1.1.2 1.2.2

Dr. Babasaheb Ambedkar Technological University

(Established as a University of Technology in the State of Maharashtra)

(under Maharashtra Act No. XXIX of 2014)

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Proposed Course Contents for

B. Tech. in Chemical Engineering

w.e.f. June 2020

7th Semester - 8th Semester

REGISTRAR
Dr. Babasaheb Ambedkar Technological University
Lonere 402 103,
Tal Mangaon, Dist. Raigad, (Maharashtra)

Head of the Department
Chemical Engineering
Dr. Babasaheb Ambedkar
Technological University Lonere
Dist-Raigad, Maharashtra 402103

Vision

The vision of the department is to achieve excellence in teaching, learning, research and transfer of technology and overall development of students.

Mission

Imparting quality education, looking after holistic development of students and conducting need based research and extension.

Graduate Attributes

The Graduate Attributes are the knowledge skills and attitudes which the students have at the time of graduation. These Graduate Attributes identified by National Board of Accreditation are as follows:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent

responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Educational Objectives

Objective Identifier	Objectives
PEO1	To provide knowledge of sound mathematical principles underlying various concepts of Chemical Engineering.
PEO2	To develop an ability to understand complex issues in the analysis, design, implementation and operation of Chemical Engg. Systems.
PEO3	To provide knowledge of mechanisms for building large-scale Chemical-based systems.
PEO4	To develop an ability to provide Engineering-based solutions to the problems from other disciplines of science and engineering.
PEO5	To impart skills necessary for adapting rapid changes taking place in the industries.
PEO6	To provide knowledge of ethical issues arising due to deployment of new technologies in the society on large scale.

Program Outcomes

Program Outcome (POs)

Outcome Identifier	Outcomes
PO1	The graduates will possess the knowledge of various discrete mathematical structures and numerical techniques.
PO2	The graduate will demonstrate the use of Logic in representing and reasoning knowledge based systems.
PO3	The graduates will have an ability to apply mathematical formalisms of to analyze the problems.
PO4	The graduates will have knowledge of design software and concepts essential to implement these software.
PO5	The graduates will have an ability to analyze problem, specify most feasible solutions to them and to evaluate alternative solutions.
PO6	The graduates will have in-depth knowledge of core subjects of Chemical Engineering.
PO7	The graduate will have broad understanding of the impact of Chemical Engineering solutions in economic, environmental and social context.
PO8	The graduates will demonstrate use of analytical tools in gathering requirements to provide feasible solutions.
PO9	The graduates will have knowledge of design rules and patterns necessary to formulate concept based solutions.
PO10	The graduates will demonstrate the ability to build human centric interfaces to deign tools.
PO11	The graduates will possess skills necessary to communicate design engineering ideas. The skills set include verbal, written and listening skills.
PO12	The graduates will have an ability and attitude to address the ethical issues.

Program-Specific Outcomes (PSOs)

PSO 1	Make the students employable in engineering industries.
PSO 2	Motivate the students for higher studies and research.

Teaching and Evaluation Scheme Fourth Year B. Tech. (Chemical Engineering)

Sr. No.	Code	Course title	Weekly Teaching hours			Evaluation Scheme			Credit
			L	T	P	MSE	CA	ESE	
		Semester VII							
1	BTCHC 701	Process Dynamics and Control	3	1	-	20	20	60	4
2	BTCHC 702	Pollution Control in Process Industries	3	-	-	20	20	60	3
3	BTCHC 703	Transport Phenomena	3	1	-	20	20	60	4
4*	BTCHC 704	Process Equipment Design and Drawing	2	-	-	20	20	60	2
5	BTCHE 705	Elective IV A. Biochemical Engineering B. Advanced Separation Techniques C. Pharmaceuticals and Fine Chemicals D. Modeling and Simulation in Chemical Engineering E. Advanced Petroleum Refining	3	-	-	20	20	60	3
6	BTCHL 706	Process Instrumentation and Control Lab.	-	-	2	-	30	20	1
7	BTCHL 707	Process Equipment Design and Drawing Lab.	-	-	2	-	30	20	1
8	BTCHL 708	Process Design, Flow Sheeting & Simulation I Lab	-	-	2	-	30	20	1
9	BTCHP* 709	Project Work Stage – I**	-	-	4	-	20	30	2
10	BTCHF 710	Field Training / Internship/Industrial Training Evaluations (of sem. VI)	-	-	-	-	-	50	1
		Total **(750)**	14	2	10	100	210	440	22

*****In case of students opting for Internship in the eighth semester, the Project must be industry-based.***

Course Structure for Semester VIII [Fourth Year] w.e.f. 2020-2021

Course Code	Type of Course	Course Title	Weekly Teaching Scheme			Evaluation Scheme				Credits
			L	T	P	CA	MSE	ESE	Total	
BTCHC801A	(Self-Study Course)	Process Control ; Design, Analysis and assessment	2	1	--	20	20	60	100	3
BTCHC801B		Computational Fluid dynamics								
BTCHC801C		Optimization in Chemical Engineering								
BTCHC802A	(Self-Study Course)	Environmental Quality monitoring and analysis	2	1	--	20	20	60	100	3
BTCHC802B		Transport Processes-I: heat and mass transfer								
BTCHP803	Project	Project Stage-II or Internship*	--	--	30	50	--	100	150	15
Total			4	2	30	90	40	220	350	21

** Six months of Internship in the industry*

 # These subjects are to be studied on self –study mode using SWAYAM/NPTEL/Any other source

Semester - VII

1. Process Dynamics and Control

BTCHC 701	Process Dynamics And Control	3-1-0	4 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 3 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: mathematics and process instrument knowledge

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

CO 1	Understand the dynamic behavior of different processes
CO2	Analyze different components of a control loop
CO3	Analyze stability of feedback control system
CO4	Design controllers for first and second order processes
CO5	Analyze frequency response for controllers and processes

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO2	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO3	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO4	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
CO5	✓	✓	✓	✓	-	-	-	-	-	-	-	-

Detailed Syllabus

UNIT I: Introduction Block diagrams, closed loop and open loop control systems, Basic control actions.

