION**	9
	Introduction to mass transfer operations; Molecular diffusion in gases, liquids and solids; diffusivity measurement and prediction; multi-component diffusion.	
II	**MASS TRANSFER COEFFICIENTS**	9
	Eddy diffusion, concept of mass transfer coefficients, theories of mass transfer, different transport analogies, application of correlations for mass transfer coefficients, inter phase mass transfer, relationship between individual and overall mass transfer coefficients. NTU and NTP concepts, Stage-wise and differential contractors.	
III	**HUMIDIFICATION**	9
	Humidification – Equilibrium, humidity chart, adiabatic and wet bulb temperatures; humidification operations; theory and types of cooling tower, dehumidifiers and humidifiers using enthalpy transfer unit concept.	
IV	**DRYING**	9
	Drying– Equilibrium; classification of dryers; batch drying – Mechanism and time of cross through circulation drying, continuous dryers – material and energy balance; determination of length of rotary dryer using rate concept.	
V	**CRYSTALLISATION**	9
	Crystallization - Equilibrium, classification of crystallizers, mass and energy balance; kinetics of crystallization – nucleation and growth; design of batch crystallizers; population balance model and design of continuous crystallizers.	
	Total Instructional Hours	**45**

Course Outcomes	Upon completion of the course, students can be able to
	CO1: Explain the diffusion process in all three phases.
	CO2: Examine the concept of mass transfer coefficients and theories.
	CO3: Illustrate the principle of Humidification operation.
	CO4: Classify and demonstration of different dryers..
	CO5: Sketch the design concepts of the crystallizer.

TEXT BOOKS:

1. Treybal, R.E., "Mass Transfer Operations", 3rd Edition, McGraw-Hill,1981.
2. G.K. Roy, Fundamentals of Heat and Mass Transfer, Khanna Publishers, Sixth Edition, 2017.
3. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", 7thEdition., McGraw-Hill,2005.

REFERENCE BOOKS:

1. Coulson, J.M. and Richardson, J.F., "Chemical Engineering" Vol. I and II,4th Edition, Asian Books Pvt. Ltd., India,1998.
2. Foust A.S, "Principles of Unit Operations", 2nd Edition, John Wiley,2008.

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19CH4202 - Mass Transfer – I

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.0	3.0	-	1.0	-	-	-	-	-	-	-	-	3.0	3.0
CO2	3.0	3.0	-	2.0	-	-	-	-	-	-	-	-	3.0	3.0
CO3	3.0	3.0	-	3.0	-	2.0	2.0	2.0	-	-	-	2.0	3.0	3.0
CO4	3.0	3.0	-	3.0	-	2.0	2.0	2.0	-	-	-	2.0	3.0	3.0
CO5	3.0	3.0	2.0	3.0	-	2.0	2.0	2.0	-	-	-	2.0	3.0	3.0
AVG	3.0	3.0	2.0	2.4	-	2.0	2.0	2.0	-	-	-	2.0	3.0	3.0

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Programme	Course Code	Name of the Course	L	T	P	C
B.Tech	19CH4203	**CHEMICAL ENGINEERING THERMODYNAMICS - II**	3	0	0	3

Course Objectives	The student should be able to
	• Understand the behavior of fluids under PVT conditions and also apply them for practical purpose.
	• Apply the correlation in phase equilibrium.
	• Determine the COP in refrigeration cycles.

UNIT	DESCRIPTION	INSTRUCTIONAL HOURS
I	**PROPERTIES OFSOLUTIONS**	9
	Partial molar properties - ideal and non-ideal solutions - standard states definition and choice - Gibbs-Duhem equation - excess properties of mixtures.	
II	**PHASEEQUILIBRIA**	9
	Criteria for equilibrium between phases in multi component non-reacting systems in terms of chemical potential and fugacity - application of phase rule - vapour-liquid equilibrium, phase diagrams for homogeneous systems and for systems with a miscibility gap - effect of temperature and pressure on azeotrope composition - liquid-liquid equilibrium - ternary liquid-liquid equilibrium.	
III	**CORRELATION AND PREDICTION OFPHASEEQUILIBRIA**	9
	Activity coefficient-composition models - thermodynamic consistency of phase equilibrium - application of the correlation and prediction of phase equilibrium in systems of engineering interest particularly to distillation and liquid extraction processes.	
IV	**CHEMICAL REACTIONEQUILIBRIA**	9
	Standard free energy change and reaction equilibrium constant - evaluation of reaction equilibrium constant - prediction of free energy data - equilibria in chemical reactors - calculation of equilibrium compositions for homogeneous chemical reactors - thermodynamic analysis of simultaneous reactions.	
V	**REFRIGERATION**	9
	Principles of refrigeration- methods of producing refrigeration- liquefaction process- co-efficient of performance - evaluation of the performance of vapour compression and gas refrigeration cycles.	
	Total Instructional Hours	**45**

