Criteria: 1.1.2

Details of Programme Syllabus Revision

हरकोर्ट बटलर प्राविधिक विश्वविद्यालय
नवाबगंज, कानपुर – 208002, उ.प्र., भारत
HARCOURT BUTLER TECHNICAL UNIVERSITY
NAWABGANJ, KANPUR - 208002, U.P., INDIA
(Formerly Harcourt Butler Technological Institute, Kanpur)
Phone : +91-0512-2534001-5, 2533812, website : http://www.hbtu.ac.in, Email : vc@hbtu.ac.in

100 YEARS 1921 - 2021

Department: Mechanical Engineering

School: Engineering
Name of Programme: B. Tech. Mechanical Engineering

Academic Session 2021-22

Total no. of courses in the Programme: 28

%Change in the course **curriculum: 21.42%**

Number of Courses where syllabus revision was carried out BoS

Sl. No.	Subject Name	Subject Code	Details
1.	Material Science	EME-203/253	Syllabus change shown in red
2.	Machine Drawing	EME-207/257	Syllabus change shown in red
3.	Applied Thermodynamics	EME-206	Change in credits and syllabus shown in red
4.	Manufacturing Science-II	EME-301	Change in credits and syllabus shown in red
5.	Computer Added Design	EME-306	Change in credits and syllabus shown in red
6.	Finite Element Methods	EME-415/436	Change in syllabus shown in red

Signature and Seal
Head of Department

HARCOURT BULTER TECHNICAL UNIVERSITY KANPUR SCHOOL OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

Semester wise Course Structure

B. Tech. Mechanical Engineering

(Applicable from Session 2019-2020 for new entrants)

SEMESTER III

Sr. No.	Course Type	Subject Code	Course Title	Credits (L-T-P)	Sessional Marks				ESM	Total Mark
					MSE	TA	Lab	Total		
1.	BSC	BMA 251	Maths-III	4(3-1-0)	30		-	50	50	100
2.	ESC	EME 251	Strength of Material	5(3-1-2)	15	20	15	50	50	100
3.	PCC	EME 253	Material Science	4(3-0-2)	15	20	15	50	50	100
4.	PCC	EME 255	Engineering Thermodynamics	4(3-1-0)	30	20	-	50	50	100
5.	PCC	EME 257	Machine Drawing	2(0-0-4)	-	20	30	50	50	100
6.	HSMC	HHS 251	Engg. Economics & Management	3(3-0-0)	30	20	-	50	50	100
7.	MC (Non- credit)	HHS 255	Indian Constitution	0(2-0-0)	30	20	-	50	50	100
Total Credits				**22**						

SEMESTER IV

Sr. No.	Course Type	Subject Code	Course Title	Credits (L-T-P)	Sessional Marks				ESM	Total
					MSE	TA	Lab	Total		
1.	BSC	BMA 256	CONM	4(3-1-0)	30	20	-	50	50	100
2.	ESC	ECE 252	Engineering Fluid Mechanics	5(3-1-2)	15	20	15	50	50	100
3.	PCC	EME 256	Applied Thermodynamics	3(3-0-0)	30	20	-	50	50	100
4.	PCC	EME 254	Manufacturing Science-I	4(3-0-2)	15	20	15	50	50	100
5.	PCC	EME 258	Kinematics of Machine	3(3-0-0)	30	20	-	50	50	100
6.	HSMC	HHS 254	Organizational Behavior	3(3-0-0)	30	20	-	50	50	100
7.	MC (Non- credit)	ECS 260	Cyber Security	0(2-0-0)	30	20	-	50	50	100
Total Credits				**22**						

SEMESTER V

Sr. No.	Course Type	Subject Code	Course Title	Credits (L-T-P)	Sessional Marks				ESM	Total Marks
					MSE	TA	Lab	Total		
1.	PCC	EME 351	Manufacturing Science-II	4(3-0-2)	15	20	15	50	50	100
2.	PCC	EME 353	Heat & Mass Transfer	4(3-0-2)	15	20	15	50	50	100
3.	PCC	EME 355	Dynamics of Machine	4(3-0-2)	15	20	15	50	50	100
4.	PCC	EME 357	Machine Design-I	4(3-0-2)	15	20	15	50	50	100
5.	PCC	EME 359	IC Engines	3(3-0-0)	30	20	-	50	50	100
6.	OEC (Maths)	BMA 351	Operation Research	3(3-0-0)	30	20	-	50	50	100
Total Credits				22						

SEMESTER VI

Sr. No.	Course Type	Subject Code	Course Title	Credits (L-T-P)	Sessional Marks				ESM	Total Marks
					MSE	TA	Lab	Total		
1.	PCC	EME 352	Fluid Machinery	4(3-0-2)	15	20	15	50	50	100
2.	PCC	EME 354	Machine Design II	4(3-0-2)	15	20	15	50	50	100
3.	PCC	EME 356	Computer Aided Design	3(3-0-0)	30	20	-	50	50	100
4.	PCC	EME 358	Measurements	3(2-0-2)	15	20	15	50	50	100
5.	PCC	EME 360	Energy Conversion	3(2-0-2)	15	20	15	50	50	100
6.	PCC	EME 362	Power Plant Engineering	2(2-0-0)	30	20	-	50	50	100
7.	OEC (Humanities)	HHS 352	Entrepreneurship Development	3(3-0-0)	30	20	-	50	50	100
Total Credits				22						

SEMESTER VII

Sr. No.	Course Type	Subject Code	Course Title	Credits (L-T-P)	Sessional Marks				ESM	Total Mark
					MSE	TA	Lab	Total		
1.	PCC	EME 451	Refrigeration & Air Conditioning	4(3-0-2)	15	20	15	50	50	100
2.	PCC	EME 453	Computer Aided Manufacturing	3(3-0-0)	15	20	15	50	50	100
3.	PEC	PEC-I	List is attached	3(3-0-0)	30	20	-	50	50	100
4.	PEC	PEC-II	List is attached	3(3-0-0)	30	20	-	50	50	100
5.	OEC	OEC-I	List is attached	3(3-0-0)	30	20	-	50	50	100
6.	Industrial Training	EME-461	Industrial Training	1(0-0-2)	-	50	-	50	50	100
7.	Seminar	EME-471	Seminar	1(0-0-2)	-	50	-	50	50	100
8.	Project	EME-497	Project	4(0-0-8)	-	50	-	50	50	100
Total Credits				22						

SEMESTER VIII

Sr. No.	**Course Type**	**Subject Code**	**Course Title**	**Credits (L-T-P)**	**Sessional Marks**				**ESM**	**Total Mark**
					MSE	**TA**	**Lab**	**Total**		
1.	PEC	EME 415/454	Finite Element Method	4(3-1-0)	30	20	-	50	50	100
2.	PEC	PEC-IV	List is attached	4(3-1-0)	30	20	-	50	50	100
3.	OEC	OEC-II	List is attached	4(3-1-0)	30	20	-	50	50	100
4.	Project	EME-498	Project	10(0-0-20)	-	50	-	50	50	100
Total Credits				**22**						

Total Programme Credits : 172

MATERIAL SCIENCE (EME-203)

Type	L	T	P	Credits
PCC	3	0	2	4

Prerequisite: Fundamental knowledge of Intermediate level physics and chemistry.

Course Objectives:

The objective of the subject is to know the fundamental science and engineering principles relevant
to materials. To understand the structure, properties, processing and performance of the principalclasses of materials.

Course Content:

Unit I

Introduction: Importance of materials, Brief review of modern atomic concepts, atomic models, chemical bonding, metallic bonds; Crystalline and non-crystalline structures; Concept of unit cell, Bravis space lattices, common crystal structures- cubic and hexagonally closed packed structures, co- ordination number, packing factor, Miller indices for crystallographic planes and directions, X-ray crystallography techniques. Micro structural examination and grain size determination. Structure- property interrelationship, comparative study of microstructure of various metals & alloys such as mild steel, cast iron, brass and bronzes.

Unit II

Structural imperfections- point, line, planer and volume defects. Dislocations in solids- edge, screw and mixed dislocations, energy of dislocations, Frank Reed source of dislocation, strain hardening, slip systems, twin and tilt boundary, grain boundary defects and their significance.
Diffusion in solids - Fick's first and second laws of diffusion.
Mechanical properties and testing: stress- strain diagram, ductile v/s brittle materials. stress v/s strength, toughness, hardness, fracture, fatigue and creep, Mechanical testing- tensile test, hardness test, impact test, fatigue test, creep test, non destructive evaluation.

Unit III

hase diagram and equilibrium diagrams: Unary and binary diagrams, phase rules, types of equilibrium diagrams, types of solid solution, Hume-Rothery criteria of solid solution formation, intermetallic compounds.
Ferrous materials: Classification of steels, alloy steels, their applications, cast irons- its properties and uses. Iron carbon equilibrium diagram, time-temperature-transformation (T-T-T) curves- pearlite, bainite and martensite formations.
Heat treatment processes- annealing, normalizing, quenching, tempering, important case hardening processes; Non-ferrous metals and alloys, brasses, bronzes, bearing materials- its properties and uses, aluminum alloys such as Duralumin.

Unit IV

Magnetic Properties: magnetism – dia-, para- and ferro-magnetism, hysteresis, Soft and hard magnets, Magnetic storages; Electric properties: Energy band concept of conductor, insulator and semi- conductors, p-n junction and transistors, Basic devices and its application, Superconductivity and its applications, Messier effect, type I & II superconductors, high temperature superconductors.

Unit V

Ceramics- structure, properties and applications of ceramics, Polymers- types and its applications. Composite materials- its types and uses; Performance of materials in service- brief theoretical consideration of fracture, fatigue, corrosion and its control.

Text books:

1. Material Science & Engineering by W.D. Callister, Jr., Addison-Wesley Pub.Co.
2. Engineering Materials, Vol. I &II by Ashby & Jones, Pergemon Press.

Reference books:

1. Elements of Material Science & Engineering by Van Vlack, John Wiley & Sons
2. Material Science by V. Raghvan, Prentice Hall of India

MATERIAL SCIENCE & TESTING LAB

Any 8 experiments out of following:

1. To identify different kind of materials by observation.

2. To prepare specimen for metallographic examination.

3. To perform Jominy End Quench Test to determine hardenability of steel.

4. To determine Rockwell Hardness of given test specimen.

5. To determine Brinell Hardness of given test specimen.

6. To determine Vicker's hardness of given test specimen.

7. To perform tensile test on given specimen using UTM.

8. To perform Compression Test on given specimen using UTM.

9. To perform Izod&Charpy Impact test.

10. To perform Torsion test on given specimen.

11. To perform fatigue test on given specimen.

12. To perform Creep test.

13. To perform Bend (flexural) test on the given specimen.

MACHINE DRAWING (EME257)

Type	L	T	P	Credits
PCC	0	0	4	2

Prerequisite: Fundamental knowledge of engineering graphics.

Course Objectives:
The objective of this subject is to make student acquire knowledge of joints such as riveting, threaded joints etc.. The student also is enabled to prepare the assembly of various machine or engine components and miscellaneous machine components.

Course Outcomes:

1. Student will be aware with fundamentals of machine drawing.
2. Student will be able to understand principles of orthographic projections for machine drawing.
3. To draw the projections of machine elements including keys, couplings, cotters, riveted, bolted and welded joints.
4. To draw the assembled view using drawings of machine components and Engines.
5. To free hand sketches of machine elements

Course Content:

In this subject all the topics will be covered with a lecture at start of class

Introduction: Graphic language, Classification of drawings, Principles of drawing, IS codes for Machine drawing, Lines, Scales, Sections, Dimensioning, Standard abbreviations.
Orthographic Projections: Principles of first and third angle projections, drawing and sketching of machine elements in orthographic projections, spacing of views.
Screwed (Threaded) fasteners: Introduction, Screw thread nomenclature, forms of threads, Thread series, Thread designation, Representation of threads, Bolted joints, Locking arrangement for nuts, Foundation bolts.

Keys and cotters: Keys, Cotter joints.

Shaft couplings: Introduction, Rigid and flexible coupling.

Riveted Joints: Introduction, Rivets and riveting, Rivet heads, Classification of riveted joints.

Assembly drawing Introduction, Engine parts, Stuffing box etc.

Free hand sketching: Introduction, Need for free hand sketching, Free hand of sketching of some threaded fasteners and simple machine components.

Exposure to suitable 2D/3D drafting software.

Reference books:

2. Machine Drawing by N.Siddeshwar, P.Kannaiah, V V S Shastry,TMH, New Delhi
3. Machine Drawing by K L Narayana, P. Kannaiah, K VenkatReddy,New Age IntnlPubl
4. Engineering Drawing Practice for Schools & Colleges, SP46-1998 (BIS)

APPLIED THERMODYNAMICS (EME-206)

Type	L	T	P	Credits
PCC	3	1	0	4

Prerequisite: A course on Engineering Thermodynamics

Course Objectives:
This course focuses upon the application of different laws and principles of thermodynamics as well as physics for realizing useful thermodynamic processes in different thermal systems.

Course Content:

Unit-I
Boilers: Steam generators-classifications. Working of fire-tube and water-tube boilers, boiler mountings & accessories, supercritical boilers, waste heat recovery steam boilers, Draught & its calculations, air pre heater, feed water heater, super heater. Boiler efficiency, Equivalent evaporation. Boiler trial and heat balance.
Condenser: Classification of condenser, Air leakage, Condenser performance parameters

Unit-II
Steam Engines: Rankine and modified Rankine cycles, Working of stream engine, Classification of steam engines, Indicator diagram, Saturation curve, Missing quantity.
Steam & Gas Nozzles: Flow through nozzle, Variation of velocity, Area and specific volume, Choked flow, Throat area, Nozzle efficiency, Off design operation of nozzle, Effect of friction on nozzle, Super saturated flow.

Unit-III
Vapour Power cycles: Carnot vapour power cycle, Effect of pressure & temperature on Rankine cycle, Reheat cycle, Regenerative cycle, Feed water heaters, Binary vapour cycle, Combined cycles, Cogeneration.
Steam Turbines : Classification of steam turbine, Impulse and reaction turbines, Staging, Stage and overall efficiency, Reheat factor, Bleeding, Velocity diagram of simple & compound multistage impulse & reaction turbines & related calculations work done efficiencies of reaction, state pointlocus, Losses in steam turbines, Governing of turbines.

Unit-IV
Gas Turbine: Gas turbine classification Brayton cycle, Principles of gas turbine, Gas power cycles with intercooling, reheat and regeneration and their combinations, Stage efficiency, Isentropic efficiency, Polytropic efficiency. Deviation of actual cycles from ideal cycles.
Jet Propulsion: Introduction to the principles of jet propulsion, Turbojet and turboprop engines & their processes, Principle of rocket propulsion, Introduction to Rocket Engine.

Unit-V
Compressors:
Classification, Reciprocating compressors, Single and Multi stage compressors; Rotary compressors, Classification, Centrifugal compressor fundamentals, Surging and stalling, Roots blower, Vaned compressor, Air Motors, Compressor characteristic curves. **Unconventional Energy Systems:** Sterling engines, Thermo-ionic converters, Thermoelectric generators, Photovoltaic generators,

Magneto-hydrodynamic generators, Solar thermal collectors, Heliostats, Fuel Cells.

Textbooks:

1. Applied thermodynamics by Onkar Singh, New Age International (P) Publishers Ltd.
2. Basic and Applied Thermodynamics by P.K. Nag, Tata McGraw Hill

Reference books:

1. Theory of Stream Turbine by W.J. Kearton
2. Steam & Gas Turbine by R.Yadav, CPH Allahabad
3. Gas Turbine, by V. Ganeshan, Tata McGraw Hill Publishers.
4. Gas turbine Theory & Practice, by Cohen & Rogers, Addison Weslay Long man
5. Reciprocating and Rotary Compressors, by Chlumsky, SNTI Pub., Czechoslovakia
6. Turbines, Compressors and Fans, by S.M.Yahya, Tata McGraw Hill Pub.

MANUFACTURING SCIENCE-II (EME-351)

Type	L	T	P	Credits
PCC	3	0	2	4

Prerequisite: Basic course in Workshop Practice and strength of material

Course Objective:
The course aims at understanding basic manufacturing process viz. chip removal process, Grinding process, understanding of abrasive process, joining processes and chip less metal removal processes.

Course Outcomes:

After completion of course a student will:

CO1	Understand basic importance of tools, cutting fluid, tool materials in order to have high quality of production
CO2	Understand the applications of grinding and super finishing processes,
CO3	Understand the various methods of welding and their applications,
CO4	Understand the capabilities of various machine tools and components that can be manufactured on a particular machine tool
CO5	Understand manufacturing processes and their capabilities.
CO6	Understand the working of various manufacturing machines.

Course Content:

Unit-I

Metal Cutting: Mechanics of metal cutting. Geometry of tool and nomenclature.ASA system orthogonal vs. oblique cutting. Mechanics of chip formation, types of chips. Shear angle relationship. Merchant's force circle diagram. Cutting forces, power required for turning, milling and drilling. Cutting fluids/lubricants. Tool materials. Tool wear and tool life. Machinability. Force measurement. Economics of metal cutting.

Unit-II

Grinding &Super finishing
(i) Grinding: Grinding wheels, abrasive & bonds, cutting action. Grinding wheel specification. Grinding wheel wear - attritions wear, fracture wear. Dressing and Truing. Max chip thickness and grinding criteria. Surface and Cylindrical grinding. Centerless grinding.
(ii) Super finishing: Honing, lapping, polishing.

Unit-III

Joining Methods: Survey of welding and allied processes. Gas welding and cutting, process and equipment. Arc welding : Power sources and consumables. TIG & MIG processes and their parameters. Resistance welding - spot, seam, projection etc. Other welding processes such as atomic hydrogen, submerged arc, electroslag, friction welding. Soldering & Brazing. Shrinkage/residual stress in welds. Distortions & Defects in welds and remedies. Weld decay in HAZ. Joining of non metallic components, Introduction to unconventional welding.

Unit-IV

Machine Tools: (i) Lathe : Principle, construction, types, operations, Turret / capstan, semi / Automatic, Tool layout ; (ii) Shaper, slotter, planer : Construction, operations & drives; (iii) Milling : Construction, Milling cutters, up & down milling. Dividing head & indexing. Various types of milling cutters; (iv) Drilling and boring: Drilling, boring, reaming tools. Geometry of twist drills.

Unit V:

Limitations of conventional manufacturing process and need of unconventional manufacturing processes. Mechanical processes such as Ultrasonic machining, Abrasive jet machining, Abrasive water jet machining; Thermal energy based processes such as Electro chemical, Electro discharge, Laser and Electron beam machining.

Textbooks:

1. Manufacturing science by Ghosh and Mallik
2. Manufacturing science by Degarmo

Reference books:

1. Fundamentals of Metal Cutting and Machine tools by Boothroyd
2. Production Technology by R.K. Jain
3. Production Engineering Science by P.C. Pandey
4. Modern Machining Processes by P.C. Pandey& H.S. Shan
5. Fundamentals of metal cutting & machine tools – Juneja, Shekhon& Seth, New Age Publ.
6. Process & materials of manufacturing - Lindburg.
7. Metal Cutting Principles by M.C. Shaw, Oxford Univ. Press.

EME351: MANUFACTURING SCIENCE-II LAB

Any 8 experiments out of the following:

1. Shear-angle determination (using formula) with tube cutting (for orthogonal) on lathe Machine.
2. Taper turning operation on lathe.
3. Bolt (thread) making on Lathe machine.
4. Tool grinding (to provide tool angles) on tool- grinder machine.
5. Gear cutting on Milling machine.
6. Machining a block on shaper machine.
7. Finishing of a surface on surface- grinding machine.
8. Drilling holes on drilling machine and study of twist-drill.
9. Study of different types of tools and its angles & materials.
10. Experiment on tool wear and tool life.
11. Gas welding of a lap/butt joint.
12. Arc welding of a lap/butt joint.
13. Resistance spot welding of two thin metallic sheets.
14. Experiment on Electro discharge machining.
15. Experiment on CNC machines.

COMPUTER AIDED DESIGN (EME-306)

Type	L	T	P	Credits
PCC	3	1	2	5

Prerequisite:

Course Objectives:

To introduce the student to the roles of CAD for part design and complete product development.

Course Content:

UNIT-1

Introduction to CAD- Computer systems & hardware for CAD-Input & output devices, types of display devices- CRT, principles of raster scan and vector graphics. Scan conversions, Plotting of points, Line drawing, Computer Graphic & its standards- GKS, IGES. Computer Graphics Software & its configuration. Graphics Standard.

UNIT-2

Transformations: Homogenous coordinate system, Scaling, Translation, shear, Reflection about axis & line. Viewing 3D on 2D screen: Representation of 3D shapes, rendering of surfaces and solids, hidden lines, edges and surface removals, Shading models, Shadows, Representation scheme for colors and its mixing; Curves: Analytical & Parametric curves, Continuity, Hermite curves, Bezier curves, B-spline curves, NURBS.

UNIT-3

Surface generations- Hermite & Bezier, ruled, lofted, revolved and swept surfaces. Mesh based Numerical methods for integration & differential equations, Finite Difference Method. Basic Concepts of FEM: Governing equations, Stiffness matrix, Selection of approximation functions, Shape functions & its derivation. Derivation of stiffness matrix, Approaches of FEM,

UNIT-4

1-D FEM applications with one degree approximation function: Stress & strain, Heat conduction, Truss, Beam elements-1-D with 2 degree of freedom applications & problems

UNIT-5

2D Applications: 2D elements and applications: Triangular element-Constant strain triangle (CST) problems, Meshless methods. Reverse Engg & Rapidprotoyping - FDM based 3D printer, scope of 3D printing

Textbooks:

1. Computer Graphics by Hearn and Baker
2. Finite Element Method with applications in Engg. by Desai, Eldho, Shah, Pearson

Reference books:

1. CAD/CAM by Groover & Zimmers, PHI Ltd.
2. CAD/CAM: Theory &Parctice by Zeid & Sivasubramanian, TMH
3. CAD by Tai-Ram Hsu &Dipendra K Sinha, West Publ. Co.
4. Finite Element Method Dhanraj & Prabhkaran, Oxford Higher Education
5. Finite Element in Engineering by Singiresu S. Rao, Elsevier

CAD LAB

Any 5 experiments out of following:

1. Transformations algorithm experiment for translation/rotation/scaling: writing program and running it on

computer.

2. 2DGeometry drawing algorithm experiment e.g. for straight line and circle: writing theprogram and running it on computer.

3. 2DGeometry drawing algorithm experiment e.g. for Bezier curves, B-Spline curves and circle:writing the program and running it on computer

4. Study of types of modeling e.g. wire frame, B-Rep etc.
5. Computer Aided Drafting: understanding and use of available CAD package commands, 3Ddrawing.

6. Writing a small program for FEM for 2 spring system and running it. or using a FEM package.

Course Outcomes:

Student will be able to

1. Understand the role of computers for design and manufacturing.
2. Understand basic hardwares and computer graphics for CAD.
3. Understand the parametric mathematical formulation for geometric transformations, curve& surface generation and 3D modeling.
4. Understand the fundamentals of finite element method with engineering applications.
5. Physically observe CAD workstations and develop the programs to generate curves andsurfaces. Create 2D and 3D model of components using CREO.
6. Use FEA packages to solve engineering problems.

FINITE ELEMENT METHOD (EME-415/ 454)

Type	L	T	P	Credits
PEC	3	1	0	4

Prerequisite:

Course Objectives:

To provide the theoretical and practical knowledge of the finite element based modeling and analysis for the mechanical systems.

Course Content:

UNIT-1

Fundamental Concepts: Introduction, Historical Background, FEM/FDM/Mesh free Methods, Stresses and Equilibrium, Boundary Conditions, Strain Displacement Relations, Stress-Strain Relations, Rayleigh-Ritz Method, Galerkin Method, Saint Venant's Principle. MatrixAlgebra: Basic Matrix Operations, Basic Types of Matrices, Eigenvalues and Eigenvectors

UNIT-2

One Dimensional Problems: Finite element Modeling, Coordinates and Shape Functions, Potential Energy Approach, Galerkin Approach, Assembly of the Global Stiffness Matrix and Load Vector

UNIT-3

Two Dimensional Problems: Finite Element Modeling, Constant Strain Triangle (CST), Problem Modeling and Boundary Conditions, Axisymmetric Solids subjected to Axisymmetric Loading: Axisymmetric Formulation.

UNIT-4

Finite Element Modeling: Triangular Element, Problem Modeling and Boundary, Conditions, Two-Dimensional Isoparametric Elements: Four-Node Quadrilateral, Numerical, Integration, Higher- Order Elements.

UNIT-5

Scalar Field Problems: Steady-State Heat Transfer, Torsion, Potential Flow, Electric and Magnetic Fields, Dynamic Analysis: Formulation, Element Mass Matrices, Evaluation of Eigen values and Eigenvectors, Overview of a Commercial Finite Element Code: ANSYS

Textbooks:

1. Introduction to Finite Elements in Engineering by T.R. Chandrupatla and A.D. Belegundu, Prentice-Hall of India
2. An Introduction to the Finite Element Method by J.N. Reddy, McGraw-Hill

Reference Books:

1. Finite Element Procedures in Engineering Analysis by K.J. Bathe, Englewood Cliffs, Prentice Hall
2. Concepts and Applications of Finite Element Analysis by R.D. Cook, Wiley
3. Introduction to the Finite Element Method by C.S. Desai and J.F. Abel, Van Nostrand Reinhold
4. The Finite Element Method - Linear Static and Dynamic Finite Element Analysis by T.J.R. Hughes, Englewood Cliffs, Prentice-Hall
5. The Finite Element Method in Engineering by S.S. Rao, Pergamon.
6. An Analysis of the Finite Element Method by G. Strang and G.J. Fix, Englewood Cliffs, PrenticeHall
7. The Finite Element Method by O.C, Zienkiewicz, McGraw-Hill

FINITE ELEMENT METHOD LAB

1. To find the deflection, stress and strain in a cantilever beam with point load at the end.

2. To find the deflection, stress and strain in a cantilever beam with uniformly distributed load.

3. To study the effect of the change of geometrical properties for the beahviourof cantilever beam.

4. To find the temperature within the composite wall with the transfer of heat using conduction mode.

5. To study the stress strain analysis of a rectangular plate (thick and thin).

6. To study the vibrational performance of beam.

Course Outcomes:

Students will be able to

1. To get the historical mathematical background of FEM and application of advanced computersfor this.
2. Apply finite element method to solve problems in solid mechanics, heat transfer and fluid mechanics. Apply the FEM for two dimensional problems.
3. Develop the codes using MATLAB for solving the FEM problems and also use of FEMsoftware.
4. Develop the codes using MATLAB for solving the FEM problems
5. Use FEM software to solve problems.

हरकोर्ट बटलर प्राविधिक विश्वविद्यालय
नवाबगंज, कानपुर – 208002, उ.प्र., भारत
HARCOURT BUTLER TECHNICAL UNIVERSITY
NAWABGANJ, KANPUR - 208002, U.P., INDIA
(Formerly Harcourt Butler Technological Institute, Kanpur)
Phone : +91-0512-2534001-5, 2533812, website : http://www.hbtu.ac.in, Email : vc@hbtu.ac.in

100 YEARS 1921 - 2021

Department: Electrical Engineering
School: School of Engineering
Name of Programme: B.Tech.
Academic Session 2021-22
Total no. of courses in the Programme: Courses Offered by Department - 24

% Change in the course curriculum: 25%

No. of courses where syllabus revision was carried out BoS		
S. No.	**Name of course**	**Course code**
1	Electrical Machines-I	EEE-252
2	Electrical Measurement and Measuring Instrument	EEE-256
3	Control System	EEE-351
4	Electrical Machines-II	EEE-355
5	Power System-I	EEE-357
6	Power System-II	EEE-352

Number of Courses related with employability/ entrepreneurship/ skill development

Courses related with employability/ entrepreneurship/ skill development		
S. No.	**Name of course**	**Course code**
1	Electrical Engg.	EEE-151
2	Basic System Analysis	EEE-251
3	Introduction to Digital System	EEE-253
4	Introduction to Electrical Engg. Material	EEE-255
5	Electrical Circuit Analysis	EEE-257
6	Electrical Machines-I	EEE-252
7	Electrical Measurement and Measuring Instrument	EEE-256
8	Bio-medical Instrumentation	EEE-258
9	Control System	EEE-351
10	Microprocessors	EEE-353
11	Electrical Machines-II	EEE-355
12	Power System-I	EEE-357
13	Utilization of Electrical Energy and Traction	EEE-359
14	Power System-II	EEE-352
15	Power Electronics	EEE-354
16	Power Station Practice	EEE-356
17	Electromagnetic Field Theory	EEE-358
18	Electric Drives	EEE-401
19	PEC-I	PEC-I
20	PEC-II	PEC-II
21	OEC-I	OEC-I

22	PEC-III	PEC-III
23	PEC-IV	PEC-IV
24	OEC-II	OEC-II

Elective courses in the programme

Elective courses			
S. No.	**Name of Programme**	**Name of Course**	**Course code**
1	**B.Tech.**		
	PEC-I		
		Instrumentation and Process Control	EEE 411
		HVDC Transmission Systems	EEE 413
		Special Topics in Control Systems	EEE 415
		Electrical Energy Conservation and Auditing	EEE 417
		Power System Design	EEE 419
		Advance Power Electronics	EEE 421
	PEC-II		
		Advanced control System	EEE 423
		Special Electrical Machines	EEE425
		Optimal Control System	EEE 427
		Power System Protection	EEE 429
		Electrical Machine Design	EEE 431
		Real Time Simulation Techniques of Power Electronic Converters	EEE 433
	OEC-I		
		Non-Conventional Energy Sources	OEE 433
		Power Plant Engineering	OEE 435
	PEC-III		
		Neural Network and Fuzzy System	EEE 440
		Power System Security and Analysis	EEE 442
		Applied System Theory	EEE 444
		Power Quality and FACTS	EEE 446
		Wind and Solar Energy Systems	EEE 448
		Modeling and Simulation Electrical Machines	EEE 450
	PEC-IV		
		Robotics and Automation	EEE 452
		Power System Dynamics and Control	EEE 454
		Industrial Instrumentation	EEE 456
		Electrical and Electronics Engineering Materials	EEE 458
		Electrical and Hybrid Vehicles	EEE 460
		Advanced Electric Drives	EEE 462
	OEC-II		
		Industrial Measurements	OEE 433
		Industrial Control Systems	OEE 435

New courses introduced		
S. No.	**Name of course**	**Course code**
1	Introduction to Digital System	EEE-253
2	Introduction to Electrical Engg. Material	EEE-255
3	Bio-medical Instrumentation	EEE-258
4	Utilization of Electrical Energy and Traction	EEE-359

Signature and Seal

Head of Department

Old Syllabus

EEE-204	Measurements and Instrumentation	3L:0T:2P	4 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to Design and validate DC and AC bridges. Analyze the dynamic response and the calibration of few instruments.

Learn about various measurement devices, their characteristics, their operation and their limitations.

Understand statistical data analysis.

Understand computerized data acquisition.

Lectures/Demonstrations:

(1) Philosophy Of Measurement: Methods of Measurement, Measurement System, Classification of instrument system, Characteristics of instruments & measurement system, Errors in measurement & its analysis, Standards. Concepts relating to Measurements: True value, Accuracy, Precision, Resolution, Drift, Hysteresis, Dead-band, Sensitivity.

(3)

(2) Analog Measurement of Electrical Quantities : Electrodynamic ,Thermocouple, Electrostatic & Rectifier type Ammeters & Voltmeters , Electrodynamic Wattmeter, Three Phase Wattmeter, Power in three phase system , errors & remedies in wattmeter and energy meter.

(5)

MODULE II:

Instrument Transformer and their applications in the extension of instrument range, Introduction to measurement of speed , frequency and power factor. Sensors and Transducers for physical parameters: temperature, pressure, torque, flow. Speed and Position Sensors.

(6)

MODULE III:

Measurement of Parameters: Different methods of measuring low, medium and high resistances, measurement of inductance & capacitance with the help of AC Bridges, Q Meter. Errors in Measurements. Basic statistical analysis applied to measurements: Mean, Standard Deviation, Six-sigma estimation, C_p, C_{pk}.

(7)

MODULE IV:

(1) AC Potentiometer: Polar type & Co-ordinate type AC potentiometers , application of AC Potentiometers in electrical measurement, Current and Voltage Measurements. Shunts, Potential Dividers. Instrument Transformers, Hall Sensors.

(3)

(2) Magnetic Measurement: Ballistic Galvanometer , flux meter , determination of hysteresis loop, measurement of iron losses. Measurements of R, L and C.

(4)

MODULE V:

(1) Digital Measurement of Electrical Quantities: Concept of digital measurement, block diagram Study of digital voltmeter, frequency meter Power Analyzer and Harmonics Analyzer; Electronic Multimeter.

(2)Cathode Ray Oscilloscope : Basic CRO circuit (Block Diagram),Cathode ray tube (CRT) & its components , application of CRO in measurement ,Lissajous Pattern.; Dual Trace & Dual Beam Oscilloscopes. Digital Multi-meter, True RMS meters, Clamp-on meters, Meggers.

Digital Storage Oscilloscope.

EEE-202	**Electrical Machines-I**	**3L:1T:2P**	**5 credits**

Course Outcomes:

At the end of this course, students will demonstrate the ability to

Understand the concepts of magnetic circuits.

Understand the operation of dc machines.

Analyse the differences in operation of different dc machine configurations.

Analyse single phase and three phase transformers circuits.

Module 1: Magnetic fields and magnetic circuits (6 Hours)

Review of magnetic circuits - MMF, flux, reluctance, inductance; review of Ampere Law and Biot Savart Law; Visualization of magnetic fields produced by a bar magnet and a current carrying coil - through air and through a combination of iron and air; influence of highly permeable materials on the magnetic flux lines.

Module 2: Electromagnetic force and torque (9 Hours)

B-H curve of magnetic materials; flux-linkage vs current characteristic of magnetic circuits; linear and nonlinear magnetic circuits; energy stored in the magnetic circuit; force as a partial derivative of stored energy with respect to position of a moving element; torque as a partial derivative of stored energy with respect to angular position of a rotating element. Examples - galvanometer coil, relay contact, lifting magnet, rotating element with eccentricity or saliency

Module 3: DC machines (8 Hours)

Basic construction of a DC machine, magnetic structure - stator yoke, stator poles, pole-faces or shoes, air gap and armature core, visualization of magnetic field produced by the field winding excitation with armature winding open, air gap flux density distribution, flux per pole, induced EMF in an armature coil. Armature winding and commutation - Elementary armature coil and commutator, lap and wave windings, construction of commutator, linear commutation Derivation of back EMF equation, armature MMF wave, derivation of torque equation, armature reaction, air gap flux density distribution with armature reaction.