UNIT II: Open loop response of simple systems: Dynamics of first order systems using transfer functions; Various first order response such as, a thermometer bulb. General response to step, ramp, impulse, and sinusoidal inputs; Concentration and temperature responses of a stirred tank;

UNIT II: Linearization of liquid level systems; Response of a pressure system, second order systems, the manometer; Response of interacting and non interacting systems.

UNIT III: Transient response of control systems: **Servo and regulated operation,** General equations for the transient response, proportional control of a signal capacity process; Integral control, Proportional-integral control and derivative action.

UNIT IV: Stability: Concept of stability, Stability criterion, Routh test for stability.

UNIT V: Frequency response analysis: First order systems, Bode diagram, and Complex numbers to get frequency response.

UNIT VI: Controller selection and tuning, Control valve characteristics and sizing, cascade control, Feed forward control. Introduction of digital control principles.

Text / References:

1. D. R. Coughanowr, Process system analysis and control, 2^{nd} ed, McGraw Hill, 1991.
2. P. Harriott, Process Control, Reprint of text, ed. Tata McGraw Hill, 1983.
3. G. Stephanopoulos, Chemical Process Control: An introduction to theory and practice, Prentice Hall, New Jersey, 1984.

2. Pollution Control in Process Industries

BTCHC 702		**Pollution Control in Process Industries**	3-0-0	3 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 3 hrs/week Tutorial: 0 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: Basics of Chemical Process Industries

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

CO 1	Analyze the effects of pollutants on the environment
CO2	Understand meteorological aspects of air pollution
CO3	Understand air pollution control methods
CO4	Select treatment technologies for water/wastewater/solid waste
CO5	Design unit operations for pollution control

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	-	-	-	-	✓	-	-	-	-	-
CO2	✓	✓	-	-	-	-	✓	-	-	-	-	-
CO3	✓	✓	-	-	-	-	✓	-	-	-	-	-
CO4	✓	✓	-	✓	✓	-	✓	-	-	-	-	-
CO5	✓	✓	✓	✓	-	-	✓	-	-	-	-	-

Detailed Syllabus

Unit I: Introduction: Biosphere, Hydrological cycle, Nutrient cycle, Consequences of population growth, Pollution of air, Water and soil. Air pollution sources & effects: Classification and properties of air pollutants, Emission sources, Behavior and fate of air pollutants, Effect of air pollution.

Unit II: Meteorological aspects of air pollutant dispersion: Temperature lapse rates and stability, Wind velocity and turbulence, Plume behavior, Dispersion of air pollutants, Estimation of plume rise. Air pollution sampling and measurement: Types of pollutant sampling and measurement, Ambient air sampling, Stack sampling, Analysis of air pollutants.

Unit III: Air pollution control methods & equipment: Control methods, Source correction methods, Cleaning of gaseous effluents, Particulate emission control, Selection of a particulate collector, Control of gaseous emissions, Design methods for control equipment.

Unit IV: Control of specific gaseous pollutants: Control of sulphur dioxide emissions, Control of nitrogen oxides, Carbon monoxide control, Control of hydrocarbons and mobile sources. Water pollution: Water resources, Origin of wastewater, types of water pollutants and there effects.

Unit V: Waste water sampling, analysis and treatment: Sampling, Methods of analysis, Determination of organic matter, Determination of inorganic substances, Physical characteristics, Bacteriological measurement, Basic processes of water treatment, Primary treatment, Secondary treatment, Advanced wastewater treatment, Recovery of materials from process effluents.

Unit VI: Solid waste management: Sources and classification, Public health aspects, Methods of collection, Disposal Methods, Potential methods of disposal. Hazardous waste management: Definition and sources, Hazardous waste classification, Treatment methods, Disposal methods.

Text / References:

1. Rao C.S., Environmental Pollution Control Engineering, Wiley Eastern Limited, India, 1993.
2. Noel de Nevers, Air Pollution and Control Engineering, McGraw Hill, 2000.
3. Glynn Henry J. and Gary W. Heinke, Environmental Science and Engineering, 2nd Edition, Prentice Hall of India, 2004.
4. Rao M.N. and Rao H.V.N - Air Pollution, Tata - McGraw Hill Publishing Ltd., 1993.

De A.K - Environmental Chemistry, Tata - McGraw Hill Publishing Ltd., 1999.

3. Transport Phenomena

BTCHC 703	**Transport Phenomena**	3-1-0	4 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 3 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: Knowledge of Engineering Mathematics and fluid flow operations

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

CO 1	Understand the analogy among momentum, heat and mass transport
CO2	Formulate a mathematical representation of a flow/heat/mass transfer phenomena
CO3	Solve flow/heat/mass transfer problems either individually or coupled for simple geometries analytically
CO4	Identify the similarities among the correlations for flow, heat and mass transfer interfaces

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	√	√	√	√	-	√	√	-	-	-	-	-
CO2	√	√	√	√	-	√	-	-	-	-	-	-
CO3	√	-	√	√	-	√	-	-	-	-	-	-
CO4	√	-	√	√	-	√	-	-	-	-	-	-

Detailed Syllabus

Unit 1

1. **VISCOSITY AND MECHANISM OF MOMENTUM TRANSPORT :** Newton's Law of Viscosity; Non-Newtonian fluids ; The Bingham model; The power law model; The Elli's model and the Reiner Philippoff model; Temperature and pressure dependents of viscosity.

