RAJALAKSHMI ENGINEERING COLLEGE
(An Autonomous Institution Affiliated to Anna University Chennai)
DEPARTMENT OF CHEMICAL ENGINEERING
CURRICULUM AND SYLLABUS REGULATIONS – 2023
B.TECH – CHEMICAL ENGINEERING
CHOICE BASED CREDIT SYSTEM

VISION OF THE INSTITUTION

- To be an institution of excellence in Engineering, Technology and Management Education & Research.

- To provide competent and ethical professionals with a concern for society.

MISSION OF THE INSTITUTION

- To impart quality technical education imbibed with proficiency and humane values

- To provide right ambience and opportunities for the students to develop into creative, talented and globally competent professionals

- To promote research and development in technology and management for the benefit of the society

VISION OF THE DEPARTMENT

- To be a center of excellence in chemical engineering to provide well prepared professionals to the industries and society.

MISSION OF THE DEPARTMENT

- To provide state of art environment to the students for better learning to cater for the chemical industries and pursue higher studies.

- To provide space to the students in research to think, create and innovate things.

PROGRAM EDUCATIONAL OBJECTIVES

This program enables Chemical Engineering graduates

1. To produce employable graduates with the knowledge and competency in Chemical Engineering complemented by the appropriate skills and attributes.
2. To produce creative and innovative graduates with design and soft skills to carry out various problem solving tasks.
3. To enable the students to work as teams on multidisciplinary projects with effective communication skills, individual, supportive and leadership qualities with the right attitudes and ethics.
4. To produce graduates who possess interest in research and lifelong learning, as well as continuously striving for the forefront of technology.

PROGRAM OUTCOMES (POs)

Engineering Graduates will be able to

1. Engineering Knowledge:
Apply the knowledge of mathematics, science, and engineering fundamentals, to solve the complex chemical engineering problems

2. Problem analysis:
Identify, formulate, review research literature, and analyze complex chemical engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

3. Design/development of solutions:
Design solutions for complex chemical engineering problems and design system components or process that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal and environmental considerations.

4. Conduct investigations of complex problems:
Use research based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to proceed valid conclusions.

5. Modern tool usage:
Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modeling to complex chemical engineering activities with an understanding of the limitations.

6. The engineer and society:
   Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional chemical engineering practice.

7.Environment and sustainability:

Understand the impact of the professional chemical engineering solutions in societal and environmental contexts, and demonstrate the knowledge of and need for sustainable development.

8. Ethics:

Apply ethical principles and commit to professional ethics and responsibilities and norms of the chemical engineering practice.

9. Individual and team work:

Function effectively as an individual and as a member or leader in diverse teams, and in multidisciplinary settings.

10. Communication:

Communicate effectively on complex chemical engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Project management and finance:

Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning:

Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological changes in chemical engineering.

Program Specific Outcomes (PSOs)

1. Graduates will be able to apply chemical engineering principles to design equipment and a process plant.
2. They will be able to control and analyse chemical, physical and biological processes including the hazards associated with these processes.
3. Will be able to develop mathematical models of real-world industrial problems and compute solutions to dynamic processes.

CURRICULUM

SEMESTER – I

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
THEORY & PRACTICALS								
1	HS23111	Technical Communication I	2	0	0	2	2	HS
2	MA23112	Algebra and Calculus	3	1	0	4	4	BS
3	PH23111	Physics for Chemical Engineering	3	0	0	3	3	BS
4	CY23132	Chemistry for Technologists	3	0	2	5	4	BS
5	GE23111	Engineering Graphics	2	2	0	4	4	ES
6	GE23121	Engineering Practices- (Civil and Mechanical)	0	0	2	2	1	ES
7	MC23112	Environmental Science and Engineering	3	0	0	3	0	MC
8	GE23117	Heritage of Tamils	1	0	0	1	1	HS
		TOTAL	**17**	**3**	**4**	**24**	**19**	

SEMESTER – II

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
THEORY& PRACTICALS								
1.	HS23221	Technical Communication II	0	0	2	2	1	HS
	HS23222	English for Professional Competence						
2.	MA23212	Differential Equations and Complex Variables	3	1	0	4	4	BS
3.	CH23211	Introduction to Chemical Engineering	3	0	0	3	3	PC
4.	GE23233	Problem Solving and Python Programming	2	0	4	4	4	ES
5.	PH23233	Material Science	3	0	2	4	4	BS
6.	EE23133	Basic Electrical and Electronics Engineering	3	0	2	4	4	ES
7.	GE23122	Engineering Practices – Electrical and Electronics	0	0	2	1	1	ES
8.	MC23111	Indian Constitution and Freedom Movement	3	0	0	3	0	MC
9.	GE23217	Tamils and Technology	1	0	0	1	1	HS
		TOTAL	**18**	**1**	**12**	**26**	**22**	

SEMESTER –III

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
THEORY & PRACTICALS								
1	MA23311	Transforms and Applied Partial differential equations	3	1	0	4	4	BS
2	CY23334	Physical and Organic Chemistry	3	0	2	4	4	ES
3	CH23311	Solid Mechanics	2	1	0	3	3	ES
4	CH23312	Chemical Process Calculations	2	1	0	3	3	PC
5	CH23313	Chemical Process Industries	3	0	0	3	3	PC
6	CH23331	Fluid Mechanics for Chemical Engineers	3	0	1	4	4	PC
		TOTAL	**16**	**3**	**3**	**21**	**21**	

SEMESTER –IV

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
THEORY								
1	MA23431	Probability, Statistics and Reliability	3	0	2	4	4	BS
2	CH23411	Thermodynamics	3	0	0	3	3	PC
3	CH23412	Heat Transfer	3	0	0	3	3	PC
4	CH23431	Particle science and Technology	3	0	1	4	4	PC
5		Open Elective – 1	3	0	0	3	3	OE
PRACTICALS								
6	CS23422	Python Programming for Machine Learning	0	0	4	4	2	ES
7	GE23327	SOFT SKILLS - I	0	0	2	1	1	EEC
8	CH23421	Technical Analysis Lab	0	0	4	4	2	PC
		TOTAL	**15**	**0**	**12**	**26**	**22**	

SEMESTER – V

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
THEORY								
1	CH23511	Process Engineering Economics	3	0	0	3	3	PC
2	CH23512	Chemical Engineering Thermodynamics	3	0	0	3	3	PC
3	CH23513	Mass Transfer I	3	0	0	3	3	PC
4	CH23514	Chemical Reaction Engineering I	3	0	0	3	3	PC
5		Professional Elective I	3	0	0	3	3	PE
		Open Elective - I	3	0	0	3	3	OE
PRACTICALS								
7	GE23427	SOFT SKILLS – II	0	0	2	1	1	EEC
8	CH23521	Heat Transfer Lab	0	0	4	4	2	PC
9	CR23P51	Microfluidics Laboratory	0	0	2	2	1	PE
		TOTAL	18	0	8	25	22	

SEMESTER – VI

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
THEORY								
1	CH23611	Mass Transfer II	3	0	0	3	3	PC
2	CH23612	Chemical Reaction Engineering II	3	0	0	3	3	PC
3	CH23613	Process Control	3	0	0	3	3	PC
	CH23614	Process Equipment Design	3	0	0	3	3	PC
4		Professional Elective II	3	0	0	3	3	PE
5		Open Elective II	3	0	0	3	3	OE
PRACTICALS								
7								
8	GE23627	Problem Solving Techniques	0	0	2	1	1	EEC
9	CH23621	Mass Transfer Lab	0	0	4	4	2	PC
10	CH23622	Innovation and Design thinking for Chemical Engineers	0	0	4	4	2	PC
11		Value Added Course				30	2	EEC
		TOTAL	18	0	10	57	25	

SEMESTER – VII

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
THEORY								
1	CH23711	Transport Phenomena	3	0	0	3	3	PC
2	CH23712	Comprehensive Chemical Engineering	3	0	0	3	3	PC
3	CH23713	Computer Applications in Chemical Engineering	3	0	0	3	3	PC
4		Professional Elective III	3	0	0	3	3	PE
5		Professional Elective IV	3	0	0	3	3	PE
PRACTICALS								
6	CH23721	Chemical Reaction Engineering lab	0	0	4	4	2	PC
7	CH23722	Process Control Lab	0	0	4	4	2	PC
8	CH23723	Artificial Intelligence and Machine Learning for Chemical Engineers	0	0	4	4	2	PC
		TOTAL	**15**	**0**	**12**	**27**	**21**	

SEMESTER – VIII

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
PRACTICALS								
1		Professional Elective V	3	0	0	3	3	PE
2	CH23811	Project Work	0	0	24	24	10	EEC
		TOTAL	**3**	**0**	**24**	**27**	**13**	

PROFESSIONAL ELECTIVE VERTICAL LIST

VERTICAL I	VERTICAL II	VERTICAL III	VERTICAL IV	VERTICAL V	VERTICAL VI
Environmental Courses	**Biotechnology Courses**	**Energy Courses**	**Technology Courses**	**Allied Chemical Courses**	**Food Courses**
Environmental Engineering	Biochemical Engineering	Energy Management and Audit	Polymer Technology	Membrane Separation Process	Food microbiology
Environmental Impact assessment & clean technology	Bioprocess Engineering	Energy Conservation and Management in Process Industries	Fertilizer Technology	Instrumental Methods of Analysis	Chemical Engineering applications in Food technology
Industrial Environmental Management	Downstream processing	Renewable and Non-Renewable Energy Resources	Paper and Pulp Technology	Process modelling and simulation	Food Technology
Air Pollution and Control	Bioreaction Engineering	Solar Energy Engineering and Technology	Electrochemical Technology	Optimization in Process Industries	Introduction to food safety Analysis and Quality Risk Management.
Waste Water Treatment	Industrial Biotechnology	Fuels and Combustion	Petrochemical Technology	Fluidization Engineering	Principles of Food preservation and storage
Unit Operations in Environmental Engineering	Enzyme Engineering	Hydrogen Energy and Fuel Cells	Drugs and Pharmaceutical Technology	Piping and Instrumentation	Frontiers of Chemical Engineering

SEMESTER I

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
HS 23111	Technical Communication I	Theory	2	0	0	2
	Common to all branches of B.E/B. Tech programmes – First Semester					

Objectives:
To facilitate students develop their comprehension skills
To enable students to improve their receptive skills
To equip learners with better vocabulary and enhance their writing skills
To aid students speak effectively in all kinds of communicative contexts.
To improve the learners' basic proficiency in workplace communication

UNIT-I	DEVELOPING COMPREHENSION SKILLS	6

Listening: Introduction to Informational listening – Listening to Podcasts, News
Reading: Intentional Reading - Short Narratives and Passages.
Speaking: Introducing Oneself, Narrating a Story / Incident.
Writing: Sequential Writing – connecting ideas using transitional words (Jumbled Sentences), Process Description
Grammar: Verbs – Main & Auxiliary: Simple Tenses – Form, Function and Meaning.
Vocabulary: Word formation – Prefix, Suffix, Compound Words.

UNIT-II	LISTENING AND EXTENDED READING	6

Listening: Deep Listening – Listening to Talk Shows and Debates
Reading: In-depth Reading - Scanning Passages
Speaking: Describing Current Issues, Happenings, etc..,
Writing: Note Making, Note Taking – Paragraph Writing
Grammar: Continuous Tenses, Prepositions, Articles
Vocabulary: One Word Substitutes, Phrasal Verbs.

UNIT-III	FORMAL WRITING AND VERBAL ABILITY	6

Listening: Listening to Lectures and Taking Notes
Reading: Interpretation of Tables, Charts and Graphs
Speaking: SWOT Analysis on Oneself
Writing: Formal Letter Writing and Email Writing
Grammar: Perfect Tenses, Phrases and Clauses, Discourse Markers
Vocabulary : Verbal Analogy / Cloze Exercise

UNIT-IV	ENHANCING SPEAKING ABILITY	6

Listening: Listening to eminent voices of one's interest (Martin Luther King, APJ Abdul Kalam, etc..)
Reading: Timed Reading, Filling KWL Chart.
Speaking: Just a Minute, Impromptu
Writing: Check-list, Instructions.
Grammar: 'Wh' Questions / 'Yes' or 'No' Questions, Imperatives
Vocabulary: Synonyms, Antonyms, Different forms of the same words.

UNIT-V	LANGUAGE FOR WORKPLACE	6

Listening: Extensive Listening (Audio books, rendering of poems, etc.)
Reading: Extensive reading (Jigsaw Reading, Short Stories, Novels)
Speaking: Short Presentations on Technical Topics
Writing: Recommendations, Essay Writing
Grammar: Impersonal Passive, Reported Speech, Concord
Vocabulary : Informal Vocabulary and Formal Substitutes

Total Contact Hours: 30

Course Outcomes:
On completion of the course students will be able to
apply their comprehension skills and interpret different contents effortlessly
read and comprehend various texts and audio visual contents
infer data from graphs and charts and communicate it efficiently in varied contexts
participate effectively in diverse speaking situations
to present, discuss and coordinate with their peers in workplace using their language skills

SUGGESTED ACTIVITIES

- Ice breaker
- Just A Minute
- Ship wreck
- Hot seat
- Vocabulary building
- Chinese whispers
- Case study

SUGGESTED EVALUATION METHODS

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

Text Book(s):
1. Effective Technical Communication by M. Ashraf Rizvi (Author) 2nd Edition Paperback 2017
2. Sylvan Barnet and Hugo Bedau, 'Critical Thinking Reading and Writing', Bedford/st. Martin's: Fifth Edition (June 28, 2004)
3. Meenakshi Upadhyay, Arun Sharma – Verbal Ability and Reading Comprehension.
4. Teaching Speaking: A Holistic Approach, Book by Anne Burns and Christine ChuenMeng Goh, Cambridge University Press

Reference Books(s) / Web links:
1. Basic Vocabulary in Use: 60 Units of Vocabulary Practice in North American English With Answers 2nd Edition by Michael McCarthy (Author), Felicity O'Dell (Author), John D. Bunting (Contributor)
2. Reading Development and Difficulties By Kate Cain
3. The 7 Habits of Highly Effective People by Stephen Covey, Simon and Schuster, UK
4. Everybody Writes: Your Go-To Guide to Creating Ridiculously Good Content Hardcover by Ann Handley (Author)

Course Code	Course Title	Category	L	T	P	C
MA23112	**ALGEBRA AND CALCULUS**	BS	3	1	0	4

Common to I sem. B.E. - AERO, AUTO, MECH, MCT, R&A, CIVIL and B.Tech. - BT, FT & CHEM

Objectives:
● To introduce the matrix techniques and to illustrate the nature of the matrix.
● To address data and synthesis of the information to provide valid conclusions.
● To explain techniques of calculus which are applied in the solutions of engineering problems.
● To analyse special types of integrals by analytical methods and numerical techniques.
● To practice the techniques of Integration in finding area and volumes.

UNIT-I	MATRICES	12

Matrices - Eigenvalues and eigenvectors - Diagonalization of matrices using orthogonal transformation - Cayley-Hamilton Theorem(without proof) -Quadratic forms- Reduction to canonical form using orthogonal transformation- Numerical computation of Eigen value using Power method

UNIT-II	FUNCTIONS OF SEVERAL VARIABLES	12

Partial differentiation–Total derivative–Change of variables–Jacobians–Partial differentiation of implicit functions–Taylor's series for functions of two variables–Maxima and minima of functions of two variables–Lagrange's method of undetermined multipliers.

UNIT-III	INTEGRAL CALCULUS	12
Integral Calculus: Definite Integrals as a limit of sums - Applications of integration to area, volume - Improper integrals: Beta and Gamma integrals - Numerical computation of integrals: Trapezoidal rule - Gaussian Two point quadrature		
UNIT-IV	MULTIPLE INTEGRALS	12
Double integrals – Change of order of integration – Area enclosed by plane curves–Triple integrals–Volume of solids– Numerical computation of double integrals: Trapezoidal rule.		
UNIT-V	REGRESSION	12
Scatter diagram - Karl Pearson coefficient of correlation for raw data –Spearman rank correlation coefficient - Lines of regression - Regression equation X on Y and Y on X- Curve fitting by Principle of least squares - Fitting a straight line y = ax+b and a parabola $y = ax^2 + bx + c$.		
	Total Contact Hours:60	

Outcomes: On completion of the course students will be able to
● Demonstrate the matrix techniques in solving the related problems in engineering and technology.
● Analyse and interpret data, and synthesize information to provide valid conclusions.
● Interpret the problems in Engineering and Technology using the principles of mathematical calculus.
● Apply the analytical methods and numerical techniques to solve the related engineering problems.
● Evaluate multiple integrals to conduct investigations of complex problems.

Text Book(s):	
1.	Grewal B.S., " Higher Engineering Mathematics ", Khanna Publishers, New Delhi, 43rd Edition, 2014.
2.	Gupta S.C. and Kapoor V.K."Fundamentals of Mathematical Statistics", Sultan and Sons 10th Edition,2000.
3.	T Veerarajan, Engineering Mathematics –I , Mc Graw Hill Education, 2018.
4.	I.R. Miller, J.E. Freund and R. Johnson , "Probability and Statistics for Engineers ",4th Edition, Pearson, 2018.
5.	A. Goon, M. Gupta and B.Dasgupta , "Fundamentals of Statistics ",Vol. I & Vol. II, World Press, 2019.