Module 4: DC machine - motoring and generation (7 Hours)

Armature circuit equation for motoring and generation, Types of field excitations - separately excited, shunt and series. Open circuit characteristic of separately excited DC generator, back EMF with armature reaction, voltage build-up in a shunt generator, critical field resistance and critical speed. V-I characteristics and torque-speed characteristics of separately excited, shunt and series motors. Speed control through armature voltage. Losses, load testing and back-to-back testing of DC machines

Module 5: Transformers (12 Hours)

Principle, construction and operation of single-phase transformers, equivalent circuit, phasor diagram, voltage regulation, losses and efficiency Testing - open circuit and short circuit tests, polarity test, back-to-back test, separation of hysteresis and eddy current losses Three-phase transformer - construction, types of connection and their comparative features, Parallel operation of single-phase and three-phase transformers, Autotransformers - construction, principle, applications and comparison with two winding transformer, Magnetizing current, effect of nonlinear B-H curve of magnetic core material, harmonics in magnetization current, Phase conversion - Scott connection, three-phase to six-phase conversion, Tap-changing transformers - No-load and on-load tap-changing of transformers, Three-winding transformers. Cooling of transformers.

EEE-301	**Electrical Machines - II**	**3L:1T:2P**	**5 credits**

Course Outcomes:

At the end of this course, students will demonstrate the ability to

Understand the concepts of rotating magnetic fields.

Understand the operation of ac machines.

Analyse performance characteristics of ac machines.

Module 1: Fundamentals of AC machine windings (8 Hours)

Physical arrangement of windings in stator and cylindrical rotor; slots for windings; single-turn coil - active portion and overhang; full-pitch coils, concentrated winding, distributed winding, winding axis, 3D visualization of the above winding types, Air-gap MMF distribution with fixed current through winding - concentrated and distributed, Sinusoidally distributed winding, winding distribution factor

Module 2: Pulsating and revolving magnetic fields (4 Hours)

Constant magnetic field, pulsating magnetic field - alternating current in windings with spatial displacement, Magnetic field produced by a single winding - fixed current and alternating current

Pulsating fields produced by spatially displaced windings, Windings spatially shifted by 90 degrees, Addition of pulsating magnetic fields, Three windings spatially shifted by 120 degrees (carrying three-phase balanced currents), revolving magnetic field.

Module 3: Induction Machines (12 Hours)

Construction, Types (squirrel cage and slip-ring), Torque Slip Characteristics, Starting and Maximum Torque. Equivalent circuit. Phasor Diagram, Losses and Efficiency. Effect of parameter variation on torque speed characteristics (variation of rotor and stator resistances, stator voltage, frequency). Methods of starting, braking and speed control for induction motors. Generator operation. Self-excitation. Doubly-Fed Induction Machines.

Module 4: Single-phase induction motors (6 Hours)

Constructional features, double revolving field theory, equivalent circuit, determination of parameters. Split-phase starting methods and applications

Module 5: Synchronous machines (10 Hours)

Constructional features, cylindrical rotor synchronous machine - generated EMF, equivalent circuit and phasor diagram, armature reaction, synchronous impedance, voltage regulation. Operating characteristics of synchronous machines, V-curves. Salient pole machine - two reaction theory, analysis of phasor diagram, power angle characteristics. Parallel operation of alternators - synchronization and load division.

EEE-303	**Control Systems**	**3L:1T:2P**	**5 credits**

Course Outcomes:

At the end of this course, students will demonstrate the ability to

Understand the modellingof linear-time-invariant systems using transfer function and state-space representations.

Understandthe concept of stability and its assessment for linear-time invariant systems.

Design simple feedback controllers.

Module 1: Introduction to control problem (4 hours)

Industrial Control examples. Mathematical models of physical systems. Control hardware and their models. Transfer function models of linear time-invariant systems.

Feedback Control: Open-Loop and Closed-loop systems. Benefits of Feedback. Block diagram algebra.

Module 2: Time Response Analysis (10 hours)

Standard test signals. Time response of first and second order systems for standard test inputs. Application of initial and final value theorem. Design specifications for second-order systems based on the time-response.

Concept of Stability. Routh-Hurwitz Criteria. Relative Stability analysis. Root-Locus technique. Construction of Root-loci.

Module 3: Frequency-response analysis (6 hours)

Relationship between time and frequency response, Polar plots, Bode plots. Nyquist stability criterion. Relative stability using Nyquist criterion - gain and phase margin. Closed-loop frequency response.

Module 4: Introduction to Controller Design (10 hours)

Stability, steady-state accuracy, transient accuracy, disturbance rejection, insensitivity and robustness of control systems.

Root-loci method of feedback controller design.

Design specifications in frequency-domain. Frequency-domain methods of design. Application of Proportional, Integral and Derivative Controllers, Lead and Lag compensation in designs.

Analog and Digital implementation of controllers.

Module 5: State variable Analysis (6 hours)

Concepts of state variables. State space model. Diagonalization of State Matrix. Solution of state equations. Eigenvalues and Stability Analysis. Concept of controllability and observability.

Pole-placement by state feedback.

Discrete-time systems. Difference Equations. State-space models of linear discrete-time systems. Stability of linear discrete-time systems.

Module 6: Introduction to Optimal Control and NonlinearControl(5 hours) Performance Indices. Regulator problem, Tracking Problem. Nonlinear system-Basic concepts and analysis.

EEE- 305	**Power Systems-I**	**3L:1T:0P**	**4 credits**

Course Outcomes:

At the end of this course, students will demonstrate the ability to

Understand the concepts of power systems.

Understand the various power system components. Evaluate fault currents for different types of faults.

Understand the generation of over-voltages and insulation coordination.

Understand basic protection schemes.

Understand concepts of HVdc power transmission and renewable energy generation.

Module 1: Basic Concepts (4 hours)

Evolution of Power Systems and Present-Day Scenario. Structure of a power system: Bulk Power Grids and Micro-grids.

Generation: Conventional and Renewable Energy Sources. Distributed Energy Resources.

Energy Storage. Transmission and Distribution Systems: Line diagrams, transmission and distribution voltage levels and topologies (meshed and radial systems). Synchronous Grids and Asynchronous (DC) interconnections. Review of Three-phase systems. Analysis of simple three-phase circuits. Power Transfer in AC circuits and Reactive Power.

Module 2: Power System Components (15 hours)

Overhead Transmission Lines and Cables: Electrical and Magnetic Fields around conductors, Corona. Parameters of lines and cables. Capacitance and Inductance calculations for simple configurations. Travelling-wave Equations. Sinusoidal Steady state representation of Lines: Short, medium and long lines. Power Transfer, Voltage profile and Reactive Power.

Characteristics of transmission lines. Surge Impedance Loading. Series and Shunt Compensation of transmission lines.

Transformers: Three-phase connections and Phase-shifts. Three-winding transformers, auto-transformers, Neutral Grounding transformers. Tap-Changing in transformers.

Transformer Parameters. Single phase equivalent of three-phase transformers.

Synchronous Machines: Steady-state performance characteristics. Operation when connected to infinite bus. Real and Reactive Power Capability Curve of generators. Typical waveform under balanced terminal short circuit conditions - steady state, transient and sub-transient equivalent circuits. Loads: Types, Voltage and Frequency Dependence of Loads. Per-unit System and per-unit calculations.

Module 3: Over-voltages and Insulation Requirements (4 hours)

Generation of Over-voltages: Lightning and Switching Surges. Protection against Over-voltages, Insulation Coordination. Propagation of Surges. Voltages produced by traveling surges. Bewley Diagrams.

Module 4: Fault Analysis and Protection Systems (10 hours)

Method of Symmetrical Components (positive, negative and zero sequences). Balanced and Unbalanced Faults. Representation of generators, lines and transformers in sequence networks. Computation of Fault Currents. Neutral Grounding.

Switchgear: Types of Circuit Breakers. Attributes of Protection schemes, Back-up Protection. Protection schemes (Over-current, directional, distance protection, differential protection) and their application.

Module 5: Introduction to DC Transmission & Renewable Energy Systems (9 hours)

DC Transmission Systems: Line-Commutated Converters (LCC) and Voltage Source Converters (VSC). LCC and VSC based dc link, Real Power Flow control in a dc link. Comparison of ac and dc transmission. Solar PV systems: I-V and P-V characteristics of PV panels, power electronic interface of PV to the grid. Wind Energy Systems: Power curve of wind turbine. Fixed and variable speed turbines. Permanent Magnetic Synchronous Generators and Induction Generators. Power Electronics interfaces of wind generators to the grid.

EEE- 302	Power Systems - II	3L:1T:3P	5.5 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to

Use numerical methods to analyse a power system in steady state.

Understand stability constraints in a synchronous grid.

Understand methods to control the voltage, frequency and power flow.

Understand the monitoring and control of a power system.

Understand the basics of power system economics.

Module 1: Power Flow Analysis (7 hours)

Review of the structure of a Power System and its components. Analysis of Power Flows: Formation of Bus Admittance Matrix. Real and reactive power balance equations at a node. Load and Generator Specifications. Application of numerical methods for solution of non-linear algebraic equations - Gauss Seidel and Newton-Raphson methods for the solution of the power flow equations. Computational Issues in Large-scale Power Systems.

Module 2: Stability Constraints in synchronous grids (8 hours)

Swing Equations of a synchronous machine connected to an infinite bus. Power angle curve. Description of the phenomena of loss of synchronism in a single-machine infinite bus system following a disturbance like a three--phase fault. Analysis using numerical integration of swing equations (using methods like Forward Euler, Runge-Kutta 4th order methods), as well as the Equal Area Criterion. Impact of stability constraints on Power System Operation. Effect of generation rescheduling and series compensation of transmission lines on stability.

Module 3: Control of Frequency and Voltage (7 hours)

Turbines and Speed-Governors, Frequency dependence of loads, Droop Control and Power Sharing. Automatic Generation Control. Generation and absorption of reactive power by various components of a Power System. Excitation System Control in synchronous generators, Automatic Voltage Regulators. Shunt Compensators, Static VAR compensators and STATCOMs. Tap Changing Transformers.

Power flow control using embedded dc links, phase shifters and

Module 4: Monitoring and Control (6 hours)

Overview of Energy Control Centre Functions: SCADA systems. Phasor Measurement Units and Wide-Area Measurement Systems. State-estimation. System Security Assessment. Normal, Alert, Emergency, Extremis states of a Power System. Contingency Analysis. Preventive Control and Emergency Control.

Module 5: Power System Economics and Management (7 hours)

Basic Pricing Principles: Generator Cost Curves, Utility Functions, Power Exchanges, Spot Pricing. Electricity Market Models (Vertically Integrated, Purchasing Agency, Whole-sale competition, Retail Competition), Demand Side-management, Transmission and Distributions charges, Ancillary Services. Regulatory framework.

New Syllabus

EEE-202	Electrical Machines-I	3L: 1T: 2P	5 Credits	Course Type: PCC

Preamble:

This course will provide a good understanding to the students in the area of electrical machines. The course includes understanding of principles of electromagnetic conversion and D C machines. This course also gives an insight into single and three phase transformers.

Prerequisites: Engineering Mathematics, Basic Electrical Engineering

Course Outcomes:

On the successful completion of this course, students will be able to:

COs	Course Outcomes	Bloom's Level
CO1	Able to know about electrical machines	Remembering, Understanding
CO2	Able to understand and apply concepts of DC machines	Understanding, Applying
CO3	Able to understand and apply electromagnetic energy conversion principles	Understanding, Applying
CO4	Exhibit the knowledge of armature reaction, commutation, interpoles, windings, singly and double excited systems	Understanding, Analysing, Applying
CO5	Calculate emf, torque, current, losses etc.	Understanding, Analysing
CO6	Demonstrate fundamental understanding of transformers	Analysing, Evaluating

Mapping with Programme Outcomes:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	2	1	-	-	-	-	2
CO2	2	1	2	1	1	2	1	-	1	-	1	2
CO3	2	1	1	-	1	3	1	-	1	-	1	2
CO4	1	2	1	1	1	2	1	-	2	-	1	2
CO5	2	2	2	1	1	2	1	-	2	-	2	2
CO6	2	1	1	1	1	1	1	-	1	-	1	2

Avg.	2.0	1.3	1.2	0.7	0.8	2.0	1.0	0.0	1.2	0.0	1.0	2.0

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Outcome 1:

1. Define and classify transformers.
2. Briefly discuss the energy storage in magnetic field.
3. Explain the principle of working of DC Machine.

Course Outcome 2:

1. Explain the phenomenon of voltage build in DC shunt generators.
2. Explain Ward Leonard method.
3. Write outcomes and limitations of Swinburn's Test.

Course Outcome 3:

1. What are singly excited systems?
2. Derive expression for emf generated in DC machines.
3. Make a comprehensive technical comparison of singly and double excited systems.

Course Outcome 4:

1. What is Armature Reaction?
2. What is Commutation?
3. Explain the purposes of Inter-poles and Compensating Windings.

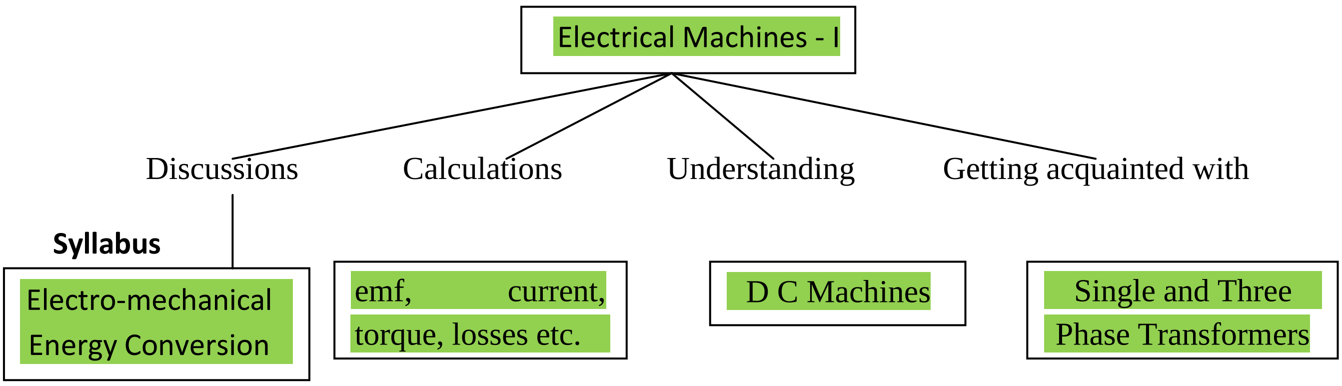
Course Outcome 5:

1. Derive expression for torque in machines with cylindrical air gap.
2. What do you understand by defining energy and co-energy?
3. Derive expressions for losses and efficiency of DC machines.

Course Outcome 6:

1. Explain efficiency and voltage regulation of transformer.
2. Describe parallel operation and load sharing of single phase and three phase transformers.
3. Explain Sumpner's Test and Polarity Test.

Concept Map



Module-I: Principles of Electro-mechanical Energy Conversion

Introduction, Flow of Energy in Electromechanical Devices, Energy in magnetic systems (defining energy & Co-energy), Singly Excited Systems; determination of mechanical force, mechanical energy, torque equation, Doubly excited Systems; Energy stored in magnetic field, electromagnetic torque, Generated emf in machines; torque in machines with cylindrical air gap

[8L]

Module-II: D.C. Machines

Construction of DC Machines, Armature winding, emf and torque equation, Armature Reaction, Commutation, Inter-poles and Compensating Windings, Performance Characteristics of D.C. generators, Voltage build in DC shunt generators

[6L]

Module–III: D.C. Machines (Continued)

Performance Characteristics of D.C. motors, starting of D.C. motors; 3-point and 4-point starters, Speed control of D.C. Motors: Field Control, armature control and Voltage Control (Ward Leonard method); Losses, Efficiency and Testing of D.C. machines (Hopkinson's and Swinburn's Test)

[9L]

Module-IV: Single Phase Transformer

Phasor diagram, efficiency and voltage regulation, all day efficiency. Testing of Transformers: O.C. and S.C. tests, Sumpner's test, Polarity test. Auto Transformer: Single phase and three phase auto transformers, volt-ampere relation, efficiency, Merits & demerits and applications

[8L]

Module-V: Three Phase Transformers

Construction, three phase transformer, Phasor groups and their connections, open delta connection, three phase to 2 phase, 6 phase or 12 phase connections, and their applications, parallel operation and load sharing of single phase and three phase transformers, excitation phenomenon and harmonics in transformers, three winding transformers

[9L]

EEE-206	Electrical Measurement and Measuring Instruments	2L: 1T: 2P	4 Credits	Course Type: PCC

Preamble:

This course will provide a good understanding about analysis to the students in the area of electrical measurements and measuring instruments. The course includes understanding of principles of measurements, error analysis, analog instruments, digital measurements and CRO. This course also gives an insight into instrument transformers, potentiometers, various bridges and magnetic measurements.

Prerequisites: Engineering Mathematics, Basic Electrical Engineering

Course Outcomes:

On the successful completion of this course, students will be able to:

COs	Course Outcomes	Bloom's Level
CO1	Able to know and analyse principles of measurements	Remembering, Understanding
CO2	Able to understand and apply concepts of analog instruments and digital measurements	Understanding, Applying
CO3	Able to understand and apply knowledge of CRO	Understanding, Applying
CO4	Exhibit the knowledge of magnetic measurement and instrument transformers	Understanding, Analysing, Applying
CO5	Calculate measurement errors and do error analysis	Understanding, Analysing
CO6	Demonstrate fundamental understanding of measurement bridges	Analysing, Evaluating

Mapping with Programme Outcomes:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	2	2	-	-	-	-	2
CO2	2	1	2	1	1	2	2	-	1	-	1	3
CO3	2	1	1	-	1	3	2	-	1	-	1	2
CO4	3	1	1	1	1	2	2	-	2	-	1	3
CO5	2	1	2	1	1	3	2	1	2	-	2	2
CO6	3	1	1	1	1	3	2	-	1	-	1	3
Avg.	2.5	1.0	1.2	0.7	0.8	2.5	2.0	0.2	1.2	0.0	1.0	2.5

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Outcome 1:

1. What is philosophy of engineering measurements?
2. What is difference between measurement and instrumentation?
3. Explain working of CRO.

Course Outcome 2:

1. Differentiate between analog and digital measurements.
2. How PMMC instruments work?
3. Explain working principle of Moving Iron instruments.

Course Outcome 3:

1. List applications of CRO.
2. Discuss applications of CRO in measurements of Phase and Frequency.
3. What are Dual-Trace and Dual-Beam Oscilloscopes?

Course Outcome 4:

1. What are principles of operation of Current Transformer and Potential Transformer?
2. Explain Ballistic Galvanometer.
3. What is Flux meter? List its advantages and applications.

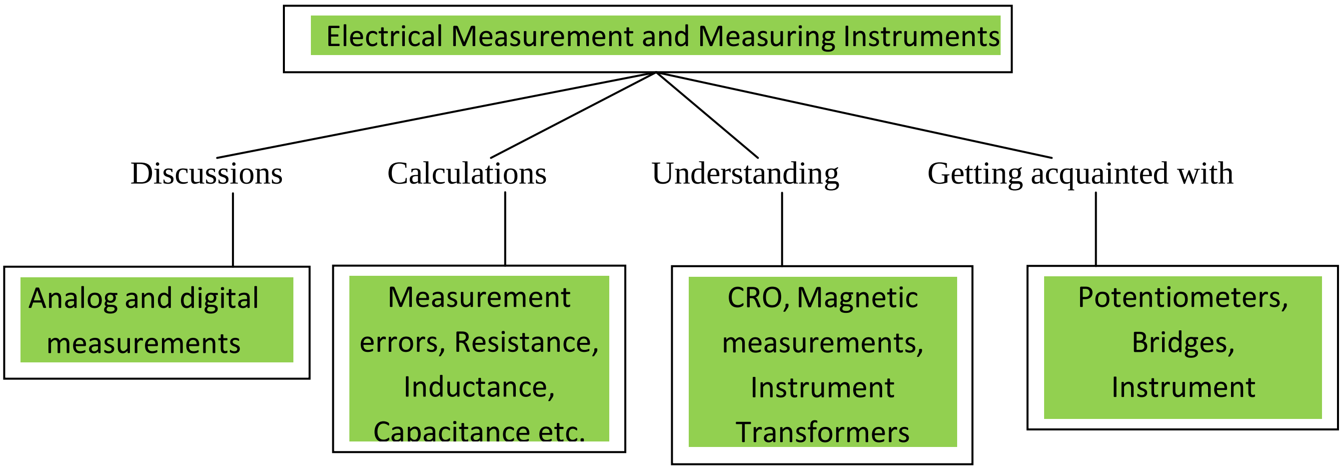
Course Outcome 5:

1. What are various errors in measurement?
2. How measurement error is carried out? List and explain its methods.
3. What is calibration?

Course Outcome 6:

1. Differentiate D.C. and A.C. Bridges.
2. How Inductance, Capacitance and Quality factor are measured?
3. Explain methods of measurements of Low, Medium, and High Resistances.

Concept Map



Syllabus

Module-I: Principles of Measurement and Error Analysis

Methods of measurement, Measurement system, Classification of instrument system, Characteristics of instruments and measurement systems, Errors in measurement and itsanalysis

[5L]

Module-II: Analog Instruments

Classification, Principle of operation of Permanent Magnet Moving Coil and Moving Iron Instruments, Voltmeters and Ammeters, Errors in Voltmeters and Ammeters, Electrodynamometer type Instruments, Power measurement.

[6L]

Module-III: Digital Measurements and Cathode Ray Oscilloscopes (CROs)

Digital Measurement of Electrical Quantities, Block Diagram study of Digital Voltmeter, Frequency Meter, Basic CRO Circuit (Block Diagram), Cathode Ray Tube (CRT) and its Components, Applications of CRO in measurements of Phase and Frequency, Dual-Traceand Dual-Beam Oscilloscopes

[6L]

Module-IV: Potentiometers and Bridges

D.C. and A.C. Potentiometers, D.C. and A.C. Bridges, Measurement of Inductance,Capacitance and Quality factor, Measurement of Low, Medium, and High Resistances

[5L]

Module V: Instrument Transformers and Magnetic Measurements

Principle of operation of Current Transformer and Potential Transformer, Error Analyses,Magnetic measurements, Ballistic Galvanometer, Flux meter, Advantages and Applications

[5L]

EEE - 301	Electrical Machines - II	3L: 1T: 2P	5 Credits	Course Type: PCC

Preamble:

This course will provide a good understanding and hold to the students in the area of electrical machine. The course includes: Basic Concepts, Modelling, Components, Analysis of synchronous machines and induction machines.

Prerequisites:

Engineering Mathematics, Engineering Physics, Basic Electrical Engineering, Electrical Circuit Analysis and

Electrical Machine - I.

Course Outcomes:

On the successful completion of this course, students will be able to:

COs	Course Outcomes	Bloom's Level
CO1	Understand the basics and needs of electrical machines	Remembering, Understanding
CO2	Able to solve problems of electrical machines	Applying, Analysing
CO3	Understand and analyse the basic operation of synchronous machine	Understanding, Analysing, Evaluating
CO4	Understand and analyse the basic operation of induction machine	Understanding, Analysing, Evaluating
CO5	Understand and analyze the basic operation of single phase induction motor and to understand basic operation of universal motor	Understanding, Analysing, Evaluating
CO6	Able to learn electrical machine and implement its concepts for life long	Remembering, Understanding, Analysing, Creating

Mapping with Programme Outcomes:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	-	-	2	-	-	1	-	-	2
CO2	3	3	1	1	1	3	1	-	2	-	-	2
CO3	3	3	1	2	1	3	1	-	2	-	-	2
CO4	3	3	1	1	1	3	1	-	2	-	-	2
CO5	3	3	1	2	1	3	1	-	2	-	-	2
CO6	3	3	2	2	2	3	1	-	3	-	1	3
Avg.	3.0	3.0	1.0	1.3	1.0	2.8	0.8	0.0	2.0	-	0.2	2.7

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Level Assessment

Questions

Course Outcome 1:

1. Explain the generation of electromagnetic torque in electric machines.
2. Compare the performance of three phase induction motor and DC motor.
3. Why three phase synchronous motor is not self starting?.

Course Outcome 2:

1. Two three phase alternators operate in parallel. The rating of one machine is 200 MW and that of other is 400 MW. The droop characteristics of their governors are 4% and 5%, respectively from no load to full load. Assuming that the governors are operating at 50 Hz. at no load, how would a load of 600 MW be shared between them. What will be the system frequency at this load?
2. A 4 pole, 50 Hz., 3-phase induction motor has a rotor resistance of 0.02 ohm per phase and standstill reactance of 0.5 ohms per phase. Determine the speed at which the maximum torque is developed.
3.A 4 pole, 3300 Volts, 50 Hz. induction motor runs at the rated frequency and voltage. The frequency of the rotor current is 2.5 Hz.. Find the per unit slip and the running speed.

Course Outcome 3:

1. Why is a rotating field system used in preference to a stationary field in synchronous machine?
2. Explain the effect of distribution of winding and use of short pitch coil on the magnitude of the generated voltage of an alternator.
3.Explain the hunting in synchronous motor. How it can be minimized?

Course Outcome 4:

1.Explain the principle of operation of three phase induction motor.
2. Discuss any one method to control the speed of three phase induction motor from stator side.
3. What do you understand by crawling in three phase induction motor?

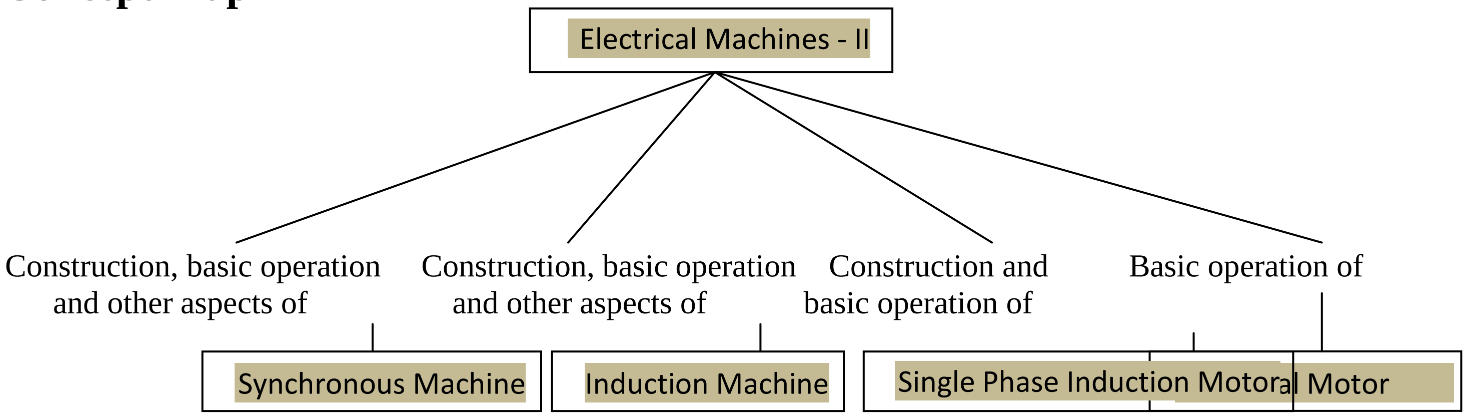
Course Outcome 5:

1. How starting torque is developed in single phase induction motor?
2. Write the applications of capacitor start capacitor run motor.
3. Briefly explain the operation of universal motor.

Course Outcome 6:

1. Give a list of industrial application of electrical machines.
2. Design and develop an electrical machine based application solving a real life problem.
3. Suggest electrical motor for electric traction system.

Concept Map



Syllabus:

Module 1: Synchronous Machine I (10 Lectures):
Constructional features, EMF Equation, Winding coefficients, equivalent circuit and phasor diagram, Armature reaction, O. C. & S. C. tests, Voltage Regulation using Synchronous Impedance Method, MMF Method, Potier‟s Triangle Method, Parallel Operation of synchronous generators, operation on infinite bus, synchronizing power and torque co-efficient

Module 2: Synchronous Machine II (7 Lectures):

Two Reaction Theory, Power flow equations of cylindrical and salient pole machines, operating characteristics Synchronous Motor: Starting methods, Effect of varying field current at different loads, V- Curves, Hunting & damping, synchronous condenser

Module 3: Three phase Induction Machine I (9 Lectures):

Constructional features, Rotating magnetic field, Principle of operation Phasor diagram, equivalent circuit, torque and power equations, Torque- slip characteristics, no load & blocked rotor tests, efficiency, Induction generator & its applications.

Module 4: Three phase Induction Machine II (7 Lectures):

Starting, Deep bar and double cage rotors, Cogging & Crawling, Speed Control (with and without emf injection in rotor circuit.)

Module 5: Single phase Induction Motor (7 Lectures):

Double revolving field theory, Equivalent circuit, No load and blocked rotor tests, Starting methods, Universal motor

EEE - 303	**Control System**	**3L: 1T: 2P**	**5 Credits**	**Course Type: PCC**

Preamble:

This course will provide a good understanding and hold to the students in the area of control system. The course includes: Basic Concepts, Modelling, Components, Response Analysis, Stability, Analysis and Design of Control Systems.

Prerequisites:

Engineering Mathematics, Engineering Physics, Basic Electrical Engineering and Electrical Circuit Analysis.

Course Outcomes:

On the successful completion of this course, students will be able to:

COs	Course Outcomes	Bloom's Level
CO1	Explain the needs and effects of control system	Remembering, Understanding
CO2	Obtain mathematical model of a given control system in transfer functions and state space, and apply the same	Applying, Analysing
CO3	Identify and also justify the type of a given control system from its model, characteristics and responses	Analysing, Evaluating
CO4	Understand Time - response analysis and time-domain analysis	Understanding
CO5	Understand Frequency - response analysis	Understanding
CO6	Analyze the system"s stability and performance in terms of the key characteristics and practical implementation, compensation.	Analysing, Creating

Mapping with Programme Outcomes:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	1	-	2	2	2	-	1	1	-	3
CO2	3	2	2	2	1	2	2	-	2	1	1	3
CO3	3	2	2	3	2	2	2	-	2	1	1	3
CO4	3	3	3	2	2	2	2	-	1	1	1	3
CO5	3	3	2	3	2	2	2	-	2	1	1	3
CO6	3	3	3	2	2	2	2	-	2	1	1	3
Avg.	3.0	2.2	2.2	2.0	1.8	2.0	2.0	0.0	1.7	1.0	0.8	3.0

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Level Assessment

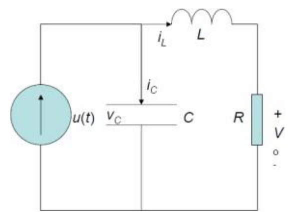
Questions Course Outcome

1:

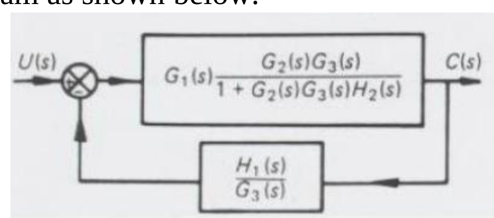
1. List various differences between closed loop control systems and open loop control systems with examples.
2. Explain the technical issues involved in ON/OFF and Hysteresis controls in dynamical systems.
3. Explain reduction of parameter variation and effects of disturbance by using negative feedback.

Course Outcome 2:

1. Obtain state space model of given electrical circuit.



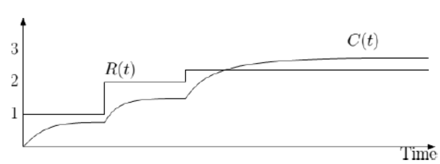
2.Obtain state space model of armature controlled DC motor.
3.Find C(s) / U(s) of the block diagram as shown below.



Course Outcome 3:

1. Identify the causality and linearity of the systems modelled with the differential equation $\frac{d^2y(t)}{dt} + 2y^2(t) = 3u(t-2)$

2. Series of step input r(t) is applied to a system and the response c(t) is recorded as below. Identify the linearity of the system.

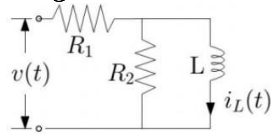


3.What is difference between type and order of a control system?

Course Outcome 4:

1. Obtain unit step response of a first order control system.

2. Find i(t) if input v(t) is a unit ramp input of the given electrical circuit.



3. Consider a third order polynomial as given below.

$s^3 + Ps^2+Qs+K = 0.$

Do its time response analysis by approximating it as a second order system using the concept of dominant poles.

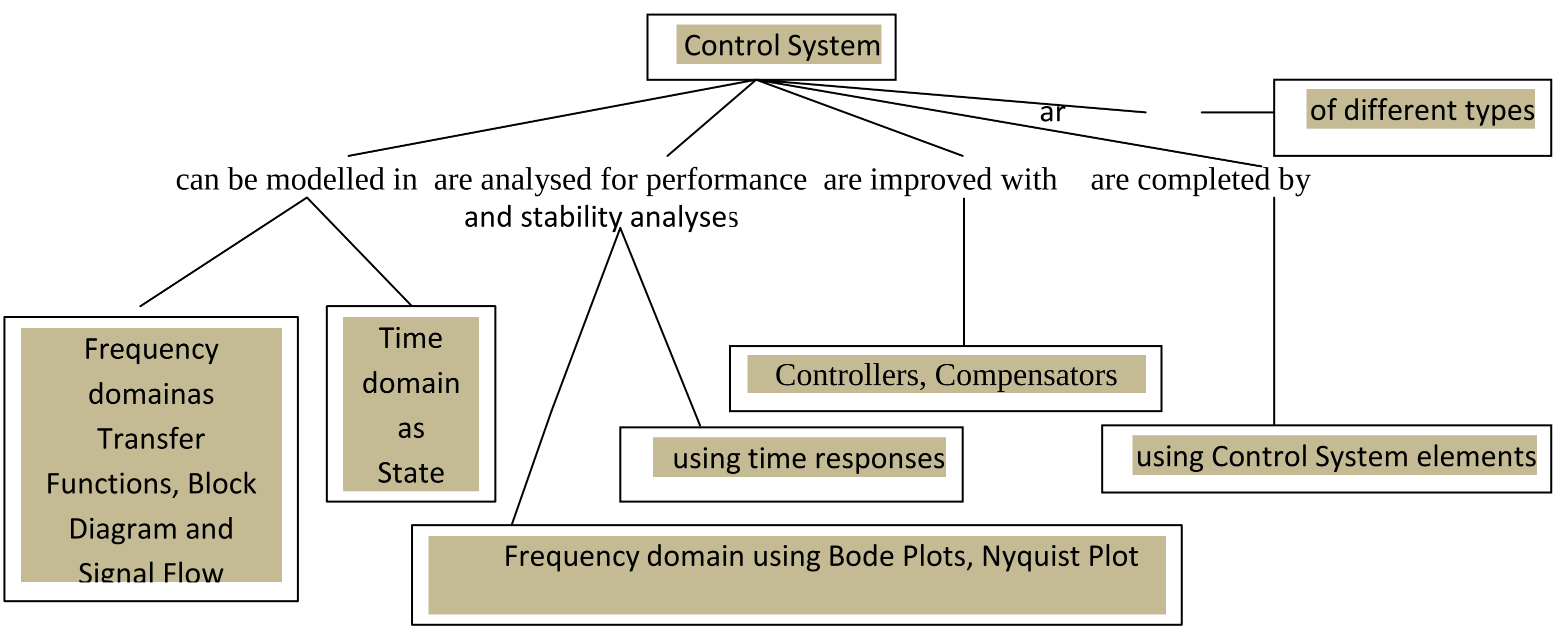
Course Outcome 5:

1. Sketch the Bode Plots of the system G(s) H(s) = 20 / (s (s +2) (s +5)), and determine gain margin and phase margin and comment on stability of the system.
2. Consider the transfer function of a general second order closed loop control system and make derivations of frequency domain specifications like resonant peak, resonant frequency and bandwidth.
3.What is correlation between time domain and frequency domain?