2. **VELOCITY DISTRIBUTIONS IN LAMINAR FLOW :** Shell momentum balances; Boundary conditions ; Flow of a falling film; flow through a circular tube; flow through annulus.

Unit 2

3. **EQUATION OF CHANGE FOR ISOTHERMAL SYSTEMS :** Equations of continuity

and motion in Cartesian and curvilinear co-ordinates; Use of the equations of change to set-up steady flow problems. Tangential annular flow of Newtonian fluid; Shape of surface of a rotating liquid.

4. **VELOCITY DISTRIBUTIONS WITH MORE THAN ONE INDEPENDENT VARIABLE**:Unsteady viscous flow ; Flow near a wall suddenly set in motion.

Unit 3

5. **INTERPHASE TRANSPORT IN ISOTHERMAL SYSTEMS :** Definition of fraction factors; Friction factors for flow in tubes; for around spheres.

6. **THERMAL CONDUCTIVITY AND MECHANISM OF ENERGY TRANSPORT :** Fourier's law of heat conduction; temperature and pressure dependence of thermal conductivity in gases and liquids.

7. **TEMPERATURE DISTRIBUTIONS IN SOLIDS AND IN LAMINAR FLOW :** Shell energy balances; Boundary conditions; Heat conduction with an electrical heat source; with a viscous heat source.

Unit 4

8. **EQUATIONS OF CHANGE FOR NON-ISOTHERMAL SYSTEMS :** Use of equations of energy and equations of motion (for forced and free convection) in non-isothermal flow; Tangential flow in an annulus with viscous heat generation; steady flow of a non-isothermal film; Transpiration cooling.

9. **TEMPERATURE DISTRIBUTIONS WITH MORE THAN ONE INDEPENDENT VARIABLE :** Unsteady heat conduction in solids; Heating of a semi-infinite slab.

Unit 5

10. **INTERPHASE TRANSPORT IN NON-ISOTHERMAL SYSTEMS :** Definition of heat transfer coefficient; Heat transfer coefficients for forced convection in tubes; for forced convection around submerged objects.

11. **DIFFUSIVITY AND THE MECHANISM OF MASS TRANSPORT :** definition of concentrations; Velocity and mass fluxes; Fick's law of diffusion; Temperature and pressure dependence of mass diffusivity.

Unit 6

12. **CONCENTRATION DISTRIBUTION IN SOLIDS AND IN LAMINAR FLOW:** Shell mass balances; Boundary conditions; Diffusion through a stagnant gas film; Diffusion with heterogeneous chemical reaction.

13. **EQUATION OF CHANGE FOR MULTICOMPONENT SYSTEMS**:Equations of continuity for a binary mixture.

14. **INTERPHASE TRANSPORT IN MULTICOMPONENT SYSTEMS:** Definition of binary mass transfer coefficients in one phase. Correlations of binary mass transfer coefficient in one phase at low mass transfer rates.

TEXT BOOK:

1. Bird R.B., Stewart W.E. and Light Foot E.N. Transport Phenomena - John Wiley International - 2nd Edition, New York, (2002).

REFERENCE BOOKS:

Christie J. Geankoplis - Transport Processes and Unit Operations - Prentice Hall of India Pvt. Ltd., New Delhi, 1997.

4. Process Equipment Design and Drawing

BTCHC 704	**Process Equipment Design and Drawing**	2-0-0	2 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 2 hrs/week Tutorial: 0 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: Knowledge of chemical engineering Processes

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

CO 1	Identify equipment and instruments based on symbols
CO2	Draw process flow diagrams using symbols
CO3	Apply mechanical design aspects to process equipment
CO4	Design heat exchangers, evaporators, absorbers, distillation columns, reactors and filters.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	✓	-	-	-	-	-	-	-	-	-	-
CO2	-	✓	-	-	✓	-	-	-	-	-	-	-
CO3	✓	-	✓	✓	✓	✓	-	-	-	-	-	-
CO4	✓	-	✓	✓	✓	✓	-	-	-	-	-	-

Detailed Syllabus

Unit I: Mechanical Design of Process Equipment: Introduction to mechanical aspects of chemical equipment design,

Unit II: Design Preliminaries, Design of cylindrical and spherical vessels under internal pressure, Design of heads and closers, Design of tall vessels.

Unit III and IV: Drawing: Drawing of process equipment symbols for fluid handling, heat transfer, mass transfer, Drawing of process equipment symbols for vessels, conveyers and feeders etc. Drawing of process equipment symbols for, separators, mixing & comminution etc. Drawing of process equipment symbols for distillation, driers, evaporators, scrubbers etc. Drawing of process equipment symbols for crystallizer, grinding, jigging, elutriation, magnetic separation, compressor etc. Drawing of basic instrumentation symbols for flow, temperature, level, pressure and combined instruments, Drawing of miscellaneous instrumentation symbols, Detailed drawing of equipment, Drawing of flow sheet.

Unit V and VI: Process Equipment Design: Design of a heat exchanger, Design of an absorber, Design of a distillation column, Design of evaporator, Design of condenser, Design of a chemical reactor.