Upon completion of the course, students can be able to

Course Outcomes	CO1: Examine the terminologies such as chemical potential, fugacity, fugacity coefficient, activity and activity coefficient.
	CO2: Apply the equations of state and activity coefficient models to describe VLE
	CO3: Illustrate and develop the relations to phase equilibrium and to solve chemical engineering problems.
	CO4: Calculate the equilibrium constants and predict the effects of temperature, pressure, and composition on equilibrium conversion.
	CO5:Understand and solve mass, energy and entropy balances to flow processes

TEXT BOOKS:

1. Smith, J.M., VanNess, H.C., & Abbot M.C, "Introduction to Chemical Engineering Thermodynamics", McGraw Hill VII Edition2004.
2. Narayanan K.V "A Text Book of Chemical Engineering Thermodynamics" Prentice Hall of India Pvt. Ltd.2001.

REFERENCE BOOKS:

1. Hougen, O.A., Watson, K.M., and Ragatz, R.A., "Chemical Process Principles Part II", Thermodynamics, John Wiley, 1970.
2. Dodge, B.F., "Chemical Engineering Thermodynamics", McGraw-Hill, 1960.
3. Sandler, S.I., "Chemical and Engineering Thermodynamics", 2nd Edition, Wiley, 1989.
4. Stanley M.Walas" Phase equilibrium in Chemical Engineering",Elsiever Science and Technologybooks.1984.

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19CH4203 - Chemical Engineering Thermodynamics - II

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.0	3.0	-	-	-	-	-	-	-	-	-	2.0	3.0	2.0
CO2	3.0	3.0	3.0	2.0	-	-	-	-	-	-	-	2.0	3.0	2.0
CO3	3.0	3.0	3.0	2.0	-	2.0	-	-	-	-	2.0	2.0	3.0	3.0
CO4	3.0	3.0	3.0	2.0	-	2.0	2.0	-	-	-	2.0	3.0	3.0	3.0
CO5	3.0	3.0	3.0	2.0	-	3.0	2.0	1.0	-	-	3.0	3.0	3.0	3.0
AVG	3.0	3.0	3.0	2.0	-	2.33	2.0	1.0	-	-	2.33	2.4	3.0	2.6

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Programme	Course Code	Name of the Course	L	T	P	C
B.Tech	19CH4251	**MECHANICAL OPERATIONS**	3	0	2	4

Course Objectives
- **The student should be able to.**
  - Understand the basic information and the systematic diagrams of Unit operations involved in Chemical industries.
  - Apply the concepts of design, operation details and schematic of industrial equipment
  - Choose the right separation technology for easy separation of chemical components

UNIT	DESCRIPTION	INSTRUCTIONAL HOURS
I	**PARTICLE CHARACTERIZATION AND MEASUREMENT** General characteristics of solids, different techniques of size analysis- Static - Image analysis and Dynamic analysis - Light scattering techniques, shape factor, surface area determination, estimation of particle size. Advanced particle size analysis techniques. Screening methods and equipment, screen efficiency, ideal and actual screens: **Sieve analysis.**	9+3
II	**PARTICLE SIZE REDUCTION AND SIZE ENLARGEMENT:** Laws of size reduction, energy relationships in size reduction, methods of size reduction, classification of equipments, crushers, grinders, disintegrators for coarse, intermediate and fine grinding, power requirement, work index; Advanced size reduction techniques- Nano particle fabrication-Topdown approach - Bottom-up approach. Size enlargement - Importance of size enlargement, principle of granulation, briquetting, pelletisation, and flocculation. Fundamentals of particle generation: **Reduction ratio in Jaw Crusher, Ballmill.**	9+4
III	**PARTICLE SEPARATION** Gravity settling, sedimentation, thickening, elutriation, double cone classifier, rake classifier, bowl classifier. Centrifugal separation - continuous centrifuges, super centrifuges, design of basket centrifuges; industrial dust removing equipment, cyclones and hydro cyclones, electrostatic and magnetic separators, heavy media separations, floatation, jigging: **Characteristics of batch Sedimentation, Separation characteristics of Cyclone separator, Froth floatation.**	9+4
IV	**FILTRATION AND FILTRATION EQUIPMENT** Theory of filtration, Batch and continuous filters, Flow through filter cake and filter media, compressible and incompressible filter cakes, filtration equipments - selection, operation and design of filters and optimum cycle of operation, filteraids. **Batch filtration studies using Leaf Filter and Plate and Frame Filter press.**	9+4
V	**MIXING AND PARTICLE HANDLING** Mixing and agitation - Mixing of liquids (with or without solids), mixing of powders, selection of suitable mixers, power requirement for mixing. Storage and Conveying of solids - Bunkers, silos, bins and hoppers, transportation of solids in bulk, different types of conveyors.	9