Course Outcome 6:

1. Sketch the Root Locus for system G(s) H(s) = K / (s(s +2) (s^2 +5)), and find the value of K for damping of 0.6.
2. Consider a unity feedback system given as G(s) = 2 / (s (s+20) (s+40)). Find out the lead compensator such that (a) the maximum overshoot allowed is about 20% (b) the settling time improves by a factor of five.
3. Do a practical realization of a Lag Compensator with the help of resistors and capacitor.

Concept Map



Syllabus:

Module 1: Basic Concepts (7 Lectures): Systems - Types of control systems, Notion of feedback, Open and Closed loop systems, Fundamental control actions (ON/OFF, Hysteresis control), Servomechanism, Physical examples, Reduction of parameter variation and effects of disturbance by using negative feedback, Digital Control vs. Analog Control.

Module 2: Control System Components and Modelling (8 Lectures): Servo Motors and actuators (control valves, solenoids), Stepper Motor , Modelling and representations of control systems: Ordinary differential equations, Transfer functions, Block diagrams, Signal flow graphs, Brief introduction of State-space representations.

Module 3: Time - Response Analysis (9 Lectures): Test Signals, Time response of first order and second order systems, Time domain specifications, Steady state errors and error constants, Effect of addition of Poles and Zeros, Dominant poles and zeros of Transfer function, PID Controllers - Derivative error, derivative output, integral error, Design specifications of second order systems, Design considerations for higher order systems, Performance indices.

Module 4: Time - Domain Analysis and Stability(7 Lectures): Review of State variable technique, conversion of State variable model to Transfer Function model and vice-versa, Diagonalization, Controllability and Observability and their Testing, Solution of state equations, Stability: Concept, Algebraic criteria and conditions, Characteristic equation, Routh-Hurwitz criteria and limitations, Root locus concept and construction.

Module 5: Frequency - Domain Analysis and Stability (9 Lectures): Frequency responses and Frequency domain specifications - Concepts of gain margin and phase margin, Correlation between time and frequency responses, Nyquist stability criterion, Nyquist plot, Bode plots, Nichol"s chart, Concepts of Lead, Lag and Lead-lag compensators and their implementation.

EEE - 305	Power System - I	3L: 1T: 0P	4 Credits	Course Type: PCC

Preamble:

This course will provide a good understanding and hold to the students in the area of power system. The course includes calculations of resistance, inductance, capacitance of transmission line, power system components, performance analysis of transmission lines, various aspects of insulators and tower of Power Systems.

Prerequisites:

Engineering Mathematics, Engineering Physics, Basic Electrical Engineering and Electrical Circuit Analysis.

Course Outcomes:

On the successful completion of this course, students will be able to:

COs	Course Outcomes	Bloom's Level
CO1	Able to know about various components of power system and supply system	Remembering, Understanding
CO2	Able to calculate inductance and capacitance of various configurations of transmission lines	Understanding, Applying, Analysing
CO3	Evaluating various aspects of insulators used in power system network	Analysing, Evaluating
CO4	Understand various aspects of corona and interference, and their effects on transmission line performance	Understanding, Analysing,
CO5	Able to do mechanical and electrical design calculations of transmission line	Understanding, Analysing, Applying
CO6	Able to identify various aspects of grounding and familiarization with EHVAC, HVDC systems	Remembering, Understanding

Mapping with Programme Outcomes:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	2	1	-	-	-	-	3
CO2	3	1	2	1	1	2	1	-	1	-	1	2
CO3	3	1	1	-	1	2	1	-	1	-	2	2
CO4	3	2	1	1	1	2	1	-	2	-	1	3
CO5	3	2	2	1	1	2	1	-	2	-	2	3
CO6	3	1	1	1	1	1	1	-	1	-	1	2
Avg.	3.0	1.3	1.2	0.7	0.8	1.8	1.0	0.0	1.2	0.0	1.2	2.5

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Outcome 1:

1.What do you understand by different types of supply systems?
2. Briefly describe bus bar in an electrical system.
3. Explain proximity effect.

Course Outcome 2:

1.Derive an expression for the capacitance per kilometer of a single phase line taking into account the effect ofground .
2.Show that the inductance per unit length of an overhead transmission line due to internal flux linkages inconstant and is independent of the size of the conductor.
3. Derive expression for the inductance of a three phase line with conductors un-transposed.

Course Outcome 3:

1. Explain various types of insulators used in transmission line.
2. What do you beam by term, "String Efficiency" in overhead line insulators?
3.A string of six insulator unit has mutual capacitance ten times the capacitance to ground. Determine thevoltage across each unit as a fraction of the operating voltage. Also, determine the string efficiency.

Course Outcome 4:

1. Discuss inductive interference between power and communication lines.
2. Write advantages and disadvantages of corona.
3. What are methods to reduce corona loss?

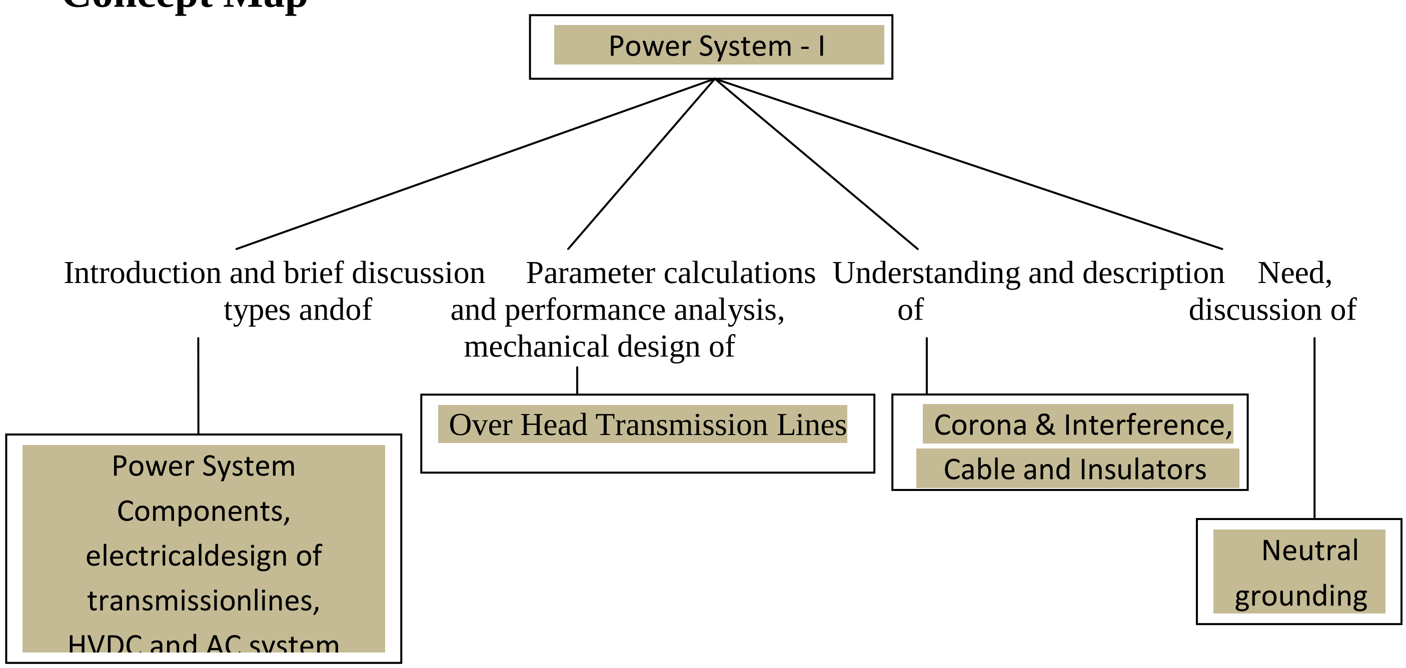
Course Outcome 5:

1. Derive expressions for sag and tension in a power conductor strung between two supports at equal heightstaking into account the wind and ice loading also.
2. What is sag template? How it useful for location of towers and stringing of power conductors.3.What is basis of selection of ground wire in transmission line design?

Course Outcome 6:

1. What is the necessity of neutral grounding?
2. What are different grounding practices?
3. Compare EHV AC and HVDC transmission systems.

Concept Map



Syllabus:

Module 1: Power System Components (8 Lectures):

Single line Diagram of Power system, Brief description of power system Elements: Synchronous machine, transformer, transmission line, bus bar, circuit breaker and isolator, Supply System, Different kinds of supply system and their comparison, choice of transmission voltage, Transmission Lines: Configurations, types of conductors, resistance of line, skin effect, Kelvin‟s law, Proximity effect

Module 2: Over Head Transmission Lines (8 Lectures):

Calculation of inductance and capacitance of single phase, three phase, single circuit and double circuit transmission lines, Representation and performance of short, medium and long transmission lines, Ferranti effect, Surge impedance loading

Module 3: Corona and Interference (8 Lectures):

Phenomenon of corona, corona formation, calculation of potential gradient, corona loss, factors affecting corona, methods of reducing corona and interference, Electrostatic and electromagnetic interference with communication lines. Overhead line Insulators: Type of insulators and their applications, potential distribution over a string of insulators, methods of equalizing the potential, string efficiency

Module 4: Mechanical Design of transmission line (8 Lectures):

Catenary curve, calculation of sag & tension, effects of wind and ice loading, sag template, vibration dampers Insulated cables: Type of cables and their construction, dielectric stress, grading of cables, insulation resistance,capacitance of single phase and three phase cables, dielectric loss, heating of cables

Module 5: Neutral grounding and electrical design of transmission line (8 Lectures):

Necessity of neutral grounding, various methods of neutral grounding, earthing transformer, grounding practices

Electrical Design of Transmission Line: Design consideration of EHV transmission lines, choice of voltage, number of circuits, conductor configuration, insulation design, selection of ground wires, EHV AC and HVDC Transmission: Introduction to EHV AC and HVDC transmission and their comparison, use of bundle conductors, kinds of DC links, and incorporation of HVDC into AC system

EEE - 302	**Power System - II**	**3L: 2T: 0P**	**5 Credits**	**Course Type: PCC**

Preamble:

This course will provide a good understanding and hold to the students in the area of power system. The course includes concepts, modelling, components, calculations, simple designing and analysis of power system.

Prerequisites:

Basic Electrical Engineering, Power System - I

Course Outcomes:

On the successful completion of this course, students will be able to:

COs	Course Outcomes	Bloom's Level
CO 1	Understanding basics and needs of representation of power system components	Remembering, Understanding
CO 2	Able to solve problems of faults analyses, stability analyses of power system	Applying, Analysing
CO 3	Understanding basic concepts of load flow	Understanding, Analysing, Evaluating

CO 4	Understanding and analyse the basiccomponents of power system stability	Understanding, Analysing, Evaluating
CO 5	Handling problems of fault analysis usingcomputer	Understanding, Analysing, Evaluating
CO 6	Able to learn power system and itsconcepts for life long	Remembering, Understanding, Analysing, Creating

Mapping with Programme Outcomes:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	-	-	2	-	-	1	-	-	2
CO2	3	3	1	1	1	3	1	-	2	-	-	2
CO3	3	3	1	2	1	3	1	-	2	-	-	2
CO4	3	3	1	1	1	3	1	-	2	-	-	2
CO5	3	3	1	2	1	3	1	-	2	-	-	2
CO6	3	3	2	2	2	3	1	-	3	-	1	3
Avg.	3.0	3.0	1.0	1.3	1.0	2.8	0.8	0.0	2.0	-	0.2	2.7

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) ifthere is no correlation, put "-"

Course Level Assessment

QuestionsCourse Outcome 1:

1. Define load flow analyses and classify the buses.
2. Explain the need of symmetrical component.

Course Outcome 2:

1. Derive the relation to calculate line-to-ground fault current in threephase alternator.
2. Derive the swing equation.

Course Outcome 3:

1. Obtain the load flow equation for Gauss-Siedel Method.
2. Compare the performance of Gauss-Siedel Method and Neuton-RaphsonMethod.

Course Outcome 4:

1. Differentiate steady-state and transient stability.
2. Explain equal area criterion and apply it on the three phase alternatorwhen its mechanical input is suddenly raised.

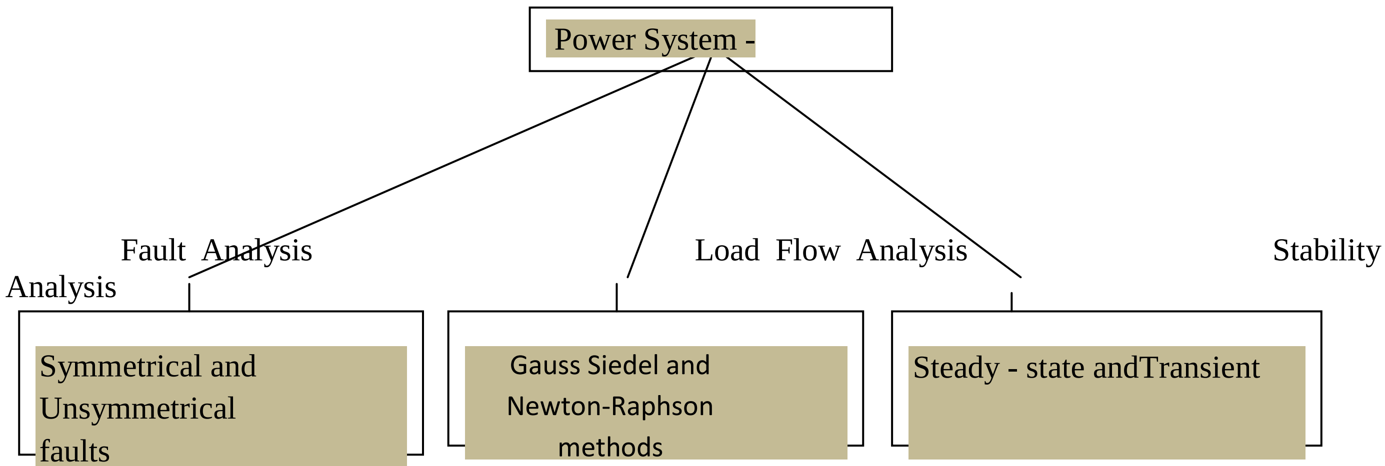
Course Outcome 5:

1. Explain nodal admittance matrix (Ybus).
2. Do all necesssray derivations for electrical variables in the case of Line to ground fault on an unloaded generators and power system network with and without fault impedance.

Course Outcome 6:

1. Show all needed calculations of 3-phase short circuit current and reactance ofsynchronous machine.
2. What are various factors affecting steady state and transient stability andalso explain methods of its improvement?

Concept Map



Syllabus:

Module 1: Representation of Power System Components and Symmetrical fault analysis (10 Lectures):

Representation of Power System Components:
Synchronous machines, Transformers, Transmission lines, One line diagram, Impedance and reactance diagram, per unit System
Symmetrical fault analysis:
Transient in R-L series circuit, calculation of 3-phase short circuit current and reactance of synchronous machine, internal voltage of loaded machines under transient conditions

Module 2: Symmetrical components and Unsymmetrical faults (10 Lectures):

Symmetrical components:

Symmetrical Components of unbalanced phasors, power in terms ofsymmetrical components, sequence impedances and sequence networks Unsymmetrical faults:
Analysis of single line to ground fault, line-to-line fault and Double Line to ground fault on an unloaded generators and power system networkwith and without fault impedance

Module 3: Building of Z_{bus} and introduction to computer method for fault analysis (10 Lectures):

Formation of Z_{bus} using singular transformation and Z_{bus} building algorithm, Introduction to computer method for short circuit calculations

Module 4: Load Flow (10 Lectures):

Introduction, bus classifications, nodal admittance matrix (Y_{bus}), Development of load flow equations, Load flow solution using Gauss Siedel and Newton-Raphson method

Module 5: Power System Stability (10 Lectures):

Stability and Stability limit, Steady state stability study, Derivation ofSwing equation, Transient stability studies by equal area criterion and step-by-step method, Factors affecting steady state and transient stability and methods of improvement

Text Books:

1. W. D. Stevenson, Jr. "Elements of Power System Analysis", Mc Graw Hill
2. C. L. Wadhwa, "Electrical Power System", New Age International
3. I. J. Nagrath and D. P. Kothari, "Power System Enginerring", TMH

Reference Books:

1. Chakraborthy, Soni,Gupta & Bhatnagar, "Power System Engineering", Dhanpat Rai & Co.
2. T.K Nagsarkar & M.S. Sukhija, "Power System Analysis" Oxford University Press,2007.

Course Contents and Lecture Schedule

Module No.	Topic(s)	No. of Lectures
1	Synchronous machines, Transformers, Transmissionlines, One line diagram, Impedance and reactance diagram, per unit System	5
1	Transient in R-L series circuit, calculation of 3-phase short circuit current and reactance ofsynchronous machine, internal voltage of loaded machines under transient conditions	5
2	Symmetrical Components of unbalanced phasors,power in terms of symmetrical components, sequence impedances and sequence networks	4
2	Analysis of single line to ground fault, line-to- line fault and Double Line to ground fault on an unloaded generators and power system network with and without fault impedance	6
3	Formation of Z_{bus} using singular transformation and Z_{bus}building algorithm,	5

3	Introduction to computer method for short circuit calculations	5
4	Introduction, bus classifications, nodal admittance matrix (Y_{bus}), Development of load flow equations	4
4	Load flow solution using Gauss Siedel and Newton-Raphson method	6
5	Stability and Stability limit, Steady state stability study, Derivation of Swing equation	4
5	Transient stability studies by equal area criterion and step-by-step method	4
5	Factors affecting steady state and transientstability and methods of improvement	2

हरकोर्ट बटलर प्राविधिक विश्वविद्यालय
नवाबगंज, कानपुर – 208002, उ.प्र., भारत
HARCOURT BUTLER TECHNICAL UNIVERSITY
NAWABGANJ, KANPUR - 208002, U.P., INDIA
(Formerly Harcourt Butler Technological Institute, Kanpur)
Phone : +91-0512-2534001-5, 2533812, website : http://www.hbtu.ac.in, Email : vc@hbtu.ac.in

100 YEARS
1921 - 2021

Department: Biochemical Engineering

School: Chemical Technology

Name of Programme: B. Tech. Biochemical Engineering

Academic Session 2021-22

Total no. of courses in the Programme: 21

% Change in the course curriculum: 23%

Number of Courses where syllabus revision was carried out BoS

S. No.	Name of course	Course code
1	Microbiology Lab	TBE 257
2	Bioinformatics	TBE 359
3	Bioreaction Engineering	TBE 360
4	Fermentation Technology Lab	TBE 362

Number of Courses related with employability/ entrepreneurship/ skill development

S. No.	Name of Course	Course code
1	Microbiology	TBE 255
2	Microbiology Lab	TBE 257
3	Biochemistry	TBE 256
4	Molecular Biology & Genetic Engineering	TBE 355
5	Bioprocess Engineering	TBE 357
6	Bioinformatics	TBE 359
7	Down Stream Processing	TBE 354
8	Fermentation Technology	TBE 356
9	Environmental Biotechnology	TBE 358
10	Bioreaction Engineering	TBE 360
11	Fermentation Technology Lab	TBE 362
12	Enzyme Engineering & Technology	TBE 451
13	Bioreactor Design	TBE 453
14	IPR & Biosafety regulation Food Biotechnology	TBE 455 TBE 457
15	Plant Cell Biotechnology Novel Bioproducts	TBE 459 TBE 461
16	Industrial Training	TBE 493
17	Seminar	TBE 495

18	Project	TBE 497 & TBE 498
19	Sustainable Bio-Energy Recourses Bioprocess Equipment Design	TBE 452 TBE 454
20	Instrumentation and Control in Bioprocesses Biomaterial Science & Engineering	TBE 456 TBE 458
21	Biotechnology Entrepreneurship	TBE 492

Elective Courses in the Programme

S. No.	Program Elective Courses	Name of Course	Course code
1	PEC I	IPR & Biosafety regulation Food Biotechnology	TBE 455 TBE 457
2	PEC II	Plant Cell Biotechnology Novel Bioproducts	TBE 459 TBE 461
3	PEC III	Sustainable Bio-Energy Recourses Bioprocess Equipment Design	TBE 452 TBE 454
4	PEC IV	Instrumentation and Control in Bioprocesses Biomaterial Science & Engineering	TBE 456 TBE 458

New Courses Introduced

S. No.	**Name of Course**	**Course code**
1	Microbiology Lab	TBE 257
2	Bioinformatics	TBE 359
3	Bioreaction Engineering	TBE 360
4	Fermentation Technology Lab	TBE 362

Head
Deptt. of Biochemical Engineering
School of Chemical Technology
. H. Technical University, Kanpur-02

Signature and Seal
Head of Department

ANNEXURE-II

TBE-201: MATERIAL & ENERGY BALANCE

L	T	P	C
3	1	0	4

Course objectives: The objective of the course is to impart:

- The knowledge of principles of material and energy balances applied during unit operation in food processing
- The knowledge of designing and optimizing the process in food technology

Course outcomes

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

CO1	Understand the basic of engineering principles for the calculation of material and energy balance	Understanding
CO2	Apply material and component balance in unit operation of food processing	Apply
CO3	Understand fluid flow required to perform material balance in mechanical and rheological operations of food materials	Understanding
CO4	Apply energy balance for the calculation of thermal and freezing load in unit operation of food processing	Apply
CO5	Understand material and energy balance simultaneously during analysis for multicomponent systems	Understanding

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	1	-	-	-	1	-	-	-	-	-	1	2	2
CO2	2	1	1	1	-	1	1	-	-	-	-	2	3	3
CO3	2	-	-	-	-	-	1	-	-	-	-	1	1	1
CO4	2	1	-	-	-	1	1	-	-	-	-	2	2	2

CO5	2	1	-	-	-	1	1	-	-	-	-	2	2	2
Average	2	1	1	1	1	1	1	1	3	1	1	2	2	2

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

If there is no correlation, put "-"

Course Level Assessment Questions

Course Outcome 1 (CO1)

- Review of basic Engineering mathematics
- Basics of unit and dimensions
- Fundamental of material and energy balance
- Stress-strain behavior in materials
- Fundamentals of fluid flow

Course Outcome 2 (CO2)

- Basics of material and component balance
- Material balance in unit operation
- Problems related to material balance in food processing

Course Outcome 3 (CO3)

- Fundamentals of fluid flow study in food processing
- Mass balance continuity equation
- Newtonian and Non-Newtonian Fluids power law equation
- Calculation of Energy losses and Pressure drops in flow systems

Course Outcome 4 (CO4)

- Energy balance in food operations
- Enthalpy Changes in Foods during Freezing
- Application of Humidity and psychrometric chart in food processing
- Properties of Saturated and Superheated Steam

Course Outcome 5 (CO5)

- Understanding simultaneous Material and Energy Balances
- Material and energy balance during analysis for multicomponent systems
- Unsteady State Material and Energy Balances

Syllabus

Module-I: Introduction to material & Energy Balance

Review of basic engineering mathematics; units and dimensions; material and energy balance. Principles of Fluid Flow - Introduction to stress strain behavior in materials; properties of fluid viscosity; capillary tube viscometer; power law equation for pseudo plastic; Newtonian and dilatant fluids; flow in pipes-friction, laminar and turbulent flow equations, considerations in pumping fluid.

Module-II: Material Balance

Basic Principles: Law of Conservation of Mass, Process Flow Diagrams, System Boundaries, Total Mass Balance, Component Mass Balance, Material Balance Problems Involved in Dilution, Concentration, and Dehydration, Steady State, Volume Changes on Mixing, Batch versus Continuous processing, Blending of Food Ingredients, Total Mass and Component Balances, Use of Specified Constraints in Equations, Problems related to material balance in food processing.

Module-III: Fluid-Flow Theory

Introduction, Fluid statics, fluid pressure, absolute pressures, gauge pressures, head, Fluid dynamics, Mass balance continuity equation; Energy balance; Potential energy; Kinetic energy; Pressure energy; Friction loss; Mechanical energy; Other effects; Bernouilli's equation flow from a nozzle; Viscosity shear forces viscous forces; Newtonian and Non-Newtonian Fluids power law equation; Streamline and turbulent flow; dimensionless ratios; Reynolds number; Energy losses in flow; Friction in Pipes Fanning equation Hagen Poiseuille equation; Blasius equation; pipe roughness; Moody graph; Energy Losses in Bends and Fittings; Pressure Drop through Equipment; Equivalent Lengths of Pipe; Compressibility Effects for Gases; Calculation of Pressure Drops in Flow Systems

Module-IV: Energy balance

General Principles, Energy Terms, Heat Content, Enthalpy, Specific Heat of Solids and Liquids, Enthalpy Changes in Foods during Freezing, Freezing Point Depression by Solutes, Sensible Heat of Water and Ice at Temperatures Below the Freezing Point, Total Enthalpy Change, Specific Heats of Gases and Vapours. Humidity and psychrometric chart, Energy balance calculations in humidification and adiabatic cooling. Steam table, Properties of Saturated and Superheated Steam

Module-V: Analysis of Material and Energy Balance

Simultaneous Material and Energy Balances: Degrees of freedom analysis for multicomponent systems, combined steady state material and energy balances for units with multiple sub-systems, Unsteady State Material and Energy Balances: Transient materials and energy balances involving with and without chemical reactions.

Reference Books and Suggested Readings:

Title	Authors
Fundamentals of Food Process Engineering; 2nd ed, 2000, CBS Publishers	Toledo RT;
Fundamentals of Food Process Engineering	D.R.Heldman and R.P.Singh
Basic Principles and Calculations in Chemical Engineering	David Himmelblau; Printice Hall of India
Chemical process Principles, Material and Energy Balances, 2nd Edition, New Age International.	Hougen,O.A., Watson, K.M., and Ragatz, R.A.

TBE-203 FLUID FLOW & UNIT OPERATIONS

L	T	P	C
3	1	2	5

Course objectives: The objective of this course is to impart

- Knowledge of various fluid properties and their measurement.
- Knowledge of different types flow and flow behavior during flow of fluid through pipes.
- Knowledge of varius losses occurs during fluid flow.

CO1	Understand the concept of viscosity and other fluid properties and their measurement.	Understanding
CO2	Differentiate various types of fluid flows and understand the types of motion.	Understanding
CO3	Understand and apply differential balance of fluid flow to solve the problems related to fluid flow.	applying
CO4	Understand the concept of energy losses during fluid flow in a pipe.	Understanding
CO5	Understand the principle involved in various unit operations.	Understanding
CO6	Conduct various experiments to apply the concepts of fluid mechanics and unit operations.	Analyzing

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	1	-	-	-	-	-	-	-	1	-	1	1	1
CO2	2	1	1	1	-	1	-	-	-	-	-	1	2	2
CO3	3	2	2	2	-	1	1	-	-	1	-	1	3	3
CO4	3	1	1	1	-	1	1	-	-	-	-	1	2	2
CO5	3	2	1	1	-	-	-	-	-	-	-	2	3	3
CO6	3	2	2	1	1	1	1	1	3	1	1	2	3	3
Average	**3**	**1.5**	**1.4**	**1.5**	**1**	**1**	**1**	**1**	**3**	**1**	**1**	**1.33**	**2.33**	**2.33**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module I: Introduction and properties of fluids

Introduction to fluids, properties of fluids: viscosity, thermodynamic properties, compressibility, Surface tension and Capillarity, Vapour pressure and cavitation, Pressure and it's measurement; fluid pressure at a point, pressure variation in a fluid at rest, simple manometers and differential manometers, hydrostatic forces on submerged surfaces, buoyancy and floatation.

Module II: Kinematics of fluid flow

Introduction, methods of describing fluid flow, types of fluid flow; steady and unsteady; uniform and non-uniform, laminar and turbulent, rotational and irrotational, Rate of flow or discharge, continuity equation, velocity potential and flow net, types of motion and voricity.

Module III: Dynamics of fluid flow

Conservation laws, Euler's equation of motion, Bernoulli's equation, applications of Bernoulli's equation, viscous flow, Raleigh's method and Buckingham's π theorem, types of similarities, dimensional analysis, dimensionless numbers**. Flow Measurements and pumps**: Orifice and venturi meter, Pitot tube, Rotameter and other flow measuring instruments, Positive displacement and centrifugal pumps.

Module IV: Flow through pipes, orifices and flow over dub-merged objects

Internal flow: laminar and turbulent flow in pipes, general equation for head loss – Darcy- Weisbach and Fanning's equations, Moody's diagram, energy losses through pipe fittings, flow through network of pipes. **Boundary layer flows-**Introduction, Prandtl's boundary layer equation and Boundary layer separation. Flow around submerged bodies: Drag force, lift and drag coefficient, drag on flat plate circular cylinder and sphere.

Module V: Unit operations

Different types of screening equipment in industries, Screen efficiency, **Filtration:** Governing equations, constant pressure operation, constant flow operation, cycle time, types of filters. **Centrifuges and Cyclones**: Gravity settling, centrifugal separation, cyclone separations, separation efficiency, pressure loss, **Size reduction -** Rittingers Law, Kicks law, Bondscrushing law, Work index, Problems, Classification of size reduction equipment : Crushers, Grinders, Ultra-fine grinders, Cutting machines, Problems.

Module VI: Laboratory experiments

Determine coefficient of discharge of an orifice meter, venturimeter, determine the friction factor for the pipes, verify the Bernoulli's Theorem, find critical Reynolds number for a Pipe flow, determine the meta-centric height of a floating body, determine the minor losses due to sudden enlargement, sudden contraction and bends.

Reference Books and Suggested Readings:

Title	**Authors**
A textbook of fluid mechanics and hydraulic machines. Laxmi publications	Bansal, R. K. (2004)
Unit Operations of Chemical Engineering: McGraw Hill	McCabe and Smith

Course Title : MICROBIOLOGY

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-205	4	3	1	0	30	20	-	50	50	100

Objective:-

The objective of this course is to enable the students to understand importance of microorganisms in Biochemical Engineering to acquaintance them with scope and basic techniques of microbiology.

Course outcome:- On successful completion of the course student will be able to –

CO 1	Understand difference between bacteria, yeast and molds on the basis of their morphology, physiology and microscopic enumeration.	**Apply**
CO2	Understand growth curve, growth kinetics and continuous cultures.	**Apply**
CO3	Hands on Isolation and maintenance of pure cultures and quantitative estimation of growth.	**Apply**
CO4	Know various physical and chemical methods for control of microorganisms. Various infectious diseases and Vaccines.	**Apply**
CO5	Understand occurrence of microorganisms in soil, water, air and food.	**Apply**

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1							1				1	3	3
CO2	1	2	2	2		2						1	3	3
CO3	1	2		3			2					1	3	3
CO4	3	2						1				1	3	3
CO5	3	2	2	2				1				1	3	3
Total	2	2	2	2		2			2			1	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

SYLLABUS

UNIT-I

Microbiology and its scope, landmark discoveries relevant to field of microbiology, microscopy, classification, morphology and physiology of bacteria, yeast, molds, algae and virus. Microscopic observation of bacteria, yeast and mould, Phase contrast and electron microscopy Gram staining, counting of cells (both direct and indirect), growth curve, MPN.

UNIT-II

Microbial growth kinetics, growth curve, diauxic growth factors influencing growth, continuous and synchronous culture, Microbial nutrition and reproduction.

UNIT-III

Pure culture techniques – microbial culture media, isolation, identification and maintenance of cultures, characteristics of pure culture, enumeration techniques.

UNIT-IV

Physical and chemical method of control of microorganisms, classification of infectious diseases caused by bacteria,viruses,fungi, immune response, antigen-antibody interaction. Pathogen-host interaction ,Vaccines.

UNIT-V

Microbial ecology, occourence of microorganism in soil . water, air, food and sewage , food spoilage, food borne infections and food poisoning.Antibiotics classification and their mode of action.

Reference-

1. " Microbiology '' by M.J. Pelezar , Jr. E.C.S. Chan and N.R. Krieg, 5th Ed., TMH Book Company.

2 " Foundation in Microbiology'', Kathleen Talaro & Arthur Talaro , W.C.B.Wm.C. Brown Publishers (1994)

3.Prescott's Microbiology By Joanne Willey and Linda Sherwood and Christopher J. Woolverton

Course Title : MICROBIOLOGY LAB

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-207	2	0	0	4	-	20	30	50	50	100

Experiments:

1. Study of parts of compound microscope and its handling.
2. Preparation of liquid culture media for bacterial growth
3. Preparation of agar plate and agar slants.
4. To isolate the micro-organism by streake plate method.
5. To isolate the micro-organism by pour plate method.
6. To isolate the micro-organism by spread plate technique.
7. To isolate the micro-organism by serial dilution technique.
8. To identify Gram positive and gram negative bacteria.
9. Measurement of cells/spores by counting chamber (haemocytometer procedure)

TBE-202: HEAT TRANSFER OPERATIONS

L	T	P	C
3	0	0	3

Course objectives: The objective of the course is to impart:

- Basic understanding of the phenomena of heat transfer, to develop methodologies for solving a wide variety of practical application in food processing
- Useful information concerning the performance and design of particular heat transfer systems like heat exchanger and processes used in food processing operations.