Text / References:

1. Brownell L.E, Process Equipment Design - Vessel Design, Wiley Eastern Ltd., 1986.
2. Bhattacharya B.C., Introduction to Chemical Equipment Design - Mechanical Aspects, CBS Publishers and Distributors, 2003.
3. Towler, G. P. and R. K. Sinnott, Chemical Engineering Design, Principles, Practice and Economics of Plant and Process Design, 2nd Edition, Butterworth Heinemann, 2012.
4. Donald Kern, Process Heat Transfer, 1st Edition, Tata McGraw-Hill Education, 1950
5. Robert E. Treybal, Mass-Transfer Operations, 3rd Edition, McGraw-Hill Book Company, 1981.

5. Elective IV

BTCHC 705	A. Biochemical Engineering B. Advanced Separation Techniques C. Pharmaceuticals and Fine Chemicals D. Modeling and Simulation in Chemical Engineering E. Advanced Petroleum Refining	3-0-0	3 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 2 hrs/week Tutorial: 0 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

A. Biochemical Engineering

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

CO 1	Understand cell and enzyme kinetics
CO2	State methods of immobilization
CO3	Calculate volume of a bioreactor
CO4	State sterilization methods
CO5	Select downstream process to separate the products

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO2	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO3	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO4	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
	✓	✓	✓	✓	-	-	-	-	-	-	-	-

Detailed Syllabus

Unit I: Introduction: Biotechnology, Biochemical Engineering, Biological Process, Definition of Fermentation.

Unit II: Enzyme Kinetics: Introduction, Simple Enzyme Kinetics, Enzyme Reactor with Simple Kinetics, Inhibition of Enzyme Reactions, and Other Influences on Enzyme Activity. Immobilized Enzyme: Immobilization techniques and effect of mass transfer resistance.

Unit III: Industrial application of enzymes: Carbohydrates, starch conversion and
cellulose conversion. Cell Cultivation: Microbial cell cultivation, animal cell cultivation, plant cell cultivation, cell growth measurement and cell immobilization.

Unit IV: Cell Kinetics and Fermenter Design: Introduction, growth cycle for batch
cultivation, stirred tank fermenters, multiple fermenters connected series, cell recycling, alternate fermenters and structured model. Sterilization: Sterilization methods, thermal death kinetics, design criterion, batch sterilization, continuous sterilization and air sterilization.

Unit V: Agitation and Aeration: Introduction, basic mass transfer concepts, correlation for mass transfer co-efficient, measurement of interfacial area, correlations for 'a' and D32, gas-holdup, power consumption, determination of oxygen absorption rate, correlation for kLa, scale-up and shear sensitivity.

Unit VI: Downstream Processing: introduction, solid-liquid separation, cell rupture,
recovery and purification.

Text / Refernces:

2. Lee J.M., Biochemical Engineering, Ebook, version 2.32, 2009.
3. James E. Bailey & David F. Ollis, Biochemical Engineering Fundamentals, 2nd edition, McGraw Hill International, 1986.
3. Michael L. Shuler & Fikret Kargi, Bioprocess Engineering - Basic Concepts, 2nd edition, Prentice Hall of India, New Delhi, 2002.

B. Advanced Separation Techniques

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

CO 1	Classify the membranes
CO2	Differentiate various membrane processes
CO3	Understand the methods of membrane preparation
CO4	Compare membrane process with other methods of separation
CO5	Understand principles thermogravimetry and of differential thermal analyses.
CO6	Characterize chemical, inorganic and engineering materials using analytical techniques

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	✓	-	-	-	-	-	✓	-	-	-
CO2	-	-	✓	-	-	-	-	-	✓	-	-	-
CO3	-	-	✓	-	-	-	-	-	✓	-	-	-
CO4	-	-	✓	-	-	-	-	-	✓	-	-	-
CO5	-	-	✓	-	-	-	-	-	✓	-	-	-
CO6	-	-	✓	-	-	-	-	-	✓	-	-	-

Detailed Syllabus

Unit I and II: Solute transport parameters for membrane performance predictionin RO/UF systems involving aqueous and non aqueous solution. Physic - chemical. Polar, on- polar criteria governing RO separations - membrane transport mechanism.

Unit III and IV: Membrane fouling and compaction. TFC membrane development

RO/UF/Ed process design and module analysis. RO/F/ED and DD in acid and enzyme recovery from scarified hydrolytes.

Unit V and VI: Membrane techniques in reclamation of water and chemicals along with pollution control from industrial effluents. Cost benefits analysis in resources cycling and environmental quality improvement by MT. Industrial processing with membranes - membrane reactor concept in biotechnology concentration. Gas separation by RO.

Text / References:

1. S. Sourirajan and T. Matsuuura (Ed.), RO - UF: Principles and Applications, NRCC Publications, Ottawa, Canada (1986).
2. Munir Cheryan, UF Applications Handbook, Technique Publishing Co, Lancaster, USA (1986).

C. Pharmaceuticals and Fine Chemicals

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

CO 1	Know different grades of Chemicals
CO2	Understand different methods of preparation of reagents
CO3	Know uses and testing of pharmaceuticals
CO4	Know the techniques for manufacture of pharmaceuticals
CO5	Understand tablet making and coating techniques

Mapping of Course outcomes with Program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1								✓	✓		✓	
CO2								✓	✓		✓	
CO3									✓		✓	
CO4								✓	✓		✓	
CO5								✓	✓		✓	

Unit 1:
A brief outline of different grades of chemicals – Reagent grade and Laboratory grade. Outlines of preparation – Different methods of preparation of Reagent grade and Laboratory grade Chemicals.