Total Instructional Hours   45+15 = 60

Course Outcomes

Upon completion of the course, students can be able to
CO1: Understand the general characteristics of solids, screening and sieve analysis.
CO2: Examine the particle size reduction processes and to operate the size reduction equipment
CO3: Illustrate the methods of particles separation
CO4: Understand the theory of filtration and filtration equipment
CO5: Understand the particle handling and the power required for mixing.

TEXT BOOKS:
1. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", 7th Edn., McGraw-Hill, 2005.
2. Coulson, J.M. and Richardson, J.F., "Chemical Engineering" Vol. I, 5th Edn., Asian Books Pvt. Ltd., India, 2006.

REFERENCE BOOKS:
1. Brown G.G., et.al., "Unit Operations", 1st edition., CBS Publisher, New Delhi, 2005.
2. Badger W.L. and Banchero J.T., "Introduction to Chemical Engineering", Tata McGraw Hill, 1st Edition, 2002.
3. Foust, A. S., Wenzel, L.A., Clump, C.W., Naus, L., and Anderson, L.B., "Principles of Unit Operations", 2nd Edn., John Wiley & Sons, 2008.

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19CH4251 - Mechanical Operations

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.0	2.0	1.0	2.0	-	-	3.0	-	-	-	-	-	3.0	2.0
CO2	3.0	3.0	2.0	2.0	2.0	1.0	-	-	-	-	-	-	3.0	2.0
CO3	2.0	2.0	2.0	-	-	-	-	-	-	-	-	-	3.0	2.0
CO4	3.0	3.0	2.0	-	3.0	-	3.0	-	-	-	-	-	3.0	2.0
CO5	3.0	2.0	2.0	2.0	2.0	1.0	1.0	-	1.0	-	2.0	-	-	2.0
AVG	2.8	2.4	1.8	2.0	2.33	1.0	2.33	-	1.0	-	2.0	-	3.0	2.0

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Programme	Course Code	Name of the Course	L	T	P	C
B.Tech	19MA4153	**APPLIED PROBABILITY STATISTICS**	3	0	2	4

Course Objectives	
	• Construct a well defined knowledge of random variables.
	• Explain the concept of two dimensional random variables and determine covariance.
	• Introduce Correlation concepts to understand the relation between two random variables.
	• Describe some basic concepts of statistical methods for testing the hypothesis.
	• Analyze the design of experiment techniques to solve various engineering problems.

UNIT	DESCRIPTION	INSTRUCTIONAL HOURS
I	**PROBABILITY AND RANDOM VARIABLE** Random variable –Discrete and continuous random variables – Probability mass function - Probability density function – Cumulative distribution functions - Moment generating functions. **Introduction to R programming and Application of descriptive statistics – Mean, Median, Mode, variance and Box plot .**	9+3
II	**TWO DIMENSIONAL RANDOM VARIABLES** Joint probability mass function - Joint probability density function – Marginal Probability mass function – Marginal probability density function - Conditional Probability mass function - Conditional Probability density function – Independent random variables. **Application of Normal distribution.**	9+3
III	**CORRELATION AND REGRESSION** Correlation – Karl Pearson's correlation coefficient – Spearman's Rank Correlation – Regression lines (problems based on Raw data only). **Applications of Correlation and Regression.**	9+3
IV	**HYPOTHESIS TESTING** Large sample test based on Normal distribution - test of significance for single mean and difference of means -Small sample test – t test for single mean and difference of mean - F distribution for variance, Chi – Square test for independence of attributes – Goodness of fit. **Application of Student t- test for Single mean and difference of means, Application of Chi – square test**	9+3
V	**ANALYSIS OF VARIANCE** Introduction, assumptions of analysis of variance, completely randomized design, randomized block design, Latin square design. **Applications of Latin square design.**	9+3
	Total Instructional Hours	60