Course outcomes

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

CO1	Understand the basic of engineering principles of heat transfer and their significance in practical applications	Understanding
CO2	Apply steady state heat conduction with heat generation like heat flow through slab, hollow sphere and cylinder with linear heat transfer, including uniform/non-uniform heat generation	Apply
CO3	Understand unsteady state heat conduction and convection widely used in thermal processing of food materials	Understanding
CO4	Apply mechanism of radiation heat transfer in systems used for advanced food processing operations including solar radiation	Apply
CO5	Understand the concept of heat exchanger and application of different types of heat exchangers used in dairy and food processing industry	Understanding

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	1	-	-	-	2	-	-	-	-	-	1	2	2
CO2	2	1	1	1	-	1	1	-	-	-	-	2	3	3
CO3	2	-	-	-	-	-	1	-	-	-	-	2	1	1

CO4	2	1	-	-	-	2	1	-	-	-	-	2	2	2
CO5	2	2	-	-	-	1	1	-	-	-	-	2	1	2
Average	2	1	1	1	1	2	1	1	3	1	1	2	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Course Level Assessment Questions

Course Outcome 1 (CO1)

- Knowledge about basic heat transfer modes
- Basics of food properties measurements and errors
- Fundamental of conduction as heat transfer
- heat transfer through materials

Course Outcome 2 (CO2)

- concept of steady state heat conduction with heat generation
- temperature distribution with different boundary conditions
- Understanding extended surfaces (fins) of uniform area
- Effectiveness and efficiency of the fins used in food processing

Course Outcome 3 (CO3)

- Fundamentals of unsteady state heat conduction
- Concept of system with negligible internal resistance in various geometries
- Understanding convection heat transfer and film coefficient
- Calculation of Energy losses and Pressure drops in flow systems

Course Outcome 4 (CO4)

- Energy balance in food operations
- Enthalpy Changes in Foods during Freezing
- Application of Humidity and psychrometric chart in food processing
- Properties of Saturated and Superheated Steam

Course Outcome 5 (CO5)

- Understanding simultaneous Material and Energy Balances
- Material and energy balance during analysis for multicomponent systems
- Unsteady State Material and Energy Balances

Syllabus

Module-I: Introduction to Heat Transfer

Basic heat transfer processes, heat transfer coefficients, properties related to heat transfer, food properties measurements and errors; One-dimensional steady state conduction: Theory of heat conduction, Fourier's law and its derivation, Concept of electrical analogy and its application for thermal circuits, heat transfer through composite walls and insulated pipelines

Module-II: Steady State Heat Conduction with Heat Generation & Dissipation

One-dimensional steady state heat conduction with heat generation: Heat flow through slab, hollow sphere and cylinder with linear heat transfer, uniform/non-uniform heat generation, development of equations of temperature distribution with different boundary conditions; Steady-state heat conduction with heat dissipation to environment: Introduction to extended surfaces (fins) of uniform area of cross-section and with Equation of temperature distribution with different boundary conditions; Effectiveness and efficiency of the fins

Module-III: Unsteady State Heat Transfer and Convection

Introduction to unsteady state heat conduction: System with negligible internal resistance and in various geometries; Convection: Forced and free convection, use of dimensional analysis for correlating variables affecting convection heat transfer; Newton's Law of cooling, film coefficient, and correlation of dimensionless number, Combined free and forced convection; Dimensionless numbers: Concept of Nusselt number, Prandtl number, Reynolds number, Grashoff number, some important empirical relations used for determination of heat transfer coefficient; Heisler charts and calculations

Module-IV: Heat Transfer by Radiation

Radiation: Heat radiation, emissivity, absorptivity, transmissivity, radiation through black and grey surfaces, determination of shape factors; Radiation: Stefan –Boltzmann law, emissivity, mechanism of radiation heat transfer in systems including solar radiation, collectors. Heat transfer analysis involving conduction, convection and radiation

Module-V: Heat Exchanger & Application

Heat Exchangers: General discussion, fouling factors, jacketed kettles, LMTD, parallel and counter flow heat exchangers, Overall heat transfer coefficient, fouling factors, log mean temperature difference heat exchange mechanism in various types of heat exchangers, e.g. Tubular, extended surface and plate heat exchangers, effectiveness – NTU relationship; Application of different types of heat exchangers in dairy and food industry

Reference Books and Suggested Readings:

- Eduardo Cao. 2010. Heat Transfer in Process Engineering. The McGraw-Hill Companies, Inc., New York, USA.
- J.P. Holman. 2010. Heat Transfer, 10th Ed. McGraw-Hill Book Co., Boston, USA.
- Don W. Green and Robert H. Perry. 2008. Perry's Chemical Engineers' Handbook. McGraw-Hill Co., Inc., NY, USA.
- R. K. Rajput. 2008. Heat and Mass Transfer. S. Chand and Co., New Delhi
- John H. Lienhard IV and John H. Lienhard V. 2008. A Heat Transfer Textbook. Phlogiston Press, Cambrige, MA, USA.
- Warren L. McCabe, Julian Smith, Peter Harriott. 2004. Unit Operations of Chemical Engineering, 7th Ed. McGraw-Hill, Inc., NY, USA.
- Christie John Geankoplis. 2003. Transport Processes and Separation Process Principles, 4th Ed. Prentice-Hall, NY, USA.
- J, M. Coulson, J. F. Richardson, J. R. Backhurst and J. H. Harker. 1999. Coulson & Richardson's Chemical Engineering, Vol. 1, Fluid Flow, Heat Transfer and Mass Transfer, 6th Ed. Butterworth–Heinemann, Oxford, UK.

TBE 204: CHEMICAL ENGINEERING THERMODYNAMICS

L	T	P	C
3	0	0	3

Course objectives:

- To understand the theory and applications of classical thermodynamics, thermodynamic properties, equations of state, methods used to describe and predict phase equilibria.

Course outcomes

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

CO1	Understand the basic of thermodynamics and the terminology associated with engineering thermodynamics.	Understanding
CO2	Understand the knowledge of contemporary issues related to chemical engineering thermodynamics	Understanding
CO3	Understand and apply the knowledge of phase equilibria in two-component and multicomponent systems.	Understanding
CO4	Understand the thermodynamic properties of substances in gas or liquid state of ideal and real mixture	Understanding
CO5	Apply the knowledge of various thermodynamic cycles	Applying

CO-PO Mapping

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	1	1	-	-	1	1	-	-	-	-	1	3	3
CO2	3	2	1	-	-	1	1	-	-	-	-	2	2	2
CO3	3	1	-	-	-	2	1	-	-	-	-	2	3	3
CO4	2	1	-	-	-	2	1	-	-	-	-	2	3	3
CO5	3	2	1	1	-	1	1	-	-	-	-	2	3	3
CO6	3	3	2	2	1	1	1	1	3	1	1	2	3	3
Average	**3**	**2**	**1**	**2**	**1**	**1**	**1**	**1**	**3**	**1**	**1**	**2**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) ss *If there is no correlation, put* "-"

Syllabus

Module 1

Basic Concepts & First Law of Thermodynamics: Scope of thermodynamics, System & Surroundings, Properties -Force, Temperature & pressure, Equilibrium, Processes- Reversible & Irreversible, Work, Heat, Energy, Phase rule, Joule's Experiment, Internal energy, Enthalpy, Heat capacities, Application of first law to closed & open systems. Volumetric properties of pure fluids: PVT behavior of pure substances, Virial equation of state and its application, ideal gas and cubic equation of state, Generalized correlations for gases and liquids.

Module 2

Second Law of Thermodynamics: Heat engine and its efficiency, Heat pump, Refrigerator, COP, Second law of Thermodynamics, Kelvin–Planck statement & Clausius Statement, Carnot's cycle and Carnot theorems, Clausius inequality, Entropy balance for open systems, ideal work and lost work, Principle of entropy.

Module 3

Thermodynamic properties of pure substances in solid, liquid and vapor phases; P-vT behaviour of simple compressible substances, phase rule, thermodynamic property tables and charts, ideal and real gases, ideal gas equation of state and van der Waals equation of state; law of corresponding states, compressibility factor and generalized compressibility chart, T-ds relations, Helmholtz and Gibbs functions, Gibbs relations, Maxwell relations, Joule-Thomson coefficient, coefficient of volume expansion, adiabatic and isothermal compressibilities, Clapeyron and Clapeyron-Clausius equations.

Module 4

Dalton's and Amagat's laws, properties of ideal gas mixtures, air-water vapor mixtures and simple thermodynamic processes involving them; specific and relative humidities, dew point and wet bulb temperature, adiabatic saturation temperature, psychrometric chart.

Module 5

Carnot vapor cycle, ideal Rankine cycle, Rankine reheat cycle, air-standard Otto cycle, air-standard Diesel cycle, air-standard Brayton cycle, vapor-compression refrigeration cycle.

Reference

1. "Introduction to Chemical Engineering Thermodynamics" by J.M. Smith and H.C. Van Ness,
2. McGraw Hill International Ltd, 2005.

   "Chemical Engineering Thermodynamics" by Y.V.C. Rao, Universities Press (India) Ltd.

Course Title: BIOCHEMISTRY

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-206	5	3	1	3	15	20	15	50	50	100

Objective:- : Biochemistry focuses on understanding the biochemical control of biological processes, particularly in the microbial cell, and the tools for investigating these mechanisms.

Course outcome:- On successful completion of the course student will be able to –

CO 1	Understand the polymeric biomolecules and their monomeric building blocks.	**Apply**
CO2	Know the specificity of enzymes (biochemical catalysts), and the mechanism involved in enzyme action.	**Apply**
CO3	Understand the metabolism of glucose, leads ultimately to the generation of large quantities of ATP. Describe the metabolism of fats and amino acids, and explain their role for energy generation. Describe the replication of DNA, and explain the transfer of genetic information	**Apply**
CO4	Understand Concept of protein metabolism.	**Apply**
CO5	Understand Concept of Nucleic acid biosynthesis	**Apply**

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	1			2		2	2					1	2	3
CO2	1			2		2	2					1	2	3
CO3	1	3		2		2	2					1	2	3
CO4	1	3		2		2	2					1	2	3
CO5	1	3		2		2	2					1	2	3
CO6	**1**	**3**		**2**		**2**	**2**					**1**	**2**	**3**
Total	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Unit 1: Introduction-aims and scope. Structure and function of biomolecules: carbohydrates, proteins, lipids, nucleic acids, vitamins and coenzymes.

Unit 2: Structure and function of enzymes, mechanism of enzymatic catalysis and enzyme kinetics.

Unit 3: Biological membranes and transport across them. Bioenergetics. Metabolic pathways for breakdown of carbohydrates-glycolysis, pentose phosphate pathway, citric acid cycle, electron transport chain, Photophosphorylation. Lipid metabolism. Nucleic acid metabolism: mechanism and biosynthesis of DNA and RNA.

Unit 4: Protein metabolism; out lines of amino acid metabolism. Protein biosynthesis, inhibitors of protein synthesis.

Unit 5: Biochemistry Lab

1 Estimation of carbohydrates.
2. Estimation of proteins.
3. Estimation of nucleic acids:
4. Separation of amino acids by paper chromatography.
5. Thin layer Chromatography.
6. Assay of enzyme activity and enzyme kinetics.

References:

1. “Principles of Biochemistry”, A.L. Lehninger, D.L. Neston, N.M. Cox, CBS Publishers & Distributors.
2. “Biochemistry”, Lubert Stryer, W.H. Freemen & Co. , New York.
3. “General Biochemistry”, J.H. Weil, New Age International (PLD).
4. “An Introduction to Practical Biochemistry”, David T. Plummer, Tata McGraHill Co. Ltd., New Delhi.

TBE-301: MASS TRANSFER OPERATIONS

L	T	P	C
3	1	0	4

Course objectives: The objective of the course is to impart:

- Basic understanding of the phenomena of mass transfer, to develop methodologies for solving a wide variety of practical application in food processing
- Useful information concerning the principle and working of particular mass transfer unit operations like drying, evaporation used in food processing operations.

Course outcomes

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

CO1	Understand the basic of engineering principles of mass transfer and their significance in practical applications	Understanding
CO2	Understand the concept of mass transfer coefficients and related dimensionless numbers	Understanding
CO3	Understand principles of drying, equilibrium and free moisture widely used in handling and storage of food materials	Understanding
CO4	Apply mechanism of evaporation in food processing operation by using different type of evaporators	Apply
CO5	Apply the concept of absorption and crystallization used in different food processing operations	Understanding

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	1	-	-	-	1	-	-	-	-	-	1	2	2
CO2	2	2	2	1	-	1	1	-	-	-	-	2	3	3
CO3	2	-	-	-	-	-	2	-	-	-	-	1	1	1
CO4	2	1	-	-	-	2	1	-	-	-	-	2	2	2
CO5	2	2	-	-	-	2	2	-	-	-	-	2	1	2
Average	2	2	1	1	1	1	1	1	3	1	1	2	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Course Level Assessment Questions

Course Outcome 1 (CO1)

- Knowledge about basic mass transfer operation
- Basics of molecular diffusion in fluids
- Fundamental of diffusion in mass transfer
- Diffusion coefficient measurement and prediction

Course Outcome 2 (CO2)

- concept of steady state heat conduction with heat generation
- temperature distribution with different boundary conditions
- Understanding extended surfaces (fins) of uniform area
- Effectiveness and efficiency of the fins used in food processing

Course Outcome 3 (CO3)

- Fundamentals of drying as mass transfer operation
- Concept of drying conditions including constant-rate and falling-rate
- Calculation of drying time under different drying conditions
- Principle and designing of different dryer

Course Outcome 4 (CO4)

- Fundamentals of evaporation as mass transfer operations
- Application of evaporation in food processing
- Principal and working of different evaporators
- Design of single and multiple effect evaporator

Course Outcome 5 (CO5)

- Understanding absorption for binary and multi component systems
- Material and energy balance during absorption and crystallization
- Principles of Crystallization and their application
- Types of Crystallizers used in practice

Syllabus

Module-I: Introduction to Mass Transfer

Introduction to Mass transfer operation, Concentration, Mass & Molar Avg. Velocity, Mass & Molar Flux, N & J flux, Fick's law of diffusion, Steady state molecular diffusion in fluids under stagnant and laminar flow conditions, steady state diffusion: of A through non-diffusing B, equimolar counter diffusion. Effect of Temperature and Pressure on diffusivity; Diffusion coefficient measurement and prediction

Module-II: Interphase Mass Transfer & M.T. Coefficients

Concept of Equilibrium, Diffusion between two phases, Modes of Convective Mass transfer; Introduction to Mass transfer coefficients, Gas Phase & Liquid Phase M.T. coefficients, Local & Overall M.T. coefficients, Dimensionless Numbers in Mass transfer, Simultaneous Heat & Mass Transfer, Steady state co- current & counter-current processes

Module-III: Drying

Importance of drying in processes, principles of drying, equilibrium and free moisture, bound and unbound water, constant drying conditions, constant-rate, period, critical moisture content and falling-rate period, porous solids and flow by capillarity, calculation of drying time under constant drying conditions. Classification of dryers, solids handling in dryers, equipment for batch and continuous drying processes: working principle of tray driers, tower driers, rotary driers, spray driers. Concept of freeze drying

Module-IV: Evaporation

Introduction, single- and multiple- effect operation, long tube vertical evaporators, agitated-film evaporators, evaporator capacity, BPE and Duhring's rule, evaporator economy, enthalpy balances for single effect evaporator. Multiple effect evaporators, methods of feeding, capacity and economy of multiple effect evaporators, multiple effect calculations

Module-V: Absorption & Crystallization

Absorption - Equilibrium solubility of gases, Material balance for transfer of one component. Counter current multistage operations for binary and multi component systems. Continuous contactors, absorption with chemical reaction Concept of HTU and NTU; Industrial Absorbers; Sparged vessels (bubble columns), mechanically agitated vessels for a single phase and gas liquid contact; Principles of Crystallization, Super saturation, Nucleation, Crystal growth, Material & Energy Balance applied to Crystallizers, Types of Crystallizers used in practice.

Reference Books and Suggested Readings:

- Warren L. McCabe, Julian Smith, Peter Harriott. 2004. Unit Operations of Chemical Engineering, 7th Ed. McGraw-Hill, Inc., NY, USA.

- Christie John Geankoplis. 2003. Transport Processes and Separation Process Principles, 4th Ed. Prentice-Hall, NY, USA.
- J, M. Coulson, J. F. Richardson, J. R. Backhurst and J. H. Harker. 1999. Coulson & Richardson's Chemical Engineering, Vol. 1, Fluid Flow, Heat Transfer and Mass Transfer, 6th Ed. Butterworth–Heinemann, Oxford, UK.
- M. Necati Özişik. 2008. Heat Conduction, 2nd Ed. John Wiley & Sons, NY, USA.
- Robert E. Treybal. 2014. Mass Transfer Operations, 3rd Ed. McGraw-Hill Book Company, Auckland, USA.
- Earle RL. 2012. Unit Operations in Food Processing. Pergamon Press.

TBE-303 CHEMICAL REACTION ENGINEERING

L	T	P	C
3	0	0	3

Course objectives:

- To apply knowledge from calculus, differential equations, thermodynamics, general chemistry, and material and energy balances to solve reactor design problems,
- To examine reaction rate data to determine rate laws, and to use them to design chemical reactors,
- To simulate several types of reactors in order to choose the most appropriate reactor for a given need,
- To design chemical reactors with associated cooling/heating equipment.

CO1	Able to develop an understanding of the basic concepts involved in using reaction rate equations and kinetic constant	Understand Apply
CO2	Perform derivations of rate equations for non-elementary reactions both in homogenous and in heterogeneous reacting systems	Apply
CO3	Able to understand the role of temperature and concentration in the rate equation	Understand
CO4	Perform constant volume batch reactor calculations	Apply
CO5	Develop calculations using the integral method and applying differential method of analysis using reactions with different orders	Understand Apply

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	3	-	-	-	-	-	-	1	-	1	1	1
CO2	3	3	3	1	-	1	-	-	-	1	-	1	2	2
CO3	3	3	3	2	-	2	-	-	-	1	-	1	2	2
CO4	3	3	1	-	2	1	-	-	-	1	-	1	2	2
CO5	3	3	2	2	2	1	-	-	2	1	-	3	2	2
Average	**3**	**2.8**	**2.4**	**1.6**	**2**	**1.2**			**2**	**1**		**1.4**	**2**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

SYLLABUS

Module- I

Rate of Reaction, Elementary and non-elementary homogeneous reactions, Molecularity and order of reaction, Mechanism of reaction, temperature dependency from thermodynamics, collision and activated complex theories. Integral and differential methods for analyzing kinetic data, interpretation of constant volume reactor, zero, first, second and third order reactions, half life period, irreversible reaction in parallel and series, catalytic reaction, auto catalytic reaction, reversible reactions.

Module-II

Interpretation of variable volume batch reactions for zero, first and second order reactions, Space-time and state-velocity, design equation for ideal batch, steady-state continuous stirred tank, steady-state plug flow reactors for isothermal reaction.

Module- III

Design for single reactions, Size comparison of single reactors, Multiple reactor systems, plug flow/mixed flow reactors in series and parallel, reactors of different types in series, optimum reactor size, recycle reactor, autocatalytic reactions.

Module -IV

Introduction to multiple reactions, qualitative discussion about product distribution, quantitative treatment of product distribution and of reactor size, selectivity, the side entry reactor, irreversible first-order reactions in series, Quantitative treatment: plug flow or batch reactor, Quantitative treatment: mixed flow reactor, Successive irreversible reactions of different orders, reversible reactions, irreversible series-parallel reactions, the Denbigh reactions and their special cases, Heat of reaction from thermodynamics, equilibrium constants from thermodynamics, General graphical design procedure for non-isothermal reactors, Optimum temperature progression, Heat effects: Adiabatic operations and non-adiabatic operations, Exothermic reactions in mixed flow reactors.

Module -V

Residence time distribution of fluids in vessels, State of aggregation of the flowing systems, Earliness of mixing, Role of RTD, State of Aggregation and earliness of mixing in determining reactor behavior, E, F and C curves, Conversion in Non-ideal flow reactors.

Reference Books:

Levenspiel, O. (1998). Chemical reaction engineering book, 3rd edn,

Year-III, Semester-V

Course Title: Molecular Biology and Genetic Engineering

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-305	4	3	0	2	30	20	-	50	50	100

Objective:-

- Students will understand concept of transcription, translation and its regulation.
- Students will understand about the concept of genes and heredity.
- Students will come to know about r-DNA technology and the concepts of gene expression and its control.
- Students will understand the concept of DNA sequencing and gene cloning.

Course outcome:- On successful completion of the course student will be able to –

CO 1	Analyze Molecular structure of genes and chromosomes apply concepts of molecular genetics to develop new techniques in various fields like medical, pharmaceuticals, food production etc.	**Apply**
CO2	apply concepts of molecular genetics to develop new techniques in various fields like medical, pharmaceuticals etc.Understand the fundamentals of molecular biology and genetic engineering.	**Apply**
CO3	Understand Regulation and clustering of genes.	**Apply**
CO4	An exposure to recent developments in genetic engineering techniques, treatment of various diseases including cancer, diabetes and hereditary diseases.	**Apply**
CO5	Case studies of GMO Production.	**Apply**

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	2		1		2						2	3	3
CO2	1	2		1		2	2					2	3	3
CO3	1	2	2	1		2						2	3	3
CO4	1	2	2	1		2	2					2	3	3
CO5	1	2	2	1		2						2	3	3
Total	1	2	2	1		2	2					2	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put* "-"

SYLLABUS

Unit-I

Development of Molecular Biology. Nucleic acids: forms, structure and functions. Gene:

Its concept, construction and inheritance. Inter and intra molecular non-covalent interaction in living system.

Unit-II

Replication of DNA. Transcription and its regulation. Genetic codes: their identification, characteristics and function. Repression and inhibition mechanism. Prokaryotic translation process.

Unit-III

Controlling of Prokaryotic Gene Expression: control circuit of operon. Construction and control of Lac operon and Tryptophan operon.

Unit-IV

r-DNA Technology: Principles, construction, properties of vectors. Restriction enzyme: properties, function and application. Techniques used in r-DNA Technology. Strategy of Gene cloning, expression of gene and selection of genetically modified cells.

Unit-V

Case studies for genetic modification in *E. coli* and yeast. Developement of GMO ,Restriction mapping, DNA sequencing and DNA/RNA Labelling.

References :

1. "Molecular Biology of the Gene", J.D. Watson, Melnopark, California.
2. "Lewin's GENES XII", Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick, Jones & Bartlett Learning (2017).
3. "Biochemistry", A.L. Lehninger, Worth Publication, New York.
4. " Recombinant DNA Technology", Dhillon J.R., John Wiley & Sons, New York.
5. "Genetics", P.K. Gupta, Rastogi Publication, Meerut.

Year III, Semester-V

Course Title: Bioprocess Engineering

<u>Evaluation Scheme:</u>

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-307	5	3	0	4	15	20	15	50	50	100

<u>Objective:- :</u> To introduce the engineering principles of bioprocesses including microbial kinetics, sterilization principles and design considerations.

<u>Course outcome</u>:- On successful completion of the course student will be able to –

CO 1	Describe and analyze phenomena, problems in bioprocesses, apply engineering principles to address issues in bioprocesses.	**Apply**
CO2	Identify limiting factors in a bioprocess and propose solutions to address biological and engineering problems. Analyze kinetics of cell growth or enzyme-catalyzed reactions.	**Apply**
CO3	Analyse the environmental factors which affect cell growth and optimization process of cell growth	**Apply**
CO4	Identify suitable sterilization process/module for media and air. Determination of the air requirement in a bioreactor system	**Apply**
CO5	scale up the bioprocess for large scale production of biomolecules.	**Apply**

COs	**Pos**												**PSOs**	
	1	**2**		**1**	**2**		**1**	**2**		**1**	**2**		**1**	**2**
CO1	3		**CO1**	3		**CO1**	3		**CO1**	3		**CO1**	3	
CO2	3	3	**CO2**	3	3	**CO2**	3	3	**CO2**	3	3	**CO2**	3	3
CO3	3	3	**CO3**	3	3	**CO3**	3	3	**CO3**	3	3	**CO3**	3	3
CO4	3	3	**CO4**	3	3	**CO4**	3	3	**CO4**	3	3	**CO4**	3	3
CO5	3	3	**CO5**	3	3	**CO5**	3	3	**CO5**	3	3	**CO5**	3	3
Total	**3**	**3**	**Total**	**3**	**3**	**Total**	**3**	**3**	**Total**	**3**	**3**	**Total**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

<u>Syllabus</u>

Unit 1

Microbial growth patterns and kinetics; substrate utilization and product formation in batch and continuous reactors; Scale up of Bioreactors

Unit 2

Mass and energy balance in a typical bioconversion process and yield concepts etc.

Unit 3

Sterilization of media: principles, batch and continuous sterilization processes. Sterilization of air: principles, methods of air sterilization.

Unit 4

Aeration and agitation: Oxygen transfer in microbial systems, oxygen demands, mass transfer theories, measurements of volumetric oxygen transfer coefficient, rheology of fermentation fluids.

Unit 5:

Design and execution of simple laboratory scale experiments on the following topics:

1. Effect of physical and chemical environment on growth; selected biochemical tests.
2. Growth kinetic studies of yeast in a bench top lab fermenter under controlled conditions.
3. Studies on settling characteristics of various microbial cultures.
4. Study the solid state fermentation with suitable example.

References:

1. "Biochemical Engineering Fundamentals" by J.E. Bailey and D.F. Ollis, McGraw-Hill Book Co., New York.
2. "Principle of Fermentation Technology", P.F. Stanbury and A. Whitaker; Pergamon Press.
3. Bioprocess Engineering – P.M. Doran
3. "Biochemical Engineering", Shuichi Aiba, Arthur E. Humphrey, Nancy F. Millis; University of Tokyo Press.
4.. "Basic Biotechnology", J. Bu'lock, B. Kristiansen, Academic Press.

Course Title: Bioinformatics

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-309	3	3	0	0	30	20	-	50	50	100

Unit-I

Definitions of informatics, chronological history Molecular Biology's Central dogma; Gene structure and information content, protein structure and function, Molecular Biology tools.

Unit–II

Database concept, Biological Database; (Different types of data books spl. biochemical pathway databases). Sequence analysis, pairwise alignment and database searching. Multiple sequence alignments, Trees and profiles.

Unit–III

Genomies and gene recognition; from sequencing genes to genomes sequence assembly, Annotation and analyzing whole genome sequences, functional genomics.

Unit-IV

Predicting protein structure and function from sequences, Determine the structures of proteins, Predicting the structures of proteins, from 3D to 1D. Feature detection, in protein sequences, Secondary structure prediction, predicting 3D structures.

Unit-V

Application and software tools for bioinformatics, challenges for bioinformatics, Industry drug design & DNA chip.

Course Title: INSTRUMENTATION and PROCESS CONTROL

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-302	3	2	1	0	15	20	15	50	50	100

Course Objectives: The objectives of this course are to impart:

- To gain the knowledge of different process instruments widely used in food and chemical industries.

Course Outcomes: On the successful completion of the course the students will be able to:

CO 1	Understand the principles involved in measurements. Attain knowledge on different measurement methods employed in industrial processing and manufacturing.	Understand
CO 2	Application of different pressure measurement devices in food and chemical industries.	Analysis & Create
CO 3	Application of different temperature measurement devices in food and chemical industries.	Understand, Analysis & Create
CO 4	Application of various level and flow measurement devices in food and chemical industries.	Analysis & Create
CO 5	Measurement of viscosity, thermal conductivity, chromatography, moisture analyzers, etc.	Create & Analysis

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	-	-	1	-	-	-	-	1
CO2	3	1	1	1	-	3	3	3	1	1	-	1
CO3	3	3	2	2	3	-	-	-	1	-	-	2
CO4	3	3	3	2	3	1	1	-	-	-	-	2
CO5	3	3	2	2	3	-	-	-	1	1	3	2
Avg.	3	2	1.6	1.4	3.0	2.0	1.67	3.0	1.0	1.0	3.0	2

Syllabus

Module-I

Characteristics of measurement system, classification, performance characteristics, dynamic calibration, errors, statistical error analysis, reliability and related topics

Module-II

Temperature measurement, definitions and standards, techniques and classification-temperature measurement using change in physical properties, electrical type temperature sensors, radiation thermometry

Module-III

Measurement of pressure: Manometers, Elastic pressure transducers, Measurement of Vacuum.

Module-IV

Flow measurement; head types-area flow meters, mass flow meters, positive displacement type flow meters, electrical type flow meters and solid flow measurement. Level measurement; float types- hydrostatic types, thermal effect types, electrical methods and solid level measurement, density and viscosity measurement

Module-V

Instruments for analysis, spectroscopic analysis by absorption, emission, mass, diffraction and color, gas analysis by thermal conductivity, chromatography, moisture analysis and liquid composition analysis, measurement of pH

Reference Books and Suggested Readings:

Title	Author
Industrial Instrumentation and Control, Prentice Hall of India, 2016.	Singh, S. K.
Industrial Instrumentation, Wiley Eastern Ltd., New York, 1990.	Eckman, D.P.
Principles of industrial instrumentation, Tata McGraw Hill, 2008.	Patranabis
Instrumentation Measurement and Analysis, Tata McGraw Hill, 1978.	Nakra and Chaudhary

Year III, Semester-VI
Course Title : DOWN STREAM PROCESSING

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-304	3	2	1	0	30	20	-	50	50	100

Objective:-

Objective of this course is to enable the student to understand importance of Down Stream Processing in Industrial fermentation .

Course outcome:- On successful completion of the course student will be able to –

CO 1	Understand complex nature of fermentated broth and , complexities in isolation and purification of bioproducts	**Apply**
CO2	Understand solid-liquid separation methods, cell disruption methods.	**Apply**
CO3	Understand precipitation methods , aqueous two phase extraction , adsorption and membrane based separation.	**Apply**
CO4	Understand principle, practice and applications of chromatographic techniques, Electrophoresis.	**Apply**
CO5	Finishing operations – crystallization, drying and formulation	**Apply**

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3					2						3	3	3
CO2	3					2						3	3	3
CO3	3	3	2			2						3	3	3
CO4	3	2	2	2		2	2					3	3	3
CO5	3	1	2			2						3	3	3
Total	**3**	**2**	**2**	**2**		**2**	**2**					**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

SYLLABUS

UNIT-I

Characterization of bioproducts: flocculation and conditioning of broth.

UNIT-II

Mechanical separation : Filtration, centrifugation ,Cell disruption

UNIT-III

Membrane based separation, , Protein precipitation and its separation; Aqueous two phase extraction , Adsorption.

UNIT-IV

Chromatographic separation based on size, charge, hydrophobic interaction, metal ion affinity. Electrophoresis.

UNIT-V

Crystallization and drying.

REFERENCES:-

1. "Biochemical Engineering Fundamentals '' by J.E. Bailey and D.F.Ollis, McGraw –Hill Book Co., New York.
2. " Basic Biotechnology '' , J. Bu'lock , B. Krishtiansen, Academic Press
3 " Comprehensive Biotechnology" ; Vol.2, Murray-Moo-Young , Pergamon Press, New York.

Year III, Semester-VI

Course Title: FERMENTATION TECHNOLOGY

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-306	4	3	1	0	30	20	-	50	50	100

Objective:- : To introduce the students to the various concepts of fermentation and acquire experimental knowhow of microbial production of various industrial products such as alcohol, organic acids, enzymes, amino acids etc.

Course Outcome:- On successful completion of the course student will be able to -

CO 1	Understand the various concepts of fermentation, analyze the industrial aspect of the field of microbiology.	**Apply**
CO2	Understand the industrial aspect of the field of microbiology and know the differences between aerobic and anaerobic fermentation.	**Apply**
CO3	Understand to produce some industrially important liquid fermentation products e.g. ethanol, vinegar etc,produce some industrially important biomass based fermentation products e.g. baker's yeast etc.	**Apply**
CO4	Understand solid and submerged fermentations.	**Apply**
CO5	Understand distinguish primary and secondary metabolites analyze finished microbial products.	**Apply**

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2				3						3	3	3
CO2	3	2				3						3	3	3
CO3	3	2				3						3	3	3
CO4	3	2				3						3	3	3
CO5	3	2				3						3	3	3
CO6	3	2	2	3	1	3			3			3	3	3
Total	**3**	2	**2**	**3**	**1**	**3**			**3**			**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put* "-"

SYLLABUS

UNIT-I

Alcoholic fermentation and related products. Glycerol fermentation. Malting and brewing: beer production, wine manufacturing and other distilled liquors.

UNIT-II

Microbial production of organic acids and fermentation processes. Biomass as a fermentation product: Baker's yeast, Bioinsecticides, Biofertilizers. Amino acids: Lysine and glutamic acid.

UNIT-III

Commercial enzymes: solid and submerged fermentation, recovery etc. Secondary metabolites such as antibiotics and vitamins.

UNIT-IV

Microbial transformations, vaccines, recombinant therapeutic proteins.

References:

1. "Industrial Microbiology", S.C. Prescott and C.G. Dunn, McGraw-Hill Book Company, Inc. New York.
2. "Industrial Microbiology", L.E. Casida Jr. Wiley Eastern Ltd.
3. "Microbial Technology", Vol.II, H.J. Peppler and D. Perlman, Academic Press, New York.
4. Official methods of analysis of AOAC.
5. BIS booklets for various products.
6. "An Introduction to Practical Biochemistry", David T. Plummer, Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

Year III, Semester-VI
Course Title : ENVIRONMENTAL BIOTECHNOLOGY

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-308	3	3	0	0	15	20	15	50	50	100

Objective:-
The objective of this course is to enable the students to understand necessity for treatment of waste water and various physical , chemical and biological methods of waste water treatment

Course outcome:- On successful completion of the course student will be able to –

CO1	Understand characteristics of waste water , classification of treatment methods and bioprocess kinetics applied to waste treatment.	**Understand**
CO2	Understand various aerobic methods and their design aspects of waste water treatment. viz. ASP ponds and lagoons, TF,RBC.	**Apply**
CO3	Understand theory of anaerobic digestion and digester design.	**Apply**
CO4	Understand biological removal of nitrogen and phosphorous and other advanced treatment methods. Case studies.	**Apply**
CO5	Understand methods to estimate DO, BOD , COD, solids and determination of other water pollutants, evaluation of treatment process performance.	**Apply**

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2				3						3	3	3
CO2	3	2				3						3	3	3
CO3	3	2				3						3	3	3
CO4	3	2				3						3	3	3
CO5	3	2				3						3	3	3
CO6	3	2	2	3	1	3			3			3	3	3
Total	**3**	2	**2**	**3**	**1**	**3**			**3**			**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

SYLLABUS

Unit-I

Source and Characteristics of waste, Physical and chemical methods of waste treatment. Bioprocess Kinetics applied to waste treatment.

Unit-II
Anaerobic treatment systems, UASB. Sludge digestion theory, digestor design, high rate digestion, heat transfer in digestor.

Unit-III
Theory of activated sludge process design, operation and control, BOD reduction and biomass relationship , Sequential Batch Reactors, Membrane Bioreactors, Modification, operational and design aspects.

Unit-IV
Nitification- denitrification, Phosphorous removal. Treatment and disposal of sewage and waste of the industries e.g. distilling and brewing, antibiotics and sugar etc. Bioremediation.

1

Unit-V
Experimental determination of various organic and inorganic pollutants-: DO, BOD, COD, solids-total , suspended, volatile and fixed. Evaluation of the effect of process, variables on the performance of ASP, and anaerobic digesters.

REFERENCE:
1. " Waste water Engineering: Treatment, Disposal and Reuse", Metcalf & Eddy, Inc.; Tata McGraw-Hill Publishing Company Ltd., New Delhi.
2. " Water supply and Pollution Control ", Warren Viessman Jr. and Mark J. Hammer; Harper& Row Publishers; New York.

Year IV, Semester-VII
Course Title : Bioreaction Engineering

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-310	3	3	0	0	30	20	-	50	50	100

Objective:-
The objective of this course is to enable the student to understand basic requirements for production of bioproducts , types of bioreactors .

Course outcome:- On successful completion of the course student will be able to –

CO1	Understand upstream processing in biotechnological processes.	Apply
CO2	Understand control of process parameters in bioprocesses	Apply
CO3	Understand operational problems encountered and their prevention and control,	Apply
CO4	Understand about constructional and operational features of different types of bioreactors.	Apply
CO5	Understand bioreactors used in treatment of waste water.	Apply

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3											2	3	3
CO2	3					2						2	3	3
CO3	3											2	3	3
CO4	3											2	3	3
CO5	3	2				2	2					2	3	3
Total	3	2				2	2					2	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put* "-"

SYLLABUS

UNIT-I
Bioreaction Kinetics, Food to microorganism ratio, Pure and Mixed culture kinetics

UNIT_II
Instrumentation and process control in biotechnological processes.