Unit 2:
Uses and testing of the pharmaceuticals and fine chemicals – Applications of medicinal value Chemicals and their quality testing procedures.

Unit 3:
Properties, assays and manufacture of Pharmaceuticals and fine chemicals with flow sheets- Physical and Chemical properties, methods of assessing the quality and industrial methods of formulating the drugs and fine chemicals that have no medicinal value but are used as the intermediates.

Unit 4:
Compressed Tablet making and coating – Types of tablets and Methods of compressed tablet making and coating.

Unit 5 and 6 :

Preparation of capsules and extraction of crude drugs – Industrial procedures of capsule formulation and methods of recovering the drugs formulated from the reaction mixture. Sterilization – Need for sterilization, Sterilization methods, batch and continuous sterilization.

Text / References:

1. Remington, Pharmaceutical Sciences, Mak. Publishing Co., 16th Edition, 1980.
2. William Lawrence Faith, Donald B. Keyes and Ronald L. Clark, Industrial Chemicals, 4th Edition, John Wiley & Sons, 1975.
3. Gurdeep R. Chatwal, Synthetic Drugs, Himalaya Publishing House, 2002.

D.MODELING AND SIMULATION IN CHEMICAL ENGINEERING

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

CO 1	use mass balance, component balance, energy balance and momentum balance equations for mathematical model development.
CO2	to develop lumped parameter mathematical models of heat transfer, mass transfer equipments and reactors with heat transfer.
CO3	to develop distributed parameter models of mass transfer equipments, heat exchangers and plug flow reactors.
CO4	to use basic features of modern simulation software.

Mapping of Course outcomes with Program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓										✓	✓
CO2	✓	✓									✓	✓
CO3	✓	✓	✓		✓						✓	✓
CO4			✓		✓						✓	✓

Unit 1: Basic Modeling Introduction to modeling – Types of Models, Dependent & Independent Variables, Application and scope coverage, Modeling fundamentals, Chemical engineering modeling, Several aspects of the modeling approach, General modeling procedure

Unit 2: Formulation of dynamic models Mass balance equation - Balancing procedure, Case studies: CSTR, Tubular reactor , Coffee percolator, Total mass balance, Case Studies: Tank drainage, Component balances Case Studies: Waste holding tank, Continuous heating in an agitated tank, Heating in a filling tank, Parallel reaction in a semi continuous reactor with large temperature difference, Momentum balances – Dimensionless model equations, CSTR, Gas liquid mass transfer in a continuous reactor, Multistage Evaporator

Unit 3: Modeling of stage wise processes Introduction, Stirred tank reactor, Reactor Configurations, Generalized model description, Heat transfer to and from reactors, Steam heating in jacket, Dynamics of the metal jacket walls, Batch reactor – Constant volume, Semi - Batch reactor, CSTR - Constant volume CSTR, CSTR cascade, Reactor stability, Reactor Control, Bioreactors, Trickle bed reactor

Unit 4: Mass transfer process models Liquid-liquid extraction, Binary batch distillation, Continuous binary distillation, Multi-component separation, Multi-component steam distillation, Absorber- stage wise absorption, steady state gas absorption with heat effects.

Unit 5: Modeling of distributed system Plug flow tubular reactor, Liquid phase tubular flow reactor, Gas phase tubular flow reactor contactors, Dynamic simulation of the Plug-Flow tubular reactor , Dynamic modeling of plug-flow contactors: liquid–liquid extraction column dynamics, Steady-state tubular flow with heat loss, Steady state counter-current heat exchanger, Heat exchanger dynamics

Unit 6: Process Simulation Scope of process simulation, Formulation of problem, Step for steady state simulation, Process simulation approaches for steady state simulation, Strategies, Process simulator, Structure of process simulator, Integral process simulation, Demonstration of process simulator

Text / References:

1. W. L. Luyben, —Process Modeling, Simulation and Control for Chemical Engineering, McGraw Hill Book co., 1973.

2. John Ingham, Irving, J. Dunn, Elmar, Heinzle Jiri, E. Prenosil, —Chemical Engineering Dynamics, VCH Publishers Inc., New York, 1974.

3. Amiya K. Jana, Chemical Process Modelling and Computer Simulation, Prentice Hall India, 2nd Edition, 2011.

E. Advanced Petroleum Refining

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

CO 1	Know details of different Refining Process
CO2	Understand the chemistry of refining processes

CO3	Understand the technological changes associated with refining process
CO4	Compare and know role of different catalyst

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	- -	-	-	-	-	✓	-	-	-
CO2	✓	✓	✓	-	-	-	-	-	✓	-	-	-
CO3	✓	✓	✓		-	-	-	-	✓	-	-	-
CO4	✓	✓	✓		-	-	-	-	✓	-	-	-

Detailed Syllabus :

UNIT I

Coking and thermal processes – Types,properties and uses of petroleum coke,process description for delayed coking and fluid bed coking, case study problem.

UNIT II

Catalytic Cracking – Fludized bed catalytic cracking, New design of FCC units, cracking reactions, Coking of cracking catalyst, process variables,heatrecovery,yield estimation ,capital and operating cost,casestudy problem on catalytic cracker.

UNIT III

Catalytic Hydrocracker- Hydrocracking reactions, feed preparation, process decription, hydrocracking catalyst , process variables,hydrocrckingyield,investment and operating cost,case study problem on hydrocracker.

UNIT IV

Hydroprocessing and resid processing- Composition of vacuum tower bottoms,processoptions,hydroprocessing,expanded bed hydrocracking processes,moving bed hydroprocessors, solvent extraction, summary of resid processing operations.Hydrotreating-Hydrotreating catalyst, aromatic reduction, reactions, process variables,construction and o[perating cost, case study problem on hydrotreator.