Course Outcomes	
	Upon completion of the course, students can be able to CO1: Understand the concepts of random variables. CO2: Express the phenomenon of two dimensional random variables.. CO3: Compute correlation and predict unknown values using regression. CO4: Understand the concepts of statistical methods for testing the hypothesis. CO5: Apply Design of Experiment techniques to solve various engineering problems.

TEXT BOOKS:
1. SaeedGhahramani, "Fundamentals of probability with stochastic processes", Prentice Hall New Jersy, 2016.
2. Medhi J," stochastic Processes", New Age International Publishers,New Delhi,2014.

REFERENCE BOOKS:
1. O.C. Ibe, "Fundamentals of Applied Probability and Random Processes", Elsevier, First Indian Reprint, 2010.
2. Applied statistics and Probability for Engineers by C.MontGomery ,6th Edition,Wiley Publications.
3. Walpole. R.E., Myers. R.H., Myers. S.L., and Ye. K., "Probability and Statistics for Engineers and Scientists", 8th Edition, Pearson Education, Asia, 2007.

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Programme	Course Code	Name of the Course	L	T	P	C
B.Tech	19CH4001	**HEAT TRANSFER LAB**	0	0	3	1.5

Course Objectives	• To enable the students to develop a sound working knowledge on different types of heat transfer equipment.

S.No.   **DESCRIPTION**

1. Transient heat conduction with constant heat flux
2. Heat transfer through natural convection
3. Heat transfer through forced convection
4. Heat transfer in a shell and tube heat exchanger
5. Heat transfer in a double pipe heat exchanger
6. Heat transfer in a bare and finned tube heat exchanger
7. Heat transfer in helical coils
8. Heat transfer through packed bed
9. Heat transfer in agitated vessels
10. Heat transfer in a condenser
11. Heat transfer in single effect evaporator
12. Heat transfer in multi effect evaporator
13. Stefan boltzmann experiment
14. Emissivity measurement

Total Instructional Hours   **45**

	Upon completion of the course, students can be able to
Course Outcomes	• Study transient heat conduction with constant heat flux for time: dependent temperature profiles • Examine natural and forced convection heat transfer under different fluid flow conditions. • Analyze heat transfer in shell and tube, double pipe, finned tube, and helical coil heat exchangers • Perform heat transfer analysis in condensers and single/multi: effect evaporators. • Conduct Stefan: Boltzmann and emissivity experiments for radiative heat transfer analysis.

REFERENCE BOOKS:

1. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", 7th Edn., McGraw-Hill, 2005.
2. Holman, J. P., 'Heat Transfer ', 8th Edn., Tata McGraw Hill, 1997.

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19CH4001 - Heat Transfer Lab

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.0	3.0	2.0	1.0	-	-	-	-	-	-	-	-	3.0	2.0
CO2	3.0	3.0	3.0	2.0	1.0	-	-	-	-	-	-	-	3.0	2.0
CO3	3.0	3.0	2.0	2.0	-	-	-	-	-	-	-	-	3.0	2.0
CO4	3.0	3.0	2.0	2.0	-	-	-	-	-	-	-	-	3.0	2.0
CO5	3.0	2.0	2.0	1.0	-	-	-	-	-	-	-	-	3.0	3.0
AVG	3.0	2.8	2.2	1.6	1.0	-	-	-	-	-	-	-	3.0	2.2

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Programme	Course Code	Name of the Course	L	T	P	C
B.Tech	19CH4002	**PETROCHEMICAL ANALYSIS LAB**	0	0	3	1.5

Course Objectives	• To learn basic principles involved in analysis of petrochemicalproducts.

S.No.	DESCRIPTION
1.	Sulphur content determination.
2.	Flue gas Analysis – Orsat Apparatus.
3.	Aromatic Content determination.
4.	Determination of Lead, Acid and Salt content.
5.	Analysis of petrochemicals using UV spectrophotometer.
6.	Biodegradation of petrochemicals.
7.	Bioremediation of petrochemicals.
8.	Refractive index of petrochemicals.
9.	Determination of moisture content – KF Titrator.
10.	Total acidity determination.
11.	Dynamic viscosity measurement.
12.	Calorific value of fuels.