UNIT-III
Aseptic operation, Mixing in bioreactors. Foam control in bioreactors. Computer application in bioreactor

UNIT-IV

Membrane bioreactors. Bioreactors with immobilized biocatalyst. Air lift bioreactors. Solid state bioreactors.

UNIT-V

Bioreactors in waste water treatment.

References:

1. "Principle of Fermentation Technology", P.F. Stanbury and A. Whitaker; Pergamon Press.
2. "Basic Biotechnology", J. Bu'lock, B. Kristiansen, Academic Press.
3. "Biochemical Engineering Fundamentals" by J.E. Bailey and D.F. Ollis, McGraw-Hill Book Co., New York.
4. Bioprocess Engineering Basic Concepts. 2nd edition.. Michael L. Shuler and Fikret Kargi, Prentice Hall, Upper Saddle River, NJ.
5. Bioprocess Engineering Principles Pauline Doran, Academic Press, London,

Course Title : FERMENTATION TECHNOLOGY LAB

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-312	3	0	0	6	-	20	30	50	50	100

Syllabus

Design and execution of simple laboratory scale experiments on the following topics:

1Analysis of molasses.

2.Preparation of Malt and determination of diastatic power

3.Determination of fermentation efficiency of yeast for batch production of ethanol.

4. Effect of substrate concentration on biomass yield for baker's yeast production and its characterization.

5. Fermentation efficiency for vinegar production.

6. Citric acid production by (a) solid state and (b) submerged fermentation.

7.Microbial production of enzymes by (a) solid state and (b) submerged fermentation.

8.Analysis of' finished products (rectified sprit, beer etc.).

Year IV, Semester-VII
Course Title : ENZYME ENGINEERING & TECHNOLOGY

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-401	3	2	0	2	15	20	15	50	50	100

Objective:-
The objective of this course is to enable the students to understand basics of enzyme kinetics and production and industrial application of enzymes.

Course outcome:- On successful completion of the course student will be able to –

CO1	Understand importance of enzymes , their classification and nomenclature.	**Apply**
CO2	Understand kinetics of single and multiple substrate, inhibition kinetics and activation.	**Apply**
CO3	Understand immobilization kinetics and methods of whole cell immobilization and enzyme immobilization, enzyme reactors.	**Apply**
CO4	Understand production technology of industrial enzymes.	**Apply**
CO5	Understand enzyme assay methods, immobilization methods, purification methods,operational feature of enzyme reactors.	**Apply**

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3					3							3	3
CO2	3	2				3						3	3	3
CO3	3	2				3						3	3	3
CO4	3	2				3						3	3	3
CO5	3	3				3						3	3	3
CO6	3	3	3	3	3	3	1		3			3	3	3
Total	**3**	**2.5**	**3**	**3**	**3**	**3**	**1**		**3**			**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

SYLLABUS

Unit-I

Introduction and scope of enzyme, mechanism of enzymatic catalysis, characterization of active sites and ligand binding sites.

Unit-II

Enzyme kinetics of single substrate reaction. Derivation of Michaelis- Menten equation, turover number, determination of Km and Vm (Lineweaver Burk Plot); Numerical related to enzyme kinetics, multiple-substrate reaction mechanism. Kinetics of inhibition and activation, King and Altma method, allosteric enzymes.

Unit-III

Immobilization of enzymes and cells. Methods of immobilization; Adsorption, Entrapment, Encapsulation, Covalent binding, Cross linking and their examples: Merits and demerits of different immobilization methods. Effect of micro and macro environmental parameters on the immobilized enzymes; External film and internal pore diffusion partitioning and electrostatic interaction. Performance of soluble and immobilized enzyme reactors, operational strategies, carrier life and cycle time.

Unit-IV

Production of selected industrial enzymes and their applications

Unit-V

Assay of enzyme activity and specific activity, kinetics analysis of an enzyme catalyzed reaction Immobilization of enzymes, Salt precipitation of and enzyme, immobilization of microbial cells, Comparative study of performance of soluble and immobilized enzyme reactors.

Reference:

1- Biochemical engineering fundamentals by J. E. Bailey and D.F. oils, Mcgraw Hill Books Co New York.
2- Immobilized enzymes by Trevan
3- Enzyme kinetics by Roberts
4- Enzyme engineering by Laidler
5- Enzyme technology by Chaplin and Bucke. Cambridge University Press

Course Title: BIOREACTOR DESIGN

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	TBE-403	2	2	0	0	30	20	-	50	50	100

Objective:- To provide the basic principles of reactor design for bioprocesses.
Course Outcome:- On successful completion of the course student will be able to –

CO1	Understand comprehend the state of the arts in bioreactor technology and its broad range of applications,develop mathematical descriptions of reaction kinetics in cellular systems and their relationships with bioreactor design.	**Apply**
CO2	Understand basic principles of mass and energy conservation to analyze bioreactor systems. Identify the major engineering parameters that characterizes the performance of bioreactors and techniques to measure and control these parameters.	**Apply**
CO3	Understand complete bioreactor based on targets, constraints and physical properties.	**Apply**
CO4	Understand suitable process instrumentation for monitoring and control of bioreactors.	**Apply**
CO5	Understand the problem of selection of suitable bioreactor configuration.	**Apply**

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3		1									2	3	3
CO2	3	2	1									2	3	3
CO3	3	2	1									2	3	3
CO4	3	2	1	1	2	1						2	3	3
CO5	3	2										2	3	3
Total	**3**	**2**	**1**	**1**	**2**	**1**						**2**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put* "-"

SYLLABUS

UNIT-I

Design equations for batch, continuous and fed batch reactors. Non- ideal flow behaviour of Batch and continuous flow reactors.

UNIT-II

Novel bioreactor configuration such as fluidized bed reactor, air-lift reactor, bubble column, membrane bioreactor etc.

UNIT-III

Bioreactor operation measurement and control: Aseptic operations, measurement and control of process variables (pH, dissolved oxygen, viscosity, temperature, NADH), agitative power and foam control.

UNIT-IV

On-line analysis, bioprocess control and computer coupled bioreactors. Bioprocess economics.

References:

2. "Principle of Fermentation Technology", P.F. Stanbury and A. Whitaker; Pergamon Press.
2. "Basic Biotechnology", J. Bu'lock, B. Kristiansen, Academic Press.
3. "Biochemical Engineering Fundamentals" by J.E. Bailey and D.F. Ollis, McGraw-Hill Book Co., New York.
4. Bioprocess Engineering Basic Concepts. 2nd edition.. Michael L. Shuler and Fikret Kargi, Prentice Hall, Upper Saddle River, NJ.
5. Bioprocess Engineering Principles Pauline Doran, Academic Press, London,

Course Title: IPR and Biosafety Regulation

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	TBE-405	3	3	0	0	30	20	-	50	50	100

Objective:-

- To introduce history and evolution of IPR- like patent, design and copy right, Indian patent act 1970 (amendment 2000), international convention in IPR, major changes in Indian patent system as post TRIPS effects (i) obtaining patent (ii) geographical indication.
- Student will understand various forms of IPR, Requirement of a patentable novelty, invention step and prior art and state of art, procedure.
- To understand the Rights/protection, infringement or violation, remedies against infringement – civil and criminal.
- Detailed information on patenting biological products, Biodiversity, Budapest treaty, Appropriate case studies

Course outcome:- On successful completion of the course student will be able to –

CO 1	Understand the importance of intellectual property rights.	**Apply**
CO2	Understand the legal aspects of Rights/protection, infringement or violation, remedies against infringement – civil and criminal.	**Apply**
CO3	Understand to file patent application and review it.	**Apply**
CO4	Understand to work as patent review officer and consultant.	**Apply**
CO5		

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3		2				3					3	3	3
CO2	3	2	2			3	3					3	3	3
CO3	3		2			3	3					3	3	3
CO4	3		2			3	3					3	3	3
CO5	3		2			3	3					3	3	3
Total	**3**	**2**	**2**			**3**	**3**					**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

SYLLABUS

UNIT-I

Jurisprudential definition and concept of property, right, duties and their correlation. History and evolution of IPR- like patent, design and copy right etc.

UNIT-II

Indian patent act, international convention in IPR. TRIPS agreement; IPR issues in relation to biotech products/ processes; architecture of patent application.

UNIT-III

Detailed information on patenting biological products, biodiversity, Budapest treaty, appropriate case studies. Biosafety Principles - environment and health risk assessment; biosafety regulatory guidelines and controlling agencies.

UNIT-IV

Environmental law for hazardous microorganisms and GMOs; Biotechnology Related Issues of Public Concern. Bioethics.

UNIT-V

Regulatory issues concerning the global biotechnology & pharmaceutical industries, including Good Laboratory & Clinical Practice (GLP & GCP).

References:

1. "An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology", Padma Nambisan, Academic Press (2017).
2. "IPR, Biosafety and Bioethics", Shomini Parashar, Deepa Goel, Pearson India (2013).
3. "Intellectual property rights in the global economy", Maskus, Keith E, Institute for International Economics, Washington(2000).
4. "Intellectual property rights in India", V. K. Ahuja, Lexis Nexis India (2009

Course Title: FOOD BIOTECHNOLOGY

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	TBE-407	3	3	0	0	30	20	-	50	50	100

Objective:-

The objective of this course is to enable the students causes of food spoilage and its effects , various methods to prevent food spoilage and testing and quality control of food materials.

Course outcome:- On successful completion of the course student will be able to –

CO1	Understand about food spoiling microorganisms and microbial examination of food,	**Apply**
CO2	Understand about food borne infections and food poisoning	**Understand**
CO3	Understand principles and practice of food preservation by various methods	**Apply**
CO4	Understand about good manufacturing practices, testing and quality control of food.	**Apply**
CO5	Understand about Production of fermented foods and treatment and disposal of food waste	**Apply**

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3	2		3	1				1		3	1
CO2						3		3	3			2	1	3
CO3		3	3	2			1				1			
CO4		3		2					3		1	2		
CO5	3									3				
Total	**3**	**3**	**3**	**2**		**3**	**1**	**3**	**3**	**3**	**1**	**2**	**2**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

SYLLABUS

Unit 1. Introduction:

Important genera of food borne microorganisms, factors affecting the growth and survival of microorganisms in food Direct examination, culture techniques, MPN count, dye reduction assay,

Unit 2. Microbiological examination of food:

Microbial spoilage of food, common food borne diseases, bacterial agents of food borne illness, non-bacterial agents of food borne illness.

Unit 3. Food preservation:

Principles of food preservation, asepsis, anaerobic conditions, removal of microorganisms, low temperature, high temperature, radiation, drying, chemical preservatives and miscellaneous methods, canning.

Unit 4. Cleaning

Cleaning and disinfection code for good manufacturing practices, microbial and chemical safety of food products, indicator organisms, ISO, hazard analysis and critical control points, sterility testing.

Unit 5. Fermented foods:

Fermented milk, cheese, sauerkraut, fermented meat, beer, vinegar, fish products, products of baking, oriental foods. Role of enzymes in different food products (bakery, cheese, beverage production and cereal products) and industries, utilization of food waste for production of valuables.

Text /Reference Books:

- Modern Food Microbiology by James M. J., CBS Publishers and Publishers.
- Food Microbiology by Freiser.
- Willis Biotechnology, Challenges for the flavour and food industries by Lidsay, Elsevier Applied Science.
- Food Biotechnology by Roger A., Gordan B., and John T.
- Basic Food Microbiology by George J. B., CBS Publishers and Distributors.

Course Title: Plant Cell Biotechnology

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	TBE-409	3	3	0	0	30	20	-	50	50	100

Objective:-

- To teach the students about tissue culture techniques.
- To familiarize the students with applied aspects of plant biotechnology.
- To make the students aware of transgenic plants.
- To understand the gene transfer methods.
- To teach the students about the production of secondary metabolites of plant origin.

Course outcome:- On successful completion of the course student will be able to –

CO 1	Understand about Plant cell and concept of totipotency.	**Apply**
CO2	Exposure to various plant products of industrial importance.	**Apply**
CO3	To optimize production of secondry metabolites from suspension culture and characterization of product.	**Apply**
CO4	Formulate nutrient optimization for plant cell growth	**Apply**
CO5	To work in industry producing transgenic plants.	

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2		2			2						3	3	3
CO2	2		2			2						3	3	3
CO3	2		2			2						3	3	3
CO4	2	2	2			2						3	3	3
CO5	2	2	2	1		2						3	3	3
Total	**2**	**2**	**2**	**1**		**2**						**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put* "-"

SYLLABUS

UNIT-I

Special features and organization of plant cells; totipotency and regeneration of plants, examples of regeneration from leaves, roots, stem etc.

UNIT-II

Plant product of industrial importance, biochemistry of major metabolic pathways and products, cells suspension culture development.

UNIT-III

Large scale production of secondary metabolites from suspension cultures. Characterization, kinetics of growth and product formation. Initiation and maintenance of callus cultures,cell suspension- continous and batch cultures.

UNIT-I V

Nutrient optimization, cells growth regulators, biological and technological barriers, mutation,Genome reorganization induced invitro, somaclonal variation and gametoclonal variations, meristem culture, embryo culture, micropropagation importance and applications.

UNIT-V

Genetic engineering of plant cell, plant cells reactors and their performance. Immobilized plant cell reactor and novel design concepts.

References:

1. "Plant Tissue Culture and its Biotechnological Application", W. Barz, E. Reinhard and M.H. Zenk (Eds.); Springer-Verlag, Berlin.

2. "Plant Cell Biotechnology", H. Smith and Mantell (Eds); Cambridge University Press, Cambridge.

Course Title: NOVEL BIOPRODUCTS

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	**TBE-411**	**3**	**3**	**0**	**0**	**30**	**20**	**-**	**50**	**50**	**100**

Objective:-

To acquaintance the students with production and application of novel bioproducts with emphasis on use of renewable resources.

Course outcome:- On successful completion of the course student will be able to –

CO1	Understand production of biopreservatives, biopolymers, xanthan , gum etc.	**Apply**
CO2	Understand microbial process for production of biopharmaceuticals, bioinsecticides etc.	**Understand**
CO3	Understand technology for use of renewable resources for production of novel bioproducts.	**Apply**
CO4	Understand production of liquid and gaseous biofuels, salient features of biofuel cells, biosensors and biomarkers with their application.	**Apply**
CO5	Understand miscellaneous uses of microorganisms for example in steroid transformations, bioconversion of vegetable oils , bioleaching and MEOR.	**Apply**

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3											3	3	3
CO2	3	2	1			1						3	3	3
CO3	3	2	1			1						3	3	3
CO4	3	2	1			1						3	3	3
CO5	3		1									3	3	3
Total	**3**	**2**	**1**			**1.25**						**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

SYLLABUS

Unit-I

Production and application of natural Biopreservatives (Bacteriocin/ Nisin). And Biopolymers (Pullulan/Xanthan Gum and PHB) production and application.

Unit-II

Production and application of Biopharmaceuticals and biopesticides production by microorganisms.

Unit-III

Liquid and gaseous biofuels, biofuel cells and application, biosensors and biomarkers.

Unit-IV

Biotransformation, bioleaching, microbiology and enhanced oil recovery.

References:

1. "Principle of Fermentation Technology", P.F. Stanbury and A. Whitaker; Pergamon Press.
2. "Basic Biotechnology", J. Bu'lock, B. Kristiansen, Academic Press.
3. "Biochemical Engineering Fundamentals" by J.E. Bailey and D.F. Ollis, McGraw-Hill Book Co., New York.
4. Bioprocess Engineering Basic Concepts. 2nd edition.. Michael L. Shuler and Fikret Kargi, Prentice Hall, Upper Saddle River, NJ.
5. Bioprocess Engineering Principles Pauline Doran, Academic Press, London,

Course Title: PRINCIPLES OF BIOCHEMICAL ENGINEERING

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
OEC	OBE-433	3	3	0	0	30	20	-	50	50	100

Objective:- This course introduces the basic aspects of biochemical engineering and bioprocess technology and their commercial implications to the students from various disciplines.

Course Outcome:- On successful completion of the course student will be able to –

CO1	Understand comprehend the state of the arts in bioreactor technology and its broad range of applications, develop mathematical descriptions of reaction kinetics in cellular systems and their relationships with bioreactor design.	**Apply**
CO2	Understand basic principles of mass and energy conservation to analyze bioreactor systems. Identify the major engineering parameters that characterize the performance of bioreactors and techniques to measure and control these parameters.	**Apply**
CO3	Understand complete bioreactor based on targets, constraints and physical properties.	**Apply**
CO4	Understand suitable process instrumentation for monitoring and control of bioreactors.	**Apply**
CO5	Understand the problem of selection of suitable bioreactor configuration.	**Apply**

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3											3	3	3
CO2	3	2	1			1						3	3	3
CO3	3	2	1			1						3	3	3
CO4	3	2	1			1						3	3	3
CO5	3		1									3	3	3
Total	**3**	**2**	**1**			**1.25**						**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

SYLLABUS

UNIT-I

Introduction: Development and prospects of biochemical engineering. Characteristics of living organisms, classification, morphology and physiology of microorganisms.

UNIT-II

Growth, reproduction and nutritional aspects of micro-organisms. Culture isolation, maintenance. Physical and chemical control of micro-organisms.

UNIT-III

General requirements of the microbial processes. Batch fermentation, growth and product formation kinetics. Sterilization of media and air. Aeration and agitation. Down stream processing.

UNIT-IV

Production of alcohol, glycerol, organic acids, baker's yeast, enzymes.

UNIT-V

Antibiotics, biofertilizers,biopesticides. Concepts of biological waste treatments. New developments in biotechnology.

References:

1. "Biochemical Engineering Fundamentals" by J. E. Bailey & D. F. Ollis (1987) 2nd Ed McGraw Hill International Edition.
2."Bioprocess Engineering Principles" by P. M. Doran, (1995) Academic Press.
3. "Industrial Microbiology", S.C. Prescott and C.G. Dunn, McGraw-Hill Book Company, Inc. New York.
4. "Industrial Microbiology", L.E. Casida Jr. Wiley Eastern Ltd.

TBE-413: Industrial Training

L	T	P	C
0	0	4	2

The students offer summer internship of 6 to 8 weeks would be giving presentation on the work they performed or learned during training

COURSE OBJECTIVES: The objectives of this course is to enable the students

- To expose to industrial environment
- To acquaint with the various machines for the manufacturing of food products
- For testing of raw materials and finished products

Course Outcome

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

CO1	Understand the plant layout, work culture and human relationship.	Understand
CO2	Apply the theoretical knowledge in understanding the working of various machines and manufacturing processes	Apply
CO3	Understand the process sequence and optimization of process parameters.	Apply, Analyze
CO4	To get exposure to various conventional and modern tools and equipment for testing of raw materials and finished products	Apply
CO5	To analyze the research problem and devise methodology/ steps to solve it and development of products	Analyze, Create

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	3	2	-	-	2	1	3	3	2	3	3	2	2
CO2	3	2	2	1	2	2	-	1	2	-	2	3	2	2
CO3	3	3	3	2	3	2	1	2	2	2	2	3	2	2
CO4	3	3	2	3	3	-	-	-	-	-	1	3	2	2
CO5	3	3	3	3	3	3	2	1	3	2	3	3	2	2
Average	3	3	2	2	3	2	1	2	3	2	2	3	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

TBE-415: Seminar

L	T	P	C
0	0	4	2

COURSE OBJECTIVES: The objectives of this course is to enable the students

- Study a topic of latest developments/innovative technology on their own and to prepare a dissertation report on this topic.
- Present a lecture on the topic on power point format.
- Improve the communication skill of the students.

Course Outcome

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

CO1	Review, collect and study literature on a topic of interest	Understand
CO2	Apply the knowledge to prepare a report on this topic.	Apply
CO3	Deliver a lecture on the topic on power point format and answer questions from audience, if any	Apply
CO4	While being in the audience listen to the lectures delivered by other participants evaluate the same and comment on the same	Evaluate
CO5	Analyze own shortcomings as well as that of other participants and improve upon the same	Analyze, Evaluate

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	3	2	3	3	2	2	-	2	-	2	3	2	2
CO2	3	3	2	2	3	2	3	2	2	3	2	2	2	2
CO3	3	-	-	-	2	2	2	-	2	3	2	2	2	2
CO4	3	-	-	-	-	1	1	2	3	3	1	2	2	2
CO5	2	-	1	2	1	2	3	1	3	3	2	3	2	2
Average	**3**	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

TBE-417: PROJECT

L	T	P	C
0	0	8	4

COURSE OBJECTIVES: The objectives of this course is to enable the students

- To identify a food product that can be manufactured in India or a research problem and conduct experiment.
- To prepare a report for a project based on manufacturing of product/ development of technology
- To present a lecture on the topic on power point format.
- To improve the communication skill of the students.

Course Outcome

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

CO1	Review, collect and study literature on a topic of interest	Understand
CO2	Apply the knowledge to prepare a report on the same	Apply
CO3	Evaluate the collected literature and formulate a project	Apply, Evaluate
CO4	Define a process/method for completion of the same	Apply
CO5	Analyze sustainability of the technology	Analyze

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	-	-	3	-	2	1	-	1	-	2	3	2	2
CO2	3	2	2	2	1	2	3	-	2	3	3	2	2	2
CO3	3	3	3	2	3	2	2	2	3	3	3	3	2	2
CO4	3	2	2	-	2	1	2	3	3	3	3	3	2	2
CO5	3	3	3	-	1	2	3	3	2	1	2	3	2	2
Average	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**3**	**2**	**3**	**3**	**2**	**2**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

TBE – 419 : EDUCATIONAL TOUR

L	T	P	C
0	0	0	0

Students will be taken to the visit of industries/research organization, in their field of specialization, during the vacation period

OBJECTIVE: The objective of this course is to enable the students

- to visit industries/research organization in their field of biochemical engineering during the vacation period.
- to demonstrate a variety of product formation and manufacturing processes in industries specialization.
- to learn professional ethics.

Course Outcome

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

CO1	visit industries/research organization in their field of biochemical engineering.	Engineer and Society Life long Learner
CO2	to demonstrate a variety of product formation and manufacturing processes in industries specialization.	Engineer and Society Individual & Team Work
CO3	To learn professional ethics.	Ethics
CO4	improve the communication skill of the students.	Communication
CO5	Analyze environment and sustainability of related technology.	Analyze Environment & Sustainability

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3					3			1			3	3	3
CO2	3	2				2	2		1			3	3	3
CO3	3							3				3	3	3
CO4	3									3		3	3	3
CO5	3					2	3		1			3	3	3
Total	**3**	**2**				**3.5**	**2.5**	**3**	**1**	**3**		**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Year IV, Semester-VIII

Course Title: Sustainable Bio-Energy Recourses

Evaluation Scheme:

Course Type	**Subject Code**	**Credits**	**Periods**			**Sessional Marks**				**ESE**	**Total Marks**
			L	**T**	**P**	**MSE**	**TA**	**Lab.**	**Total**		
PEC	**TBE-402**	**4**	**3**	**1**	**0**	**30**	**20**	**-**	**50**	**50**	**100**

Objective:- :To provide knowledge about various types of bio-energy, processing, production and utilization of various form of biomass; Also aware about the importance of bio-energy for clean environment and about the sustainability.

Course outcome:- On successful completion of the course student will be able to –

CO 1	Analyze the importance of various Bioenergy resources and their utilization.	Apply
CO2	Utilize the concept of biogas production, gasohol and biodiesel.	Apply
CO3	Solve the problems related to production process & technology based on bio-energy.	Apply
CO4	Apply techniques for production of bio-energy from biomass at large scale	Apply
CO5	Design and construct biological fuel cell.	Apply

COs	**Pos**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3					3						3	3	3
CO2	3	3	3	2		3						3	3	3
CO3	3	3	3	2		3						3	3	3
CO4	3	3	3	2	2	3			3			3	3	3
CO5	3	3	3	2	2	3			3			3	3	3
Total	**3**	**3**	**3**	**2**	**2**	**3**	**3**		**3**			**3**	**3**	**3**

1:Slight(Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Unit-I:

Bioenergetics, Biomass Sources, Characteristics & Preparation: Biomass Sources and Classification. Chemical composition and properties of different biomass materials and bio-fuels – Sugar cane molasses and other sources for fermentation ethanol-Sources and processing of oils and fats for liquid fuels.

Unit-II:

Biogas, Technology: Feedstock for biogas production, Aqueous wastes containing biodegradable organic matter, animal residues. Microbial and biochemical aspects: Operating parameters for biogas production. Digesters for rural application.

Unit-III:

Bio-Ethanol and Bio-Diesel Technology: Production of Fuel Ethanol by Fermentation of Sugars. Gasohol as a Substitute for Leaded Petrol. Trans-Esterification of Oils to Produce Bio-Diesel.

Unit-IV:

Pyrolysis and Gasification of Biomass: Thermo-chemical conversion of ligno-cellulose biomass – Biomass processing for liquid fuel production - Pyrolysis of biomass-Pyrolysis regime, effect of particle size, temperature, and products obtained.

Unit-V:

Combustion of Biomass and Cogeneration Systems: Combustion of Woody Biomass: Theory, Calculations and Design of Equipments. Case Studies: Combustion of Rice Husk, Use of Bagasse for Cogeneration.

References :

1. “Introduction to Bioenergy”, Vaughn C. Nelson and Kenneth L. Starcher, CRC Press (2016).
2. “Biofuels and Bioenergy”, John Love and John A. Bryant”, John Wiley & Sons Ltd. (2017).
3. “Bioenergy : Biomass to Biofuels”, Anju Dahiya, Academic Press(2014).

Course Title: Bioprocess Equipment Design

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	TBE-404	4	3	1	0	30	20	-	50	50	100

Objective:-

- To introduce the basic design concepts for bioprocess equipments
- Students will know about the design of equipments to facilitate mixing and aeration
- Students will know how to control the temperature of the bioprocess system
- To teach the design of equipments used for downstream processing
- To provide the basic concept of scale up

Course outcome:- On successful completion of the course student will be able to –

CO 1	Students will be able to know the different materials, pipings and pumps used in bioprocessing .	Apply
CO2	Student will be able to understand the design aspects of aerators and agitators	Apply
CO3	Students will be able to conceptualize the application of heating and cooling system in bioprocessing	Apply
CO4	Student will be able to know about the design of various purification techniques	Apply
CO5	Students will gain knowledge about the scale up of bioprocesses	

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3					1	2					3	3	3
CO2	3					1	2					3	3	3
CO3	3					1	2					3	3	3
CO4	3	2	1			1	2					3	3	3
CO5	3					1	2					3	3	3
Total	**3**	**2**	**1**			**1**	**2**					**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

SYLLABUS

Unit 1
Selection of materials, pumps, piping, valves for bioprocess systems

Unit 2
Design of aeration system, design of agitation system, power requirements in gassed and ungassed bioreactors

Unit 3
Heating and cooling systems in bioprocess industries

Unit 4
Design of centrifuge, Design of filtration systems, Design of crystallizer, Design of dryers

Unit 5
Scale-up: criteria, basic concepts and related problems.

References:

- Perry's handbook of Chemical Engineering
- Bioprocess Engineering Principles: Pauline M. Doran ,Publisher Elsevier
- William M(Bill) Huitt, Bioprocessing piping and equipment design: a campanign guide for the ASME BPE standard-Wiley-ASME press series.
- Bioprocess Engineering : Systems Equipment and facilities : Bjorn K Lybersen

Course Title: INSTRUMENTATION AND CONTROL IN BIOPROCESSES

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	TBE-406	4	3	1	0	30	20	-	50	50	100

Objective:-

The objective of this course is to enable the student to understand basic concepts of biosensors, components of biosensors and their application in industry, medical science and environmental studies.

Course outcome:- On successful completion of the course student will be able to –

CO1	Understand the basic principles of instrumentation and control	Apply
CO2	Understand about various types of biological sensors and their applications.	Apply
CO3	Understand about various types of transducers, their functioning and criteria for selection.	Apply
CO4	Understand chemical, electrochemical and optical sensing mechanism and tools.	Apply
CO5	Understand applications of Biosensors in industry, medical and environmental studies. Biochips and their application.	Apply

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3											3	3	3
CO2	2	2	2			2						3	3	3
CO3	3											3	3	3
CO4	3					2						3	3	3
CO5	3	2				2						3	3	3
Total	3	2	2			2						3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

SYLLABUS

Unit 1. Introduction

Parameters required to be measured and controlled in bioprocesses: flow, DO, pH, CO_2, Temperature, level, foam etc. Introduction to instrumentation and control in bioprocesses. Use of PLC, HMI and SCADA in bioprocess control.

Unit 2. Biosensors

Concepts and applications, Biosensing and biosensor technology.

Unit 3. Transduction principles:

Classification of transducers, selection of transducers, Temperature transducers: thermo-resistive transducers, thermoelectric, chemical thermometry. Pressure transducer, photoelectric transducers, flow transducers.

Unit 4. Analytical techniques:

Chemical sensing methods, optical sensing mechanisms and tools, eletrochemical sensing mechanisms and tools, mass spectroscopy.

Unit5. Application

Applications of biosensor-based instruments to the bioprocess industry, application of biosensors to environmental samples, introduction to biochips and their application in modern sciences.

Text /Reference books:

- Transducers for Biomedical Instruments by S.C. Cobbold, Prentice Hall.
- Principles of Medical Electronics & Biomedical Instrumentation by Rao and Guha, University Press, India.
- Coughnour and Koppel, " Process Systems Analysis and Control ", McGraw-Hill, New York, 1986.
- S. K. Singh, " Industrial Instrumentation and Control ", Tata McGraw-Hill, 2008.
- George Stephanopolous, " Chemical Process Control ", Prentice-Hall of India Pvt-Ltd., New Delhi, 1990.
- Nakra and Chaudhary, " Instrumentation Measurement and Analysis", Tata McGraw Hill, 1978.
- P. K. Sarkar, " Process Dynamics and Control", Prentice Hall India, 2014.
- D. N. Considine, "Process Instrumentation and Controls Handbook", Considine, McGraw Hill.

Course Title: BIO-MATERIALS SCIENCE AND ENGINEERING

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	TBE-408	4	3	1	0	30	20	-	50	50	100

Objective:-

The objective of this course is to enable the students with properties of Biomaterials , their characteristics, and applications.

Course outcome:- On successful completion of the course student will be able to –

CO1	Understand about structure, property characteristics and testing of biomaterials.	Understand
CO2	Understand compatibility of biomaterials with living bodies.	Understand
CO3	Understand production technology of biomaterials such as biopolymers and other materials having specific use for example drug delivery.	Apply
CO4	Understand about materials suitable for implants such as orthopedic and dental implants.	Apply
CO5	Understand about materials suitable for soft tissue replacement for example implants for cardiovascular and ophthalmology and organs transplant. Legal Issues related to use of biomaterials.	Apply

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3											2	3	3
CO2	3					2						2	3	3
CO3	3											2	3	3
CO4	3											2	3	3
CO5	3	2				2	2					2	3	3
Total	**3**	**2**				**2**	**2**					**2**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Unit 1. Introduction:

Introduction and overview of biomaterials, structure and property relation in materials and characterization and testing of biomaterials.

Unit 2. Interactions of materials:

Interactions of materials with human body, bio-compatibility of materials, metals, alloys, ceramics, polymers and composites as biomaterials.

Unit 3. Biopolymers:

Biopolymers, natural materials, material for drug delivery: biodegradable polymers.

Unit 4. Implants:

Materials for hard tissue replacement: orthopedic implants, dental implants.

Unit 5.

Materials for soft tissue replacement: dermal and facial prosthesis, cardiovascular implants, ophthalmology, materials for artificial organs transplant and extracorporeal device. legal issues related to development of biomaterials.

Text/Reference Books:

- Biomaterials: An Introduction by Park J.B. and Lakes R.S., Plenum Press, New York.
- Biomaterials, Medical Devices & Tissue Engineering: An Integrated Approach by Silver F.H., Chapman and Hall publication.
- Biomaterials by Bhat Sujata V., Narosa Publishing House.
- Biomaterials science: an introduction to materials in medicine by Buddy D. Ratner., Elsevier Academic Press.
- Biomaterials: A Tantalus Experience by Jozef A. Helsen., Yannis Missirlis Springer.
- Biomaterials by Temenoff Johnna S., Dorling Kindersley India Pvt Ltd.

TBE-410: PROJECT

L	T	P	C
0	0	20	10

COURSE OBJECTIVES: The objectives of this course is to enable the students

- To articulate a clear research question or problem and formulate a hypothesis
- To identify and practice research ethics and responsible conduct in research
- To communicate confidently and constructively with fellow students and faculty as mentors explain their research to others in the field and to broader audiences through research presentation

Course Outcome: On the successful completion of the course, students will be able to:

CO1	Identify and utilize relevant previous work that supports their research	Understand
CO2	Identify and apply appropriate methodologies to address the research question or creative objective	Apply
CO3	Work collaboratively with other members, demonstrating effective communication and problem-solving skills	Apply
CO4	Present the research work effectively in a conference	Apply
CO5	Analyze the sustainability of related technology	Analyze

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	-	-	3	-	2	1	-	1	-	2	3	2	2
CO2	3	2	2	2	1	2	3	-	2	3	3	2	2	2
CO3	3	3	3	2	3	2	2	2	3	3	3	3	2	2
CO4	3	2	2	-	2	1	2	3	3	3	3	3	2	2
CO5	3	3	3	-	1	2	3	3	2	1	2	3	2	2
Average	3	3	3	2	2	2	2	3	2	3	3	2	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

हरकोर्ट बटलर प्राविधिक विश्वविद्यालय
नवाबगंज, कानपुर–208002, उ0प्र0, (भारत)
Harcourt Butler Technical University
Nawabganj, Kanpur-208002, U.P. (INDIA)
(Formerly Harcourt Butler Technological Institute, Kanpur)
Phone: +91-0512-2534001-5, Fax : +91-0512-2533812, Website : http://www.hbtu.ac.in E-mail : vc@hbtu.ac.in

Department: Plastic Technology

School: School of Chemical Technology

Name of Programme: B. Tech.