Reference Books(s) / Web links:	
1.	Ramana. B.V., " Higher Engineering Mathematics ", McGraw Hill Education Pvt. Ltd, New Delhi, 2018.
2.	T Veerarajan ,Fundamentals of Mathematical Statistics , yesdee publications, 2017.
3.	Erwin Kreyszig ," Advanced Engineering Mathematics ", John Wiley and Sons, 10th Edition, New Delhi, 2016.
4.	Bali, N.P. and Manish Goyal, A Text Book of Engineering Mathematics, Lakshmi Publications Pvt. Ltd., New Delhi, 2006.
5.	N. Draper & H. Smith,"Applied Regression Analysis" III edition, Wiley, 1998.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MA23112.1	3	2	1	-	-	-	-	-	-	-	1	-	-	-	-
MA23112.2	3	2	-	1	-	-	-	-	-	-	1	1	1	-	-
MA23112.3	2	2	-	-	-	-	-	-	-	-	1	1	-	-	-
MA23112.4	3	3	1	-	-	-	-	-	-	-	1	1	-	-	-
MA23112.5	2	2	-	-	-	-	-	-	-	-	-	-	1	-	-
Average	2.6	2.2	1	1	-	-	-	-	-	-	1	1	1	-	-

Subject Code	Subject Name	Category	L	T	P	C
PH23111	**PHYSICS FOR CHEMICAL ENGINEERING** For Sem I- B.Tech. Chemical Engineering	BS	3	0	0	3

Objectives:
☙ To familiarize the characteristics of crystal structure in solids and methods of crystal growth.
☙ To impart knowledge on the elastic properties of solids and viscosity of liquids.
☙ To introduce the significance of lasers, optical fibres and their applications as sensors and tool for communication.
☙ To familiarize the basic principles of heat transfer and the concepts of thermal conductivity, thermal insulation and their applications.
☙ To introduce the fundamentals of Quantum physics and make them to comprehend the importance of quantum concepts in the field of advanced research and technology.

UNIT-I	**PROPERTIES OF MATTER**		9

Elasticity – Stress-strain diagram and its uses -twisting couple - Torsion pendulum: theory and experiment - bending of beams –area moment of inertia - bending moment – cantilever - applications – uniform and non-uniform bending I-shaped girders. Viscosity: Streamline flow, Turbulent flow, Critical velocity, Coefficient of viscosity, Poiseuille's formula for flow of liquid through a capillary tube.

UNIT-II	**THERMAL PHYSICS**		9

Transfer of heat energy – thermal expansion of solids and liquids – expansion joints - bimetallic strips - thermal conduction, convection and radiation –thermal conductivity - Forbe's and Lee's disc method: theory and experiment - conduction through compound media (series and parallel) – thermal insulation – applications: heat exchangers, refrigerators, ovens and solar water heaters.

UNIT-III	**CRYSTAL PHYSICS**		9

Single crystalline, polycrystalline and amorphous materials – single crystals: unit cell, crystal systems, Bravais lattices, Miller indices – inter-planar distances - coordination number and packing factor for SC, BCC, FCC, HCP and diamond structures. –crystal imperfections: point defects, line defects, surface defects and volume defects.

UNIT-IV	**QUANTUM PHYSICS**		9

Black body radiation – Planck's theory (derivation) – wave particle duality – concept of wave function and its physical significance – Schrödinger's wave equation – time independent and time dependent equations – particle in a one-dimensional box – tunneling (qualitative) – electron microscope – scanning tunneling microscope.

UNIT-V	**LASERS AND FIBER OPTICS**		9

Lasers: Characteristics, Einstein's A and B coefficients derivation – resonant cavity, optical amplification (qualitative) –CO_2 laser - Semiconductor lasers: homojunction and heterojunction. Fiber optics: principle, numerical aperture and acceptance angle - types of optical fibers (material, mode, refractive index) – losses associated with optical fibers - fiber optic sensors : pressure and displacement.

		Contact Hours	:	45

Course Outcomes:
On completion of the course, the students will be able to
☙ acquire a strong understanding on the crystal structures and various techniques of crystal growth.
☙ gain sound knowledge and better understanding on the elastic behaviour of ductile materials, bending of beams and viscosity of liquids.
☙ Appreciate the significance of Einstein's theory and to explain the working of different types of lasers, optical fibre communication and their respective applications
☙ Recognize the difference between conduction, convection and radiation and also able to describe various experimental methods of determining thermal conductivity of materials.
☙ Comprehend the role played by concepts of quantum physics in the working of advanced research equipment like tunnelling electron microscope , scanning electron microscope .
Suggested Activities

	Problem solving sessions
Suggested Evaluation Methods	
☙	Quizzes
☙	Class Presentation / Discussion
Text Book(s):	
1	Bhattacharya, D.K. & Poonam, T. "Engineering Physics". Oxford University Press, 2015.
2	Gaur, R.K. & Gupta, S.L. "Engineering Physics". Dhanpat Rai Publishers, 2012.
3	Pandey, B.K. & Chaturvedi, S. "Engineering Physics". Cengage Learning India, 2013.
Reference Books(s) / Web links:	
1	Halliday, D., Resnick, R. & Walker, J. "Principles of Physics". Wiley, 2015.
2	Serway, R.A. & Jewett, J.W. "Physics for Scientists and Engineers". Cengage Learning, 2017.
3	Tipler, P.A. & Mosca, G. "Physics for Scientists and Engineers with Modern Physics'. W. H. Freeman, 2007.
4	Arthur Besier and S. RaiChoudhury, Concepts of Modern Physics (SIE), 7th edition, McGraw-Hill Education, 2017.
5	R. Murugeshan and Kiruthiga Sivaprasath, Modern Physics, S. Chand, 2015.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	1	-	-	-	-	-	-	-	-	-	1	1	-
CO 2	3	2	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	1	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	3	1	-	-	-	-	-	-	-	-	-	1	1	-
CO 5	3	1	2	-	-	-	-	-	-	-	-	-	-	-	-
Average	3	1.8	1.6	-	-	-	-	-	-	-	-	-	1	1	-

Subject Code	Subject Name	Category	L	T	P	C
CY23132	**CHEMISTRY FOR TECHNOLOGISTS**	**BS**	**3**	**0**	**2**	**4**
	Common to B.TECH. - CHEMICAL ENGG., FT & BT					

Course Objectives:
● To acquire knowledge on Surface chemistry for industrial and domestic uses.
● To impart the knowledge on principles of electrochemistry for engineering applications.
● To provide an insight into the latest Nanotechnology to pursue further research.
● To appreciate the need for and importance of Polymer materials and Heterocyclic compounds.
● To enhance the knowledge in line with the modern techniques for material analysis.

UNIT-I	**SURFACE CHEMISTRY**	**9**
	Introduction – Adsorption- difference between adsorption and absorption - types of adsorption - Factors influencing adsorption - Adsorption from solutions- Types of adsorption isotherms - Freundlich adsorption isotherm - Langmuir adsorption isotherm - Industrial applications of adsorption – Adsorption Chromatography - Role of adsorption in Catalysis - Enzyme catalysis- Michael's Menten equation.	
UNIT-II	**ELECTROCHEMISTRY**	**9**

	Terminology involved in electrochemistry – Types of Cells - Galvanic and concentration cells- Derivation of Nernst equation - Applications of Electrochemical series - Types of Electrodes - Hydrogen, Calomel, ion-selective electrode - Determination of pH using glass electrode - Determination of electrode potentials - Conductometric titrations - Potentiometric titration- Redox titration.	
UNIT-III	**NANO CHEMISTRY**	**9**
	Basic Definitions - Distinction between nanoparticles and bulk materials - size-dependent properties - Mechanical, Chemical, Optical, Electrical and Magnetic properties – Nanoparticles - nanoclusters, nanorods, nanotubes and nanowires - Synthesis of nanoparticles - Precipitation method - Hydrothermal synthesis - Solvothermal synthesis - Sonochemical synthesis - Chemical vapor deposition – Electrodeposition - biogenic synthesis - Applications of nanomaterials.	
UNIT-IV	**POLYMERS AND HETEROCYCLES**	**9**
	Polymers – Introduction - Polymerization - Types of Polymerization - Condensation, Addition, Coordination, Copolymerization - Mechanism of Polymerization - Free Radical Mechanism - Biopolymers - PLA and PHB - Synthesis properties and applications. Heterocyclic compounds - Synthesis and electrophilic and nucleophilic substitution reactions of pyrrole - furan - thiophene- pyridine- quinoline - isoquinoline.	
UNIT-V	**ANALYTICAL TECHNIQUES**	**9**
	Electromagnetic spectrum - absorption of radiation - electronic, vibrational and rotational transitions - Thermal methods of analysis - TGA, DTA – Principle, instrumentation and applications - Spectro Analytical methods - Colorimetry, IR, UV-visible spectroscopy - Principles instrumentation and applications.	
	Total Contact Hours:45	

Description of the Experiments	Total Contact Hours:30
1.	Construction and determination of EMF of simple electrochemical cells and concentration cells
2.	Estimation of acids by pH metry
3.	Determination of corrosion rate on mild steel by weight loss method
4.	Estimation of mixture of acids by conductometry
5.	Estimation of extent of corrosion of iron pieces by potentiometry
6.	Estimation of copper / ferrous ions by spectrophotometry
7.	Estimation of DO by using sensors
8.	Estimation of concentration of sulphate/ Chloride ions in the given sample solution.
9.	Determination of molecular weight of a polymer by viscometry method
10.	Synthesis of nanomaterials by simple precipitation method
11.	Verification of adsorption isotherms (acetic acid on charcoal)
12.	Determination of phase change temperature of a solid.

Course Outcomes: At the end of the course the student will be able to:
● Explore the applications of Surface Chemistry in domestic and industrial uses.
● Employ the basic principles of Electrochemistry in our daily life appliances.

●	Synthesize Nano materials for modern engineering applications.
●	Recognize the need of advanced polymer and heterocyclic compounds in industrial applications.
●	Identify the structure of unknown/new compounds with the help of spectroscopy.

Text Book(s):

1. P. C. Jain and Monika Jain, "Engineering Chemistry", DhanpatRai Publishing Company (P) Ltd,New Delhi, 2015
2. O.G.Palanna, "Engineering Chemistry", McGraw Hill Education (India) Pvt, Ltd, New Delhi, 2017
3. Shikha Agarwal "Engineering Chemistry-Fundamentals and applications", Cambridge University Press, New Delhi, 2015

Reference Books(s)

- A Text Book of Engg. Chemistry, Shashi Chawla, Dhanpat Rai & Co. (P) Ltd.
- B.K. Sharma, "Industrial chemistry", Krishna Prakashan Media (P) Ltd, Meerut, 2016.
- Polymer Science, V R Gowariker, N V Viswanathan, Jayadev, Sreedhar, Newage Int. Publishers, 4th Edition, 2021.
- PradeepT, "A Text Book of Nanoscience and Nanotechnology", Tata McGraw Hill, New Delhi, 2012
- An Introduction to nanomaterials and nanoscience (PB 2020) : Asim K DAS, Mahua Das, CBS publishers and distributors Pvt. Ltd.
- Laboratory Manual Engg. Chemistry, Anupma Rajput, Dhanpat Rai & Co

Lab equipment required:

S. No	Name of the Equipment	Quantity Required
1.	pH meter	10
2.	Ion selective electrodes for various ions in solution	10
3	Spectrophotometer	4
4	Magnetic stirrer with hot plate	10
5	Shaker	5

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CY23312.1	2	1	1	-	-	-	1	1	-	-	-	-			
CY23312.2	2	2	1	-	-	-	-	-	-	-	-	1			
CY23312.3	3	2	2	-	-	-	-	-	-	-	-	-			
CY23312.4	2	2	1	-	-	-	1	1	-	-	-	-			
CY23312.5	2	1	1	-	-	-	-	-	-	-	-	-			
AVG.	2.2	1.6	1.2	-	-	-	1	1-	-	-	-	1			

Subject Code	Subject Name	Category	L	T	P	C
GE23111	ENGINEERING GRAPHICS	ES	2	2	0	4

OBJECTIVES:

- To understand the importance of the drawing in engineering applications
- To develop graphic skills for communication of concepts, ideas and design of engineering products
- To expose them to existing national standards related to technical drawings.
- To improve their visualization skills so that they can apply this skill in developing new products.
- To improve their technical communication skill in the form of communicative drawings

CONCEPTS AND CONVENTIONS (Not for Examination)   1

Importance of graphics in engineering applications–Use of drafting instruments– BIS conventions and specifications–Size, layout and folding of drawing sheets– Lettering and dimensioning. Basic Geometrical constructions.

UNIT-I PLANE CURVES AND PROJECTION OF POINTS   5+12

Curves used in engineering practices: Conics–Construction of ellipse, parabola and hyperbola by eccentricity method – Cycloidal Curves–Construction of cycloid, epicycloid and hypocycloid – Construction of involutes of square and circle–Drawing of tangents and normal to the above curves.

Principles of Projection and Projection of points.

UNIT-II PROJECTION OF LINES AND PLANE SURFACES   6+12

Projection of straight lines (First angle projection) inclined to both the principal planes – Determination of true lengths and true inclinations by rotating line method

Projection of planes (polygonal and circular surfaces) inclined to both the principal planes by rotating object method.

UNIT-III PROJECTION OF SOLIDS AND PROJECTION OF SECTIONED SOLIDS
                                                                                                                          6+12

Projection of simple solids like prisms, pyramids, cylinder and cone when the axis is inclined to one of the principal planes by rotating object method.

Sectioning of solids in simple vertical position when the cutting plane is inclined to HP and perpendicular to VP – obtaining true shape of the section.

Practicing three-dimensional modeling of simple objects by CAD software (Not for examination)

UNIT-IV DEVELOPMENT OF SURFACE AND ISOMETRIC PROJECTIONS   6+12

Development of lateral surfaces of simple and sectioned solids – Prisms, pyramids cylinders and cones.

Principles of isometric projection–isometric scale–Isometric projections of simple solids and truncated solids - Prisms, pyramids, cylinders and cones

Model making of isometric projection of combination of solids as assignment (Not for End semester)

UNIT-V FREE HAND SKETCHING AND PERSPECTIVE PROJECTIONS   6+12
Free Hand sketching: Freehand sketching of multiple views from pictorial views of objects -
Freehand sketching of pictorial views of object from multiple views

Perspective projection of simple solids-Prisms, pyramids, cylinder and cone by visual ray method.

Total Contact Hours: (L=30; P=60) 90 Periods

OURSE OUTCOMES:

After learning the course, the students should be able

- To construct different plane curves and to comprehend the theory of projection
- To draw the basic views related to projection of lines and planes
- To draw the projection of simple solids and to draw the projection of development of surfaces of Sectioned solids in simple vertical position
- To draw the orthographic projection from pictorial objects and Isometric projections of simple solids
- To visualize Perspective view of simple solids

TEXT BOOK (S):
1. Bhatt N.D. and Panchal V.M., "Engineering Drawing", Charotar Publishing House, 50th Edition, 2010.
2. Natarajan K.V., "A text book of Engineering Graphics", Dhanalakshmi Publishers, Chennai, 2017.

REFERENCE BOOKS(S) / WEB LINKS:
1. Varghese P I., "Engineering Graphics", McGraw Hill Education (I) Pvt.Ltd., 2013.
2. V.B Sikka "Civil Engineering Drawing", S.K Kataria & Sons, New Delhi.
3. Venugopal K. and PrabhuRaja V., "Engineering Graphics", New Age International (P)Limited, 2008.
4. Gopalakrishna K.R., "Engineering Drawing" (Vol. I&II combined), Subhas Stores, Bangalore, 2017.
5. Basant Agarwal and Agarwal C.M., "Engineering Drawing", McGraw Hill Publishing Company Limited, New Delhi, 2018.