UNIT V

Catalytic reforming and isomerization- Feed preparation,catalytic reforming processes,reforming catalysts, reactor design,yields and costs.

Isomerization – Capital and operating costs, isomerization yield, case study problem on Reformer and isomerization unit.

UNIT VI

Alkylation and polymerization – Alkylation reactions, process variables, alkylation feed stocks, alkylation products, HF and sulfuric acid alkylation process, cpmpareason between the processes, alkylation yields and costs, poplymerization , case study problem on alkylation and polymerization.

Texts / References:

J.H. Gary, " Petroleum Refining - Technology and Economics" 3rd Ed., Marcel DekkarInc, 1994

G.D.Hobson, " Modern Petroleum Technology" Vol.I& II ,5th Ed., Applid science ,London

6. Process Instrumentation and Control Laboratory

BTCHL 706	**Process Instrumentation And Control Laboratory**	0-0-2	1 Credits

Practical Scheme:	**Examination Scheme:**
Practical: 2 hrs/batch	Continuous Assessment: 30 Marks End Semester Exam: 20 Marks

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

CO1	Calculate the characteristics of control valves
CO2	Determine the dynamics of level and temperature measurement process
CO3	Determine the dynamics of two capacity liquid level process without interaction and with interaction, U-tube manometer
CO4	Determine the performance of controllers for a flow process, pressure process, level process, temperature process
CO5	Evaluate the performance of cascade control

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	-	-✓	--		✓	-	-	✓	-		-
CO2	✓	-	-	--		✓	-	-	✓	-		-
CO3	✓	-	-	--		✓	-	-	✓	-		-
CO4	✓	-	-	--		✓	-	-	✓	-		-
CO5	✓	-	-	--		✓	-	-	✓	-		-

List of Experiments:

1. To determine the time constant of given thermometer with positive step change.
2. To determine the time constant of given thermometer with negative step change.
3. To determine the time constant and valve properties of single tank system.
4. To study the step response of two tank non-interacting liquid level system and compare the observed transient response with the theoretical transient response.

5.. To study the step response of two tank interacting liquid level system and compare the observed transient response with the theoretical transient response for the condition T1=T2=T.

6. To study the impulse response of a tank.

7. Process Equipment Design and Drawing Lab

BTCHL 707	**Process Equipment Design and Drawing Lab**	0-0-2	1 Credits

Practical Scheme:	**Examination Scheme:**
Practical: 2 hrs/batch	Continuous Assessment: 30 Marks End Semester Exam: 20 Marks

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

CO 1	Identify equipment and instruments based on symbols
CO 2	Draw process flow diagrams using symbols
CO 3	Apply mechanical design aspects to process equipments
CO 4	Design heat exchangers, evaporators, absorbers, distillation columns, reactors, filters etc.

Mapping of Course outcomes with Program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						✓			✓		✓	
CO2						✓			✓		✓	
CO3					✓	✓			✓		✓	
CO4					✓	✓			✓		✓	

List of Experiments : Based on the theory course students should design and draw the sheets of chemical process vessels.

7. Process Equipment Design and Drawing Lab

BTCHL 707	**Process Equipment Design and Drawing Lab**	0-0-2	1 Credits

Practical Scheme:	**Examination Scheme:**
Practical: 2 hrs/batch	Continuous Assessment: 30 Marks End Semester Exam: 20 Marks

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

CO 1	Identify equipment and instruments based on symbols
CO 2	Draw process flow diagrams using symbols
CO 3	Apply mechanical design aspects to process equipments
CO 4	Design heat exchangers, evaporators, absorbers, distillation columns, reactors, filters etc.

Mapping of Course outcomes with Program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						✓			✓		✓	
CO2						✓			✓		✓	
CO3					✓	✓			✓		✓	
CO4					✓	✓			✓		✓	

List of Experiments : Based on the theory course students should design and draw the sheets of chemical process vessels.

8. Process Design, Flow Sheeting & Simulation I Lab

BTCHL 708		Process Design, Flow Sheeting & Simulation I Lab	0-0-2	1 Credits

Practical Scheme:	**Examination Scheme:**
Practical: 2 hrs/batch	Continuous Assessment: 30 Marks End Semester Exam: 20 Marks

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

CO1	Identify equipment and instruments based on symbols
CO2	Draw process flow diagrams using symbols
CO3	Apply mechanical design aspects to process equipment
CO4	Design heat exchangers, evaporators, absorbers, distillation columns, reactors and filters.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	✓	-	-	✓	-	-	-	-	-	✓	✓
CO2	-	✓	-	-	✓	-	-	-	-	-	-	-
CO3	✓	-	✓	✓	✓	✓	-	-	-	-	-	-
CO4	✓	-	✓	✓	✓	✓	-	-	-	-	-	-

Detailed Syllabus

Unit I: **Mathematical models of chemical engineering systems:** Introduction; Use of mathematical models; Scope of coverage; Principles of formulation; Fundamental laws; Contimuity equation; Energy equation; Equations of motion; Transport equations; Equations of state; Equilibrium; Chemical kinetics.

Unit II: Examples of Mathematical Models of Chemical Engineering Systems: Introduction; Series of isothermal, constant holdup CSTRs; CSTRs with variable hold-ups; Two heated tanks; Gas phase pressurized CSTR; Non-isothermal CSTR; Single component vaporizer; Multicomponent flash drum; Batch reactor; Reactor with mass transfer; Ideal binary distillation column; Batch distillation with holdup; pH systems.