Academic Session 2021-22

Total no. of courses in the Programme: 60

% Change in the course curriculum : 12/60=20%

No. of courses where syllabus revision was carried out BoS		
S. No.	**Name of course**	**Course code**
1	Polymer Chemistry	TPL 201
2	Polymerization Engineering I	TPL 202
3	Polymer Processing I	TPL 301
4	Rheology and Testing of Polymers	TPL 303
5	Polymer Processing II	TPL 302
6	Structure & Property of Polymers	TPL 304
7	Polymerization Engineering II	TPL 306
8	Technology Of Elastomers	TPL 401
9	Advanced Polymeric Materials	TPL 403
10	Programme Elective Course II (Polymer Ahesives and Foams)	TPL 409
11	*Programme Elective Course III (Plastic Packaging & Waste Management)	TPL 402
12	PEC I (Polymer Blends & Alloys)	TPL 455

Number of Courses related with employability/ entrepreneurship/ skill development

Courses related with employability/ entrepreneurship/ skill development		
S. No.	**Name of course**	**Course code**
1	Polymer Chemistry	TPL 251
2	Polymer Chemistry Lab	TPL 253
3	Fluid Mechanics and Mechanical operation	TPL 255
4	Materials & Energy Balance	TPL 257
5	Polymerization Engineering I	TPL 252
6	Heat Transfer Operations	TPL 254
7	Chemical Engineering Thermodynamics	TPL 256

8	Polymer Processing I	TPL 351
9	Rheology and Testing of Polymers	TPL 353
10	Polymer Testing Lab	TPL 355
11	Mass Transfer Operations	TPL 357
12	Chemical Reaction Engineering	TPL 359
13	Polymer Processing II	TPL 352
14	Structure & Property of Polymers	TPL 354
15	Polymerization Engineering II	TPL 356
16	Plastic Product and Mold Design	TPL 358
17	Polymer Composite	TPL 360
18	Instrumentation & Process Control	TPL 362
19	Technology Of Elastomers	TPL 451
20	Advanced Polymeric Materials	TPL 453
21	Industrial Training	TPL 493
22	Seminar	TPL 495
23	Project	TPL 497

Elective courses in the programme

S. No.	**Program Elective Courses**	**Name of Course**	**Course code**
1	PEC I	Polymer Blends & Alloys Polymer Product Technology	TPL 455 TPL 457
2	PEC II	Polymeric Adhesives & Foams Polymer Nanocomposites	TPL 459 TPL 461
3	PEC III	Plastic Packaging & Waste Management Polymer Coating Technology	TPL 452 TPL 454
4	PEC IV	Process Modeling & Simulation Computer Aided Equipment Design	TPL 456 TPL 458

New courses introduced		
S. No.	Name of course	Course code
1	Polymer Product Technology	TPL 457
2	Polymer Nanocomposites	TPL 461
3	Polymer Blends and Alloys	TPL 455
4	Polymer Chemistry Lab	TPL 253
5	Polymer Testing Lab	TPL 355

Signature and Seal

Head of Department

Dr. Indira Nigam
Professor & Head
Dept. of Plastic Technology
H.B. Technical University, Kanpur

SEMESTER WISE COURSE STRUCTURE & EVALUATION SCHEME

B. TECH. CHEMICAL TECHNOLOGY- PLASTIC TECHNOLOGY

Semester-I

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab.	Total		
1	BSC	Engineering Chemistry	BCY 101	4	3	0	2	15	20	15	50	50	100
2	BSC	Mathematics I	BMA 101	4	3	1	0	30	20	-	50	50	100
3	ESC	Electronics & Instrumentation Engineering	EET 101	3	3	0	0	30	20	-	50	50	100
4	ESC	Engineering Graphics	ECE 101	3	0	0	6	30	20	-	50	50	100
5	ESC	Computer Concepts & Programming	ECS 101	4	3	0	2	15	20	15	50	50	100
6	ESC	Workshop Practice	EWS 101	2	0	0	4	--	20	30	50	50	100
7	MC (Non Credit)	Environment & Ecology	ECE 103	0	2	0	0	30	20	-	50	50	100
		Total Credits 20											**600**

Semester-II

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks ESE					Total Marks
					L	T	P	CT	TA	Lab	Total		
1	BSC	Physics	BPH 102	4	3	0	2	15	20	15	50	50	100
2	BSC	Mathematics II	BMA 102	4	3	1	0	30	20	-	50	50	100
3	ESC	Electrical Engineering	EEE 102	4	3	0	2	15	20	15	50	50	100
4	ESC	Engineering Mechanics	EME 102	3	3	0	0	30	20	-	50	50	100
5	HSMC	English Language & Composition	HHS 102	2	2	0	0	30	20	-	50	50	100
6	HSMC	Professional Communication	HHS 104	3	3	0	2	15	20	15	50	50	100
		Total Credits 20											**600**

Semester-III

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	BSC	Mathematics III	BMA 201	4	3	1	0	30	20	-	50	50	100
2	PCC	Polymer Chemistry	TPL 201	4	3	1	0	30	20	-	50	50	100
3	PCC	Polymer Chemistry Lab	TPL 203	2	0	0	4	-	20	30	50	50	100
4	ESC	Fluid Mechanics and Mechanical operation	TPL 205	5	3	1	2	15	20	15	50	50	100
5	PCC	Materials & Energy Balance	TPL 207	4	3	1	0	30	20	-	50	50	100
	HSMC	Organizational Behaviour	HHS 203	3	3	0	0	30	20	-	50	50	100
7	MC (Non Credit)	Cyber Security	ECS 205	0	2	0	0	30	20	-	50	50	100
	Total Credits 22												**600**

Semester IV

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	BSC	Modern Analytical Techniques	BCY 202	4	3	0	2	15	20	15	50	50	100
2	BSC	Computer Oriented Numerical Methods	BMA 202	4	2	1	2	15	20	15	50	50	100
3	PCC	Polymerization Engineering I	TPL 202	5	3	1	2	15	20	15	50	50	100
4	ESC	Heat Transfer Operations	TPL 204	3	2	1	0	30	20	-	50	50	100
5	PCC	Chemical Engineering Thermodynamics	TPL 206	3	2	1	0	30	20	-	50	50	100
6	HSMC	Engg Economics & Management	HHS 202	3	3	0	0	30	20	-	50	50	100
7	MC (Non Credit)	Indian Constitution	HHS 206	0	2	0	0	30	20	-	50	50	100
	Total Credits 22												**600**

Semester-V

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	PCC	Polymer Processing I	TPL 301	5	3	1	2	15	20	15	50	50	100
2	PCC	Rheology and Testing of Polymers	TPL 303	4	3	1	0	30	20	-	50	50	100
3	PCC	Polymer Testing Lab	TPL 305	2	0	0	4	-	20	30	50	50	100
4	PCC	Mass Transfer Operations	TPL 307	4	3	1	0	30	20	-	50	50	100
5	PCC	Chemical Reaction Engineering	TPL 309	4	3	1	0	30	20	-	50	50	100
6	OEC (Humanities)	Open Elective Course -I	HHS 341	3	3	0	0	30	20	-	50	50	100
	Total Credits			**22**									**600**

Semester-VI

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab.	Total		
1	PCC	Polymer Processing II	TPL 302	3	2	0	2	15	20	15	50	50	100
2	PCC	Structure & Property of Polymers	TPL 304	3	2	1	0	30	20	-	50	50	100
3	PCC	Polymerization Engineering II	TPL 306	4	3	0	2	15	20	15	50	50	100
4	PCC	Plastic Product and Mold Design	TPL 308	3	2	1	0	30	20	0	50	50	100
5	PCC	Polymer Composite	TPL 310	3	3	0	0	30	20	0	50	50	100
6	PCC	Instrumentation & Process Control	TPL 312	3	2	1	0	30	20	-	-	50	100
7	OEC (Maths)	Open Elective Course -II	BMA 342	3	3	0	0	30	20	-	50	50	100
		Total Credits		**22**									**700**

Semester-VII

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	PCC	Technology Of Elastomers	TPL 401	2	2	0	0	30	20	-	50	50	100
2	PCC	Advanced Polymeric Materials	TPL 403	3	2	0	2	15	20	15	50	50	100
3	PEC	Programme Elective Course I (Polymer Blends & Alloys OR Plastic Product Technology)	TPL 405 OR TPL 407	3	3	0	0	30	20	-	50	50	100
4	PEC	Programme Elective Course II (Polymer Ahesives and Foams OR Polymer Nanocomposite)	TPL 409 OR TPL 411	3	3	0	0	30	20	-	50	50	100
5	OEC (Plastic Tech.)	Open Elective Course -III	TPL 415	3	3	0	0	30	20	-	50	50	100
6		Industrial Training	TPL 461	2	0	0	4	-	50	-	50	50	100
7		Seminar	TPL 471	2	0	0	4	-	50	-	50	50	100
8		Project	TPL 497	4	0	0	8	-	50	-	50	50	100
	Total Credits			**22**									**800**

Semester-VIII

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	PEC	*Programme Elective Course III (Plastic Packaging & Waste Management OR Polymer Coating Technology)	TPL 402 OR TPL 404	4	3	1	0	30	20	-	50	50	100
2	PEC	*Programme Elective Course IV (Process Modeling & Simulation Or Computer aided Equipment Design)	TPL 406 OR TPL 408	4	3	1	0	30	20	-	50	50	100
3	OEC (Chemical Engg.)	*Open Elective Course –IV (Transport Phenomena)	TCH 420	4	3	1	0	30	20	-	50	50	100
4		Project	TPL 498	10	0	0	20	-	50	-	50	50	100
		Total Credits		**22**									**400**

*** Online Courses**

List of Programme Elective Courses

S. No.	PEC Names	Subject Name	Subject Code	C (L-T-P)
1.	Programme Elective Course I	Polymer Blends & Alloys	TPL 405	3 (3-0-0)
		Polymer Product Technology	TPL 407	
2.	Programme Elective Course II	Polymeric Adhesives & Foams	TPL 409	3 (3-0-0)
		Polymer Nanocomposites	TPL 411	
3.	Programme Elective Course III	Plastic Packaging & Waste Management	TPL 402	4 (3-1-0)
		Polymer Coating Technology	TPL 404	
4.	Programme Elective Course IV	Process Modeling & Simulation	TPL 406	4 (3-1-0)
		Computer Aided Equipment Design	TPL 408	

List of Open Elective Courses

S. No.	OEC Names	Subject Name	Subject Code	C (L-T-P)
1.	Open Elective Course II (Humanities)	Entrepreneurship Development	HHS 341	3 (3-0-0)
2.	Open Elective Course II (Maths)	Operations Research	BMA 342	3 (3-0-0)
3.	Open Elective Course III (Plastic Technology)	Introduction to Polymer Technology	TPL 415	3 (3-0-0)
4.	Open Elective Course IV (Chemical Engg)	Transport Phenomenon	TCH 420	4 (3-1-0)

B. Tech. Chemical Technology - Plastic Technology

Semester- 3

TPL 201 POLYMER CHEMISTRY

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	PCC	Polymer Chemistry	TPL 201	4	3	1	0	30	20	-	50	50	100

OBJECTIVE: The objective of this course is to enable the students

- To understand the mechanism of polymerization.
- To understand various techniques used for polymerization.
- To understand the characterization of polymers by molecular weight.
- To understand the reactions and degradation of polymers.

Course Outcome

CO1		Understand the fundamentals types and properties of polymers.	Understand
CO2		Understand and apply the chain growth polymerization and it's kinetics.	Apply
CO3		Understand and apply the step growth polymerization, its kinetics, mechanism and crosslinking.	Apply
CO4		Analyze molecular weight and molecular weight distribution of polymers, copolymers, etc.	Analyze
CO5		Understand and analyze co-polymerization and its types, ring opening polymerization.	Analyze

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**3**	**2**
CO1	3						1					3	3	3
CO2	3					2						3	3	3
CO3	3	2										3	3	3
CO4	3	2			1			1				3	3	3
CO5	3	2	2	2				1				3	3	3
Total	**3**	**2**	**2**	**2**	**1**	**2**	**1**	**1**				**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module-I: Basics of Polymer formation

Basic concepts and terminology such as monomer, polymer, functionality and structure of polymers. Transitions in polymers, and discuss applications of polymers.

Module-II: Introduction to polymerizations

Overview of polymer/petrochemical industries with reference to application, classification of polymers, stereochemistry of polymers, general theory of chain growth polymerization. Free radical polymerization, types of initiators. Kinetics of free radical polymerization, auto-acceleration.

Module -III: Condensation Polymerizations

General characteristics of condensation polymerization, kinetics and mechanism. Carother's equation, development of cross-linked structures. Step polymerization and its utility.

Module-IV: Molecular Weight and its Control

Concept of Molecular weight of polymers, factors affecting molecular weight and molecular weight distribution, polydispersity. Chain transfer reactions, retarders, inhibitors, effect of temperature on polymerization

Module-V: Copolymerization and other Reactions

Copolymerization reactions and its utility. Kinetics of copolymerization, copolymerization behavior and types of copolymers. Stereo-chemistry of polymerization. Ring-opening polymerization.

Reference Books and Suggested:

1. F. W. Billmeyer, "Text Book of Polymer Science ", John. Wiley & Sons, 1990.
2. Vasant R. Gowariker, "Polymer Science", New Age International, 1986.
3. Premamoy Ghosh, " Polymer Science and Technology ", Tata McGraw-Hill Education, 1990.
4. George Odian, " Principles of Polymerization ", Wiley, 1981.
5. Paul J. Flory, " Principles of Polymer Chemistry ", Cornell University Press, 1953.
6. Robert W. Lenz, " Organic Chemistry of Synthetic High Polymers ", John Wiley & Sons Inc, 1967.
7. D. Margerison, " An Introduction to Polymer Chemistry ", Pergamon, 1967.
8. Introduction to Polymers, R.J. Young & P.A. Livell Ch. & Hall, London, 1981
9. Polymer Chemistry, Seymour & Caraher, Marcel Decker, 2003

TPL 203 POLYMER CHEMISTRY LAB

L	T	P	C
0	0	4	2

OBJECTIVE: The objective of this course is to enable the students

- To apply laboratory methods of analysis for estimation of purity monomers, initiators and solvents used for polymerization.
- To apply laboratory techniques for determination of physical properties of monomers and solvents
- To apply analytical methods for identification of polymers

Course Outcome

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

CO1	apply laboratory methods of analysis for estimation of purity	Apply
CO2	apply laboratory techniques for determination of physical properties of monomers and solvents	Apply
CO3	apply analytical methods for identification of polymers	Apply

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**3**	**2**
CO1	3	2		1		2	2		3	2		3	3	3
CO2	3	2		1		2	2		3	2		3	3	3
CO3	3	2		1		2	2		3	2		3	3	3
Total	**3**	**2**		**1**		**2**	**2**		**3**	**2**		**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Module-VI: Laboratory Experiments

Determination of refractive index of organic compounds, purification, determination of yield and refractive index of monomers and solvents, determination of percentage purity of initiator, viz. benzoyl peroxide, potassium persulfate, AIBN, raw materials, viz. phenol and formaldehyde, determination of density of plastic sample, identification of known and unknown polymer (unprocessed and processed) samples.

	Laboratory Experiments	
1	Determination of refractive index of organic compounds	03
2	Purification of monomers and determining the yield and refractive index of the purified monomer	06
3	Purification of solvent by washing and determination of yield	06
4	Determination of percentage purity of initiators, viz. benzoyl per oxide, AIBN, etc.	06
5	Determination of percentage purity of potassium persulphate	06

6	Determination of percentage purity of phenol	06
7	Determination of percentage purity of formaldehyde	06
8	Determination of density of given polymer sample	03
	Determination of specific gravity of given moulded sample of plastic	03
10	Identification of known and unknown polymer (unprocessed and processed) samples	12

Reference Books and Suggested :

1. George Odian, " Principles of Polymerization ", Wiley, 1981.
2. Paul J. Flory, " Principles of Polymer Chemistry ", Cornell University Press, 1953.
3. Robert W. Lenz, " Organic Chemistry of Synthetic High Polymers ", John Wiley & Sons Inc, 1967.

TPL 205 FLUID MECHANICS&MECHANICAL OPERATIONS

L	T	P	C
3	**1**	**2**	**5**

Assessment:

Sessional: 50 marks

End Semester: 50 marks

Course Objective:

To understand basic concept of fluid flow and its application to chemical process industries including pipe flow, fluid machinery and agitation & mixing.

Course outcomes:

CO 1	Understand the need of fluid mechanics for chemical engineers	Understand
CO 2	Understand the basic terms and their concepts of fluid flow	Understand
CO 3	Apply the knowledge to develop a dimensional number for the fluid flow	Apply, Create
CO 4	Understand the fundamentals in characterization and classification of solids	Apply, Analyze
CO 5	Understand the sieving performances using different sieve size	Analyze, Evaluate
CO 6	Calculate the crushing efficiency of different size reduction equipment using crushing laws	Analyze, Evaluate

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	3	1	1	-	-	2	-	-	1	-	2	**3**	**2**
CO2	3	3	3	-	-	1	1	-	-	1	-	2	3	3
CO3	3	3	3	3	2	1	1	-	-	1	-	2	3	2
CO4	3	2	1	-	-	2	2	-	-	1	-	2	3	3
CO5	3	3	1	3	1	2	1	-	-	1	-	3	3	2
CO6	3	2	2	2	1	2	1	-	3	1	-	3	3	3
Avg.	3.00	2.67	1.83	1.50	0.67	1.33	1.33	-	0.5	1	-	2.33	3	2.5

Syllabus

Module I (8 hours)

Introduction to process fluid mechanics; Fundamental concepts: Definition of a fluid; Continuum hypothesis; Velocity field; Stress field; Newtonian and non-Newtonian fluids, Fluid statics: pressure variation in a static fluid, hydrostatic forces on submerged surfaces, buoyancy, Manometers. Dimensional analysis and similitude: Buckingham Pi theorem and applications

Module II (8 hours)

Macroscopic Balances: derivation of integral balances for mass, energy and momentum; Derivation of engineering Bernoulli equation with losses, Application of macroscopic balances: Losses in expansion, Force on a reducing bend, Diameter of a free jet; Jet ejector. Flow measurement: Orifice meter, venturi meter, Pitot tube, and Rota meter.

Module III (8 hours)

Differential balances of fluid flow: derivation of continuity and momentum (Navier-Stokes) equations for a Newtonian fluid, Boundary layer theory, Pipe flows and fittings: laminar and turbulent flows; friction factor charts, losses in fittings, Fluid transportation: Valves and Pumps and Compressors.

Module IV (8 hours)

Flow through packed and fluidized beds: Flow through beds of solids, motion of particles through the fluid, Particle settling, Fluidization, minimum fluidization velocity, Mixing and Agitation- power consumption, mixing times, scale up

Module V (8 hours)

Filtration: Governing equations, constant pressure operation, constant flow operation, cycle time, types of filters. Centrifuges and Cyclones: Gravity settling, centrifugal separation, cyclone separations, separation efficiency, pressure loss,

Reference:

1. McCabe and Smith, Unit Operations of Chemical Engineering: McGraw Hill

2. Coulson & Richardson , Chemical Engineering Vol. I: Pergamon, 1979 McGraw hill

3. Gupta, Vijay and S. K. Gupta, “Fluid Mechanics and its Applications”, Wiley Eastern, New Delhi (1984).

4. W.L.Badger and J.T.Banchero, Introduction to Chemical Engineering, TMH (1979)

TPL 207 MATERIAL AND ENERGY BALANCE

L	T	P	C
3	1	0	4

Assessment:
Sessional: 50 marks
End Semester: 50 marks
Course Objective:

To understand and apply the basics of calculations related to material and energy flow in the processes.

Course Outcome

CO1	Demonstrate comprehensive understanding of material and energy balance equations for open and closed systems.	Understand, Apply, Remember
CO2	Select appropriate basis and conduct degree of freedom analysis before solving material and energy balance problems.	Apply, Evaluate
CO3	Make elementary flow-sheets and perform material and energy balance calculations without and with chemical reactions, and involving concepts like recycle, bypass and purge.	Analyse, Evaluate
CO4	Perform process calculations utilizing psychometric charts and steam tables.	Understand, Apply, Evaluate
CO5	Apply simultaneous material and energy balance calculations for steady state continuous flow systems and unsteady state systems	Understand, Apply, Evaluate

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	3	2	1	-	-	-	-	-	-	1	1	**1**	**3**
CO2	3	3	3	2	-	-	-	-	-	-	-	1	2	3
CO3	3	3	3	3	2	2	1	-	-	1	1	1	2	3
CO4	3	3	2	2	1	-	-	-	-	1	1	1	1	3
CO5	3	3	2	1	-	-	-	-	-	-	1	1	2	3
Avg	3	3	2.4	1.8	0.6	0.4	0.2	-	-	0.4	0.8	1	1.6	3

Syllabus

Module 1 (9 hours)

Dimensions, system of units and their conversions, Mass and volume relations, Basic stoichiometric principles, limiting and excess reactants, Degree of completion, Conversion, selectivity, yield. Ideal gas law, Dalton’s Law, Amagat’s Law, Introduction to degrees of freedom analysis.

Module 2 (7 hours)

Vapor pressure of liquids and solids, Vapor pressure plot (Cox chart), Vapor pressures of miscible and immiscible liquids and solutions, Raoult’s Law and Henry’s Law. Humidity and saturation use of humidity charts for engineering calculations.

Module 3 (8 hours)

Material balance without chemical reactions and its application to unit operations like distillation, absorption etc. Material balance with chemical reaction Recycle, bypass and purging.

Module 4 (8 hours)

Heat capacity of gases, liquids and solutions Heat of fusion and vaporization. Steady state energy balance for systems with and without chemical reactions. Calculations and application of heat of reaction combustion, formation, neutralization and solution. Enthalpy-concentration charts. Orsat analysis Calculation of theoretical and actual flame temperatures

Module 5 (8 hours)

Simultaneous material and energy balance. Introduction to Unsteady state material and energy balance.

Suggested Text books

1. Hougen, O.A., Watson, K.M and Ragatz, R.A., " Chemical Process Principles Part-I ",John Wiley and Asia Publishing, 1970.
2. Himmelblau, D.M., “Basic Principles and Calculations in Chemical Engineering" ,sixth Edition, Prentice Hall Inc., 1996.
3. Felder, R.M. & Rousseau, R.W. "Elementary Principles of Chemical Processes ", 3rd edition. JohnWiley. (1999)
4. Bhatt, B.L., VORA, S.M., “Stoichiomentry ", Tata McGraw-Hill, 1976.

Suggested Reference Books

1. Venkataramani, V., Anantharaman, N., Begum, K. M. MeeraSheriffa, “ProcessCalculations” , Second Edition, Prentice Hall of India.
2. Sikdar, D. C., “Chemical Process Calculations”, Prentice Hall of India.

Semester- 4

TPL 202 POLYMERIZATION ENGINEERING – I

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
3	PCC	Polymerization Engineering I	TPL 202	5	3	1	2	15	20	15	50	50	100

OBJECTIVE: The objective of this course is to enable the students

- To understand various polymerization techniques and catalysts used to produce addition polymers.
- To understand the copolymerization techniques to produce important co-polymers.
- To learn the manufacturing of thermosetting resins, molding powders from phenol formaldehyde and melamine.

Course Outcome

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

CO1	Understand industrial methods of polymerization, different aspects of a polymerization plant, reactors, safety and plant automation.	Understand
CO2	Understand stereo specific catalyst and polymerizations.	Understand
CO3	Understand and apply the production process for commodity thermoplastics.	Apply
CO4	Understand and apply the production process for common thermoset polymers.	Apply
CO5	Understand and analyze production technology, properties and applications of polymers and their copolymers.	Analyze
CO6	Apply techniques of polymerization for synthesis of polymers at lab scale.	Apply

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**3**	**3**
CO1	3					2	1					3	3	3
CO2	3					2	1					3	3	3
CO3	3	3				2	1	1				3	3	3
CO4	3	3				2		1				3	3	3
CO5	3	3	3	2	1	2				1	1	3	3	3
CO6	3	3	2	2		2			2			3	3	3
Total	**3**	**3**	**2.5**	**2**	**1**	**2**	**1**	**1**	**2**	**1**	**1**	**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module-I: Industrial Polymerization

Industrial methods of polymerization such as bulk, solution, suspension, emulsion. Layout and arrangement of polymer plant. Types of polymer production processes and reactors. Safety and plant automation.

Module-II: Stereospecific Polymerizations
Concept of stereo-chemistry of polymers, stereo-specific polymerization. Catalyst – their utility in polymer manufacture, Zeigler Natta, Metallocene and other catalyst systems.

Module-III: Production of Commodity Thermoplastics
Manufacturing processes, properties and applications of various polyolefins such as LDPE, HDPE, and their copolymer grades, polypropylene and its copolymer grades.

Module-IV: Production of thermoset resins
Manufacturing details, properties and applications of various thermosetting resins such as phenol-formaldehyde, urea-formaldehyde and melamine-formaldehyde and preparation of molding powders.

Module-V: Production of polymers and copolymers of styrene & Vinyl chloride
Production technology, properties and application of polystyrene, poly(vinyl_chloride), and their copolymer grades.

Module-VI: Laboratory Experiments
Application of polymerization techniques to synthesize polymers at lab scale, determination of molecular weight of polystyrene and K-value of PVC by Ostwald Viscometer.

Reference Books and Suggested Readings :

1. J. A. Brydson, " Polymer Materials ", Butterworth-Heinemann, 1990.
2. Mark &Overberger, " Encyclopedia of Polymer Science & Tech. " Wiley-Interscience, 1986.
3. J. Scheries& W. Kaminsky, " Metallocene based Polymers ", Wiley, 2000.
4. Vasant R. Gowariker, "Polymer Science ", New Age International, 1986.
5. Christopher C. Ibeh, " Thermoplastic Materials: Properties, Manufacturing Methods, and Applications ", Taylor and Francis Group, 2011.

TPL 204 HEAT TRANSFER OPERATIONS

L	T	P	C
2	1	0	3

Assessment:

Sessional: 50 marks

End Semester: 50 marks

Course Objective: To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries.

Course outcomes:

CO 1.	Understand different modes of heat transfer.	Understand
CO 2	Apply the concepts of one-dimensional and multi-dimensional; steady and unsteady state conduction heat transfer, and relevant boundary and initial conditions in problem solving.	Apply, Analyze ,Evaluate
CO 3.	Apply the knowledge of analytical and graphical (temperature charts) techniques in solving specific transient heat conduction problems, including lumped and one-dimensional systems	Apply, Evaluate
CO 4	Understand the concept of temperature-dependent buoyancy which causes natural free convection, and apply the dimensionless Grashof number used in correlations for free convective heat transfer calculations	Understand, Analyze, Evaluate
CO 5.	Understand phase-change phenomena and latent heat of vaporization, including free convective, nucleate and film boiling, as well as dropwise and film condensation	Understand, Analyze

		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1		3	2	1	1	-	-	2	-	-	1	-	1	**1**	**2**
CO2		3	3	3	3	2	1	1	-	-	1	-	1	2	2
CO3		3	3	3	3	3	1	1	-	-	1	1	1	1	2
CO4		3	2	3	3	3	2	2	-	-	1	1	1	2	2
CO5		3	3	3	3	1	2	1	-	-	1	1	1	1	2
Avg.		3	2.6	2.6	2.6	1.8	1.2	1.4	-	-	1	0.6	1	1.4	2

Syllabus

Module 1 (6 hours)

Introduction ot heat transfer and general concepts of heat transfer by conduction, convection and radiation, Conduction: Basic concepts of conduction in solids, liquids, gases, steady state temperature fields and one dimensional conduction without heat generation e. g. through plain walls, cylindrical and spherical surfaces, composite layers, Insulation materials, critical and optimal, insulation thickness, Extended surfaces, fins and their applications, Introduction to unsteady state heat transfer.

MODULE 2 (6 hours)

Convection: Fundamentals of convection, Basic concepts and definitions, natural and forced convection, hydrodynamic and thermal boundary layers, laminar and turbulent heat transfer inside tubes, Dimensional analysis, determination of individual and overall heat transfer coefficients, heat transfer in molten metals.

MODULE 3(6 hours)

Radiation: Basic laws of heat transfer by radiation, black body and gray body concepts, view factors, Kirchoff's law, solar radiations, combined heat transfer coefficients by convection and radiation.

MODULE 4(6 hours)

Heat Transfer by phase change: Condensation of pure vapours, film wise and drop wise condensation, eat transfer in boiling liquids, boiling heat transfer coefficients, Evaporation: Elementary principles, types of evaporators, Single and multiple effect evaporators.

MODULE 5(6 hours)

Heat exchangers: Types of heat exchangers, Principal components of a concentric tube & shell-and-tube heat exchangers, baffles, tube and tube distribution, tubes to tube sheet joint, heat exchanger with multiple shell and tube passes, log-mean temperature difference, overall heat transfer coefficient, fouling factors, design of double pipe and shell and tube heat exchangers.

BOOKS:

1. "Heat Transfer principles and applications" Dutta, B. K., PHI
2. "Heat Transfer" Holman J. P, 9th Ed. McGraw Hill.
3. "Process Heat Transfer". Kern D. Q. McGraw Hill Book
4.Heat and Mass Transfer Fundamentals and Applications, Cengel Y. A. and Ghajar A. J., McGraw Hill,5th edition, 2016.

TPL 206 CHEMICAL ENGINEERING THERMODYNAMICS

Assessment:
Sessional: 50 marks

End Semester: 50 marks

L	**T**	**P**	**C**
2	**1**	**0**	**3**

Course Objective:

To understand the theory and applications of classical thermodynamics, thermodynamic properties, equations of state, methods used to describe and predict phase equilibria.

Course outcomes:

CO 1	Understand the basic of thermodynamics and the terminology associated with engineering thermodynamics	Understand
CO 2	Understand the knowledge of contemporary issues related to chemical engineering thermodynamics	Understand
CO 3	Understand and apply the knowledge of phase equilibria in two-component and multi-component systems	Understand, Apply
CO 4	Analyse the thermodynamic properties of substances in gas or liquid state of ideal and real mixture	Apply
CO 5	Understand intermolecular potential and excess property behaviour of multi-component systems	Understand

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	2	1	1	-	-	1	-	-	1	-	1	**1**	**2**
CO2	3	1	1	1	-	3	3	-	-	1	-	1	2	2
CO3	3	3	2	2	3	-	-	-	-	1	-	1	1	2
CO4	3	3	3	2	3	1	1	-	-	1	-	1	2	2
CO5	3	2	2	3	2	1	1	-	-	1	-	1	2	2
Avg.	3	2.2	1.8	1.8	1.6	1	1.2	-	-	1	-	1	1.6	2

Syllabus

Module 1 (8 hours)

Basic Concepts & First Law of Thermodynamics: Scope of thermodynamics, System & Surroundings, Properties -Force, Temperature & pressure, Equilibrium, Processes- Reversible & Irreversible, Work, Heat, Energy ,Phase rule, Joule's Experiment, Internal energy, Enthalpy, Heat capacities, Application of first law to closed & open systems.Volumetric properties of pure fluids: PVT behavior of pure substances, Virial equation of state and its application ,ideal gas and cubic equation of state, Generalized correlations for gases and liquids.

Module 2 (6 hours)

Second Law of Thermodynamics: Heat engine and its efficiency, Heat pump, Refrigerator, COP, Second law of Thermodynamics, Kelvin–Planck statement &Clausius Statement, Carnot's cycle and Carnot theorems, Clausius inequality, Entropy balance for open systems, ideal work and lost work, Principle of entropy.

Module 3 (6 hours)

Residual properties, two phase systems: Clapeyron equation, Estimation of thermodynamic properties by using graphs and tables.Solution thermodynamics Theory: Fundamental property relation, Chemical potential and phase equilibria ,Partial properties ,Ideal gas mixture model.

Module 4 (6 hours)

Fugacity and fugacity coefficient for pure species and in solution, Ideal solution model and excess properties.Solution thermodynamics Application: Liquid phase properties from VLE data, Models for the excess Gibbs energy, Property changes of mixing.

Module 5 (4 hours)

Phase Equilibria: Nature of equilibrium, phase rule, VLE qualitative behavior, Simple Models for VLE, VLE by Modified Raoultslaw and VLE from K-value charts.

Reference

1. "Introduction to Chemical Engineering Thermodynamics" by J.M. Smith and H.C. Van Ness, McGraw Hill International Ltd, 2005.

2. "Chemical Engineering Thermodynamics" by Y.V.C. Rao, Universities Press (India) Ltd. Hyderabad.

3. "Chemical and Process Thermodynamics", Kyle B.G., 3rd ed., Prentice Hall. 1999

4. "Chemical Engineering Thermodynamics", by Narayanan, K.V., Prentice Hall. 2007

SEMESTER- 5

TPL 301 POLYMER PROCESSING – I

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	PCC	Polymer Processing I	TPL 301	5	3	1	2	15	20	15	50	50	100

OBJECTIVE: The objective of this course is to enable the students

- To understand the various processing techniques used for polymer processing.
- To learn the fundamentals of extrusion and different extrusion processes of thermoplastics.
- To learn the basic principle of compounding of thermoplastics and calendaring process.
- To process plastics on different types of moulding machines and prepare simple articles.

Course Outcome

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

CO1	Understand the concepts of Extrusion process of plastic materials.	Understand
CO2	Understand and apply the utility of the single screw and multiple screw extruder systems.	Apply
CO3	Apply knowledge of extrusion process for manufacturing of different extruded plastic products.	Apply
CO4	Understand and apply compounding ingredients and methods for modification of polymer properties.	Apply
CO5	Understand the concept and utility of calendaring process for polymer/plastics.	Understand
CO6	Apply different parameters related to processing machines for formation of plastic products.	Apply

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**3**
CO1	3					2						3	**3**	**3**
CO2	3					2				1		3	3	3
CO3	3	3	2			2			1	1		3	3	3
CO4	3	2	2	2		2	2	1			1	3	3	3
CO5	3	1	2			2						3	3	3
CO6	3	3	2	2	1	3	2	1	3	2	1	3	3	2
Total	**3**	**2.5**	**2**	**2**	**1**	**2**	**2**	**1**	**2**	**1**		**3**	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Course Level Assessment Questions

Syllabus

Module-I: Introduction to Polymer Processing and Extrusion

Concepts of Polymer Processing; Concepts of Extrusion process for plastics- basic operation and analysis, solids conveying, drag induced conveying, melting mechanism, power consumption in metering zone. Overall extruder performance, die and screw characteristics curves.

Module-II: **Fundamentals of Extrusion Process of Polymers**
Fundamentals of single screw extrusion, twin screw extrusion and co-extrusion operation; Construction of Barrel and screw for commodity, heat sensitive and engineering plastics.

Module-III: Extrusion Processes for plastic products
Extrusion process détails, basic principles, equipment used, and applications for plastic product formations viz. film, pipe, lamination, profiles, wire, cable, etc.; Casting process for films; Reactive extrusion: basic principles, equipment used and applications.

Module-IV: Compounding of Polymers
Importance and concept of compounding of polymers; compounding additives viz. fillers, plasticizers, colorants, stabilizers, blowing agents, flame-retardants, antioxidants, etc. Mixing, blending and compounding equipments. Finishing of Plastics.

Module-V: Calendaring of plastics

Calendaring- description and features of calendaring process, calendar roll arrangements, application of calendaring.

Module VI: Laboratory Experiments

Preparation of simple plastic products and test specimen on Extrusion; Preparation of Fiber reinforced plastic sheet by using glass fiber mat and unsaturated polyester resin; Preparation of sheet by Hydraulic press/Two Roll Mill

Reference Books and Suggested Readings :

1. Plastics Extrusion, by Allen Grief
2. Plastic Engineering Handbook (SPI), by Frados
3. Screw extrusion of Plastics, by Jacobi
4. Plastic materials and processes (a concise encyclopedia), by Charles Harper
5. Polymer Mixing and Extrusion Technology, by Nicholas Cheremisinoff
6. Plastics Extrusion Technology, Hanser SPE, 1996
7.

TPL 303 RHEOLOGY AND TESTING OF POLYMERS

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	PCC	Rheology and Testing of Polymers	TPL 303	4	3	1	0	30	20	-	50	50	100

OBJECTIVE: The objective of this course is to enable the students

- To understand the fundamentals of polymer rheology and testing.
- To interpret the flow behavior of polymer melts by mechanical models.
- To understand various properties of plastic materials.