CO PO PSO MAPPING

CO/PO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO 1	3	2	2	1	-	1	-	2	2	2	-	2			
CO 2	3	2	2	1	-	1	-	2	2	2	-	2			
CO 3	3	2	2	1	-	1	-	2	2	2	-	2			
CO 4	3	2	2	1	-	1	-	2	2	2	-	2			
CO 5	3	2	2	1	-	1	-	2	2	2	-	2			

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

Subject Code	Subject Name (Laboratory Course)	Category	L	T	P	C
GE23121	ENGINEERING PRACTICES – Civil& Mechanical	ES	0	0	2	1

Objectives:

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

List of Experiments	
CIVIL ENGINEERING PRACTICE	
1.	Study of pipeline joints, its location and functions: valves, taps, couplings, unions, reducers, and elbows in household fittings.
2.	Preparation of basic plumbing line sketches for wash basins, water heaters, etc.
3.	Hands-on-exercise: Basic pipe connections – Pipe connections with different joining components.
Carpentry Works:	
4.	Study of joints in roofs, doors, windows and furniture.
5.	Hands-on-exercise: Woodwork, joints by sawing, planning and chiselling.
MECHANICAL ENGINEERING PRACTICE	
6.	Preparation of butt joints, lap joints and T- joints by Shielded metal arc welding.
7	Gas welding practice.
Basic Machining:	
8	Simple Turning and Taper turning
9	Drilling Practice
Sheet Metal Work:	
10	Forming & Bending:
11	Model making – Trays and funnels
12	Different type of joints.
Machine Assembly Practice:	
13	Study of centrifugal pump
14	Study of air conditioner
	Total Contact Hours : 30

Course Outcomes:	
☐	Able to perform plumbing activities for residential and industrial buildings considering safety aspects while gaining clear understanding on pipeline location and functions of joints like valves, taps, couplings, unions, reducers, elbows, etc.
☐	Able to perform wood working carpentry activities like sawing, planning, cutting, etc. while having clear understanding of the joints in roofs, doors, windows and furniture.
☐	Able to produce joints like L joint, T joint, Lap joint, Butt joint, etc. through arc welding process while acquiring in depth knowledge in the principle of operation of welding and other accessories
☐	Able to perform operations like Turning, Step turning, Taper turning, etc. in lathe and Drilling operation in drilling machine
☐	Able to perform sheet metal operations like Forming, Bending, etc. and fabricating models like Trays, funnels, etc.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	1	1	1	-	-	2	1	-	2	-	-	2	-	2	1
CO 2	1	1	1	-	-	2	1	-	2	-	-	2	-	2	1
CO 3	1	1	1	-	-	2	1	-	2	-	-	2	-	2	1
CO 4	1	1	1	-	-	2	1	-	2	-	-	2	-	2	1
CO 5	1	1	1	-	-	2	1	-	2	-	-	2	-	2	1

Subject Code	Subject Name (Theory course)	Category	L	T	P
MC23112	**ENVIRONMENTAL SCIENCE AND ENGINEERING** **Common to all branches of B.E./B.Tech. courses (Except B.Tech-CSBS)**	MC	3	0	0

Objectives:

- To develop the understanding of environmental and associated issues
- To develop an attitude of concern for the environment
- To promote enthusiasm in participating environmental protection initiatives
- To nurture skills to solve environmental degradation issues

UNIT-I	**Air and Noise pollution**	9
	Definition –sources of air pollution –chemical and photochemical reactions in the atmosphere - formation of smog, PAN, acid rain, ozone depletion, particulate pollutants- Air quality standards-Air quality indices - control of particulate air pollutants- gravitational settling chambers, cyclone separators, wet collectors, fabric filters (Bag- house filter), electrostatic precipitators (ESP)-catalytic converters.Noise pollution – sources - health effects - standards- measurement and control methods.	
UNIT-II	**Water pollution and its management**	9
	Definition-causes-effects of water pollution-point and nonpoint sources of wastewater- marine pollution - thermal pollution - Control of water pollution by physical, chemical and biological methods – wastewater treatment-primary, secondary and tertiary treatment- sources and characteristics of industrial effluents- zero liquid discharge.	
UNIT-III	**Solid waste and Hazardous waste management**	9
	Solid waste – types- municipal solid waste management: sources, characteristics, collection, and transportation- sanitary landfill, recycling, composting, incineration, energy recovery options from waste - Hazardous waste – types, characteristics, and health impact - hazardous waste management: neutralization, oxidation reduction, precipitation, solidification, stabilization, incineration and final disposal.E-waste- definition-sources-effects on human health and environment- E-waste management- steps involved - Role of E-waste management within the initiatives of the Govt. of India- Swachh Bharat Mission.	
UNIT-IV	**Sustainable Development**	**9**

Sustainable development- concept-dimensions-sustainable development goals - value education- gender equality – food security - poverty – hunger - famine - Twelve principles of green chemistry - Green technology - definition, importance - Cleaner development mechanism - carbon credits, carbon trading, carbon sequestration, eco labeling-International conventions and protocols-Disaster management.

UNIT-V	**Environmental Management and Legislation**	9

Environmental Management systems - ISO 14000 series- Environmental audit- Environmental Impact Assessment- life cycle assessment- human health risk assessment - Environmental Laws and Policy- Objectives - Polluter pays principle, Precautionary principle - The Environment (Protection) Act 1986 - Role of Information technology in environment and human health.

	Total Contact Hours	**: 45**	

Course Outcomes:	
On completion of the course, the students will be able to	
CO1	associate air and noise quality standards with environment and human health.
CO2	illustrate the significance of water and devise control measures for water pollution.
CO3	analyze solid wastes and hazardous wastes.
CO4	outline the goals of sustainable development in an integrated perspective.
CO5	comprehend the significance of environmental laws.

Text Books:	
1	Benny Joseph, 'Environmental Science and Engineering', Tata McGraw-Hill, New Delhi, 2016
2	Anubha Kaushik and C. P. Kaushik's "Perspectives in Environmental Studies", 6th Edition, New Age International Publishers ,2018.
3	Johri R., E-waste: implications, regulations, and management in India and current global best practices, TERI Press, New Delhi
Reference Books	
1	R.K. Trivedi, 'Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards', Vol. I and II, Enviro Media. 38. Edition 2010.
2	Cunningham, W.P. Cooper, T.H. Gorhani, 'Environmental Encyclopedia', Jaico Publ., House, Mumbai, 2001.
3	Fowler B, Electronic Waste – 1 st Edition (Toxicology and Public Health Issues), 2017Elsevier

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2	PSO3
MC23112.1	1	2	3	1	-	2	2	2	1	1	1	2			
MC23112.2	1	2	3	1	-	2	2	2	1	1	1	2			
MC23112.3	-	-	3	1	-	2	3	2	1	-	1	2			
MC23112.4	-	1	2	1	1	3	3	2	1	1	1	2			
MC23112.5	-	1	2	-	-	2	2	2	1	2	2	2			
AVG.	0.4	1.2	2.6	0.8	0.2	2.2	2.4	2	1	1	1.2	2			

GE 23117 தமிழர் மரபு **L T P C**

1 0 0 1

அலகு I மொழி மற்றும் இலக்கியம்: **3**

இந்திய மொழிக் குடும்பங்கள் - திராவிட மொழிகள் - தமிழ் ஒரு செம்மொழி - தமிழ் செவ்விலக்கியங்கள் - சங்க இலக்கியத்தின் சமய சார்பற்ற தன்மை - சங்க இலக்கியத்தில் பகிர்தல் அறம் - திருக்குறளில் மேலாண்மைக் கருத்துக்கள் - தமிழிக் காப்பியங்கள், தமிழகத்தில் சமண பௌத்த சமயங்களின் தாக்கம் - பக்தி இலக்கியம், ஆழ்வார்கள் மற்றும் நாயன்மார்கள் - சிற்றிலக்கியங்கள் - தமிழில் நவீன இலக்கியத்தின் வளர்ச்சி - தமிழ் இலக்கிய வளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்பு.

அலகு II மரபு - பாறை ஓவியங்கள் முதல் நவீன ஓவியங்கள் வரை - சிற்பக் கலை:

3

நடுகல் முதல் நவீன சிற்பங்கள் வரை - ஐம்பொன் சிலைகள் - பழங்குடியினர் மற்றும் அவர்கள் தயாரிக்கும் கைவினைப் பொருட்கள், பொம்மைகள் - தேர் செய்யும் கலை - சுடுமண் சிற்பங்கள் - நாட்டுப்புறத் தெய்வங்கள் - குமரிமுனையில் திருவள்ளுவர் சிலை - இசைக் கருவிகள் - மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் - தமிழர்களின் சமூக பொருளாதார வாழ்வில் கோவில்களின் பங்கு.

அலகு III நாட்டுப்புறக் கலைகள் மற்றும் வீர விளையாட்டுகள்: **3**

தெருக்கூத்து, கரகாட்டம், வில்லுப்பாட்டு, கணியான் கூத்து, ஒயிலாட்டம், தோல்பாவைக் கூத்து, சிலம்பாட்டம், வளரி, புலியாட்டம், தமிழர்களின் விளையாட்டுகள்.

அலகு IV தமிழர்களின் திணைக் கோட்பாடுகள்: **3**

தமிழகத்தின் தாவரங்களும், விலங்குகளும் - தொல்காப்பியம் மற்றும் சங்க இலக்கியத்தில் அகம் மற்றும் புறக் கோட்பாடுகள் - தமிழர்கள் போற்றிய அறக்கோட்பாடு - சங்ககாலத்தில் தமிழகத்தில் எழுத்தறிவும், கல்வியும் - சங்ககால நகரங்களும் துறை முகங்களும் - சங்ககாலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி - கடல்கடந்த நாடுகளில் சோழர்களின் வெற்றி.

அலகு V இந்திய தேசிய இயக்கம் மற்றும் இந்திய பண்பாட்டிற்குத் தமிழர்களின் பங்களிப்பு: **3**

இந்திய விடுதலைப்போரில் தமிழர்களின் பங்கு - இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப் பண்பாட்டின் தாக்கம் - சுயமரியாதை இயக்கம் - இந்திய மருத்துவத்தில், சித்த மருத்துவத்தின் பங்கு - கல்வெட்டுகள், கையெழுத்துப்படிகள் - தமிழ்ப் புத்தகங்களின் அச்சு வரலாறு.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு - மக்களும் பண்பாடும் - கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).

2. கணினித் தமிழ் - முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).

3. கீழடி - வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)

4. பொருநை - ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)

5. Social Life of Tamils (Dr. K. K. Pillay) A joint publication of TNTB & ESC and RMRL – (in print)

6. Social Life of the Tamils – The Classical Period (Dr. S. Singaravelu)(Published by: International Institute of Tamil Studies.

7. Historical Heritage of the Tamils (Dr. S. V. Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).

8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies).

9. Keeladi – 'Sangam City Civilization on the banks of river Vaigai' (Jointly Published by: Department of archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)

10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)

11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)

12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

SEMESTER II

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
HS 23221	Technical Communication II	Theory	0	0	2	1
	Common to all branches of B.E/B. Tech programmes –Second Semester					

Objectives:
● To facilitate students to improve their vocabulary for a better communication
● To enable learners to understand and reproduce language
● To aid students to write technical reports in a convincing manner
● To expose students to different sentence structures
● To equip learners to present their ideas in an efficient manner

UNIT-I	VOCABULARY FOR BETTER COMMUNICATION	6
	Listening: Telephonic Conversations and TV News	
	Reading: Newspapers and Magazines	
	Speaking: Conversational Practice: Speaking in a given situation, Asking permission and requesting etc..,	
	Writing: Job Application Letter and Resume	
	Grammar: Reference words: pronouns and determiners	
	Vocabulary: Guessing meanings of words in different contexts.	
UNIT-II	FUNCTIONAL LANGUAGE ASPECTS	6
	Listening: Motivational listening – listening to real life challenges	
	Reading: Articles and Technical reports	
	Speaking: Using Polite Expressions, Indirect Questions	
	Writing: Paraphrasing a Text, Poem	
	Grammar: Purpose Statements, Cause and Effect Expressions	
	Vocabulary: Neologisms.	
UNIT-III	TECHNICAL REPORTWRITING	6
	Listening: Empathetic Listening – Giving Solutions to Problems	
	Reading: Inferential Reading	
	Speaking: Dialogues – Interviewing Celebrities / Leaders / Sportspersons, etc..,	
	Writing: Report Writing	
	Grammar: Functional Usage of Expressions – used to, gone / been, etc..,	
	Vocabulary: Words Often Confused	
UNIT-IV	STRUCTURAL GRAMMAR	6
	Listening: Comprehension (IELTS practice tests)	
	Reading: Intensive Reading for specific information	
	Speaking: Pick and Talk	
	Writing: Proposals	
	Grammar: Sentence Structures – Simple, Compound, Complex Sentences	
	Vocabulary: Replacing dull words with vivid ones	
UNIT-V	PRESENTATION SKILLS	6
	Listening: Discriminative listening – sarcasm, irony, pun, etc..,	
	Reading: Practice of chunking – breaking up reading materials	

Speaking: Mini presentation on some topic

Writing: Minutes of the meeting

Grammar: Correction of Errors

Vocabulary: Advanced vocabulary – fixing appropriate words in the given context.

Total Contact Hours: 30

Course Outcomes:

On completion of the course students will be able to

- communicate effectively using appropriate vocabulary

- use the acquired language skills to comprehend various types of language contents

- evaluate different texts and write effective technical content

- use appropriate sentence structures to convey their thoughts in varied contexts

- present their concepts and ideas in an effective manner

SUGGESTED ACTIVITIES

- Story Lines
- One truth and two lies
- Hang Man
- Pictionary
- Case study
- Word Scramble

SUGGESTED EVALUATION METHODS

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

Text Book(s):

5. Raymond Murphy, "Intermediate English Grammar," Second Edition , Cambridge University Press, 2018

6.   Meenakshi Raman & Sangeeta Sharma, "Technical Communication" Third Edition, Oxford University Press, 2015

7. Teaching Speaking: A Holistic Approach, Book by Anne Burns and Christine ChuenMeng Goh, Cambridge University Press

Reference Books(s) / Web links:

- Michael McCarthy (Author), Felicity O'Dell (Author), John D. Bunting (Contributor), "Basic Vocabulary in Use: 60 Units of Vocabulary Practice in North American English With Answers" 2nd Edition

- Dale Carnegie, "The Art of Public Speaking," Insight Press

● Jack C. Richards & Theodore S. Rodgers, " Approaches and Methods in Language Teaching, Second Edition, Cambridge University Press

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
HS23221. 1	-	-	-	1	-	-	-	-	-	2	-	-	-	-	-
HS23221. 2	-	-	-	1	-	-	-	-	-	3	-	-	-	-	-
HS23221. 3	-	2	-	1	-	-	-	-	-	3	-	-	-	-	-
HS23221. 4	-	-	-	1	-	-	-	-	2	3	-	-	-	-	-
HS23221. 5	-	-	-	1	-	-	-	-	2	2	-	-	-	-	-
Average	-	2	-	1	0	0	0	0	2	2.6	-	-	-	-	-

Subject Code	Subject Name	Category	L	T	P	C
HS 23222	English for Professional Competence Common to all branches of B.E/B. Tech programmes –Second Semester	HS	0	0	2	1

Objectives:	
☐	To facilitate the learners in acquiring listening and reading competence
☐	To enable the learners to communicate effectively through written and oral medium
☐	To assist the learners in preparing for competitive examinations
☐	To train the students in acquiring corporate skills
☐	To inculcate professional standards among the students and make them realize their responsibility in addressing the challenges

UNIT-I	RECEPTIVE SKILLS	6
Listening – Comprehensive Listening – Watching the news – Listening to a peer giving presentation, etc. – Critical Listening – Watching a televised debate, Listening to poems – **Reading** – Extensive Reading – Short stories and One-act Plays – Intensive Reading – Articles or Editorials in Magazines, Blog posts on topics like science and technology, arts, etc.		
UNIT-II	**PRODUCTIVE SKILLS**	6
Speaking – Demonstrative Speaking – Process description through visual aids – Persuasive Speaking – Convincing the listener with the speaker's view – **Writing** – Descriptive Writing - Describing a place, person, process – Subjective Writing – Autobiography, Writing based on personal opinions and interpretations		
UNIT-III	**ENGLISH FOR COMPETITIVE EXAMS**	6
An introduction to International English Language Testing System (IELTS) – Test of English as a Foreign Language (TOEFL) – Graduate Record Examination (GRE) – Civil Service, Indian Economic Service Examination, Indian Statistical Service Examination, Combined Defence Services Examination, Staff Selection- (Language Related) – Aptitude tests.		
UNIT-IV	**CORPORATE SKILLS**	6
Critical Thinking and Problem Solving – Case Study, Brainstorming, Q & A Discussion – **Team work and Collaboration** – Activities like Office Debates, Perfect Square, Blind Retriever, etc. – **Professionalism and Strong Work Ethics** – Integrity, Resilience, Accountability, Adaptability, Growth Mind set		
UNIT-V	**PROJECT WORK**	6
Case Study based on the challenges faced by the employers and the employees – Devise Plan, Provide Solution		

	Total Contact Hours	30

Course Outcomes:
On completion of the course, students will be able to
● interpret and respond appropriately in the listening and reading contexts.
● express themselves effectively in spoken and written communication
● apply their acquired language skills in writing the competitive examinations
● exhibit their professional skills in their work place
● identify the challenges in the work place and suggest strategies solutions

	Reference Books
1	How to Read Better & Faster, Norman Lewis, Goyal Publishers
2	Teaching Speaking: A Holistic Approach, Book by Anne Burns and Christine Chuen Meng Goh, Cambridge University Press
3	The Official Cambridge Guide To IELTS by Pauline Cullen, Cambridge University Press
4	The 7 Habits of Highly Effective People by Stephen Covey, Simon and Schuster, UK

Reference Books(s) / Web links:
1.   Board of Editors. Sure Outcomes. A Communication Skills Course for Undergraduate Engineers and Technologists. Orient Black Swan Limited, Hyderabad, 2013.
2. Hartley, Mary. "The Power of Listening," JaicoPublishing House; First Edition (2015).
3. Chambers, Harry. "Effective Communication Skills for Scientific and Technical Professionals," Persues Publishing, Cambridge, Massachusetts, 2000.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
HS23222. 1	-	1	-	-	-	-	-	-	-	3	-	-	-	-	-
HS23222. 2	-	1	-	-	-	-	-	-	-	3	-	-	-	-	-
HS23222. 3	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
HS23222. 4	-	-	-	-	-	-	2	2	-	3	-	-	-	-	-
HS23222. 5	-	-	1	-	-	-	2	-	-	3	-	-	-	-	-
Average	0	1	1	0	0	0	2	2	0	3	0	0	-	-	-

Course Code	Course Title	Category	L	T	P	C
MA23212	**DIFFERENTIAL EQUATIONS AND COMPLEX VARIABLES**	BS	3	1	0	4
	Common to II Sem. B.E. –AERO, AUTO, BME, CIVIL, EEE, ECE, MECH, MCT, R&A and B. Tech. - BT, FT & CHEM					

Objectives:
● To provide students with an introduction to the theory of ordinary differential equations through applications, methods of solution, and numerical approximations.
● To introduce students to how to solve linear Partial Differential with different methods.
● To enable the students to study the Laplace Transforms, properties of Laplace Transform, inverse Laplace Transform and some applications to solve the differential equations and integral equations.