Unit III: General Concepts of Simulation for Process Design: Introduction; Process simulation models; Methods for solving non-linera equations; Recycle partitioning and tearing; Simulation examples.

Unit IV: Design of Piping network using software tools

Unit V: Design of following equipment using ASPENPLUS or any good software

a. Heat Exchanger
b. Absorption column
c. Distillation column
d. Reactor
e. Evaporator
f. Flow sheeting of a chemical plant
g. Simulation of a small size chemical plant.

Unit VI: Simulation of a chemical plant using AUTOPLANT or any good software.

TEXT BOOK:

1. William L. Luyben - Process Modeling, Simulation and Control for Chemical Engineers - 2nd edition, McGraw Hill International Edition; 1990 (Ch. 1, 2 and 4)
2. Lorentz T. Biegler, E. Ignacio Grossmann and Arthur W. Westerberg - Systematic Methods of Chemical Process Design - Prentice Hall International - 1997.

9. Project Work Stage – I

9	**BTCHP* 709**	Project Work Stage – I**	-	-	4	-	20	30	2

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

CO1	State the exact title of the project and problem definition
CO2	Explain the motivation, objectives and scope of the project
CO3	Review the literature related to the selected topic of the project
CO4	Design the mechanism, components of the system and prepare detailed drawings.
CO5	Evaluate the cost considering different materials/manufacturing processes

Mapping of Course outcomes with Program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		✓	✓	✓	✓	✓					✓	
CO2		✓	✓	✓		✓		✓			✓	
CO3		✓	✓	✓	✓	✓					✓	
CO4	✓	✓	✓	✓	✓	✓					✓	
CO5	✓	✓	✓	✓	✓	✓		✓			✓	

The students in a group of not more than FOUR will work under the guidance of the faculty member on the project work undertaken by them. The completion of work, the submission of the report and assessment should be done at the end of VII Sem.

The project work should consist of any of the following or appropriate combination:

1. A comprehensive and up-to-date survey of literature related to study of a phenomenon or product.
2. Design of any Process/ equipment.
3. Critical Analysis of any design or process for optimizing the same.
4. Experimental verification of principles used in applications related to various specializations related to Chemical Engineering.
5. Software development for particular applications.

6. A combination of the above.

It is expected that the students should complete at least 40% of the total project work in VII Semester. The objective is to prepare the students to examine any design or process or phenomenon from all angles, to encourage the process of independent thinking and working and to expose them to industry.

The students may preferably select the project works from their opted elective subjects. The students should submit the report in a prescribed format, before the end of VII semester. The report shall be comprehensive and presented typed on A_4 size sheets and bound. Number of copies to be submitted is number of students plus two. The assessment would be carried out by the panel of examiners for both, term work and oral examinations.

10. Field Training / Internship/Industrial Training Evaluations

10	**BTCHF 710**	Field Training / Internship/Industrial Training Evaluations (of sem. VI)	-	-	-	-	-	50	1

Examination Scheme:
End Semester Exam: 50 Marks

Pre-Requisites: None

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

CO1	Aware of industrial culture and organizational setup
CO2	Understand to apply/link academic knowledge to industry

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						✓	✓			✓	✓	✓
CO2						✓	✓			✓	✓	✓

Students will have to undergo 6 weeks training programme in the Industry during the summer vacation after VIth semester examination. It is expected that students should understand the organizational structure, various sections and their functions, products/services, testing facilities, safety and environmental protection measures etc.

Also, students should take up a small case study and propose the possible solution(s).

They will have to submit a detailed report about the training programme to the faculty coordinator soon after joining in final year B.Tech. Programme. They will have to give a power point presentation in front of the group of examiners.

Semester VIII

Process Control : Design, analysis and assessment

BTCHC 801A	**Process Control : Design, analysis and assessment**	2-1-0	3 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 2 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

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

CO1	Understand models for control
CO2	Analyse transfer function models using various techniques
CO3	Solve problems using stability analysis and frequency response analysis
CO4	Understand multivariable control
CO5	Evaluate controller performance using MATLAB tutorials

Mapping of Course outcomes with Program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓			✓			✓	
CO2	✓	✓	✓	✓				✓				
CO3	✓	✓	✓	✓								
CO4	✓	✓	✓					✓				
CO5	✓	✓	✓					✓				

Unit 1 : Introductory concepts, Models for control, control structures, state space modeling

Unit 2 : Analysis of Transfer function models, Laplace transforms, stability, Controllers and closed loop transfer functions,

Unit 3 : Stability analysis, Controller tuning : Stability based methods, frequency response analysis, traditional advanced control strategies

Unit 4 : Controller tuning : Direct Synthesis, Nyquist stability criterion, traditional multivariable control

Unit 5 : Multivaraible control, Model predictive control fundamentals and its implementation

Unit 6 : Controller performance assessment and diagnosis fundamentals and its implementation, MATLAB tutorials

Computational fluid dynamics

BTCHC 801B	Computational Fluid Dynamics	2-1-0	3 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 2 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

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

CO1	Derive flow governing equations using CFD.
CO2	Do turbulence modelling and discretization
CO3	Solve discretized linear algebraic equation using various methods
CO4	Solve coupled equations using various methods
CO5	Understand structured and unstructured grid generation methods

Mapping of Course outcomes with Program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓	✓		✓				
CO2	✓	✓	✓	✓		✓		✓				
CO3	✓	✓	✓	✓		✓						
CO4	✓	✓	✓	✓								
CO5	✓	✓	✓					✓				