Course Outcome

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

CO1	Understand the fundamentals of polymer rheology.	Understand
CO2	Apply mathematical models to interpret the flow behaviour of polymer melts.	Apply
CO3	Understand and apply the concept of measurement of viscosity and apply knowledge in handling rheological instruments.	Apply
CO4	Understand and apply testing of plastics materials for its mechanical, electrical, optical, and thermal properties.	Apply
CO5	Apply characterization techniques viz. FTIR, NMR, TGA & DSC to elucidate the properties of polymers.	Apply

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	1	1	1		3						3	3	3
CO2	3	2	2	2		3						3	3	3
CO3	3	3	3	2		3		1				3	3	3
CO4	3	3	3	2	2	3	1	1	3			3	3	3
CO5	3	3	3	2	2	3	1		3	1		3	2	3
Total	**3**	**1.8**	**1.8**	**1.8**	**2**	**3**	**1**	**1**	**3**	**1**		**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module -I: Fundamentals of Polymer Rheology
Introduction to polymer rheology, importance of rheology on polymer processing techniques such as extrusion, injection molding, etc., Newtonian and non-Newtonian fluids, time independent and time-dependent fluids, visco-elastic behavior, constitutive equations.

Module-II: Mechanical Models and Polymer Rheology

Mechanical models, discussion of models for flow and deformation in polymers and treatment of measurable rheological properties

Module – III: Measurement of viscosity and Rheometers
Measurement of viscosity and normal stresses. Viscous heat generation. Interpretation of time-temperature sensitivity of viscoelastic solids and liquids. Rheometers.

Module-IV: Testing of Polymer Properties
Testing of polymer properties viz. thermal, optical, electrical, and mechanical properties as per standard specifications, viz. ASTM, ISO, etc. and its importance, correlation of these tests with actual performance.

Module-V: Characterization of Polymers
Introduction to polymer characterization by instrumental techniques such as IR, NMR, DSC, TGA, etc.

Reference Books and Suggested Readings :

1. J. D. Ferry, " Visco-elastic properties of polymers ", Wiley, 1980.
2. J. Ferguson and Z. Kemblowski, " Applied fluid rheology ", Springer Netherlands, 1991.
3. R.B. Brown, " Handbook of Plastics Test Method ", CRC Press, 1999.
4. Brown and Vishnu Shah, " Handbook of Plastic Testing Technology ", Wiley-Blackwell, 1998.
5. John M. Dealy, Kurt F. Wissburn, " Melt Rheology & its Role in Plastics processing theory & applications ", Springer Netherlands, 1998.
6. Brydson, JA, " Flow Properties of Polymer Melts ", CBLS, 1970.
7. Christopher W. Macosko, " Rheology, Principles, measurements and applications ", Wiley-VCH, 1994.

TPL 305 POLYMER TESTING LAB

L	T	P	C
0	0	4	2

OBJECTIVE: The objective of this course is to enable the students

- To determine various mechanical properties of plastic and rubber materials
- To determine the rheological properties of polymers
- To determine the thermal properties of polymers.

Course Outcome

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

CO1	Testing of various mechanical properties of plastic and rubber materials	Apply
CO2	Testing of the rheological properties of polymers	Apply
CO3	Testing of the thermal properties of polymers	Apply
CO4	Analyze testing of plastic materials on different testing equipments.	Analyze

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2	2	1		3			3	3		3	3	3
CO2	3	2	2	1		3			3	3		3	3	3
CO3	3	2	2	1		3			3	3		3	3	3
CO4	3	2	2	1	2	3	1		3	3		3	3	3
Total	**3**	**2**	**2**	**1**	**2**	**3**	**1**		**3**	**3**		**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Course Outcome

Determination of various mechanical properties of polymers and rubbers by standard test methods
Determination of viscosity and melt flow index of polymers.
Determination of various thermal properties of polymers by standard test methods
Analyze properties for their correlation with actual performance

Module-VI: Laboratory Experiments
Determination of Tensile Strength and Percent Elongation of polymer film/sheet/molded plastic/rubber specimen
Determination of the Izod/Charpy Impact Strength of given specimen,
Determination of the Vicat Softening point/
Melt Flow Index of given plastic sample,
Determination of the Shore A Hardness of Rubber Sheet,

Determination of the Percent Water Absorption in 24 hours of Molding Plastic samples, Determination of the Falling Dart Impact Strength of polyethylene film,
Determination of viscosity of polymer by Brookefield viscometer,

	Laboratory Experiments	
1	Determination of Tensile Strength and Percent Elongation of polymer film/sheet	06
2	Determination of the Vicat Softening point of given plastic sample on Vicat Softening Point apparatus	06
3	Determination of Tensile strength, Modulus and Percent Elongation of moulded plastic specimen	06
4	Determination of the Izod/Charpy Impact Strength of given specimen	06
5	Determination of the Melt Flow Index of polymer raw material by MFI tester	06
6	Determination of the Shore A Hardness of Rubber Sheet	06
7	Determination of the Percent Water Absorption in 24 hours of Moulding Plastic samples	06
8	Determination of the Falling Dart Impact Strength of polyethylene film using Falling Dart Impact Tester	06
	Determination of viscosity of polymer by Brookefield viscometer	06
10	Determination of Tensile strength, Modulus and Percent Elongation of rubber specimen	06
	Total hours	**60**

TPL 307 MASS TRANSFER OPERATION

L	T	P	C
3	1	0	4

Assessment:

Sessional: 50 marks

End Semester: 50 marks

Course Objectives: The purpose of this course is to introduce the undergraduate students with the most important separation equipments in the process industry, and provide proper understanding of unit operations.

Course outcomes:

CO 1	Understand the principles of molecular diffusion and basic laws of mass transfer.	Understand,
CO 2	Ability to determine mass transfer rates using Fick's Law	Apply
CO 3	Estimate diffusion coefficients and apply to practical problems	Apply
CO 4	Ability to determine convective mass transfer rates	Apply
CO 5	Analyze the Similarity of mass, heat and momentum transfer – Analogy and understand the humidification processes and use of psychometric chart	Analyze

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	2	2	1	-	-	-	-	-	1	1	1	**1**	**2**
CO2	3	2	1	1	-	-	-	-	-	1	1	1	2	1
CO3	3	2	3	2	3	-	-	-	-	1	1	1	1	2
CO4	3	3	2	2	3	-	-	-	-	1	1	1	1	2
CO5	3	3	3	3	2	-	-	-	-	1	1	1	3	2
Avg	3	2.4	2.2	1.8	1.6	-	-	-	-	1	1	1	1.6	1.8

Syllabus

Module I (8 hours)

Mass Transfer and Diffusion: Steady-state ordinary molecular diffusion: Fick's law of diffusion; Velocities in mass transfer, Equimolar counter diffusion; unimolecular diffusion, Diffusion coefficients: Diffusivity in gas mixtures, diffusivity in liquid mixtures, Diffusivity in solids, One-dimensional, steady-state, molecular diffusion through stationary media, Mass transfer in turbulent flow: Reynolds analogy; Chilton-Colburn analogy; Other analogies, Models for mass transfer at a fluid-fluid interface: Film theory; Penetration theory; surface-renewal theory; film-penetration theory, Two-film theory and overall mass transfer coefficients. Introduction to absorption.

Module II (8 hours)

Distillation: Pressure-composition, Temperature-composition, Enthalpy-composition diagrams for ideal and non-ideal solutions; Raoult's law and its application; Maximum and minimum boiling mixtures; Concept of relative volatility; Single Stage Distillation-Differential distillation, Flash vaporization; Vacuum, molecular and steam distillations.

Module III (8 hours)

Liquid-Liquid Extraction: Applications; Ternary liquid-liquid equilibria; Triangular graphical representation; Equipment used for single stage and multistage continuous operation; Analytical and graphical solution of single and multistage operation.

Module IV (8 hours)

Solid-Liquid Extraction: Applications; Solid-liquid equilibrium; Equipment used in solidliquid extraction; Single and multistage crosscurrent contact and countercurrent operations; Overall stage efficiency; Determination of number of stages. Introduction to Humidification and drying.

Module V (8 hours)

Adsorption: Description of adsorption processes and their application, Types of adsorption, Nature of adsorbents; Adsorption isotherms and adsorption hysteresis; Stagewise and continuous contact adsorption operations, Determination of number of stages, Equipments; Ion exchange, Equilibrium relationship; Principle of ion-exchange, techniques and applications. Introduction to Crystallization theory.

BOOKS:

1. Treybal, R.E. "Mass Transfer Operations", 3rd ed. New York: McGraw-Hill, (1980).

2. Seader, J.D. and Henley, E.J., "Separation Process Principles", 2nd ed., Wiley India Pvt. Ltd., New Delhi (2013).

3. Sherwood, T. K., Pigford, R. L. and Wilke, C.R. "Mass Transfer" McGraw Hill (1975).

4. Geankoplis, C.J. "Transport Processes and Separation Process Principles", 4th ed., PHI Learning Private Limited, New Delhi (2012).

TPL 309 CHEMICAL REACTION ENGINEERING

L	T	P	C
3	1	0	4

Assessment:

Sessional: 50 marks
End Semester: 50 marks

Course Objective: To apply knowledge from calculus, differential equations, thermodynamics, general chemistry, and material and energy balances to solve reactor design problems, To examine reaction rate data to determine rate laws, and to use them to design chemical reactors, To simulate several types of reactors in order to choose the most appropriate reactor for a given need, To design chemical reactors with associated cooling/heating equipment.

Course Outcomes:

CO 1	Able to develop an understanding of the basic concepts involved in using reaction rate equations and kinetic constants	Understand, Apply
CO 2	Perform derivations of rate equations for non-elementary reactions both in homogenous and in heterogeneous reacting systems	Apply
CO 3	Able to understand the role of temperature and concentration in the rate equation	Understand
CO 4	Perform constant volume batch reactor calculations	Apply
CO 5	Develop calculations using the integral method and applying differential method of analysis using reactions with different orders	Understand, Apply

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	2	3	-	-	-	-	-	-	1	-	1	**1**	**2**
CO2	3	3	3	1	-	1	-	-	-	1	-	1	2	1
CO3	3	3	3	2	-	2	-	-	-	1	-	1	1	2
CO4	3	3	1	-	2	1	-	-	-	1	-	1	1	2
CO5	3	3	2	2	2	1	-	-	2	1	-	3	3	2
Avg.	3	2.8	2.4	1	0.8	1	-	-	0.2	1	-	1.4	1.6	1.8

Syllabus

Module I (8 hours)

Rate of Reaction, Elementary and non-elementary homogeneous reactions, Molecularity and order of reaction, Mechanism of reaction, temperature dependency from thermodynamics, collision and activated complex theories. Integral and differential methods for analyzing kinetic data, interpretation of constant volume reactor, zero, first, second and third order reactions, half life period, irreversible reaction in parallel and series, catalytic reaction, auto catalytic reaction, reversible reactions.

Module II (8 hours)

Interpretation of variable volume batch reactions for zero, first and second order reactions, Space-time and state-velocity, design equation for ideal batch, steady-state continuous stirred tank, steady-state plug flow reactors for isothermal reaction.

Module III (8 hours)

Design for single reactions, Size comparison of single reactors, Multiple reactor systems, plug flow/mixed flow reactors in series and parallel, reactors of different types in series, optimum reactor size, recycle reactor, autocatalytic reactions.

Module IV (8 hours)

Introduction to multiple reactions, qualitative discussion about product distribution, quantitative treatment of product distribution and of reactor size, selectivity, the side entry reactor, irreversible first-order reactions in series, Quantitative treatment: plug flow or batch reactor, Quantitative treatment: mixed flow reactor, Successive irreversible reactions of different orders, reversible reactions, irreversible series-parallel reactions, the Denbigh reactions and their special cases, Heat of reaction from thermodynamics, equilibrium constants from thermodynamics, General graphical design procedure for non-isothermal reactors, Optimum temperature progression, Heat effects: Adiabatic operations and non-adiabatic operations, Exothermic reactions in mixed flow reactors.

Module V (8 hours)

Residence time distribution of fluids in vessels, State of aggregation of the flowing systems, Earliness of mixing, Role of RTD, State of Aggregation and earliness of mixing in determining reactor behavior, E, F and C curves, Conversion in Non-ideal flow reactors.

Reference Books:

Levenspiel, O., “Chemical Reaction Engineering”, 3rd edition, John Wiley (1998).

SEMESTER- 6

TPL 302 POLYMER PROCESSING – II

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab.	Total		
1	PCC	Polymer Processing II	TPL 302	3	2	0	2	15	20	15	50	50	100

OBJECTIVE: The objective of this course is to enable the students

- To understand the injection molding process and components of injection molding machine.
- To understand the processing techniques like thermoforming, calendaring, rotational moulding, blow molding etc.
- To process plastics on different types of moulding machines and prepare simple articles.

Course Outcome

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

CO1	Understand the fundamentals of injection molding process for conversion of thermoplastic and analyze processing parameters and variables for modification and improvement of quality of products.	Analyze
CO2	Understand the processing techniques for conversion of thermoset materials like compression, transfer molding and casting.	Understand
CO3	Understand formation of low cost plastic products by thermoforming process and analyze utility of process for different applications.	Analyze
CO4	Understand formation of hollow plastic products and analyze utility of various techniques, for production of hollow products.	Analyze
CO5	Understand reactive processes for formation of plastic products like RIM.	Understand
CO6	Apply different parameters related to processing machines for formation of plastic products.	Apply

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	1	1	1	3	1	1	1	1		2	3	2
CO2	3		1	1		3	1	1	1	1		2	3	2
CO3	3	3	1	1		3	2	1	1	1		2	3	2
CO4	3	3				3	1	1	1	1		2	3	2
CO5	3	3				3	1	1	1	2		3	3	2
CO6	3	3	3	3	1	3	2	1	3	2	1	3	3	2
Total	**3**	**3**	**1.5**	**1.5**	**1**	**3**	**1.3**	**1**	**1.3**	**1.3**	**1**	**2.3**	**3**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module-I: Injection Molding of Thermoplastics

Basic concepts of injection molding of thermoplastics Principle and theory of standard injection molding operation, molding cycle, Process variables, temperature, pressure, injection rate, etc. and their importance for machine cycle and quality of product. Faults and remedies in injection molding operation. Advances in injection molding.

Module-II: Molding Processes for Thermoset polymers

Concept of Injection molding of thermoset polymers and process details. General concept of compression and transfer molding process, the description of various types of compression and transfer molding processes and their utility in processing of thermosetting materials.

Module-III: Thermoforming Process

Concepts of thermoforming process and various means of forming. Description of various thermoforming methods. Thermoforming process variables affecting the product quality. Thermoforming faults and remedies. Thermoforming machines.

Module-IV: Molding Process for hollow products

General description of blow molding processes, type of blow molding machines, die shaping, parison control, process variables, blow molding faults and their remedies.

Rotational molding process description and features of rotational molding machines. Process variables in rotational molding process

Stretch blow molding process. Concepts of stretching temperature, transparency, etc. various types of stretch blow molding operation.

Module-V: In-situ Reaction Molding process

Reaction injection molding (RIM) Process, its basic principles, process description and utility. Concept of Casting of polymers, description of process for polymers like epoxy resins, nylons, polyurethanes, etc.

Module VI: Laboratory Experiments

Preparation of simple plastic products and test specimen on Injection Molding Machine; Preparation of simple article on Blow Molding Machine, Preparation of Fiber reinforced plastic sheet by using glass fiber mat and unsaturated polyester resin; Preparation of sheet by Hydraulic press/Two Roll Mill; Preparation of PET Bottle on Stretch Blow Moulding Machine, Preparation of an article by Rotational Molding Machine.

Reference Books and Suggested Readings :

1. Plastic Engg. HandBook, by Frados.
2. Injection and Compression Moulding Fundamentals, by Isayev.
3. Encyclopedia of Polymer Science and Technology Vol. 1-23, by Mark &Overberger.
4. HandBook of Injection Moulding, by Rosato& Rosato.
5. Practical Thermoforming Principles & Applications, by J. Florian.

TPL 304 STRUCTURE AND PROPERTY OF POLYMERS

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab.	Total		
2	PCC	Structure & Property of Polymers	TPL 304	3	2	1	0	30	20	-	50	50	100

OBJECTIVE: The objective of this course is to enable the students

- To understand about different structure of polymers and study the effect of structure on the mechanical, thermal, optical, electrical and chemical properties of polymers.
- To learn about the prediction of various physical, thermal, electrical, optical and chemical properties of polymers by using additive principle.

Course Outcome

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

CO1	Understand correlation between polymers structure and property.	Understand
CO2	Apply mathematical equations to interpret the concept of molecular weight averages and MWD on polymer properties.	Apply
CO3	Understand the concept of polymer crystallinity and its role to analyze polymer properties.	Analyze
CO4	Apply mathematical equations to analyze polymer solution properties.	Analyze
CO5	Understand and apply the concept of flexibility to interpret the glass transition temperature.	Apply

Cos	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3					3	3					3	2	3
CO2	3			2		3		1				3	3	2
CO3	3	3		2		3		1	2			3	3	3
CO4	3	3	3	2	2	3			2	1	1	3	2	3
CO5	3	3	3	2	2	3			2			3	2	3
Total	**3**	**3**	**3**	**2**	**2**	**3**	**3**	**1**	**2**	**1**	**1**	**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module-I: General Structural Features of Polymers
Basic structures in polymers, structure-property relationship. Effect of chemical composition and types of bonds in structure of polymer, intermolecular forces.

Module-II: Molecular weight averages and Molecular mass heterogeneity
Molecular weight averages and distributions. Determination of molecular weight averages. Polydispersity and MWD.

Module -III: Polymer Crystallinity and its measurement
Orientation of crystalline and amorphous zones and study of its effects on polymer properties. Polymer single crystal, dimensions of polymer chain, degree of crystallinity and its measurement.

Module-IV: Polymer-in-solution
Polymer-solvent interaction, good and poor solvents, intrinsic viscosity and Mark-Houwink equation, concept of fractionation processes.

Module-V: Flexibility and movement of macromolecules
Concept of flexibility, various factors deciding flexibility of polymers, polymer properties affected by flexibility, glass transition temperature (Tg), factors affecting glass transition temperature. Effect of copolymerization on properties. Degradation behaviour of polymers.

Reference Books and Suggested Readings :

1. Text Book of Polymer Science, F. W. Billmeyer, John Wiley & Sons, 2009.
2. Properties and structure of polymers, A. T. Tobolsky, Wiley, New York, 1960.
3. Polymer Chemistry, C. E. Carrshar, Marcel Dakker Inc., 2003.
4. Polymer Solutions – Introduction to Physical Properties, Teraoka, Iwao, John Wiley and Sons, Inc., 2002.
5. Polymer Chemistry – An Introduction, M. P. Stevens, Oxford University Press, 1990.
6. Encyclopedia of Polymer science and Technology, H.F.Mark, N.G. Gaylord, and N. M. Bikales, Eds., Interscience Publishers, New York, 1971.
7. Advanced Polymeric Materials: Structure property relationship, by G.O.Shonaike and S.G.Advani, Ed. CRC Press, 2000.

TPL 306 POLYMERIZATION ENGINEERING – II

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab.	Total		
3	PCC	Polymerization Engineering II	TPL 306	4	3	0	2	15	20	15	50	50	100

OBJECTIVE: The objective of this course is to enable the students

- To understand synthesis, , manufacturing process, properties and applications of engineering plastics.
- To learn the manufacturing of thermoset resins and their applications.
- To understand the synthesis and manufacturing of flexible and rigid polyurethanes and analyze their properties and applications.

Course Outcome

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

CO1	Understand concept of engineering plastics, synthesis and manufacturing of common engineering plastics and their properties for variety of applications.	Understand
CO2	Understand monomers and their properties, chemistry of synthesis and manufacturing of high performance thermoplastic materials and analyze their properties and utility for variety of application.	Analyze
CO3	Understand concept and characteristics of specialty plastics and their applications.	Understand
CO4	Understand monomers, chemistry of synthesis, manufacturing, curing and properties of high temperature thermoset polymers like epoxy resin, and analyze their properties and utility for variety of applications.	Analyze
CO5	Understand synthesis, manufacturing, properties and applications of specific polymers and analyze their utility to meet desired end use properties.	Understand
CO6	Apply polymerization techniques for synthesis of modified polymers.	Apply

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2	1			3	1	1		1		3	3	3
CO2	3	2	1			3	1	1		1		3	3	2
CO3	3	2	1			3	1	1	1	1		3	3	2
CO4	3	2	1	1		3	1	1		1		3	3	2
CO5	3	2	1	1	1	3	2	1	1	1		3	3	2
CO6	3	2	2	3	1	3	2	1	3	2	1	3	3	3
Total	**3**	**2**	**1.1**	**3**	**1**	**3**	**1.3**	**1**	**1.2**	**1.1**	**1**	**3**	**3**	**2.3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module-I: Engineering Thermoplastics-I
General characteristics of commodity, engineering and high performance polymers. Monomers, chemistry of synthesis, manufacturing process, properties and applications of common engineering plastics such as ABS and polycarbonate.

Module-II: Engineering Thermoplastics-II
Monomers, chemistry of synthesis, manufacturing process, properties and applications of polyamides, polyesters, fluorine-containing polymers, etc.

Module-III: Specialty Thermoplastics
Monomers, chemistry of synthesis, manufacturing process, properties and applications of polyphenylene oxide, acetal resins, polysulphones and other specialty plastics.

Module-IV: Thermoset polymers-I
Monomers, chemistry and manufacturing process of thermosetting resins such as epoxy resins, unsaturated polyesters resins, polyimides, etc. their curing mechanism and effect of curing parameters on properties and applications of these polymers.

Module-V: Thermoset polymers-II
Synthesis and manufacturing of flexible and rigid polyurethanes and polyacrylatyes, and their properties and applications.

Module-VI: Laboratory Experiments
Preparations of copolymers, ester gum resin, polyester resin, graft copolymer, molding powder depolymerization of polystyrene; Determination of epoxide equivalent and amine values. Analysis of gel time of epoxy resin. Modification of epoxide equivalent of resin. Apply modification methods for improvement of polymers like epoxy, resin, styrene.

Reference Books and Suggested Readings :

1. Polymer production, by Mayo & Smith
2. Polymer Materials, by J. A. Brydson
3. Encyclopedia of Polymer Science & Tech., Vol 1-23, by Mark &Overberger
4. Handbook of Plastic Technology, Vol 1, by Allen W. S.
5. Handbook of Plastic Technology, Vol 2, by Allen W. S. and G. M. Swallowe
6. Vinyl acetate emulsion polymerization and copolymerization with acrylic monomers, by H.Yildilin Erbil
7. Handbook Of Thermoplastics, by Olagoke Olabisi
8. Engineering polymers, R.W. Dyson Chapman Hall NY 1990

TPL 308 PLASTIC PRODUCT AND MOULD DESIGN

L	T	P	C
2	1	0	3

OBJECTIVE: The objective of this course is to enable the students

- To understand the concepts of product design and composite product design and important design features.
- To understand various parts of injection mold and their types.
- To learn the problems related to multicavity injection molds and their solution.
- To understand the design concept for different types of extrusion dies.

Course Outcome

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

CO1	Understand and apply design of polymeric products, design criteria based upon product functions and geometry.	Understand
CO2	Understand and apply design features for mold designs for plastic product.	Understand
CO3	Understand and apply design concepts for structure of injection molds with materials.	Apply
CO4	Understand concepts and apply design in structure of compression & transfer molds.	Apply
CO5	Understand and apply concepts in structure of extrusion dies.	Apply

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3		1				1		1			2	3	3
CO2	3	2	1				1		1			2	3	3
CO3	3	2	1							1		2	3	3
CO4	3	2	1	1	2	1						2	3	3
CO5	3	2										2	3	3
Total	**3**	**2**	**1**	**1**	**2**	**1**	**1**		**1**	**1**		**2**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module-I: Plastic product design criteria
Design of polymeric products, design criteria based upon product functions and geometry, material selection by property assessment, selection of appropriate forming processes.

Module-II: Product Design Features
Moulding consideration: Draft, radii, dimensional tolerances, wall thickness, ribs and bosses, inserts, sink marks, undercuts, feeding system, gate location, flow pattern, shrinkage and post moulding shrinkage.

Module-III: Injection Mold Design

Injection mould design: single, multi cavity, semi automatic and automatic moulds, Types of injection moulds, their applications, detailed structure and working. Materials for mould making & Mould making processes.

Module-IV: Design Concept of other Mold types
Design concepts for compression molds and transfer molds. Extradites dies basics, types and general structure.

Module-V:Computer Aided Design
Concept of CAD/CAM in product design moulding and plastic. Modeling and Simulation applications for mold designing, such as mould flow etc.

Reference Books and Suggested Readings :

1. Plastic Product Design, by R. D. Beck.
2. Injection mould Design, by R.G.W. Pye.
3. Plastic Mould Engg, Hand Book, by J. H. Dubois & W. I. Pribble.
4. Dies for Plastic Extrusion, by M. V. Joshi.
5. Injection Moulding Hand Book, by Rosato & Rosato.

TPL 310 POLYMER COMPOSITE

L	T	P	C
3	0	0	3

OBJECTIVE: The objective of this course is to enable the students

- To understand concept of polymer composite and basic construction.
- To understand the properties and manufacturing of various polymer matrix materials used for polymer composites.
- To know the manufacturing and properties of various reinforcements used in polymer composites.
- To learn various processing techniques, testing and applications of fibers in reinforced plastics.

Course Outcome

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

CO1	Understand the concept of composite materials and reinforcement.	Understand
CO2	Understand the types and forms of reinforcement materials used in composites.	Understand
CO3	Understand various thermoset and thermoplastic materials used in composites.	Understand
CO4	Understand different production techniques for composite structures like hand-layup, bag molding etc.	Understand
CO5	Apply knowledge of production technique for making different structure like hybrid structure and sandwich structure.	Apply

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3											3	3	3
CO2	3		2			2						3	3	3
CO3	3		2			2						3	3	3
CO4	3	2	2			2						3	3	3
CO5	3	2	2	1		2						3	3	3
Total	**3**	**2**	**2**	**1**		**2**						**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module-I: Introduction to polymer composites
Introduction to composite materials, comparison of different materials with composites-advantages and disadvantages. Principles of composite reinforcement. Effect of fibrous reinforcement on composite strength.

Module-II: Reinforcements for Polymer composites
Types of reinforcement such as natural, glasses, carbon/graphite, aramid fibers boron fibers and their utility in polymer composites various forms of reinforcement and surface treatment of fibers

Module-III: Matrices for Polymer composites

Thermosetting and thermoplastic material used for the composites and their selection for a particular application

Module-IV: Production Techniques -I

Processing and production techniques like hand-layup, bag moulding, filament winding and pultrusion

Module-V: Production Techniques -II

Prepegs, their manufacture and characterization. Sheet moulding and dough moulding compounds and their processing. preform and resin transfer moldings.
Hybrid and sandwich type composites.

Reference Books and Suggested Readings :

1. Hand Book of Composites, by George Lubin
2. Hand Book of Fibre glass and Advanced Plastic Composites, by G. Lubin
3. Reinforced Thermoplastics, by W.V. Titov
4. Engineering Design for Plastics, by Eric Baer
5. Glass Engineering Hand Book, by E.S. Shend
6. Plastics and Composites welding Handbook by Grewell, Benatar& Park
7. Polymer and composite Rheology by R. K. Gupta
8. Reinforced Plastic Handbook by Rosato&Rosato

TPL 312 INSTRUMENTATION & PROCESS CONTROL

L	T	P	C
2	1	0	3

Assessment:

Sessional: 50 marks

End Semester: 50 marks

Course Objectives:

To gain the knowledge of different process instruments and various control processes for closed loop and open loop systems..

Course outcomes:

CO1	Understand and interpret control diagrams	Understand
CO2	.Design and tuning of controllers for specific applications	Apply
CO3	Calculate the dynamic response of closed loop systems	Analyze
CO4	Understand the principles involved in measurements, Attain knowledge on different measurement methods employed in industrial processing and manufacturing.	Understand
CO5	Understand and Analyze the different temperature measurement devices in Chemical industries.	Understand and Analyze

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO1 1	PO1 2	PSO 1	PSO 2
CO1	3	3	2	2	1	-	-	-	-	1	1	2	**2**	**2**
CO2	3	3	3	2	3	-	-	-	-	1	1	2	2	2
CO3	3	3	3	3	3	-	-	-	-	-	-	2	2	2
CO4	3	1	1	-	-	-	-	-	-	1	1	2	2	2
CO5	3	2	1	2	2	-	-	-	-	-	-	2	2	2
CO6	3	3	3	2	2	-	-	-	3	2	1	2	2	2
Avg	3	2.5	2.16	1.83	1.83	-	-	-	0.5	0.83	0.66	2	**3**	**2**

Module 1 (8 hours)

Introduction to Process control systems, Use of Laplace & Inverse Laplace Transformation in study of Process Dynamics & Control. Characteristics of measurement system, classification of measuring instruments.

Module 2 (8 hours)

Dynamic Modeling of a Process, Dynamic behavior of First order system, First order systems in series & second & higher order systems for various kind of inputs, Linearization of nonlinear systems, Transportation & Transfer Lag.

Module 3 (8 hours)

Classification of control systems, Regulator & Servo control, Feed Forward & Feed backward control, Negative & Positive Feedback Control, Modes of control action, Controllers & Final control Elements, Reduction of Block & Signal Flow Diagrams.

Module 4 (8 hours)

Principles of measurements and classification of process control instruments, Functional elements of an instrument, Static & Dynamic Characteristics of instruments, Transducers, Error analysis, Measurement of temperature: expansion thermometers, Resistance Thermometers, thermocouples, Thermistors, Pyrometers.

Module 5 (8 hours)

Flow measurement: Inferential flow measurements, Quantity flow meters, Mass flow meters. Flow measurement, head types-area flow meters, mass flow meters, positive displacement type flow meters, electrical type flow meters and solid flow measurement.

Suggested Text Books

1. Coughnour and Koppel, " Process Systems Analysis and Control ", McGraw-Hill, New York, 1986.
2. George Stephanopolous, " Chemical Process Control ", Prentice-Hall of India Pvt-Ltd., New Delhi, 1990.

3. Singh, S. K. , Industrial Instrumentation and Control , Prentice Hall of India, 2016

4 .Eckman, D.P., Industrial Instrumentation, Wiley Eastern Ltd., New York, 1990

SEMESTER- 7

TPL 401 TECHNOLOGY OF ELASTOMERS

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	PCC	Technology Of Elastomers	TPL 401	2	2	0	0	30	20	-	50	50	100

OBJECTIVE: The objective of this course is to enable the students

- To provide the knowledge of manufactory process of natural rubber and synthetic of different synthetic rubbers.
- To enable the students to understand the need of various additives and compounding of rubbers and vulcanization.

Course Outcome

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

CO1	Understand characteristic properties of elastomers, utility of compounding ingredients for variety of applications.	Understand and Apply
CO2	Understand source, procurement process, properties, vulcanization and applications of natural rubber.	Understand
CO3	Understand chemistry of synthesis, manufacturing process, properties and applications of synthetic rubbers.	Understand
CO4	Understand processing methods and vulcanization of elastomers.	Understand
CO5	Analyze quality and testing of properties of various rubbers.	Analyze

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3											3	3	3
CO2	2	2	2			2						3	3	3
CO3	3											3	3	3
CO4	3					2						3	3	3
CO5	3	2				2						3	3	3
Total	**3**	**2**	**2**			**2**						**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module-I: Introduction to elastomers and compounding

Definition and characteristics of rubber and elastomer, significance of structure and important features of elastomers. Compounding ingredients and method of compounding, various compounding equipments. Types of fillers, their characteristics and affect on rubber properties. Mechanism of reinforcement of elastomers. Carbon black its characteristics and methods of production. Mastication of rubbers.

Module-II: Natural rubber

History of natural and synthetic elastomers Production of different grades of natural rubber from latex, modified natural rubber and its derivatives. Application of latex, technically specified rubber, chemistry of vulcanization and various vulcanization techniques.

Module-III: Synthetic Rubber -I

Manufacturing processes, properties and application of synthetic elastomers viz. styrene-butadiene rubbers, acrylonitrile- butadiene rubber, butyl rubber, polychloroprene rubber.

Module-IV: Synthetic Rubber -II

Manufacturing processes, properties and application of ethylene-propylene rubber, polyurethane elastomers, chlorosulphonated polyethylene, polysulphide and silicon rubber, Concept of various types of thermoplastic elastomers and their applications, styrene butadiene TPE, polyurethane based TPE.

Module-V:Industrial fabrication of Rubber Products

Industrial fabrication of rubber article such as transmission belts, hoses, tyres, dipped goods. Processing techniques of rubbers, applications and manufacturing of articles from latex. Testing methods for determination of properties and curing of rubbers.

Reference Books and Suggested Readings :

1. Rubber Technology & Manufacture, by C.M.Blow
2. Encyclopedia of Polymer Science and Technology Vol. 1-23, by Mark &Overberger
3. Rubber Technology, by Maurice Morton
4. Synthetic Rubbers, by D.C. Blacklay
5. Anil .K. Bhowmic, Howard L. Stephens (Edt), Handbook of Elastomers – New Developments & Technology, Marcel Decker Inc. New York 1988.

TPL 403 ADVANCED POLYMER MATERIALS

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
2	PCC	Advanced Polymeric Materials	TPL 403	3	2	0	2	15	20	15	50	50	100

OBJECTIVE: The objective of this course is to enable the students

- To understand the basics syntheses and applications of high performance polymers.
- To understand the determination of various properties using analytical instruments.

Course Outcome

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

CO1	Understand chemistry of synthesis of polymers for high tech applications and analyze the properties of high performance polymers for specific application like aerospace, telecomm, biomedical, defense etc.	Understand
CO2	Understand and apply chemistry, preparation, properties and applications of high temperature resistant polymers.	Apply
CO3	Understand the preparation, properties and applications of liquid crystalline polymers, silicone polymer, and any newly developed material. Nano-fillers and nano-composites, their processing and economics.	Understand
CO4	Understand and analyze self-reinforced polymer composite, high energy absorbing polymer, super absorbent polymers, and polymers for biomedical applications.	Analyze
CO5	Understand modification techniques for preparation of specific polymers like polymer blends & alloys.	Understand
CO6	Characterize polymers using analytical instruments like DSC, TGA, UV spectrophotometer.	Analyze

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3					3							2	3
CO2	3	2				3						3	2	3
CO3	3	2				3		1				3	3	3
CO4	3	2				3		1				3	3	3
CO5	3	3				3				1		3	2	3
CO6	3	3	3	3	3	3	1		3	1	1	3	3	3
Total	**3**	**2.5**	**3**	**3**	**3**	**3**	**1**	**1**	**3**	**1**	**1**	**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module-I: Role of Polymers for High-tech areas

Role of polymers for high-tech areas such as aerospace, telecommunication, defence, medical, etc.

Module-II: High performance polymers – I
Chemistry, preparation, properties and applications of high temperature resistant polymers like polyetherether ketone (PEEK), etc. Speciality polymers.

Module-III: High performance polymers – II
Preparation, properties and applications of liquid crystalline polymers, silicone polymer, and other newly developed material. Nanofillers and nanocomposites, their processing and economics.