- To explain the concept of a vector integration in a plane and in space.

- To describe basic properties of complex variables and to have the ability to compute complex integrals.

UNIT-I	ORDINARY DIFFERENTIAL EQUATIONS	12
Second and higher order Linear differential equations with constant coefficients - Method of variation of parameters – Legendre's linear equations – Numerical solution of ODE - Single Step methods: Taylor's series method, Euler's method.		
UNIT-II	PARTIAL DIFFERENTIAL EQUATIONS	12
Formation of partial differential equations - Classification of PDE – Solutions of standard types of first order partial differential equations - Lagrange's linear equation –Linear homogeneous partial differential equations of second and higher order with constant coefficients.		
UNIT-III	LAPLACE TRANSFORM	12
Laplace transform –Basic properties – Transforms of derivatives and integrals of functions - Transforms of unit step function and impulse functions, periodic functions. Inverse Laplace transform – Problems using Convolution theorem – Solution of linear ODE of second order with constant coefficients using Laplace transformation techniques		
UNIT-IV	VECTOR CALCULUS	12
Gradient, divergence and curl – Directional derivative – Irrotational and Solenoidal vector fields – Vector integration – Green's theorem in a plane, Gauss divergence theorem and Stokes' theorem (excluding proofs) – Simple applications involving cubes and rectangular parallelopipeds.		
UNIT-V	COMPLEX VARIABLES	12
Analytic functions — Construction of analytic function - Bilinear transformation –Singularities – Cauchy's integral theorem (without proof) - Residues – Residue theorem (without proof) - Simple problems - Contour integral over $|z|=1$.		
	Total Contact Hours: 60	

Course Outcomes:
On completion of the course students will be able to
● Apply the methods as a potent tool in the solution of a variety of problems in the natural sciences and technology.
● Develop specific methodologies, techniques and resources in Partial differential equations to conduct research and produce innovative results in the area of specialisation.
● Use Laplace transform and inverse transform techniques to solve the complex problems in engineering and technology.
● Apply the concepts in multivariable analysis, including space curves; directional derivative; gradient; multiple integrals; line and surface integrals; vector fields; divergence, curl ; the theorems of Green and Stokes, and the divergence theorem in different fields of engineering.
● Demonstrate the concept of Analytic functions, conformal mapping and complex integration in solving Engineering problems.

	Text Book(s):
1.	Grewal B.S., " Higher Engineering Mathematics ", Khanna Publishers, New Delhi, 43rd Edition, 2014.
2.	Veerarajan. T, Engineering Mathematics –II, Mc Graw Hill Education, 2018.
3.	Erwin Kreyszig," Advanced Engineering Mathematics ", John Wiley and Sons, 10th Edition, New Delhi, 2016.
4	Glyn James, "Advanced Modern Engineering Mathematics", Pearson Education, 4th Edition, New Delhi, 2011.
5	Jain R.K. and Iyengar S.R.K., "Advanced Engineering Mathematics", Narosa Publications, 5 th Edition, New Delhi, 2017.
	Reference Books(s) / Web links:

1.	Ramana. B.V., "Higher Engineering Mathematics ", McGraw Hill Education Pvt. Ltd, New Delhi, 2016.
2.	T Veerarajan, Transforms and Partial Differential Equations, Third Edition, 2018.
3.	Bali, N.P. and Manish Goyal, A Text Book of Engineering Mathematics, Lakshmi Publications Pvt. Ltd., New Delhi, 4th Edition 2006.
4.	Peter V.O'Neil, "Advanced Engineering Mathematics", Cengage Learning India Pvt., Ltd, 7th Edition, New Delhi, 2012.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MA23212.1	3	2	1	-	-	-	-	-	-	-	-	1	1	-	-
MA23212.2	3	2	1	-	-	-	-	-	-	-	-	1	1	-	-
MA23212.3	3	2	1	-	-	-	-	-	-	-	-	-	-	-	-
MA23212.4	2	2	1	-	-	-	-	-	-	-	-	-	-	-	-
MA23212.5	3	2	1	-	-	-	-	-	-	-	-	1	-	-	-
Average	2.8	2	1	-	-	-	-	-	-	-	-	1	1	-	-

Course Code	Course Title	Category	L	T	P	C
CH23211	**INTRODUCTION TO CHEMICAL ENGINEERING**	**PC**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1. To compare and learn real-life examples with the basics of chemical engineering.
2. To study the significance of unit operations in chemical engineering.
3. To learn the concepts of heat, mass, and momentum transport processes.
4. To be exposed to the computing methods available for chemical engineering
5. To create awareness of the scope of a chemical engineer

UNIT I   INTRODUCTION   9
Chemical Engineering in day to life with examples, Origin, and growth of chemical Engineers in chemical process industries, unit operations, and unit processes concepts, scaling up or down, application of mathematics in chemical Engineering, recent developments in chemical process industries

UNIT II UNIT OPERATIONS IN CHEMICAL ENGINEERING   9
Unit operations and kinetics of chemical reactions. flowsheet representation of process plants – the evolution of an industry – sulphuric acid and soda ash manufacture Process flow sheeting and symbols.

UNIT III TRANSPORT PROCESSES   9   Nature
of fluid, Viscosity, Frictional losses, heat transfer operations, mass transfer operations, size reduction equipment.

UNIT IV CHEMICAL ENGINEERING COMPUTER SOFTWARE TOOLS AND APPLICATIONS 9

Introduction to Process Engineering Design Software (ASPEN, HYSYS, and PRO II), Computations Using Microsoft Excel, Origin, Computer-Aided Design & Drafting, Piping and Equipment Design Software

UNIT V CAREER DIVERSITIES IN CHEMICAL ENGINEERING 9

Career Development Leading to Specialization, Chemical Engineering Job Options, Chemical and Process Engineers, Commissioning Engineer, Process Control/Automation Engineer, Process Safety Engineer, Research & Development Engineer Pharmaceutical Engineer, Pipeline Engineer Chemical Manufacturing Engineer, and Environment Engineer.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will be able

1. To relate real-life examples with chemical engineering principles
2. To understand the role of unit operations in chemical engineering.
3. To understand the concepts of heat, mass, and momentum transport processes.
4. To get an overview of various computing methods available for chemical engineering
5. To get an awareness of the scope of a chemical engineer

TEXTBOOKS:

1. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", 6th Edn., McGraw-Hill, 2001.

2.Anderson, L.B., Wenzel, L.A., "Introduction to Chemical Engineering", McGraw-Hill Book Company, Inc., New York (1961).

2. Pushpavanam, S., "Introduction to Chemical Engineering", PHI Learning Pvt. Ltd.(2012).

3. Ghosal, S.K., Sanyal, S.K., Datta, S., "Introduction to Chemical Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi(1997).

REFERENCES:

1. Rao, M.G., Sittig, M., "Dryden's Outlines of Chemical Technology", East-West Press (1997).

2. Perry, R.H., Green, D.W., "Perry's Chemical Engineers' Handbook", McGraw-Hill Book Company (2008).

CO-PO MAPPING

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CH23211.1	3	2	3	1	2	1	1	1	1	1	1	1
CH23211.2	3	3	2	2	1	1	1	1	1	2	1	3
CH23211.3	3	3	2	2	2	1	1	1	1	2	1	3
CH23211.4	3	3	3	3	1	1	1	1	1	2	1	3
CH23211.5	3	3	3	3	2	1	1	2	1	2	2	3

Subject Code	Subject Name (Lab Oriented Theory Course)	Category	L	T	P	C
GE23233	**PROBLEM SOLVING AND PYTHON PROGRAMMING**	**ES**	**2**	**0**	**4**	**4**

Objectives:	
▢	To know the basics of algorithmic problems solving
▢	To develop Python programs with conditionals and loops
▢	To define Python functions and call them
▢	To use Python data structures–-lists, tuples, dictionaries
▢	To do input/output with files in Python

UNIT-I	ALGORITHMIC PROBLEM SOLVING	6

Introduction to computers-characteristics-basic organization of a computer– algorithms-building blocks of algorithms (instructions / statements, state, control flow, functions)-notation (pseudo code, flow chart, programming language) - algorithmic problem solving - simple strategies for developing algorithms (iteration, recursion).

UNIT-II	DATA, EXPRESSIONS, STATEMENTS AND CONTROL FLOW - I	6

Python interpreter and interactive mode - values and types - data types – variables – keywords – expressions and statements- python I/O - operators- precedenceof operators– comments. Conditionals:conditional(if)-alternative(if-else)-chained conditional (if- elif- else)–nested conditional.

UNIT-III	CONTROL FLOW – II AND FUNCTIONS	7

Iteration: while – for - break – continue – pass. Illustrative programs: exchange the values of two variables- circulate the values of n variables-test for leap year. Function calls – type conversion– math function– composition- definition and use - flow of execution - parameters and arguments. Fruitful functions: return values – parameters - scope: local and global - recursion.

UNIT-IV	STRINGS	5

Strings: string slices – immutability - string functions and methods – string comparison. Illustrative programs: square root– GCD– exponentiation-sum the array of numbers linear search- binary search.

UNIT-V	LISTS, TUPLES AND DICTIONARIES	6

Lists - list operations - list slices - list methods - list loop – mutability – aliasing - cloning lists - listparameters. Tuples – immutable - tuple assignment - tuple as return value. Dictionaries: operations and methods– dictionaries and tuples– dictionaries and lists. Advanced list processing- list comprehension. Illustrative programs: Sorting.

	Contact Hours	:	30

List of Experiments		
1	Introduction to Python Programming and Python IDLE/Anaconda distribution.	
2	Experiments based on Variables, Data types and Operators in Python.	
3	Coding Standards and Formatting Output.	
4	Algorithmic Approach: Selection control structures.	
5	Algorithmic Approach: Iteration control structures.	
6	Experiments based on Strings and its operations.	
7	Experiments based on Lists and its operations.	
8	Experiments based on Tuples and its operations.	
9	Experiments based on Sets and its operations.	
10	Experiments based on Dictionary and its operations.	
11	Functions: Built-in functions.	
12	Searching techniques: Linear and Binary.	
13	Sorting techniques: Bubble and Merge Sort.	

	Contact Hours	:	60
	Total Contact Hours	**:**	**90**

Course Outcomes:	
On completion of the course, the students will be able to	
▢	Understand the working principle of a computer and identify the purpose of a computer programming language and ability to identify an appropriate approach to solve the problem.
▢	Write, test, and debug simple Python programs with conditionals and loops.
▢	Develop Python programs step - wise by defining functions and calling them.
▢	Use Python lists, tuples, dictionaries for representing compound data.
▢	Apply searching, sorting on data and efficiently handle data using flat files.

TextBooks:	
1.	Allen B. Downey, Think Python:How to Think Like a Computer Scientist, Second edition,UpdatedforPython3, Shroff/ O'Reilly Publishers, 2016 (http://greenteapress.com/wp/think-python/)

2.	Guido Van Rossum and Fred L. Drake Jr, An Introduction to Python-Revised and updated for Python3.2, Network Theory Ltd., 2011.

ReferenceBooks:	
1.	JohnVGuttag, Introduction to Computation and Programming Using Python, Revised and expanded Edition, MIT Press, 2013.
2.	Robert Sedgewick, Kevin Wayne, Robert Dondero, Introduction to Programming in Python: An Inter-disciplinary Approach, Pearson India Education Services Pvt Ltd, 2016.
3.	Timothy A.Budd, Exploring Python, Mc-Graw Hill Education (India) Private Ltd., 2015.
4.	Kenneth A. Lambert, Fundamentals of Python: First Programs, Cengage Learning, 2012.
5.	Charles Dierbach, Introduction to Computer Science using Python: A Computational Problem Solving Focus, Wiley India Edition, 2013.
6.	Paul Gries, Jennifer Campbell and Jason Montojo, Practical Programming: An Introduction to Computer Science using Python3, Second edition, Pragmatic Programmers, LLC, 2013.

Platform needed: Python3 interpreter for Windows/Linux

CO -PO–PSO matrices of course

PO/PSOCO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
GE23233.1	2	2	2	2	1	-	-	-	1	1	1	1	3	3	-
GE23233.2	2	1	1	1	1	-	-	-	-	-	1	1	3	2	-
GE23233.3	1	1	2	1	2	-	-	-	-	-	1	1	2	3	2
GE23233.4	2	2	3	2	2	-	-	-	-	-	2	1	2	2	2
GE23233.5	2	2	3	2	3	-	-	-	-	-	2	1	2	2	2
Average	1.8	1.6	2.2	1.6	1.8	0.0	0.0	0.0	0.2	0.2	1.4	1	2.4	2.4	2

1:Slight(Low)   2:Moderate(Medium)   3:Substantial(High)

Subject Code	Subject Name	Category	L	T	P	C
PH23233	**MATERIAL SCIENCE** **For Sem II - B. Tech. Chemical Engineering** **Common to I sem. B.E. - Aero, Auto, Civil, Mech, MCT and R & A**	BS	3	0	2	4

Objectives:

✍	To introduce different phases in an alloy system and their composition.
✍	To expose the equilibrium phases, invariant reactions and microstructures of ferrous alloys and their heat treatment methods.
✍	To understand the properties of conducting and superconducting materials.
✍	To teach the different types of magnetic materials and dielectric polarisations.
✍	To impart knowledge on ceramics and new engineering materials in the field of medicine and technology.

UNIT-I	PHASE DIAGRAMS	9

Solid solutions-Hume Rothery rules-Phases- Gibb's Phase rule- Phase diagram– unary system-water – binary systems-isomorphous system(Cu-Ni), eutectic system (Pb-Ag) and other invariant reactions. – Tie line rule – lever rule – Fick's laws of diffusion - Nucleation –homogeneous and heterogeneous nucleation(Qualitative)– Microstructural changes during cooling.

UNIT-II	FERROUS ALLOYS AND HEAT TREATMENT	9

Iron-carbon equilibrium diagram- Microstructure of slowly cooled steels-Eutectoid steel, Hypo and Hyper Eutectoid steel- T-T-T diagram for eutectoid steel-Tempering of martensite. Heat treatment and hardening process.

UNIT-III	CONDUCTING AND SUPERCONDUCTING MATERIALS	9

Classical free electron theory of metals –Fermi function – effect of temperature on Fermi energy – Density of energy states – Carrier concentration in metals. Superconducting Phenomena- Properties of superconductors - Type I and Type II superconductors- High Tc superconductors – Magnetic levitation and SQUID.

UNIT-IV	DIELECTRIC AND MAGNETIC MATERIALS	9

Dielectric – classification of insulating materials -Types of polarization – Internal field and deduction of Clausius-Mossotti equation – dielectric loss – different types of dielectric breakdown – paraelectric and ferroelectric materials- applications. Introduction to magnetic materials – Types of magnetic materials-Domain theory of ferromagnetism- Hysteresis- Soft and Hard magnetic materials – Ferrites and its applications,

UNIT-V	NEW ENGINEERING MATERIALS	9

Ceramics-types, preparation and their applications – Metallic glasses – Shape memory alloys – Copper base alloys – Nickel – Titanium alloys – Relaxor- Electro and magneto rheological fluids - Sensors and Actuators – polymer semiconductos – photoconducting polymers – liquid crystals - Bio-sensors – liquid Scintillation detectors –Bio materials – hydroxyapatite – PMMA – Silicone.