Unit 1 : CFD as an engineering analysis tool, derivation of flow governing equations

Unit 2 : Initial and boundary conditions, wellposedness, turbulence modelling, discretization of the governing equations using finite difference/volume methods

Unit 3 : Concepts of consistency, stability and convergence, template for the discretization of a generic unsteady transport equation, spectral analysis of errors and TVD schemes

Unit 4 : Solution of discretized linear algebraic equations, direct methods, classical iterative methods, convergence analysis, advanced methods for solution of discretized equations

Unit 5 : Solution of coupled equations: methods for compressible flows, evaluation of pressure in incompressible flows, pressure-velocity coupling algorithms

Unit 6 : Template for the solution of governing equations, structured and unstructured grid generation methods, benchmarking and calibration

Optimization in Chemical Engineering

BTCHC 801C	Optimization in Chemical Engineering	2-1-0	3 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 2 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

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

CO1	Understand formulation for optimization problems
CO2	Study basic concepts of optimization
CO3	Solve problems involving unconstrained single variable optimization
CO4	Solve problems involving unconstrained multivariable optimization
CO5	Understand software tools for optimization

Mapping of Course outcomes with Program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓						✓			
CO2	✓	✓	✓		✓							
CO3	✓	✓	✓		✓							
CO4	✓	✓	✓		✓							
CO5	✓	✓										

Unit 1 : Introduction to optimization, optimization problem formulation

Unit 2 : basic concepts of optimization

Unit 3: Unconstrained single variable optimization : methods and applications, Unconstrained multivariable optimization: methods and applications

Unit 4 : Unconstrained multivariable optimization : gradient based methods, introduction to linear programming

Unit 5 : Linear programming : simplex method, constrained non-linear programming

Unit 6: Applications of Optimization, Software tools for optimization

References:

1. Optimization of Chemical Processes, by T. F. Edgar and D. M. Himmelblau
2. Engineering Optimization : Methods and optimization by A. Ravindran and K. M. Ragsdell

Environmental Quality Monitoring and analysis

BTCHC 802A	Environmental Quality Monitoring and analysis	2-1-0	3 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 2 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

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

CO1	Understand definition of environment , health effects
CO2	Study different parameters for environment
CO3	Study methods for sampling, processing , analysis of constituents
CO4	Solve problems using dispersion models
CO5	Understand chemical exchange between air-water, soil-air, sediment-air

Mapping of Course outcomes with Program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1					✓		✓					✓
CO2					✓		✓					✓
CO3					✓		✓					✓
CO4					✓		✓					✓
CO5					✓		✓					✓

Unit1 : Introduction, definition of environment, link between source/environment/receptor, health effects, toxicology, Chemicals of concern, relevant properties for environmental fate and transport, definition of equilibrium, , equilibrium partitioning of chemicals between different phases of environment

Unit 2 : Parameters for environmental water/air/soil/sediment-screening parameters, primary air pollutants, monitoring of environmental parameters-screening parameters-BOD, COD, TOC, TDS, environmental sampling- definition and synthesis of a sampling/monitoring/analysis method, QA/QC

Unit 3 : Methods for sampling/processing/analysis of organic and inorganic constituents in air/water/soil/sediment, introduction to environmental transport-BOX Models and the application to multimedia transport of pollutants

Unit 4 : Atmospheric dispersion-Gaussian Dispersion model, fundamentals of mass transport-definition of intraphase and interphase chemical flux, interphase mass transport

Unit 5: Chemical exchange between air-water, Chemical exchange between sediment-water

Unit 6 : Chemical exchange between soil-air, overall transport model and scenario

Transport Processes I : Heat and Mass Transfer

BTCHC 802B	Transport Processes I : Heat and Mass Transfer	2-1-0	3 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 2 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

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

CO1	Understand dimensional analysis for transport processes
CO2	Study transport in spherical and cylindrical coordinates
CO3	Evaluate pressure and body forces in fluid flow
CO4	Understand forced and natural convection
CO5	Solve problems involving transport processes

Mapping of Course outcomes with Program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓			✓	✓						
CO2	✓	✓	✓			✓						
CO3	✓					✓						
CO4						✓						
CO5	✓		✓			✓						

Unit 1 : Dimensional analysis, diffusion

Unit 2 : Transport in one direction, spherical and cylindrical coordinates

Unit 3 : Pressure and body forces in fluid flow, conservation equations

Unit 4 : Diffusive Transport I and II

Unit 5 : Forced and natural convection

Unit 6 : Transport in turbulent flows

Project Stage - II

BTCHP 803	Project	Project Stage – II or Internship*	0-0-30	15 Credits

Examination Scheme:
Continuous Assessment: 50 Marks
End Semester Exam: 100 Marks

Pre-Requisites: None

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

CO1	State the aim and objectives for this stage of the project
CO2	Construct and conduct the tests,experiments on the selected topic
CO3	Analyze the results of the tests/experiments/runs/simulations etc
CO4	Discuss the findings, draw conclusions.

Mapping of Course outcomes with Program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		✓	✓	✓	✓	✓					✓	
CO2	✓	✓	✓	✓		✓		✓			✓	
CO3	✓	✓	✓	✓	✓	✓	✓				✓	
CO4	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓

Course Contents:

Since Project Stage II is in continuation to Project Stage I, the students are expected to complete the total project by the end of semester VIII. After completion of project work, they are expected to submit the consolidated report including the work done in stage I and stage II.

The report shall be comprehensive and presented typed on A4 size sheets and bound. The number of copies to be submitted is number of students plus two. The assessment would be carried out by the panel of examiners for both, term work and oral examinations.