Module-IV: High performance polymers – III
Self-reinforced polymer composite. High energy absorbing polymer. Super absorbent polymers. Polymers for biomedical applications.

Module-V: Modification of Polymers
Polymer blends and alloys, theories of polymer miscibility, various commercial blends and their applications, methods of blending.

Module-VI: Laboratory Experiments
Determination of glass transition temperature/crystallinty/heat of reaction by using Differential Scanning Calorimeter (DSC), determination of Initial Degradation Temperature (IDT), Final Degradation Temperature and char yield (FDT) of polymers by using Thermo Gravimetric Analyzer (TGA), experiments based on UV-VIS spectrophotometer, wear and friction monitor, and ultrasonicator, measurements of rheological properties of given polymer blends or mixtures.

Reference Books and Suggested Readings :

1. Encyclopedia of polymer science and technology, Vol. 14, H. F. Mark, N. G. Gaylord and N. M. Bikales, Eds., Interscience Publishers, 1971.
2. Plastic Materials, J. A. Brydson, Butterworth-Heinemann, 1999.
3. Principles of Polymers - A Advance Book, D S Bag, Nova Science publishers , N Y 2013
4. Macromolecular Synthesis, by J.R. Fllyott
5. Hand Book of Fibre glass and Advanced Plastic Composites, by G. Lubin
6. Polymer modification by John J. Merister
7. Polymer gels and Network by Yoshihido osada
1. Polymer Blends Hand Book – Vol. I & II, by L.A.Utracki

PROGRAMME ELECTIVE COURSE_I

TPL 407 POLYMER BLENDS AND ALLOYS

L	T	P	C
3	0	0	3

OBJECTIVE: The objective of this course is to enable the students

- To understand concepts of blends and alloys
- To understand the concept of miscibility and immiscibility of polymers
- To understand the types of blending techniques.
- To understand characterization techniques for blends and alloys

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

CO1	Understand the concept of blends and alloys	Understand
CO2	Understand the miscibility and immiscibility of polymers	Understand
CO3	Understand the methods of blending and alloying	Understand
CO4	Analyze the properties and application of blends	Analyze
CO5	Analyze the characterization techniques for characterization of polymer blends .	Analyze

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3					1	2					3	3	3
CO2	3					1	2					3	3	3
CO3	3					1	2					3	3	3
CO4	3	2	1			1	2					3	3	3
CO5	3			1		1	2					3	3	3
Total	**3**	**2**	**1**	**1**		**1**	**2**					**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module – I: Introduction to polymer blends

Definition of blends and alloys, reasons for blending, classification of blends; historical outline of industrial development of polymer alloys and blends; how to select blend components fundamental principles for development of polymer alloys and blends

Module – II: Miscibility/ Immiscibility of polymers

Definition of miscibility; Miscible Blends and Immiscible Blends - Difference Between Miscible and Immiscible Blends - Properties of Miscible and Immiscible Blends; Phase Equilibria Calculation; Huggins - Flory Theory; Measurement of Polymer/Polymer Interaction Parameter ; Factors Affecting Miscibility of Polymer Blends; concept of Compatibility of polymers

Module – III: Blending process

Methodsof blending; Types and Role of Compatibilizer; Compatibilization Methods; Mechanism and Properties of Compatibilized Blends; Mechanism and Theory of Toughing;
Blend preparation equipments: mixers' and their various types like banbury, hot and cold mixers, twin screw compounders, and two- roll mills, etc.Toughening of Thermoplastics and Thermosets; Thermoplastic Elastomers; Properties and Uses Interpenetrating polymer network:

Module – IV: Properties and application of polymer blends
Mechanical and thermal properties of polymer blends; Rheological Models for Miscible and Immiscible Blends, Applications of blends and alloys Automotive , Electrical and Electronics, Medical, Building and Construction, Business Machines and Communications,
Packaging

Module – V: Characterization of polymer blends
Methods of Measurements of Crystallization, Morphological and Melting Behavior of Polymer Blends, use of SEM, TEM, for characterization of blends

Reference Books and Suggested Readings :

1. L. A. Utracki, Polymer blends and alloys, Hanser Publishers, New York, 1979
2. L. M. Robeson, Polymer blends Hanser publications, USA, 2007
3. M. J. Folkes, P. S. Hope, Polymer blends and alloys, Springer, London, 2012
4. L. A. Utracki, Polymer Blends Hand book, Kluwer academic publichers, UK, 2002
5. D R Paul and S Newman, Polymer Blends Vol. I and II, Academic Press Inc, 1978.

PROGRAMME ELECTIVE COURSE_I

TPL 405 Plastic Product Technology

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
3	PEC	Programme Elective Course I Plastic Product Technology	TPL 405	3	3	0	0	30	20	-	50	50	100

OBJECTIVE: The objective of this course is to enable the students

- To understand necessity of plastic product design for efficient working.
- Understand basic and important plastic product design features.
- Apply the plastic product design features for practical situations.
- Apply knowledge of design feature in complex and assembly products.
- Understand capabilities of computer program based design softwareseg.

Course Outcome

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

CO1	Understand the basic requirements pricer to designing of a plastic product.	Understand
CO2	Understand the difference in design of plastic products in comparison on to other materials.	Understand
CO3	Understand the design guidelines of various product design features.	Apply
CO4	Apply design concepts in design of simple and complex and assembly plastic products.	Apply
CO5	Understand the applications of materials data based product and mould designing software's (eg. Moldflow).	Apply

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1														
CO2														
CO3														
CO4														
CO5														
Total														

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module-I: Plastic product design criteria

Design of polymeric products, design criteria based upon product functions and geometry, material selection by property assessment, selection of appropriate forming processes.

Module-II: Product Design Features

Moulding consideration : Draft, radii, dimensional tolerances, wall thickness, ribs and bosses, inserts, sink marks, undercuts, feeding system, gate location, flow pattern, shrinkage and post moulding shrinkage.

Module-III: Injection Mold Design

Injection mould design: single, multi cavity, semi automatic and automatic moulds, Types of injection moulds, their applications, detailed structure and working. Materials for mould making & Mould making processes.

Module-IV: Design Concept of other Mold types

Design concepts for compression molds and transfer molds. Extradites dies basics, types and general structure.

Module-V:Computer Aided Design

Concept of CAD/CAM in product design moulding and plastic. Modeling and Simulation applications for mold designing, such as mould flow etc.

Reference Books and Suggested Readings :

1. Plastic Product Design, by R. D. Beck.
2. Injection mould Design, by R.G.W. Pye.
3. Plastic Mould Engg, Hand Book, by J. H. Dubois & W. I. Pribble.
4. Dies for Plastic Extrusion, by M. V. Joshi.
5. Injection Moulding Hand Book, by Rosato & Rosato.

PROGRAMME ELECTIVE COURSE II

TPL 409 POLYMERIC ADHESIVES AND FOAMS

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
4	PEC	Programme Elective Course II Polymer Ahesives and Foams	TPL 409	3	3	0	0	30	20	-	50	50	100

OBJECTIVE: The objective of this course is to enable the students

- To understand concepts of adhesion and adhesives.
- To understand the types of adhesives and their applications, surface treatments and preparation for adhesive bonding.
- To understand formulation and production techniques for variety of adhesives.
- To understand concept, production process, properties and applications of variety of polymeric foams.

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

CO1	Understand the concept of adhesion, adhesive joints and mechanism of adhesives.	Understand
CO2	Understand and apply the surface preparation and surface treatments for various substrates.	Apply
CO3	Understand the principle of adhesives formulation and production techniques.	Understand
CO4	Analyze properties of polymers for constitution of variety of adhesives.	Analyze
CO5	Understand concept of polymer foams and their utility in variety of applications and analyze production, process and properties of Polyurethane, Polystyrene and Epoxy foams .	Understand and Analyze

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3					1	2					3	3	3
CO2	3					1	2					3	3	3
CO3	3					1	2					3	3	3
CO4	3	2	1			1	2					3	3	3
CO5	3			1		1	2					3	3	3
Total	**3**	**2**	**1**	**1**		**1**	**2**					**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module – I: Introduction and adhesion theories

Definition of adhesives and adhesive bonding, functions of adhesives, classification of adhesives, advantages and disadvantages of joining using adhesives, requirements of a good bond, theories of adhesion, definition of failure modes, mechanisms of bond failure.

Module – II: Surface preparation and surface treatments

Surface characterization. Surface preparation and surface treatments for various substrates. Techniques for evaluation of adhesives bond strength. Testing and quality control.

Module – III: Adhesives formulation and production techniques

Principle of adhesives formulation and production techniques. Adhesives formulation for various industries viz. construction, packaging, textiles, automotive, consumer, abrasives and friction materials, shoes, electrical, aerospace, etc.

Module – IV: Characteristics and applications of adhesives

Characterization and applications of hot melt adhesives, solvent-activated adhesives, anaerobic and pressure sensitive adhesives, etc. Bonding of polymeric materials to various substrates. Polymer sealants. Structural adhesives.

Module – V: Polymeric foams

Introduction to polymer foams, chemistry and physical formation, foaming ingredients, their effect on foam morphology and physical properties and applications of polymer foams. Polyurethane foam (rigid & flexible), Polystyrene foams, Epoxy foams. Recent developments in foam technology.

Reference Books and Suggested Readings :

1. Adhesives, by Skiest
2. Industrial Cold Adhesive, by Roga Dulac
3. Handbook of Adhesives Raw material, by Ernest W. Flick
4. Sealants & Adhesives, by H.A. Perry

PROGRAMME ELECTIVE COURSE II

TPL 411 POLYMER NANOCOMPOSITES

L	T	P	C
3	0	0	3

OBJECTIVE: The objective of this course is to enable the students

- To understand concept of polymer nanocomposites and their applications.
- To understand clay and carbon nanotube based nanocomposites, their formation and applications.
- To understand metal containing polymer nanocomposites.
- To understand concept of nanopolymers.

Course Outcome: On the successful completion of the course, students will be able to

CO1	understand the concept of polymer nanocomposites and nano polymer	Understand
CO2	understand formation of inorganic nano clay based polymer nanocomposites and their application	Understand
CO3	Understand formation of carbon nanotube and carbon allotropes based polymer nanocomposites and their applications.	Understand
CO4	understand formation of metal based polymer nanocompsites and their applications	Understand
CO5	understand characterization of polymer nanocomposites	Understand

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3											3	3	3
CO2	3	2	1			1						3	3	3
CO3	3	2	1			1						3	3	3
CO4	3	2	1			1						3	3	3
CO5	3		1									3	3	3
Total	**3**	**2**	**1**			**1.25**						**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module-I:Concept of Nano materials and nanocomposites

Introduction to nano materials, and nanocomposites. Construction of polymer nano-composites, importance of interface between nano fillers and polymer matrix, the advantages and disadvantages and applications of polymer nano-composites

Module-II:Polymer clay nanocomposties

Types of nano clay available, Synthesis of nano clay, their structure, properties and utility in polymer nanocomposites, formulation of Polymer clay nanocompostíes, their properties and applications, concept of ordered structures, exfoliation, interfaces, surface induced patterns, etc.

Module-III:Carbon based polymer nanocomposites

Carbon nanotubes and carbon allotropes based polymer composites, types of nano tubes, their synthesis and structure. Methods for synthesis, structures, properties and potential applications of carbon based polymer nanocomposites

Module-IV:Metal based polymer nanocomposites

Types of nano metals available and their characteristic properties, Metal based polymer nanocomposites their synthesis, structure and physicochemical properties and potential applications

Module-V:Characterization of polymers nanocomposites

Rheology and processing of polymers nanocomposites; characterization, of polymer nanocomposites for morphological, thermal and mechanical properties

Reference Books and Suggested Readings:

1. Viswanathan V.R.,N.V. and JayaderSreedhar, “Polymer Science”, New age International publications.
2. Yiu-Wing Mai and Zhong-Zhen yu“Polymernanocomposites”, CRC press.
3. Alfred rudin , “The elements of polymer science and engineering”, 2ndedition, Academic press publication.
4. Alan Kin-TakLau, Farzanahussain, Khalidlafdi, “Nano and Biocomposites”,CRC press.
5. Abe, A.-C. Albertsson, R.Duncan “Advances in polymer science”,Springer.
6. Low I. M. “Ceramic matrix composites:Microstructure, properties and Applications ”, Woodhead Publishing Limited.
7. Luigi Nicolais Gianfranco Carotenuto“Metal – polymer Nanocomposites”,WileyInterscience.

OPEN ELECTIVE (PLASTIC TECHNOLOGY)

TPL 415 INTRODUCTION TO POLYMER TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVE: The objective of this course is to enable the students

- To understand basics concepts of polymer and their utility.
- To understand the mechanism of polymerization, various, techniques of polymerization, classification and kinetics of polymers.
- To understand manufacturing process of thermoplastic and thermoset polymers; Copolymerization.

Course Outcome

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

CO1	Understand basics of polymer science and their classifications.	Understand
CO2	Understand different types of polymerizations with mechanism and kinetics.	Understand
CO3	Understand and apply various production processes of commodity plastics	Apply
CO4	Understand chemistry and apply production of common formaldehyde based thermoset.	Apply
CO5	Understand and apply different plastic processing techniques, Indian markets of Plastics.	Apply

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3		1									2	3	3
CO2	3			1		2						2	3	3
CO3	3								1	1		2	3	3
CO4	3											2	3	3
CO5	3	2	1	1		2	2		1	1		2	3	3
Total	**3**	**2**	**1**	**1**		**2**	**2**		**1**	**1**		**2**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module -I: Introduction to Polymers/Plastics
Polymeric Materials and their macro molecular nature (e.g. Plastics, rubber, fibers), concept of polymer structure, classification of polymers.

Module -II: Chemistry of polymerizations
Principle of addition and condensation polymerization, different techniques of polymerization, chemistry and kinetics of polymerization, copolymerization.

Module -III: Thermoplastic resins
Chemistry and manufacturing process of some important thermoplastic polymers such as polyethylene, polystyrene, polyvinylchloride etc., their properties and applications.

Module -IV: Thermoset resins
Chemistry and manufacturing process of some important thermoset polymers such as phenol-formaldehyde, urea-formaldehyde and melamine formaldehyde resin.

Module -V: Processing of Plastics
Processing techniques for processing of thermosets and thermoplastics, Scope of polymeric materials industries in India.

Reference Books and Suggested Readings :

References

1. Text Book of Polymer Science, F.W.J. Billmeyer, John Wiley & Sons, 1984
2. High Polymer (His chemistry in industry P. Tooley, J. murray 1971
3. Principle of Polymer Chemistry, P.J. Flory Cornell University Press, NY, 1953
4. Handbook of Polymer Synthesis, Part A & B, Hans. R. Kricheldorf, John Wiley & Sons 1991
5. Principles of Polymerization, Gorge Odeon, 2004
6. Introduction to Polymers, R.J. Young & P.A. Livell Ch. & Hall, London, 1981
7. Polymer Chemistry, Seymour & Caraher, Marcel Decker, 2003

TPL 461 INDUSTRIAL TRAINING

L	T	P	C
0	0	4	2

OBJECTIVE: The objective of this course is to enable the students

- Make students observe and learn practical knowledge of processing or manufacturing of polymers
- Understand professional ethics and discipline required in industry
- Understand and analyze product planning and implementation in industry.
- Communicate their experiences in the form of project report and power point presentation

Course Outcome

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

CO1	Acquire practical skills in any plastic and allied industry.	Understand
CO2	Understand professional ethics and discipline required in industry.	Understand & Ethics
CO3	Analyze problems in products and process and resolves by working on short term project.	Analyze & Apply
CO4	Understand and analyze product planning and implementation in industry.	Understand and Analyze
CO5	Communicate their experiences in the form of project report and power point presentation.	Apply & Analyze

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3	2		3	1				1		3	1
CO2						3		3	3			2	1	3
CO3		3	3	2			1				1			
CO4		3		2					3		1	2		
CO5	3									3				
Total	**3**	**3**	**3**	**2**		**3**	**1**	**3**	**3**	**3**	**1**	**2**	**2**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

TPL 471 SEMINAR

L	T	P	C
0	0	4	2

OBJECTIVE: The objective of this course is to enable the students

- To study a topic of latest developments/innovative technology on their own and to prepare a dissertation report on this topic.
- To present a lecture on the topic on power point format.
- To improve the communication skill of the students.

Course Outcome

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

CO1	Understand a topic of latest developments/innovative technology.	Understand
CO2	Apply the knowledge to prepare a dissertation report on this topic.	Apply
CO3	Deliver a lecture on the topic on power point format.	Apply
CO4	Improve the communication skill of the students.	Apply
CO5	Analyze environment and sustainability of related technology	Analyze

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3			1		2	3					3	3	3
CO2	3	2	2	1	1	2	3		1	3	2	3	3	3
CO3	3									3		3	3	3
CO4	3								2	3		3	3	3
CO5	3	2				2	3	1				3	3	3
Total	**3**	**2**	**2**	**1**	**1**	**2**	**3**	**1**	**1.5**	**3**	**2**	**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

TPL 497 PROJECT

L	T	P	C
0	0	8	4

OBJECTIVE: The objective of this course is to enable the students

- To identify a plastic product that can be manufactured in India or a research problem and conduct experiment.
- To prepare a feasibility report for a project based on manufacturing of product.
- To present a lecture on the topic on power point format.
- To improve the communication skill of the students.

Course Outcome

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

CO1	Understand a topic of latest developments/innovative technology.	Understand
CO2	Apply the knowledge to prepare a feasibility/dissertation report on this topic.	Apply Analyze
CO3	Deliver a lecture on the topic on power point format.	Apply
CO4	Improve the communication skills of the students.	Apply
CO5	Analyze environment and sustainability of related technology	Analyze

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3			1		3	3		3			3	3	3
CO2	3	2	2	1	1	3	3		3	3	3	3	3	3
CO3										3		3	3	3
CO4							3			3		3	3	3
CO5						3	3		3			3	3	3
Total	**3**	**2**	**2**	**1**	**1**	**3**	**3**		**3**	**3**	**3**	**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

SEMESTER- 8

PROGRAMME ELECTIVE COURSE III

TPL 402 POLYMER PACKAGING AND WASTE MANAGEMENT

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	PEC	*Programme Elective Course III Plastic Packaging & Waste Management	TPL 402 OR TPL 404	4	3	1	0	30	20	-	50	50	100

OBJECTIVE: The objective of this course is to enable the students

- To understand concept of packaging and utility of plastics in packaging.
- To analyze properties of polymers for their utility in packaging of variety of products.
- To know various sources of plastics waste generation and its management.
- To understand the recycling techniques used for various plastics.

Course Outcome

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

CO1	Understand plastic packaging, scope, advantages and disadvantages of plastic packages, and application of polymer films for packaging.	Understand
CO2	Understand and analyze selection criteria for various household and industrial polymeric packages, their testing and utility on various fields.	Analyze
CO3	Understand and apply various policies legislation related to plastic waste management and their effects on environment.	Apply
CO4	Understand recycling technologies for variety of plastics.	Understand and Ethics
CO5	Understand biodegradable polymers and prospects for biodegradable plastics based on renewable resource polymers.	Apply

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3		2				3					3	3	3
CO2	3	2	2			3	3					3	3	3
CO3	3		2	1		3	3					3	3	3
CO4	3		2			3	3	1				3	3	3
CO5	3		2			3	3				1	3	3	3
Total	**3**	**2**	**2**	**1**		**3**	**3**	**1**			**1**	**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module-I: Elements of packaging

Concept of plastic packaging, present state of packaging technology, scope of packaging, advantages and disadvantages of polymeric packages over conventional packaging materials. Polymer films for packaging.

Module-II: Polymer Packages and Quality Control
Selection criteria of various household and industrial polymeric packages. Printing on polymeric packages. Testing and quality control. Newer developments in polymer packaging.

Module-III: Plastic waste management
Global policies and regulations. Social and environmental challenges of plastic waste in India. Plastics and environment. Salient features of the plastic waste management (PWM) rules. Waste treatment of various plastic plants, estimation of power requirement and efficiency of size reduction operation of plastics.

Module-IV: Recycling Technology
Recycling and recovery of various plastics items/materials-their effect on environment. Waste collection and recycling methods. Comparative study of conversion of plastic waste into value added products.

Module-V: Biodegradable Polymers
Biodegradable polymers - prospects & utilization, prospects for biodegradable plastics based on renewable resource polymers. Biodegradable polymers for various applications viz. food packaging, agriculture, etc.

Reference Books and Suggested Readings :

1. Hand Book of Polymer Science and Technology – V0l. 4, by N.P.Cheremisinoff
2. Comprehensive Polymer Science – Vol. 7, by Sir Geoffrey Allen
3. Plastics films and packaging, by C.R.Oswin
4. Science and Technology of Polymer films, by J.F.Hamlin
5. Protective Wrapping, by C.R.Oswin
6. Environmental effect on polymeric materials, by Dominick V. Rosato & Robert T. Schwartz
7. Plastic waste management and environment, by V.P.Malhotra
8. Synthetic Rubber Waste Disposal, by L.D.Dougan & J.C.Bell
9. Plastic waste and its recovery, by M.E.Bocqueye

PROGRAMME ELECTIVE COURSE III

TPL 404 POLYMER COATING TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVE: The objective of this course is to enable the students

- Understand concept of surface coatings and constitution of paints, varnishes etc, and concept of surface preparation and treatment.
- Understand roll and types of various pigments used in paints and pigment dispersion.
- Understand rheological behaviors of paints and methods of coatings applications.

At the End of the course, Students will be able to

CO1	understand the concept of surface coating, constituents of paint, varnish and lacqers, mechanism of film formation, and characteristics of natural and synthetic polymers used in coatings, varnishes and sealants.	Understand
CO2	understand pigment and pigmentation, dispersion techniques, and role of wetting agents, driers, solvent and plasticizers in coatings.	Understand
CO3	understand principles of coating formulation, machines/ball mills used in making coating formulations, and safety, health and hazards.	Understand and Apply
CO4	understand the surface preparation and pretreatments for coatings.	Understand and Apply
CO5	understand and analyze types of coatings for industrial and architectural application, rheological behavior and testing of coatings.	Understand and Analyze

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3					1						2	3	3
CO2	3					1						2	3	3
CO3	3					1						2	3	3
CO4	3		1			1						2	3	3
CO5	3	2	1			1						2	3	3
Total	**3**	**2**	**1**			**1**						**2**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module-I: Elements of surface coatings

Origin and development of surface coating, constituents of paint, varnishes and lacquers. Functions of coatings and mechanism of film formation. Characteristics of natural and synthetic polymers used in coatings, varnishes and sealants.

Module-II: Pigments and Pigmentation

Pigment and pigmentation. Dispersion techniques, role of wetting agents, driers, solvent and plasticizers in coatings.

Module-III: Formulation and Manufacture of coatings

Principles of coating formulation. Coating manufacture. Machines/Ball mills used in making coating formulations. Safety, health and hazards.

Module-IV: Surface Preparation and Pre-treatments

Surface preparation and pretreatments. Rhelogical behaviour and testing of coatings. Application methods and curing techniques for coatings.

Module-V: Industrial and Specialty Coatings

Specialty coatings like water based coating, powder coating and high solid based coating etc. Industrial and architectural coatings and finishes.

Reference Books and Suggested Readings :

1. Organic Coating Technology Vol. I & II, by H.F.Pyne
2. Surface Coating, by OCCAA
3. Protective and Decorative coatings, by J.J.Mattiello
4. Paint and Varnishes Production Manual, by V.C.Bidlack & E.W.Fasig

PROGRAMME ELECTIVE COURSE I V

TPL 406 PROCESS MODELING AND SIMULATION

L	T	P	C
2	1	0	3

Assessment:
Sessional: 50 marks
End Semester: 50 marks

Course Objectives:
This course explores the basic concepts and steady state equations of simple systems in chemical process industries. It deals with the techniques for derivation of system model equations, data analysis and visualization. The course aims to present the basic idea and concept on process model with detailed analysis and solution of model equations for steady operation.

Course Outcomes:
Students completing the course will be able to

CO 1	Model deterministic systems and differentiate between nonlinear and linear models	Remember, Apply, Analyze
CO 2	Numerically simulate linear and non linear ordinary differential equations for deterministic systems	Apply, Analyze, Evaluate
CO 3	Estimate and validate a model based upon input and output data.	Apply, Analyze, Evaluate
CO 4	Create a model prediction based upon new input and validate the output data	Understand, Apply, Analyze, Evaluate, Create
CO 5	Develop steady state models for flash vessels, equilibrium staged processes, distillation columns, absorbers, strippers, CSTR, heat exchangers and packed bed reactors.	Remember, Apply, Analyze, Evaluate

	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	3	2	-	-	1	-	1	1	2	**1**	**1**
CO2	3	3	3	3	3	1	-	1	-	1	1	2	3	3
CO3	3	3	3	2	3	1	-	1	-	1	1	2	3	3
CO4	3	3	3	2	2	1	-	1	-	1	1	2	3	3
CO5	3	3	3	3	3	1	1	1	-	1	2	3	3	3
Avg.	3	3	3	2.6	2.6	0.8	0.2	1	-	1	1.2	2.2	3	3

Module1 (6 hours)

Introduction to mathematical modeling; Advantages and limitations of models and applications of process models of stand-alone unit operations and unit processes; Classification of models: Linear vs. Non linear, Lumped parameter vs. Distributed parameter; Static vs. Dynamic, Continuous vs. Discrete; Numerical Methods: Iterative convergence methods, Numerical integration of ODE- IVP and ODE-BVP.

Module2 (6 hours)

Concept of degree of freedom analysis: System and its subsystem, System interaction, Degree of freedom in a system e.g. Heat exchanger, Equilibrium still, Reversal of information flow, Design variable selection algorithm, Information flow through subsystems, Structural effects of design variable selection, Persistent Recycle.

Module3 (6 hours)

Simple examples of process models; Models giving rise to nonlinear algebraic equation (NAE) systems, -steady state models of flash vessels, equilibrium staged processes distillation columns, absorbers, strippers, CSTR, heat exchangers, etc.; Review of solution procedures and available numerical software libraries.

Module4 (6 hours)

Steady state models giving rise to differential algebraic equation (DAE) systems; Rate based approaches for staged processes; Modeling of differential contactors – distributed parameter models of packed beds; Packed bed reactors; Modeling of reactive separation processes; Review of solution strategies for Differential Algebraic Equations (DAEs), Partial Differential Equations (PDEs), and available numerical software libraries.

Module5 (6 hours)

Simulation and their approaches, Modular, Sequential, Simultaneous and Equation solving approach, Simulation softwares and their applications, Review of solution techniques and available numerical software libraries.

Suggested Text Books

1. Luyben W.L., "Process Modeling, Simulation, and Control for Chemical Engineering", Mc Graw Hill.
2. D. F. Rudd and C. C. Watson, " Strategy of Process Engineering", Wiley international.
3. M.M. Denn, "Process Modelling", Wiley, New York, (1990).

Suggested Reference Books

1. A. K. Jana, "Chemical Process Modelling and Computer Simulation", PHI,(2011)
2. C.D. Holland, "Fundamentals of Modelling Separation Processes", Prentice Hall, (1975)
3. Hussain Asghar, "Chemical Process Simulation", Wiley Eastern Ltd., New Delhi, (1986)

PROGRAMME ELECTIVE COURSE I V

TPL 408 COMPUTER AIDED EQUIPMENT DESIGN

L	T	P	C
2	1	0	3

Assessment:
Sessional: 50 marks
End Semester: 50 marks

Course Objectives:

The objective of this course is to acquire basic understanding of design parameters, complete knowledge of design procedures for commonly used process equipment and their attachments (e.g. internal and external pressure vessels, tall vessels, high pressure vessels, supports etc.), and different types of equipment testing methods.

Course outcomes: Students completing the course will be able to

CO1	vUnderstand the basics of process equipment design and important parameters of equipment design	Understand
CO2	Understand the basics of process equipment design and important parameters of equipment design	Understand
CO3	Design special vessels such as tall vessels, self supporting vessels, and skirt (and other support for vertical vessels).	Apply
CO4	Design liquid and gas storage tanks with and without floating roof	Apply
CO5	Select standard piping, flanges, gaskets and bolts associated with the vessels and storage tanks.	Analyze

Syllabus

Module 1 (6 hours)

Introduction: Classification of engineering materials, properties of Ferrous metals, Non ferrous metals, alloys & Ceramic materials Structure-Property relationship in materials. Deformation of Materials Fracture: Elastic deformation, Plastic deformation, Creep, Visco-elastic deformation, Different types of fracture, Corrosion And Prevention: Direct Corrosion, electro-chemical corrosion, Galvanic cells, High temperature corrosion, Passivity, factor influencing corrosion rate, Control and of corrosion-modification of corrosive environment, Inhibitors, Cathodic protection, protective coatings. Corrosion charts, Metal forming techniques (bending, Rolling, Forming) & Metal joining techniques, welding – such as Butt, Lap, fillet, corner. Inspection and testing of process vessel.

Module 2 (6 hours)

Pressure Vessels: Type of pressure vessels, Thin cylinder theory for internal pressure. Code & standard for pressure vessels (IS:2825: 1969), Design considerations, classification of pressure vessels as per codes, design of cylindrical and spherical shells under internal and external pressure, selection and design of closures and heads such as Flat, hemispherical, tori-spherical, elliptical & conical.; Introduction to compensation for opening such as nozzles & manholes etc.

Module 3 (6 hours)

Flanges: Selection of gaskets, selection of standard flanges, optimum selection of bolts for flanges, design of flanges. Inspection and testing of vessels, heads and flanges as per code specifications. Piping: Pipe thickness calculation under internal and external pressure, introduction to flexibility analysis of piping system.

Module 4 (6 hours)

Tall Tower Design: Design of shell, skirt, bearing plate and anchor bolts for tall tower used at high wind and seismic conditions. Supports: Design of lug support and saddle support including bearing plates and anchor bolts.

Module 5 (6 hours)

Storage Tanks: Introduction to Indian standards, filling and breathing losses; classification of storage tanks; Design of liquid and gas storage tanks with and without floating roof. High-pressure vessels, Fundamental equations, Compound vessels, Liquid storage tanks, Mechanical design of centrifuges, Centrifugal pressure, Bowl and spindle motion: critical speed.

Suggested Text Books

1. Brownell L. E. and Young H. E., “Process Equipment Design”, John Wiley and Sons. 2009.
2. Bhattacharya B. C., “Introduction of Chemical Equipment Design”, 1st Edition, CBS Publisher. 2008.
3. I.S.:2825-1969, “Code for Unfired Pressure Vessels”, Bureau of Indian Standards.1969.
4. I.S.:803-1962, “Code of Practice for Design, Fabrication and Erection of Vertical Mild Steel Cylindrical Welded Oil Storage Tanks”, Bureau of Indian Standards.1962.

Suggested Reference Books

1. Moss D. R., “Pressure Vessel Design Manual”, 3rd Edition, Gulf Publishers, 2004.
2. Annartone D., “Pressure Vessel Design”, 3rd Edition, Springer 2007.
3. Joshi M.V., and Mahajani, V.V., “Process Equipment Design”, 3rd Edition, Macmillan India, 2000.
4. Coulson, J.M., Richardson, J.F., and Sinnott, R.H., “Chemical Engineering Volume 6, 3rd revised Edition, Butterworth-Heinemann Ltd., 1999.

OPEN ELECTIVE COURSE IV

TCH 420 TRANSPORT PHENOMENA

L	T	P	C
2	1	0	3

Assessment:
Sessional: 50 marks
End Semester: 50 marks

Course Objectives:
This course will highlight coupling between three transport phenomena with applications in various disciplines in engineering and science, and will demonstrate to the students the common mathematical structure of transport problems. The course will deal with flow problems involving Newtonian and non-Newtonian fluids, solid-state heat conduction, forced and free convection, binary diffusion with or without chemical reaction.

Course Outcomes:

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CO1	Perform basic vector and tensor analysis	Understand, Apply,
CO2	Solve transport problems using shell balances	Apply, Evaluate
CO3	Formulate and solve one-dimensional transport problems by using the conservation equations	Analyse, Evaluate
CO4	Formulate simple multi-dimensional transport problems	Apply, Evaluate, Create
CO5	Understand and apply the shell balance and boundary conditions on various types of system	Understand, Evaluate

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	3	3	2	1	-	-	-	-	-	-	1	**1**	**2**
CO2	3	3	3	2	2	1	-	-	-	1	1	1	3	3
CO3	3	2	2	2	2	1	-	-	-	1	1	1	3	3
CO4	3	3	1	2	2	1	-	-	-	1	1	1	3	3
CO5	3	3	1	2	2	1	-	-	-	1	1	1	3	3
Avg	3	2.8	2	2	1.8	0.8	-	-	-	0.8	0.8	1	3	3
													3	**3**

Syllabus

Module1 (7 hours)
Introduction to Newton's law of viscosity, non –Newtonian fluids, pressure & temperature dependence of viscosity, estimation of viscosity from critical properties. Shell momentum balances, boundary conditions, flow of a falling film, flow through a circular tube, flow through annular, creeping flow along a solid sphere.

Module2 (7 hours)
The equation of continuity, the equation of motion, use of the equations of change to set up steady flow problems and applications.

Module3 (4 hours)
Flow near a wall suddenly set in motion, Boundary layer theory and applications.

Module4 (6 hours)
Shell energy balances, temperature profiles, average temperature, energy fluxes at surfaces, Equations of change, equation of motion for forced and free convection and applications.

Module5 (6 hours)
Definitions of concentrations, velocities & mass fluxes, Fick's law of diffusion, Temperature & pressure dependence of mass diffusivity, Maxwell's law of diffusion. shell mass balance, boundary conditions, diffusion through a stagnant gas film and applications.

Suggested Text books

1. Bird, R. B., Stewart, W. E. and Lightfoot, E. N., "Transport Phenomena", 2nd edition John Wiley (1960).
2. Bannet, C. O. and Myers J. E., "Momentum Heat and Mass Transfer" Tata McGraw Hill, (1973).

Suggested Reference Books

1. RS Brodkey and HC Hersey, "Transport Phenomena: A Unified approach", McGraw-Hill Book,(1988).

TPL 498 PROJECT

L	T	P	C
0	**0**	**20**	**10**

OBJECTIVE: The objective of this course is to enable the students

- to prepare a detailed project report on fabrication of a product/equipment/process of a plant for production of plastic product with complete lay-out or a research problem and conduct experiment.
- to assess the economic analysis and to prepare a feasibility report for a project based on manufacturing of product/equipment/process.
- to present a lecture on the topic on power point format.
- to improve the communication skill of the students.

Course Outcome

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

CO1	understand a topic of latest developments/innovative technology.	Understand
CO2	apply the knowledge to prepare a feasibility/dissertation report on this topic.	Apply Analyze
CO3	deliver a lecture on the topic on power point format.	Apply
CO4	improve the communication skill of the students.	Apply
CO5	Analyze environment and sustainability of related technology	Analyze

COs	**Pos**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3			1		3	3		3			3	3	3
CO2	3	2	2	1	2	3	3		3		3	3	3	3
CO3					2					3		3	3	3
CO4							3			3		3	3	3
CO5						3	3		3			3	3	3
Total	**3**	**2**	**2**	**1**	**2**	**3**	**3**		**3**	**3**	**3**	**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*