	Contact Hours	:	45

List of Experiments

1	Determination of Young's modulus by Non-Uniform bending method.
2	Determination of moment of inertia of the disc and Rigidity Modulus of the wire using Torsional Pendulum.
3	Determination of wavelength of diode laser and particle size of given powder.
4	Determination of numerical aperture and acceptance angle of the optical fiber cable.
5	Find the thermal conductivity of given bad conductor by Lee's disc method.
6	Determination of Hysteresis loss using B-H curve apparatus.
7	Determination of resonance frequency of LCR series circuits.
8	Determination of free space permeability using Helmholtz coil.
9	Determination of Hall co-efficient of the semiconducting material using Hall apparatus.
10	Determination of solar cell characteristics.

	Contact Hours	:	30
	Total Contact Hours	:	75

Course Outcomes:

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

✍	analyze the composition of various phases of an alloy system and their respective invariant reactions.
✍	use the microstructures of iron and their properties in industrial applications.
✍	calculate the density of energy states of conducting materials and understand the properties of superconducting materials.
✍	analyze the properties of dielectric and magnetic materials.
✍	use the properties of ceramics and new engineering materials in the field of engineering and medicine.

Suggested Activities

✍	Problem solving sessions

Suggested Evaluation Methods

✍	Quizzes
✍	Class Presentation / Discussion

Text Book(s):

1	Bhattacharya, D.K. &Poonam, T. *"Engineering Physics".*Oxford University Press, 2018.
2	Gaur, R.K. & Gupta, S.L. *"Engineering Physics".*DhanpatRai Publishers, 2018.
3	Raghavan, V. *"Physical Metallurgy: Principles and Practice"*. 3rd Edition, PHI Learning, 2019.

Reference Books(s) / Web links:

1	Balasubramaniam, R. *"Callister's Materials Science and Engineering".*Wiley India Pvt. Ltd., 2017
2	Resnick, R., Halliday, D., & Walker, J. *"Principles of Physics*", Wiley India Pvt., 2022.
3	Raghavan, V. *"Materials Science and Engineering : A First course"*. PHI Learning, 2019.
4	https://nptel.ac.in/courses/113104068
5	https://archive.nptel.ac.in/courses/115/105/115105099/

List of Equipment Available

S.No	Name of the equipment	Quantity Required	Quantity Available	Deficiency
1	Young's modulus by Non-Uniform bending method Travelling Microscope	8	13	-
2	Rigidity Modulus - Torsional Pendulum Setup	6	19	-
3	Wavelength of Laser and Characteristics -Laser source and grating plate	6	15	
4	Laser - angle of divergence and NA acceptance angle	6	8	-
5	Thermal conductivity of bad conductor- Lee's Disc setup	8	16	-
6	B-H curve Setup and CRO	6	7	-
7	LCR circuit kit	6	7	

8	Determination of permeability of free space- Helmholtz coil setup	5	5	
9	Solar cell parameters setup	6	8	-
10	Hall coefficient of Semiconductor Setup	4	4	-

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	1	1	-
CO 3	3	1	1	-	-	1	-	-	-	-	-	-	-	-	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	1	1	-	-	1	-	-	-	-	-	-	-	2	-
Average	3	2	-	-	-	-	-	-	-	-	-	-	1	-	-

Subject Code	Subject Name (Lab oriented Theory Courses)	Category	L	T	P	C
EE23133	BASIC ELECTRICAL AND ELECTRONICS ENGINEERING	ES	3	0	2	4

Objectives:

✍	To provide knowledge on the analysis of DC circuits.
✍	To provide knowledge on the analysis of AC circuits
✍	To expose the principles of electrical machines and electronic devices.
✍	To teach the concepts of different types of electrical measuring instruments and transducers.
✍	To experimentally analyze the electrical circuits and machines, electronic devices and transducers.

UNIT-I	DC CIRCUITS		9
	Electrical circuit elements (R, L and C), Voltage and current sources, Kirchhoff 's laws, Analysis of simple circuits with DC excitation, Superposition, Thevenin and Norton Theorems.		
UNIT-II	AC CIRCUITS		9
	Representation of sinusoidal waveforms, Power and Power factor, Analysis of single-phase AC circuits consisting of R, L, C, RL, RC, RLC combinations, Series resonance, Three phase balanced circuits		
UNIT-III	ELECTRICAL MACHINES		9
	Construction, Principles of operation of DC machines, Single phase Transformers, Synchronous machines, Single phase induction motors. (Qualitative Treatment Only).		
UNIT-IV	ELECTRONIC DEVICES & CIRCUITS		9
	Review of PN Junction diode – Forward and Reverse Bias – Bipolar Junction Transistor – Common Emitter characteristics – MOSFET - Introduction to operational Amplifier –Inverting and Non-Inverting Amplifier.		
UNIT-V	MEASUREMENTS & INSTRUMENTATION		9
	Introduction to transducers - Classification of Transducers: Resistive, Inductive, Capacitive, Piezoelectric, - Classification of instruments - PMMC and MI Ammeters and Voltmeters – Digital Storage Oscilloscope.		
		Contact Hours :	45

List of Experiments	
1	Verification of Kirchhoff's Laws.
2	Load test on DC Shunt Motor (Virtual Lab)
3	Load test on Single phase Transformer (Virtual Lab)
4	Load test on Single phase Induction motor (Virtual Lab)
5	Characteristics of P-N junction Diode.
6	Characteristics of CE based NPN Transistor.

| 7 | Characteristics of MOSFET |
| 8 | Characteristics of LVDT, RTD and Thermistor. |

	Contact Hours	:	30
	Total Contact Hours	:	75

Course Outcomes:

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

✍	analyse DC circuits and apply circuit theorems.
✍	calculate the power and power factor in AC circuits
✍	understand the principles of electrical machines.
✍	comprehend the principles of different types of electronic devices, electrical measuring instruments and transducers.
✍	experimentally analyze the electric circuits and machines, electronic devices, and transducers.

Suggested Activities

| ✍ | Problem solving sessions |

Suggested Evaluation Methods

| ✍ | Quizzes |
| ✍ | Class Presentation / Discussion |

Text Book(s):

1	J.B.Gupta, "Fundamentals of Electrical Engineering and Electronics" S.K.Kataria & Sons Publications, 2010.
2	Joseph A. Edminister, Mahmood, Nahri, "Electric Circuits" – Shaum Series and Systems", Schaum"s Outlines, Tata McGrawHill, Indian. 5th Edison , 2017
3	Thereja .B.L., "Fundamentals of Electrical Engineering and Electronics", S. Chand & Co. Ltd., 2008

Reference Books(s) / Web links:

1	Del Toro, "Electrical Engineering Fundamentals", Pearson Education, New Delhi, 2015
2	John Bird, "Electrical Circuit Theory and Technology", Elsevier, First Indian Edition, 2007
3	Allan S Moris, "Measurement and Instrumentation Principles", Elseveir, Third Edition, 2006
4	Rajendra Prasad, "Fundamentals of Electrical Engineering", Prentice Hall of India, Third Edition, 2014
5	A.E.Fitzgerald, David E Higginbotham and Arvin Grabel, "Basic Electrical Engineering", McGraw Hill Education(India) Private Limited, 2009
6	D P Kothari and I.J Nagarath, "Basic Electrical and Electronics Engineering", McGraw Hill Education(India) Private Limited, Third Reprint ,2016
7	https://nptel.ac.in/courses/108108076

Lab Equipment Required:

Sl. No.	Name of the Equipment	Quantity Required (For a batch of 30 students)
1.	**Verification of ohms and Kirchhoff"s Laws** 1. DC Regulated Power supply (0 - 30 V variable) 2. Bread Board 3. Resistors 4. Multimeter 5. Connecting wires	1 1 As per Circuit diagram 1 As Required
2.	**Load test on DC Shunt Motor.** 1. Ammeter MC (0-20A) 2. Voltmeter MC (0-300)V 3. Tachometer 4. Field Rheostat 500 Ω, 1.5 A 5. Connecting wires	1 1 1 1 As Required
3.	**Load Test on Induction Motor** 1. Ammeter MI (0-20A) 2. Voltmeter MI (0-300)V 3. Wattmeter – 300V, 30 A 4. Tachometer – Digital 5. Connecting Wires 6. Single phase Induction motor	1 1 1 1 As Required 1

4.	**Load test on Single phase Transformer**	
	1. Ammeter (0-30) A, (0-5) A	**1**
	2. Voltmeter (0-150)V, (0-300)V	**1**
	3. Wattmeter – 300V, 5A, UPF	**1**
	4. Autotransformer	**1**
	5. Single phase Transformer	**1**
	6. Connecting Wires	As Required
5.	**Characteristics of PN and Zener Diodes**	
	1. PN Diode (IN4007), Zener diode (6.8V, 1A)	1
	2. Resistor 1 KΩ, 100Ω	1
	3. Bread Board	1
	4. DC Regulated Power supply (0 - 30 V variable)	1
	5. Multimeter	1
	6. Connecting wires	As Required
6.	**Characteristics of BJT**	
	1. Transistor (BC107)	1
	2. Resistors- 1kΩ, 470KΩ, 1MΩ	1
	3. Bread Board	1
	4. DC Regulated Power supply (0 - 30 V variable)	1
	5. Multimeter	1
	6. Connecting wires	As Required
7	**Characteristics of MOSFET**	
	1. MOSFET (IRF510)	1
	2. Resistors- 100kΩ, 1kΩ	1
	3. Bread Board	1
	4. DC Regulated Power supply (0 - 30 V variable)	1
	5. Multimeter	1
	6. Connecting wires	As Required
7.	**Measurement of displacement of LVDT, RTD and Thermistor**	1
	1. LVDT Kit	1
	2. RTD	1
	3. Thermistor	1
	4. Multimeter	1

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3		3	1	1	2	1	1	1			
CO 2	3	3	3	3		3	1	1	2	1	1	1			
CO 3	3	3	3	3		3	1	1	2	1	1	1			
CO 4	3	3	3	3		3	1	1	2	1	1	1			
CO 5	3	3	3	3		3	1	1	2	1	1	1			
Average	**3**	**3**	**3**	**3**		**3**	**1**	**1**	**2**	**1**	**1**	**1**			

Subject Code	Subject Name	Category	L	T	P	C
GE23122	ENGINEERING PRACTICES - ELECTRICAL AND ELECTRONICS	ES	0	0	2	1

Objectives:

•	To provide hands-on experience on various basic engineering practices in Electrical Engineering.
•	To provide hands-on experience on various basic engineering practices in Electronics Engineering.

List of Experiments

A. ELECTRICAL ENGINEERING PRACTICE

1	Residential house wiring using switches, fuses, indicators, lamp and energy meter.
2	Fluorescent lamp wiring.
3	Stair case wiring.
4	Measurement of electrical quantities – voltage, current, power & power factor in RL circuit.
5	Measurement of earth resistance using Megger.
6	Study of Ceiling Fan and Iron Box

B. ELECTRONICS ENGINEERING PRACTICE

1	Study of electronic components and equipment – Resistor, colour coding, measurement of AC signal parameters (peak-peak, rms period, frequency) using CRO/DSO.
2	(a) Measurement of electrical quantities using Multimeter (b) Testing of electronic components.
3	Study of logic gates : AND, OR, EXOR and NOT.
4	Generation of Clock Signals.
5	Soldering practice – Components Devices and Circuits – Using general purpose PCB.
6	Measurement of ripple factor of Half-wave and Full-wave Rectifiers.

		Total Contact Hours	:	30

Course Outcomes:

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

•	fabricate the basic electrical circuits
•	implement the house wiring circuits
•	fabricate the electronic circuits
•	verify the truth table of logic gates
•	design the Half-wave and Full-wave Rectifiers using diodes and passive components

SUGGESTED EVALUATION METHODS

- Experiment based Viva

REFERENCE

1	Bawa H.S., "Workshop Practice", Tata McGraw – Hill Publishing Company Limited, 2007.
2	Jeyachandran K., Natarajan S. & Balasubramanian S., "A Primer on Engineering Practices Laboratory", Anuradha Publications, 2007.
3	Jeyapoovan T., Saravanapandian M. &Pranitha S., "Engineering Practices Lab Manual",Vikas Publishing House Pvt.Ltd, 2006.
4	Rajendra Prasad A. &Sarma P.M.M.S., "Workshop Practice", SreeSai Publication, 2002.

Lab Equipment Required:

S. No.	Name of the Equipment	Quantity Required
1	Residential house wiring using switches, fuse, indicator, lamp and energy meter.	3 Nos
2	Fluorescent lamp wiring.	3 Nos
3	Stair case wiring	3 Nos
4	Measurement of electrical quantities – voltage, current, power & power factor in RL circuit.	2 Nos
5	Study purpose items: Iron box, Ceiling fan.	2 each
6	Megger (250V/500V)	2 Nos.
7	Soldering guns	10 Nos.
8	Assorted electronic components for making circuits	50 Nos.
9	Small PCBs	10 Nos.
10	Multimeters	10 Nos.
11	Digital trainer kit	5 Nos.
12	CRO	8 Nos.
13	Transformer	8 Nos.
14	Function Generator	8 Nos.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	-	-	2	-	3	2	-	3			
CO 2	3	3	2	2	-	-	2	-	3	2	-	3			
CO 3	3	3	3	2	-	-	2	-	3	2	-	3			
CO 4	3	3	3	2	-	-		-	3	2	-	3			

CO 5	3	3	3	2	-	-		-	3	2	-	3		
Average	3	3	2.67	2	-	-	2	-	3	2	-	3		

Subject Code	Course Title (Theory Course)	Category	L	T	P	C
MC23111	Indian Constitution and Freedom Movement	MC	3	0	0	0

Objectives:
● To apprehend the sacrifices made by the freedom fighters.
● To inculcate the values enshrined in the Indian constitution.
● To instil a sense of responsibility as the citizens of India.
● To familiarise about the functions of the various levels of Government.
● To be informed about Constitutional and Non- Constitutional bodies.

UNIT-I	INDIAN FREEDOM MOVEMENT	9
	British Colonialism in India-Colonial administration till 1857- Revolt of 1857- Early Resistance to British Rule-Rise of Nationalism in India-**Indian Freedom Struggle under Mahatma Gandhi-**Non- Cooperation Movement-Civil Disobedience Movement- Quit India Movement-British Official response to National movement- Independence of India Act 1947-Freedom and Partition.	
UNIT-II	CONSTITUTION OF INDIA	9
	Historical Background – Indian Constitution: Constitution' meaning of the term, Sources and constitutional history, Constituent Assembly of India – Philosophical foundations of the Indian Constitution – Preamble – Fundamental Rights – Directive Principles of State Policy – Fundamental Duties – Citizenship – Constitutional Remedies for citizens.	
UNIT-III	STRUCTURE AND FUNCTIONS OF CENTRAL GOVERNMENT	9
	Union Government – Structure of the Union Government and Functions – President – Vice President – Prime Minister – Cabinet – Parliament – Supreme Court of India – Judicial Review.	
UNIT-IV	STRUCTURE AND FUNCTION OF STATE GOVERNMENT AND LOCAL BODY	9
	State Government – Structure and Functions – Governor – Chief Minister – Cabinet – State Legislature – Judicial System in States – High Courts and other Subordinate Courts- Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation, Pachayati Raj: Introduction, Elected officials and their roles, Village level: Role of Elected and Appointed officials.	
UNIT-V	CONSTITUTIONAL FUNCTIONS AND BODIES	9
	Indian Federal System – Centre – State Relations – President's Rule – Constitutional Functionaries – Assessment of working of the Parliamentary System in India- CAG, Election Commission, UPSC, GST Council and other Constitutional bodies-. NITI Aayog, Lokpal, National Development Council and other Non –Constitutional bodies.	

Total Contact Hours: 45

ourse Outcomes: Upon completion of the course, students will be able to:
● appreciate the sacrifices made by freedom fighters during freedom movement.
● be responsible citizens and abide by the rules of the Indian constitution.
● be aware of the functions of the Indian government.
● be knowledgeable about the functions of the state Government and the Local bodies.
● apply the knowledge on constitutional functions and role of constitutional bodies and non-constitutional bodies.

SUGGESTED ACTIVITIES

- Famous speeches from around the world relating to independence
- Case study
- Quiz on Portfolio and Cabinet
- Discussions on International Associations like the UN, BRICS, QUAD
- Presentation on issues around the world

SUGGESTED EVALUATION METHODS

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous assessments (CAT)

Text Book(s):
8. M. Laxmikanth , "Indian Polity:, McGraw-Hill, New Delhi.
9. Durga Das Basu, "Introduction to the Constitution of India ", Lexis Nexis, New Delhi. 21sted 2013.
10. P K Agarwal and K N Chaturvedi ,PrabhatPrakashan, New Delhi, 1sted , 2017.