Total Instructional Hours   **45**

Upon completion of the course, students can be able to

Course Outcomes	• Determine sulfur, lead, acid, salt, and aromatic content in petrochemicals and fuels
	• Conduct flue gas analysis using Orsat apparatus for combustion efficiency evaluation
	• Analyze petrochemicals using UV spectrophotometry and measure refractive index and moisture content.
	• Determine dynamic viscosity, calorific value, and total acidity of fuels and petrochemicals
	• Investigate biodegradation and bioremediation potential of petrochemicals for environmental sustainability.

REFERENCE BOOKS:

1. Text book of quantitative chemical analysis, J.Mendham, Pearson education 2008.
2. BhaskaraRao, B.K., "A Text on Petrochemicals", Khanna Publishers, 2000.
3. SukumarMaiti, "Introduction to Petrochemicals", 2nd Edition, Oxford and IBH Publishers, 2002.

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19CH4002 - Petrochemical Analysis Lab

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.0	3.0	-	-	-	-	-	-	2.0	-	-	2.0	3.0	2.0
CO2	3.0	3.0	-	-	-	-	2.0	-	2.0	-	-	2.0	3.0	2.0
CO3	3.0	3.0	2.0	-	-	-	2.0	-	2.0	-	-	2.0	3.0	2.0
CO4	3.0	3.0	2.0	-	-	-	2.0	-	2.0	-	-	2.0	3.0	2.0
CO5	3.0	3.0	2.0	-	-	-	2.0	-	2.0	-	-	2.0	3.0	2.0
AVG	3.0	3.0	2.0	-	-	-	2.0	-	2.0	-	-	2.0	3.0	2.0

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Programme	Course code	Name of the course	L	T	P	C
B.TECH/B.E	19AC4191	**Essence of Indian Traditional Knowledge**	2	0	0	0

Course Objectives:
1) The course aims at imparting basic principles of thought process, reasoning and inferencing.
2) Sustainability is at the core of Indian Traditional Knowledge Systems connecting society and nature.
3) Holistic life style of Yogic-science and wisdom capsules in Sanskrit literature are also important in modern society with rapid technological advancements and societal disruptions.
4) The course focuses on introduction to Indian Knowledge System, Indian perspective of modern scientific world-view, basic principles of Yoga and holistic health care system, Indian philosophical traditions,Indian linguistic tradition and Indian artistic tradition.

UNIT	DESCRIPTIVE	INSTRUCTIONAL HOURS
UNIT I :	Basic Structure of Indian Knowledge System	4
UNIT II :	Modern Science and Indian Knowledge System	4
UNIT III :	Yoga and Holistic Health care	4
UNIT IV :	Philosophical tradition	4
UNIT V:	Indian linguistic tradition (Phonology, Morphology, Syntax and semantics), Indian artistic tradition and Case Studies.	4

TOTAL INSTRUCTIONAL HOURS : 20

Course Outcomes:
1) Ability to understand the structure of Indian system of life.
2) Connect up and explain basics of Indian Traditional knowledge in modern scientific perspective.

REFERENCE BOOKS:
R1. V. Sivaramakrishna (Ed.), Cultural Heritage of India-Course Material, Bharatiya Vidya Bhavan, Mumbai, 5th Edition, 2014
R2. Swami Jitatmanand, Modern Physics and Vedant, Bharatiya Vidya Bhavan
R3. Fritzof Capra, Tao of Physics
R4. Fritzof Capra, The wave of Life.
R5. V N Jha (Eng. Trans,), Tarkasangraha of Annam Bhatta, Inernational Chinmay Foundation, Velliarnad, Amaku,am
R6. Yoga Sutra of Patanjali, Ramakrishna Mission, Kolkatta.
R7. GN Jha (Eng. Trans.) Ed. R N Jha, Yoga-darshanam with Vyasa Bhashya, Vidyanidhi Prakasham, Delhi, 2016.
R8. RN Jha, Science of Consciousness Psychotherapy and Yoga Practices, Vidyanidhi Prakasham, Delhi, 2016.
R9. P R Sharma (English translation), Shodashang Hridayam.

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