Reference Books(s) / Web links:
1. Sharma, Brij Kishore, "Introduction to the Constitution of India:, Prentice Hall of India, New Delhi.
2. U.R.Gahai, "Indian Political System ", New Academic Publishing House, Jalaendhar
3. Bipan Chandra, India's Struggle for Independence, Penguin Books, 2016.
4. Maciver and Page, "Society: An Introduction Analysis ", Mac Milan India Ltd., New Delhi.2nded, 2014.
5. Bipan Chandra, History of Modern India, Orient Black Swan, 2009.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MC23111.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MC23111.2	-	-	-	-	-	-	-	-		-	-	-	-	-	-
MC23111.3	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-
MC23111.4	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
MC23111.5	-	-	-	-	-	1	-	1	1	-	-	-	-	-	-
AVERAGE	-	-	-	-	-	1	-	1	1	-	-	-	-	-	-

GE23217   **தமிழரும் தொழில்நுட்பமும்**   **L T P C**

                                                    1 0 0 1

அலகு I   **நெசவு மற்றும் பானைத் தொழில்நுட்பம்:**   **3**

சங்க காலத்தில் நெசவுத் தொழில் - பானைத் தொழில்நுட்பம் - கருப்பு சிவப்பு பாண்டங்கள் - பண்டங்களில் கீறல் குறியீடுகள்.

அலகு II   **வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம்:**   **3**

சங்க காலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் & சங்க காலத்தில் வீட்டுப்பொருட்களில் வடிவமைப்பு - சங்க காலத்தில் கட்டுமான பொருட்களும் நடுகல்லும் - சிலப்பதிகாரத்தில் மேடை அமைப்பு பற்றிய விவரங்கள் - மாமல்லபுரச் சிற்பங்களும், கோவில்களும் - சோழர் காலத்துப் பெருங்கோயில்கள் மற்றும் பிற வழிபாட்டுத் தலங்கள் - நாயக்கர் காலக் கோயில்கள் - மாதிரி கட்டமைப்புகள் பற்றி அறிதல், மதுரை மீனாட்சி அம்மன் ஆலயம் மற்றும் திருமலை நாயக்கர் மஹால் - செட்டிநாடு வீடுகள் - பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோ - சாரோசெனிக் கட்டிடக் கலை.

அலகு III   **உற்பத்தித் தொழில் நுட்பம்:**   **3**

கப்பல் கட்டும் கலை - உலோகவியல் - இரும்புத் தொழிற்சாலை - இரும்பை உருக்குதல், எஃகு - வரலாற்றுச் சான்றுகளாக செம்பு மற்றும் தங்க நாணயங்கள் - நாணயங்கள் அச்சடித்தல் - மணி உருவாக்கும் தொழிற்சாலைகள் - கல்மணிகள், கண்ணாடி மணிகள் - சுடுமண் மணிகள் - சங்கு மணிகள் - எலும்புத்துண்டுகள் - தொல்லியல் சான்றுகள் - சிலப்பதிகாரத்தில் மணிகளின் வகைகள்.

அலகு IV   **வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில் நுட்பம்:**   **3**

அணை, ஏரி, குளங்கள், மதகு - சோழர்காலக் குமுழித் தூம்பின் முக்கியத்துவம் - கால்நடை பராமரிப்பு - கல்நடைகளுக்காக வடிவமைக்கப்பட்ட கிணறுகள் - வேளாண்மை மற்றும் வேளாண்மைச் சார்ந்த செயல்பாடுகள் - கடல்சார் அறிவு - மீன்வளம் - முத்து மற்றும் முத்துக்குளித்தல் - பெருங்கடல் குறித்த பண்டைய அறிவு - அறிவுசார் சமூகம்.

அலகு V   **அறிவியல் தமிழ் மற்றும் கணித்தமிழ் :**   **3**

அறிவியல் தமிழின் வளர்ச்சி - கணித்தமிழ் வளர்ச்சி - தமிழ் நூல்களை மின்பதிப்பு செய்தல் - தமிழ் மென்பொருட்கள் உருவாக்கம் - தமிழ் இணையக் கல்விக்கழகம் - தமிழ் மின் நூலகம் - இணையத்தில் தமிழ் அகராதிகள் - சொற்குவைத் திட்டம்.

                                                    TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு - மக்களும் பண்பாடும் - கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் - முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி - வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை - ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr. K. K. Pillay) A joint publication of TNTB & ESC and RMRL – (in print)

6. Social Life of the Tamils – The Classical Period (Dr. S. Singaravelu)(Published by: International Institute of Tamil Studies.

7. Historical Heritage of the Tamils (Dr. S. V. Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).

8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies).

9. Keeladi – 'Sangam City Civilization on the banks of river Vaigai' (Jointly Published by: Department of archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)

10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)

11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)

12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

III SEMESTER

Course Code	Course Title	Category	L	T	P	C
MA23311	TRANSFORMS AND APPLIED PARTIAL DIFFERENTIAL EQUATIONS	BS	3	1	0	4
	Common to III sem. B.E. - AERO, MCT, R&A and B.Tech. – BT, FT and CHEM					

Objectives:
● To express Fourier series to study the behaviour of periodic functions and their applications in system communications, digital signal processing and field theory.
● To show continuous function arising in wave and heat propagation, signals and systems using Fourier Transforms.
● To obtain solution of one dimensional wave equation with finite difference techniques.
● To solve one and two dimensional heat flow equations using finite difference methods and numerical techniques.
● To make use of Z-transform to illustrate discrete function arising in wave and heat propagation, signals and systems.

UNIT-I	FOURIER SERIES		12
Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series – Half range cosine series –Parseval's identity – Harmonic analysis.			
UNIT-II	FOURIER TRANSFORMS		12
Statement of Fourier integral theorem – Fourier transform pair – Fourier sine and cosine transforms – Properties – Transforms of simple functions – Convolution theorem – Parseval's identity - Application to boundary value problems.			
UNIT-III	WAVE EQUATION		12
Solution of one dimensional wave equation - Finite difference techniques for the solution for PDE- One Dimensional Wave Equation by Explicit method			
UNIT-IV	HEAT EQUATION		12
One dimensional equation of heat conduction – Steady state solution of two dimensional equation of heat conduction (excluding insulated edges)- Numerical computation :One dimensional heat flow equation by implicit and explicit methods			
UNIT-V	Z-TRANSFORMS		12
Z- transforms - Elementary properties – Inverse Z - transform (using residues) - Formation of difference equations – Solution of difference equations using Z- transform.			
		Total Contact Hours: 60	

Course Outcomes:
On completion of the course, students will be able to
● Demonstrate Fourier series to study the behaviour of periodic functions and their applications in engineering problems such as system communications, digital signal processing and field theory.
● Apply the shifting theorems, Fourier integral theorems, Inverse Fourier sine and cosine transforms appropriate problems in engineering and technology.
● Evaluate solution of one dimensional wave equation arising in various field of engineering using finite difference techniques.
● Apply the numerical techniques of differentiation to solution of heat flow equations arising in various branches of engineering.
● Use Z-transform to illustrate discrete function arising in wave and heat propagation, signals and systems.

Text Books:
1	Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India, 2015.

2	Veerarajan. T., "Transforms and Partial Differential Equations", Tata McGraw Hill Education Pvt.Ltd.,New Delhi, Second reprint, 2012.
3	Grewal B.S., "Higher Engineering Mathematics", 43rd Edition, Khanna Publishers, Delhi, 2014.
4	Ramana B.V., "Higher Engineering Mathematics", Tata McGraw Hill Publishing Company Limited, New Delhi, 2008.
5	P. Kandasamy, K. Gunavathy, Thilagavathy., "Engineering Mathematics Transforms and Partial Differential Equations", S.Chand & Company, 2002.

Reference Books / Web links:	
1	N. Subramaniam, K. S. Ramaswami ., "Transforms and Partial Differential Equations", Pearson Education, 2018.
2	Glyn James, "Advanced Modern Engineering Mathematics", 3rd Edition, Pearson Education, 2007.
3	Ray Wylie C and Barrett.L.C, "Advanced Engineering Mathematics" Tata McGraw Hill Education Pvt Ltd, Sixth Edition, New Delhi, 2012.
4	Bali N., Goyal M. and Watkins C., "Advanced Engineering Mathematics", Firewall Media (An imprint of Lakshmi Publications Pvt., Ltd.,), 7th Edition, New Delhi, 2009.
5	Peter V.O'Neil, "Advanced Engineering Mathematics", Cengage Learning India Pvt., Ltd, 7 th Edition, New Delhi, 2012. https://drspmaths.files.wordpress.com/2020/01/advanced-engineering-mathematics-peter-v.-o-neil.pdf

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MA23311.1	3	3	3	2	1	-	-	-	-	-	-	1	2	1	2
MA23311.2	3	3	3	2	1	-	-	-	-	-	-	1	2	1	2
MA23311.3	3	3	3	3	2	-	-	-	-	-	-	2	1	2	2
MA23311.4	3	3	2	3	2	-	-	-	-	-	-	2	1	-	1
MA23311.5	2	3	2	-	-	-	-	-	-	-	-	-	1	1	-
Average	2.8	3	2.6	2.5	1.5	-	-	-	-	-	-	1.5	1.2	1	2

Subject Code	Subject Name (Theory Laboratory embedded course)	Category	L	T	P	C
CY23334	**PHYSICAL AND ORGANIC CHEMISTRY**	BS	3	0	2	4

Objectives:

- To develop an understanding of the basic concepts of phase rule and its applications
- To acquire knowledge on distribution law and its applications
- To get familiarized with various industrial polymers.
- To learn about preparations and uses of synthetic intermediates.
- To impart knowledge on different types of drugs

	UNIT-I	PHASE RULE	9
	Phase rule - introduction, definition of terms - phase, components and degree of freedom -phase diagram- one component system(water system) - reduced phase rule - thermal analysis and cooling curves - two component systems - lead-silver system-pattinson process- compound formation with congruent melting – Mg- Zn system - vapour pressure curves and its significance.		
	UNIT-II	THE DISTRIBUTION LAW	9
	Distribution co-efficient - Distribution Law - conditions for the validity of the distribution law - I_2-CCl_4-H_2O system - nature of interaction of the solute with one of the solvents - dissociation - association - applications of distribution law and problems– Extraction process- Single and multiple- solvent		

	extraction - principle and process - batch extraction - continuous extraction.	
UNIT III	**INDUSTRIAL POLYMERS**	**9**
	Polymerisation-Methods of polymerisation (bulk polymerisation-solution polymerisation-suspension polymerisation-emulsion polymerisation)-Preparation, properties and applications of polyethylene,Teflon,PMMA,Polystytene, epoxy resins, phenol formaldehyde resins and synthetic rubbers.	
UNIT IV	**PREPARATION OF SYNTHETIC INTERMEDIATES**	**9**
	Preparations of Benzil from benzyl aldehydes - Furyl from furfural, Vannilin from catechol through guaiacol, Gramine from indole, N-actetyl-5- bromo indoline from indole, Salol from phenol, Alanine from propionic acid, Heteroauxin from indole - Uses, Reaction and mechanism of acyloin condensation, Baeyer-Villigar reaction, Gabriel's synthesis of phthalimide, Bartoli Indole synthesis	
UNIT V	**PHARMACEUTICAL CHEMISTRY**	**9**
	Drugs- Classification-based on origin and application – drug action-synthesis and mode of action of Antipyretics-Paracetamol, Anti-inflammatory drugs-Ibuprofen antibiotics-chloroamphenicol, antimalarial drugs-Chloroquine, antibacterial drugs-sulphonamide, anticancer drugs -Cis-platin.	
	Total Contact Hours:45	

Description of the Experiments	**Total Contact Hours:15**
13. A study of the association of benzoic acid in benzene	
14. Determination cryoscopic constant by Rast method	
15. Determination molecular weight by Rast method	
16. Estimation of critical solution temperature of Phenol-Water System.	
17. Determination of equilibrium constant	
18. Study of simple eutectic formed by naphthalene-biphenyl system.	
7. Determination of order of a reaction (iodination of acetone)	
8. Effect of impurity on the CST of phenol-water system	
9. Study of inversion of cane sugar by Polarimetry.	
10. Determination of acid value of oils	

Course Outcomes: At the end of the course the student will be able to:
● apply the concept of phase rule in single and multi-component systems
● associate distribution law in extraction processes
● Process the polymers by various techniques
● Develop a synthetic intermediate for an organic compound at larger scale
● be capable of synthesizing drugs.

Reference Books(s)
1. Peter Atkins, Julia de Paula, Physical Chemistry, 9th Edition, Oxford University Press.
2. K.S. Tiwari, N.K. Vishnoi and S.N. Malhotra "A text book of Organic Chemistry" fourth

Edition, Vikas Publishing House Pvt. Ltd. (2017) New Delhi.
3. R.T. Morrison and R.N. Boyd "Organic Chemistry" VII Edition Prentice Hall Inc (2010) USA.

Lab equipment required:

S. No	Name of the Equipment	Quantity Required
1.	Electrical shaker	3
2.	Polarimeter	2
3	Hot plate	4
4	Freezer	1

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1			1			1		1	1	1	
CO2	3	3	1	1			1			1	1	2	1		
CO3	3	3	1	1		1	1					1	1	1	
CO4	3	3	3	1		1	1	1		1	1	1	1	1	
CO5	3	3	3	1		1	1	1		1	1	1	1	1	
AVG.	3	3	1.8	1		1	1	1		1	1	1	1	1	

Course Code	Course Title	Category	L	T	P	C
CH23311	**SOLID MECHANICS**	ES	2	1	0	3

OBJECTIVE:

- To understand the theory of elasticity including strain/displacement and Hooke's law relationships.
- To solve for stresses and deflections of beams under unsymmetrical loading.
- To obtain stresses and deflections of beams on elastic foundations.
- To solve torsion problems in bars thin walled members.
- To obtain solutions to column buckling and plate problems.

UNIT I   STRESS, STRAIN AND DEFORMATION OF SOLIDS   9
Rigid bodies and deformable solids – forces on solids and supports – equilibrium and stability – strength and stiffness – tension, compression and shear stresses – Hooke's law and simple problems – compound bars – thermal stresses – elastic constants and Poisson's ratio – welded joints – design.

UNIT II   TRANSVERSE LOADING ON BEAMS   9
Beams – support conditions – types of Beams – transverse loading on beams – shear force and bending moment in beams – analysis of cantilevers, simply – supported beams and over hanging beams – relationships between loading, S.F. and B.M. In beams and their applications – S.F.& B.M. diagrams.

UNIT III   DEFLECTIONS OF BEAMS   9
Double integration method – Macaulay's method – Area – moment theorems for computation of slopes and deflections in beams – conjugate beam method.

UNIT IV   STRESSES IN BEAMS   9
Theory of simple bending – assumptions and derivation of bending equation (M/I = F/Y = E/R) – analysis of stresses in beams – loads carrying capacity of beams – proportioning beam sections – leaf springs – flitched beams – shear stress distribution in beams – determination of shear stress in flanged beams.

UNIT V   TORSION AND COLUMNS   9
Torsion of circular shafts – derivation of torsion equation (T/J = C/R = G0/L) – stress and deformation in circular and hollow shafts – stresses and deformation in circular and hollow shafts – stepped shafts – shafts fixed at both ends – stresses in helical springs – deflection of springs – spring constant- Axially loaded short columns – Euler's theory of long columns.

                                                            TOTAL : 45 PERIODS

OUTCOMES:
On completion of this course, the students

- Will be able to determine stress, strain and elasticity with all its prerequisites.

- Will be able to design of beams.

- Will be able to design pipelines and storage tanks.

- Will be able to develop skills on designing reaction columns.

- Will be able to perform the design analysis of support column.

TEXT BOOKS:
1. Junarkar, S.B., Mechanics of Structure Vol. 1, 21st Edition, Character Publishing House, Anand, Indian, (1995)
2. William A.Nash, Theory and Problems of Strength of Materials, Schaum's Outline Series. McGraw Hill International Editions, Third Edition, 1994.

REFERENCE:
1. Rajput.R.K., A text book of Strength of Materials, S.Chand Publications, 2022.
2. Bansal, R.K., Strength of Materials, 6th Edition, Lakshmi Publications (P) Ltd, New Delhi, (2012).

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	2	2	1	1	-	-	1	-	2	1	1	1	1
CO 2	3	3	2	2	1	1	1	-	1	1	1	1	2	2	1
CO 3	3	3	3	3	1	1	-	-	1	-	2	1	2	2	1
CO 4	3	3	2	2	1	1	1	-	1	-	1	1	2	2	1
CO 5	3	3	2	2	1	1	-	-	1	-	2	1	2	2	1

3 –SUBSTANTIAL (HIGH)   2 – MODERATE (MEDIUM)   1 – SLIGHT (LOW)

Course Code	Course Title	Category	L	T	P	C
CH23312	**CHEMICAL PROCESS CALCULATIONS**	PC	2	1	0	3

UNIT 1 - Introduction to Basic Concepts

Units and dimensions – conversion factors – mole concept –normality, molarity, and molality – density and specific gravity – methods of expressing composition of mixtures and solutions – weight fraction – mole fraction –volumetric composition – Ideal gases – Dalton's law – Amagat's law – Humidity.   **(9)**

UNIT 2 - Material Balance without Chemical Reaction

General material balance equation for steady and unsteady state - steady state material balances in distillation – absorption – extraction – crystallization – evaporator – mixer – dryer - Recycle and bypass
(9)

UNIT 3 - Material Balance with Chemical Reaction

Stoichiometric equation – stoichiometric ratio – limiting reactant – excess reactant – percentage excess reactants – conversion – yield – selectivity – material balance for single and multiple chemical reactions.
                                                                                                                                    (9)

UNIT 4 - Energy balance

General steady state energy balance equation, heat capacity, enthalpy, heat of formation, heat of reaction, heat of combustion and Calorific values. Heat of solution, heat of mixing, heat of crystallization, determination of ΔHR from standard heat of formation and standard heat of combustion – Hess's law.   **(9)**

UNIT 5 - Fuels and Combustion

Fuels, Calorific value of fuels, flue gas analysis, Orsat analysis, air/ fuel ratio calculations - theoretical and excess air requirement for solid, liquid and gaseous fuels.   **(9)**

Course Objectives

1. Understand units and conversion, composition of mixtures and humidity calculations.
2. Carry out material balance for unit operations
3. Carry out product analysis for material balance with chemical reactions
4. Estimate the enthalpy change for reactions
5. Carry out combustion calculations

Course Outcomes

1. Apply mole concepts to express the composition of mixtures
2. Apply material balance for industrial processes
3. Apply material balance with chemical reactions for industrial processes
4. Apply energy balance for industrial processes
5. Solve combustion calculations of reactions.

TEXT BOOKS:

1. Himmelblau, D.M., "Basic Principles and Calculations in Chemical Engineering", 8th Edition, Prentice Hall Inc., 2014.

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	2	2	2	1	-	-	1	-	1	1	3	1	1
CO 2	3	3	3	3	2	1	-	-	1	-	1	1	3	1	1
CO 3	3	3	3	3	2	1	-	-	1	-	1	1	3	1	1
CO 4	3	3	3	3	2	1	-	-	1	-	1	1	3	1	1
CO 5	3	3	3	3	2	1	1	-	1	-	1	1	3	1	1

2. Bhatt, B.I., and Thakore, S.B., "Stoichiometry ", 5th Edition, McGraw-Hill, 2017

3. K.V. Narayanan and B. Lakshmi Kutty," Stoichiometry and Process Calculation", 2nd Edition, PHI Learning Ltd. (2016).

REFERENCES:

1. Hougen O A, Watson K M and Ragatz R A, "Chemical Process Principles Part I: Material and Energy Balance", 2nd Edition, CBS publishers, 2004.

Course Code	Course Title	Category	L	T	P	C
CH23313	**CHEMICAL PROCESS INDUSTRIES**	PC	3	0	0	3

OBJECTIVE:

- To learn about the production of numerous chemicals found in everyday products.
- To comprehend the numerous unit processes and unit operations, as well as the sequence involved in diverse chemical businesses.
- To outline the components, present in chemical process industries and design the chemical process plant.
- To give an exposure on aspects of safety for various chemical industries.
- To impart knowledge on fertilizer, polymers and fermentation industry

UNIT I   INTRODUCTION AND CHLORO- ALKALI INDUSTRIES   9

The role of a chemical engineers in process industries, Introduction to common devices used in manufacturing processes, block diagrams, flowcharts and standard symbols used for devices, industrial safety and pollution, outline of plant and equipment design. Manufacture of Soda ash and sodium bi carbonate, chlorine and caustic soda; bleaching powder and related bleaching agents, Sodium chloride, By-products of common salt industry.

UNIT II   ACID INDUSTRIES   9

Mining and manufacture of sulphur, recovery of sulphur from polluting gases, sulphur trioxide and sulphuric acid, hydrochloric acid, synthetic ammonia, nitric acid, phosphoric acid

UNIT III   SILICATE, PAPER AND SUGAR INDUSTRIES   9

Types and manufacture of Portland cement, manufacture of glasses and special glasses, ceramics and refractories, manufacture of pulp – different processes of pulping – manufacture of paper – manufacture of boards- raw and refined sugar, by products of sugar industries, Starch and starch derivatives.

UNIT IV   OIL AND FIBRE INDUSTRIES   9

Hydrogenation of oils, fatty acids: soaps, synthetic detergents- manufacture of Nylon 6. 6. Polyesters fibres – manufacturer of – cellulosic fibres – viscose rayon production manufacture of films - cellulose acetate, PVC, polyesters - polyethylene

UNIT V   FERTILIZER INDUSTRIES   9

NPK and functions, ammonium sulphate, ammonium nitrate, ammonium phosphate, potassium chloride, potassium sulphate, single, triple super phosphate introduction to pesticides, herbicides and bio- fertilizers.

TOTAL : 45 PERIODS

COURSE OUTCOME:

At the end of the course the students

CO 1	Ability to understand the manufacturing of various inorganic and organic chemicals
CO 2	Ability to understand the process flow diagram and various process parameters
CO 3	Ability to identify engineering problems during production of sugar
CO 4	Will be able to outline the components present in various oil & fibre industries
CO 5	Will have an understanding on manufacturing fertilizers

MAPPING OF PO'S with Course Outcome:

CO	PO/PSO														
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
I	3	3	2	2	3	3	2	2	2	1	1	3	3	3	2
II	3	3	2	2	3	3	3	2	2	1	1	2	3	2	2
III	3	3	2	2	3	3	2	2	2	1	1	2	3	2	2
IV	3	3	2	2	3	3	2	2	2	2	1	2	3	2	2
V	3	3	2	2	3	3	2	2	2	1	1	2	3	2	2

TEXT BOOKS:

1. Austin, G.T., Shreve's Chemical Process Industries, Fifth Edition, McGraw-Hill International Book Co, Singapore, 2017
2. Dryden, C.E., Outlines of Chemicals Technology, Edited and Revised by Gopala Rao, M. and M. Sittig, third Edition, Affiliated East-West press,1997.

REFERENCES:

1. Shukla and G.N. Pandey "Text book on Chemical Technology", Vikas Publishing company 1997
2. Kirk and Othmer ,"Encyclopedia of Chemical Technology", III Edition,2001.
3. Srikumar Koyikkal,"Chemical Process Technology and Simulation", PHI Learning Ltd (2013).

Course Code	Course Title	Category	L	T	P	C
CH23331	**FLUID MECHANICS FOR CHEMICAL ENGINEERS**	PC	3	0	1	4

OBJECTIVE:

- ❖ To impart knowledge on fluid properties
- ❖ To explain the concepts of fluid static characteristics and their applications
- ❖ To explain the concepts of fluid at motion and its applications
- ❖ To explain the principles of dimensional analysis and its application
- ❖ To explain the principle of various instruments used to measure fluid properties

UNIT I   BASICS OF FLUID MECHANICS   9

Methods of analysis and description - fluid as a continuum – Velocity and stress field - Newtonian and non-Newtonian fluids – Classification of fluid motion – Reynold's transport theorem.

UNIT II   FLUID STATICS, KINEMATICS AND DYNAMICS   12

Fluid statics – basic equation - equilibrium of fluid element – pressure variation in a static fluid - application to manometer– Differential analysis of fluid motion – continuity equation of motion, Bernoulli equation and Navier- Stokes equation - basic of CFD modeling.

UNIT III   DIMENSIONAL ANALYSIS   12

The principle of dimensional homogeneity – dimensional analysis, Rayleigh method, and the Pi-theorem

- non-dimensional action of the basic equations -similitude - relationship between dimensional analysis and similitude - use of dimensional analysis for scale up studies

UNIT IV   FLOW THROUGH PIPES   15

Reynolds number regimes, internal flow - flow through pipes – pressure drop under laminar and turbulent flow conditions – major and minor losses; Line sizing; External flows - boundary layer concepts, boundary layer thickness under laminar and turbulent flow conditions- Flow over a sphere – friction and pressure drag - flow through fixed and fluidized beds.

UNIT V   FLOW MEASUREMENT, VALVES AND PUMPS   12

Flow measurement - Constant and variable head meters; Velocity measurement techniques; Types, characteristics, and sizing of valves; Classification, performance characteristics, and sizing of pumps, compressors, and fans

TOTAL: 60 PERIODS

TEXTBOOKS:

1. Noel de Nevers, "Fluid Mechanics for Chemical Engineers ", Third Edition, McGraw-Hill, (2017).
2. McCabe W.L, Smith, J C, and Harriot. P "Unit Operations in Chemical Engineering", McGraw Hill, VII

Edition, 2017.
3. Munson, B. R., Young, D.F., Okiishi, T.H. "Fundamentals of Fluid Mechanics", 9th Edition", John Wiley, 2021.

REFERENCES:

1. White, F.M., "Fluid Mechanics ", IV Edition, McGraw-Hill Inc., 1999.
2. James O Wilkes and Stacy G Bike, "Fluid Mechanics for Chemical Engineers' Prentice Hall PTR (International Series in Chemical Engineering) (1999).

COURSE OUTCOME: At the end of the course the students

CO 1	Can identify and obtain the values of fluid properties and understand the principles of continuity and the energy equation for fluid flow.
CO 2	Will be able to apply the principles of dimensional homogeneity
CO 3	Can understand various fluid flow phenomena under various conditions and understand theories of flow measurement equipment, pumps, and valves.
CO 4	Ability to estimate frictional losses in fluid flow and predict the coefficient of discharge for flow through pipes.
CO 5	Ability to experiment with flow measurement devices like venturi-meter and orifice meter

MAPPING OF PO'S with Course Outcome:

CO	PO/PSO														
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
I	3	3	2	2	2	-	1	-	2	1	1	3	3	2	1
II	3	3	3	3	3	-	2	-	2	1	1	2	3	2	1
III	3	3	3	1	2	-	1	-	2	1	1	3	3	3	3
IV	3	3	3	2	3	-	1	-	3	3	2	2	3	2	2
V	3	3	3	2	3	-	2	-	3	3	2	3	3	1	1

List of the Experiments

1. Calibration of Rotameter
2. Determine The Coefficient of Discharge for Venturi Meter
3. Determine The Coefficient of Discharge for Orifice Meter
4. Friction Losses in Fluid Flow in Pipes
5. Minor Losses in A Pipe
6. Determination of Viscosity of Oil by 'Redwood Viscometer
7. Determination of Viscosity of Oil by 'Ostwald Viscometer
8. Characteristics Studies of a Centrifugal Pump
9. Pressure Drop Studies in Packed Bed
10. Pressure Drop Studies in Fluidized Bed
11. Drag Coefficient of Solid Particle
12. Helical Coil

IV SEMESTER

Course Code	Course Title	Category	L	T	P	C
MA23431	**PROBABILITY, STATISTICS AND RELIABILITY**	BS	3	0	2	4
	Common to IV sem. B.Tech. - BT, FT and CHEM					

Objectives:

- To introduce the basic concepts of probability, one dimensional random variables.

- To solve the problems those are faced in testing of a hypothesis with reference to the errors in decision making.

- To analyse the different mathematical models with the help of statistical deigns and appropriate data and made valuable conclusions by proper evaluation.

- To explain the concepts of quality control in industry and to apply various tools to examine the quality of a process and product.

- To analyse statistical experiments leading to reliability modelling and to identify reliability testing components for assessment of reliability in engineering design.

UNIT-I	**PROBABILITY**	9
	One dimensional Discrete and continuous random variables – Moments – Moment generating functions – Binomial, Poisson, Uniform and Normal distributions, Two dimensional Discrete and continuous random variables – Conditional and Marginal densities.	
UNIT-II	**STATISTICAL TESTING**	9
	Maximal Likelihood estimation – Parameters of Binomial and Poisson distribution - Tests of significance – Z test: Single mean, difference of means- Chi square - F test.	
UNIT-III	**ANOVA**	9
	Design of Experiments - Completely randomized design – Randomized block design –Latin square design.	
UNIT-IV	**STATISTICAL QUALITY CONTROL**	9
	Control charts for measurements (X and R charts) – Control charts for attributes (p, c and np charts) – Tolerance limits - Acceptance sampling	
UNIT-V	**RELIABLITY**	9
	Reliability Concepts: Reliability definitions, Importance of Reliability, Quality Assurance and Reliability, Bath Tub Curve - Failure Data Analysis: Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTBF, Reliability Functions - Reliability Hazard Models: Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate, Weibull Model- Distribution functions and reliability analysis.	
	Total Contact Hours: 45	

S.No	List of Experiment (using R Software)	Total Contact Hours: 30
1	Basic Functions in R and plotting	
2	Mathematical functions in R – Integration	
3	Control flow – Loops in R	
4	Probability Distributions using R- PDF, CDF for Binomial, Poisson, Exponential, Uniform and Normal Distributions.	
5	Testing of Hypothesis – Z testing	
6	Testing of Hypothesis – F and chi square testing	
7	ANOVA – one way and two way	
8	Statistical quality control – p, np , c, X charts	
9	Reliability – MTTF, MTBF	

10	Reading , Writing data in R and working with inbuilt data sets in R

Course Outcomes:

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

- Have the critical thinking in the theory of probability and its applications in real life problems.
- Apply the different testing tools like t-test, F-test, chi-square test to analyse the relevant real life problems.
- Analyse the different mathematical models with the help of statistical deigns and appropriate data and made valuable conclusions by proper evaluation.
- Use various tools to examine the quality of a process and product in engineering and technology.
- Illustrate the basic concepts and techniques of modern reliability engineering tools.

Text Book(s):

1.	Veerarajan T, 'Probability, Statistics and Random Processes with Queueing Theory and Queueing Networks'.
2.	McGraw Hill, 2016. 2 Johnson R.A. and Gupta. C.B., "Miller and Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 7th Edition, 2007.
3.	Srinath. L.S., "Reliability Engineering", Affiliated East west press, 1991.
4.	Kandasamy P., Thilagavathi and K. Gunavathi., "Statistics and Numerical Methods", S. Chand & Company Ltd. (2010).

Reference Books(s) / Web links:

1.	Jhon wiley& Sons .Erwin Kreyszig., "Advanced Engineering Mathematics", Pearson Education, Asia, 7th Edition, 2007.
2.	Ramana. B.V., "Higher Engineering Mathematics ", McGraw Hill Education Pvt. Ltd, New Delhi, 2016.
3.	Gupta. R.C, "Statistical Quality control", Khanna Publishers, 1997
4.	Douglas.C. Montgomery, "Introduction to Statistical quality control", 7th edition, John Wiley 2012.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MA23431.1	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
MA23431.2	2	2	1		-	-	-	-	-	-	-	1	-	1	1
MA23431.3	2	2	-	2	-	-	-	-	-	-	-	1	-	1	1
MA23431.4	2	2	2	2	-	-	-	-	-	-	-	1	-	1	1
MA23431.5	2	2	2	1	-	-	-	-	-	-	-	1	-	1	1
Average	2	2	1.6	1.5	-	-	-	-	-	-	-	1	-	1	1

Course Code	Course Title	Category	L	T	P	C
CH23411	**THERMODYNAMICS**	PC	3	0	0	3

OBJECTIVES

- To train the students for the familiarization of heat and work transfer calculation by applying the basic principles.
- To develop knowledge on selecting an equation of state for representing PVT behavior of fluids
- To impart knowledge on first law and second law of thermodynamics in chemical processes mainly refrigeration processes.
- To train the students to understand the different kind of thermodynamic property relationships
- To train the students for the familiarization of single stage and multistage compression process

UNIT I   FUNDAMENTAL CONCEPTS   6

Scope of thermodynamics; Definition of system, control volume, state and path function, equilibrium, reversibility, energy, work and heat. zeroth law; temperature scales.

UNIT II   PVT RELATIONSHIPS   7

PVT behavior of fluids; Mathematical representation of PVT behavior; Generalized compressibility factor correlation; Generalized equations of state.

UNIT III   LAWS OF THERMODYNAMICS   12

Joule's experiment, internal energy, first law, energy balance for closed systems, mass and energy balance for open systems 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, Refrigeration, vapor compression and vapor absorption cycle.

UNIT IV   THERMODYNAMIC REALTIONSHIPS   12

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.

UNIT V   APPLICATIONS   8

Duct flow of compressible fluids, Compression and expansion processes, steam power plant, internal combustion engines, jet and rocket engines.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students would be able to

- Identify the difference between heat and work, isentropic and isenthalpic processes
- Use equation of state, correlation to predict the PVT data
- Analyze the process with respect to first and second law of thermodynamics and understand

entropy of the system

- Understand interrelationship of properties and their calculations

- Understand the purpose of inter cooling in multistage compressors

TEXT BOOKS:

1. Smith, J.M., Van Ness, H.C and Abbot M.M "Introduction to Chemical Engineering Thermodynamics ", McGraw Hill Publishers, VIII Edition, 2019.
2. Rao, Y.V.C., "Chemical Engineering Thermodynamics" Universities Press, 2009.
3. Narayanan, K.V. A Textbook of Chemical Engineering Thermodynamics, Prentice Hall India, II Edition, 2013.
4. Milo D. Koretsky, Engineering and Chemical Thermodynamics, Wiley Publishers, 2009.

REFERENCES:

1. Kyle, B.G., "Chemical and Process Thermodynamics III Edition", Prentice Hall of India Pvt. Ltd., 1999.
2. Pradeep Ahuja," Chemical Engineering Thermodynamics", PHI Learning Ltd, (2009).
3. Gopinath Halder," Introduction to Chemical Engineering Thermodynamics", PHI Learning Ltd (2009).
4. Yunus A. Cengel, Michael A. Boles , Mehmet Kanoglu, Thermodynamics - An Engineering Approach , McGraw Hill Publishers, 9th Edition, 2019

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	2	2	1	1	1	-	1	-	2	1	3	1	1
CO 2	3	3	2	2	1	1	-	-	1	-	1	1	3	2	1
CO 3	3	3	3	3	1	1	1	-	1	-	2	1	2	3	1
CO 4	3	3	2	2	1	1	-	-	1	-	1	1	2	3	1
CO 5	3	3	2	2	1	1	1	-	1	-	2	1	2	2	2

3 –SUBSTANTIAL (HIGH)   2 – MODERATE (MEDIUM) 1 – SLIGHT (LOW)

Course Code	Course Title	Category	L	T	P	C
CH23412	**HEAT TRANSFER**	**PC**	**3**	**0**	**0**	**3**

OBJECTIVE:

- To learn steady-state and unsteady-sate heat conduction involved in unit operations.

- To understand the mechanism of heat transfer by convection in different geometry

- To be exposed to the principles of boiling and condensation heat transfer

- To understand concepts of exchange of radiation between bodies

- To design heat transfer equipment such as Shell & Tube Heat exchangers, evaporators etc.

UNIT I   CONDUCTION HEAT TRANSFER   9

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 - Furnace concept

Refractory and Insulation-Thermal conductivity measurement; effect of temperature on thermal conductivity; Heat transfer in extended surfaces, Unsteady state heat conduction – flat plate and cylinder.

UNIT II   CONVECTION HEAT TRANSFER   9
Concepts of heat transfer by convection - Natural and forced convection, analogies between the transfer of momentum and heat - Reynold's analogy, Prandtl and Colburn's analogy. Dimensional analysis in heat transfer, heat transfer coefficient for flow through a pipe and flow over a flat plate.

UNIT III   HEAT TRANSFER WITH PHASE CHANGE   9
Heat transfer to fluids with phase change - heat transfer from condensing vapors, drop-wise and film-wise condensation, Nusselt equation for vertical and horizontal tubes, condensation of superheated vapors, Heat transfer to boiling liquids - mechanism of boiling, nucleate boiling, and film boiling.

UNIT IV   RADIATION   9
Radiation heat transfer - Black body radiation, Emissivity, Stefan - Boltzmann law, Plank's law, radiation between surfaces

UNIT V   HEAT EXCHANGERS   9
Heat exchangers-types of heat exchangers; plate heat exchangers; use of correction factor charts; heat exchangers effectiveness; the number of transfer units - Chart for different configurations - Fouling factors- Heat exchanger networks and pinch technology. Evaporation-Theory of evaporation - single effect and multiple effect evaporation

TOTAL: 45 PERIODS

COURSE OUTCOME:

- Ability to understand steady-state and unsteady-state heat conduction and solve related problems
- Ability to understand the mechanism of heat transfer by convection in different geometry
- Will be able to understand the concepts of heat transfer involving phase change
- To understand concepts of exchange of radiation between bodies
- Ability to design heat exchangers

TEXTBOOKS:

1. Holman, J. P., Souvik Bhattacharyya 'Heat Transfer', McGraw Hill Education; 10th edition ,2017
2. Ozisik, M. N., Heat Transfer: A Basic Approach, McGraw-Hill Education / Asia ,1985
3. B.K Dutta, Heat Transfer Principles and applications, PHI learning PVT Ltd, 2016
4. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", 6th Edn., McGraw-Hill, 2001.

REFERENCES:
1. Kern, D.Q., "Process Heat Transfer ", McGraw Hill Education, 2017
2. Coulson, J.M. and Richardson, J.F., "Chemical Engineering "Vol. I, Butterworth-Heinemann; 6th edition, 1999; CBS Publishers & Distributors Pvt. Ltd.

CO-PO MAPPING

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	2	2	2	1	1	1	1	1	1	3	3	1	3
CO 2	3	3	2	2	1	1	1	1	1	2	1	3	3	1	3
CO 3	3	3	2	2	2	1	1	1	1	2	1	3	3	1	3
CO 4	3	3	3	3	1	1	1	1	1	2	1	3	3	1	1
CO 5	3	3	3	3	2	1	1	2	1	2	2	3	3	1	2

Course Code	Course Title	Category	L	T	P	C
CH23431	**PARTICLE SCIENCE AND TECHNOLOGY**	**PC**	3	0	1	4

OBJECTIVE:

- To learn the characterization of solids and size reduction techniques

- To gain the knowledge on various separation processes such as solid-solid separation, Fluid-solid separation and Mechanical-physical separation.

- To select the appropriate separation technique or equipment based on nature of the solution or size of the particles.

- To expose to calculation and machinery involved in various solid handling operations

- To introduce nano-technological aspects.

UNIT I SIZE ANALYSIS AND SIZE REDUCTION   9
General characteristics of solids, different techniques of size analysis, shape factor, surface area determination, estimation of particle size. Screening methods and equipment, screen efficiency, ideal and actual screens.
Laws of size reduction, energy relationships in size reduction, methods of size reduction, classification of equipment, crushers, grinders, power requirement, work index; size enlargement - principle of granulation, briquetting, pelletisation, and flocculation.

UNIT II MECHANICAL SEPARATIONS   9
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.

UNIT III FILTRATION   9
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, filter aids.

UNIT IV MIXING, AGITATION, STORAGE AND TRANSPORTATION   9
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, conveyer selection, different types of conveyers and their performance characteristics.

UNIT V SYNTHESIS AND CHARACTERISATION OF NANOPARTICLES   9

Synthesis of Nanoparticles – Chemical and physical processing methods, Characteristics of Nanoparticles – FTIR, XRD, SEM, TEM - Applications -

LIST OF EXPERIMENTS

1. Sieve analysis
2. Batch filtration studies using a Leaf filter
3. Batch filtration studies using a Plate and Frame Filter press
4. Characteristics of batch Sedimentation
5. Reduction ratio in Jaw Crusher
6. Reduction ratio in Ball mill
7. Separation characteristics of Cyclone separator
8. Reduction ratio of Roll Crusher
9. Separation characteristics of Elutriator
10. Reduction ratio of Drop weight crusher

LIST OF EQUIPMENT FOR BATCH OF 30 STUDENTS

1. Sieve shaker
2. Leaf filter
3. Plate and Frame Filter Press
4. Sedimentation Jar
5. Jaw Crusher
6. Ball Mill
7. Cyclone Separator
8. Roll Crusher
9. Elutriator
10. Drop Weight Crusher
11. Test Sieves.

TOTAL : 60 PERIODS

Course Outcomes:

i.   Ability to characterize particles and perform experiments determine its size.

ii. Will be able to calculate and experiment the power required by various solid handling equipment's.

iii. Will be able to select the appropriate separation technique or equipment based on nature of the solution or size of the particles and perform experiments to determine its efficiency.

iv. Ability to identify various filtration equipment's in process industries and will be able to calculate time taken for filtration process and carry out experiments to determine filtration characteristics.

v.   Will be aware of various techniques involved in the synthesis of nano-materials.

TEXT BOOKS:

1. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", VII Edition., McGraw-Hill, 2017.
2. Badger W.L. and Banchero J.T., "Introduction to Chemical Engineering", Tata McGraw Hill, 2001.
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.

REFERENCE:

Coulson, J.M. and Richardson, J.F., "Chemical Engineering" Vol. I, VI Edition., Asian Books Pvt. Ltd., India, 1999.

CO-PO MAPPING

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	2	2	2	1	1	-	2	1	-	3	3	2	1
CO 2	3	3	3	3	3	1	2	-	2	1	-	2	2	2	1
CO 3	3	3	3	1	2	1	1	-	2	1	-	3	1	2	3
CO 4	3	3	3	2	3	1	1	-	2	3	-	2	2	2	2
CO 5	3	2	3	2	3	1	2	-	-	3	-	3	-	2	-
AVG	3	2.6	2.8	2	2.6	1	1.4		1.6	1.8	-	2.6	1.6	2	1.4

Subject Code	Subject Name	Category	L	T	P	C
CS23422	**Python Programming for Machine Learning** (with effect from 2023 batch onwards)	**ES**	**0**	**0**	**4**	**2**

Course Objectives:
This course is aimed at enabling the students to :
☐   Understand the relationship of the data collected for decision making.
☐   Know the concept of principal components, factor analysis and cluster analysis for profiling and interpreting the data collected.
☐   Lay the foundation of machine learning and its practical applications and prepare students for real-time problem-solving in data science.
☐   Develop self-learning algorithms using training data to classify or predict the outcome of future datasets.
☐   Distinguish overtraining and techniques to avoid it such as cross-validation.

	List of Experiments
1.	NumPy Basics: Arrays and Vectorized Computation
2.	Getting Started with pandas
3.	Data Loading, Storage, and File Formats
4.	Data Cleaning and Preparation
5.	Data Wrangling: Join, Combine, and Reshape
6.	Plotting and Visualization
7.	Data Aggregation and Group Operations
8.	Time Series
9.	Supervised Learning
10.	Unsupervised Learning and Pre-processing
11.	Representing Data and Engineering Features
12.	Model Evaluation and Improvement

Contact Hours : 60

Course Outcomes:
On completion of the course, students will be able to:
☐   Develop a sound understanding of current, modern computational statistical approaches and their application to a variety of datasets.
☐   Analyze and perform an evaluation of learning algorithms and model selection.
☐   Compare the strengths and weaknesses of many popular machine learning approaches.
☐   Appreciate the underlying mathematical relationships within and across machine learning algorithms and the paradigms of supervised and unsupervised learning.
☐   Design and implement various machine learning algorithms in a range of real-world applications.

	Text Books:
1.	Wes McKinney, Python for Data Analysis - Data wrangling with Pandas, Numpy, and IPython, Second Edition, O'Reilly Media Inc, 2017.
2.	Andreas C. Müller and Sarah Guido, Introduction to Machine Learning with Python - A Guide for Data Scientists, First Edition, O'Reilly Media Inc, 2016.

Reference Books:

1.	Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd Edition, O'Reilly Media Inc, 2019.

Subject Code	Subject Name	Category	L	T	P	C
GE23327	SOFT SKILLS-I	EEC	0	0	2	1

Objectives:

- To help the students break out of shyness.
- To build confidence
- To enhance English communication skills.
- To encourage students" creative thinking to help them frame their own opinions.

Learning and Teaching Strategy:
The program is completely student centric where the focus is on activities led by students which include role plays, discussions, debates other games as well. These activities would be supplemented by interactive use of technology and brief trainer input.

Week	Activity Name	Description	Objective
1	Introduction	The trainer and the college facilitator talk to the students about the course and in turn the students introduce themselves.	To set expectations about the course and the students are made aware of the rules and regulations involved in this program
2	If I ruled the world	This is a quick and useful game by getting students to form a circle and provide their point of view. Each student then repeats what the other has said and comes up with their own opinion.	The aim of this activity is to for students to get to know each other and also develop their listening skills as well as learning how to agree and disagree politely.
3	Picture Narrating	This activity is based on several sequential pictures. Students are asked to tell the story taking place in the sequential pictures by paying attention to the criteria provided by the teacher as a rubric. Rubrics can include the vocabulary or structures they need to use while narrating.	The aim of this activity is to make the students develop creative way of thinking.
4	Brainstorming	On a given topic, students can produce ideas in a limited time. Depending on the context, either individual or group brainstorming is effective and learners generate ideas quickly and freely. The good characteristics of brainstorming are that the students are not criticized for their ideas so students will be open to sharing new ideas.	The activity aims at making the students speak freely without the fear of being criticized. It also encourages students to come up with their own opinions.
5	Debate	Is competition necessary in regards to the learning process?	The aim of this activity is to develop the students ability to debate and think out of the box
6	Short Talks	Here the students are given topics for which they take one minute to prepare and two minutes to speak. They can write down points but can"t read them out they can only use it as a reference.	The activity aims at breaking the students" shyness and encouraging them to standup in front of the class and speak. It also aims at creating awareness that they are restricted for time so they only speak points that are relevant and important.
7	Debate	Will posting students" grades on bulletin boards publicly motivate them to perform better or is it humiliating?	This activity aims at enhancing the students unbiased thought process when it comes to exams and grades as well as develop their skills to debate
8	The Art of diplomacy	The facilitator proceeds to share multiple concepts of conversation and helps the	The aim of the lesson is to provide an opportunity for the participants to

		participants to identify the various methods of being diplomatic and how do deal with misinformation.	learn about body language and choosing the appropriate words for conversation.
9	Debate	Are humans too dependent on computers?	The aim of this activity is to test the students debating skills and thought process with a topic that affects everybody in daily life.
10	Story Completion	The teacher starts to tell a story but after 2 sentences he/she asks students to work in groups to create the rest of the story which includes the plot and the ending.	This activity aims at building their narrating skills as well as their creativity and ability to work in a team.
11	Role play debate	Students scrutinize different points of view or perspectives related to an issue. For example, a debate about the question "Should students be required to wear uniforms at school?" might yield a range of opinions. Those might include views expressed by a student (or perhaps two students – one representing each side of the issue), a parent, a school principal, a police officer, a teacher, the owner of a clothing store, and others.	The aim of this activity is to get students to speak based on other people"s perspective instead of their own. The students take the role of various characters and debate accordingly.
12	I Couldn"t Disagree More	This is a game where students practice rebuttal techniques where one student provides a thought or an idea and the other students starts with the phrase I couldn"t disagree more and continues with his opinion	The aim of this activity is to improve general communication skills and confidence.
	Feedback	At the end of the session in the final week (12) the trainer would provide feedback to the students on best practices for future benefits	The aim is to do both give feedback to students as well as obtain feedback on the course from them.
		Total Contact Hours	**30**

Course Outcomes: At the end of the course the student will be able to

●	Be more confident
●	Speak in front of a large audience
●	Be better creative thinkers
●	Be spontaneous
●	Communicate in English

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	-	-	-	-	-	-	-	-	1	3	-	1	-	-	-
CO 2	1	-	-	-	-	-	1	-	1	3	1	1	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
Average	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**3**	**1**	**1**	**-**	**-**	**-**

Course Code	Course Title	Category	L	T	P	C
CH23421	**TECHNICAL ANALYSIS LABORATORY**	**PC**	**0**	**0**	**4**	**2**

OBJECTIVE:
1. To train the students on basic principles involved in estimation and characterization of industrially important materials.
2. To provide clear understanding of basic concepts of scale up processes
3. To identify the pollutants present in water, waste water, solvents and fuels
4. To understand the principles of polymer synthesis and characterization
5. To train the students to identify the common impurities in domestic chemicals

LIST OF EXPERIMENTS

1. Water Analysis
   a. Determination of hardness
   b. Sulphate Analysis
   c. Nitrate Analysis
   d. Determination COD/BOD/DO
   e. pH and conductivity determination
   f. Total purity (HPLC)

2. Scale-up of the Chemical Process
   a. Chemical reaction progress monitoring (TLC/HPLC)
   b. Bulk-synthesis
   c. Purification
   d. Determination of yield and purity

3. Synthesis and molecular weight determination of polymers
   a. Synthesis of polymers (anionic/free-radical/RAFT)
   b. Molecular weight determination (viscometry/GPC)

4. Soap Analysis
   a. Estimation of total fatty acid
   b. Estimation of percentage alkali content

5. Oil Analysis
   a. Estimation of free acid
   b. Determination of Saponification value
   c. Determination of iodine value

6. 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

7. Analysis of Bleaching Powder
   a. Estimation of available chlorine

8. Analysis of purity of solvents
   a. Estimation of purity of ethanol/acetone/chloroform (HPLC)

9. Analysis of fuels

    a. Flash point

    b. Fire point

    c. Cloud point

    d. Pour point

    e. purity(HPLC)

10. Absorption spectrometry

    a. Beer-Lamberts Law

    b. Determination of absorption coefficient

    c. Determination of absorption wavelengths of dyes.

                                TOTAL: 45 PERIODS

OUTCOMEs:

At the end of this practical course

1. The student would have a thorough understanding on the estimation and analysis of water pollutants.
2. The student would have a clear understanding of scale up of industrial processes
3. The student could acquire skills in polymer synthesis and characterization
4. The students will be able to analyze the common composition of domestic utilities
5. The students would be aware of handling spectroscopic instruments for their research projects

CO/PO Mapping

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	3	3	3	3	3	1	3	2	1	3	3	3	3
2	3	3	3	3	3	3	3	1	3	2	1	3	3	3	3
3	3	3	3	3	3	3	3	1	3	2	1	3	3	3	3
4	3	3	3	3	3	3	3	1	3	2	1	3	3	3	3
5	3	3	3	3	3	3	3	1	2	2	1	3	3	3	3