Dr. Babasaheb Ambedkar Technological University, Lonere

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

(Under Maharashtra Act No. XXIX of 2014)
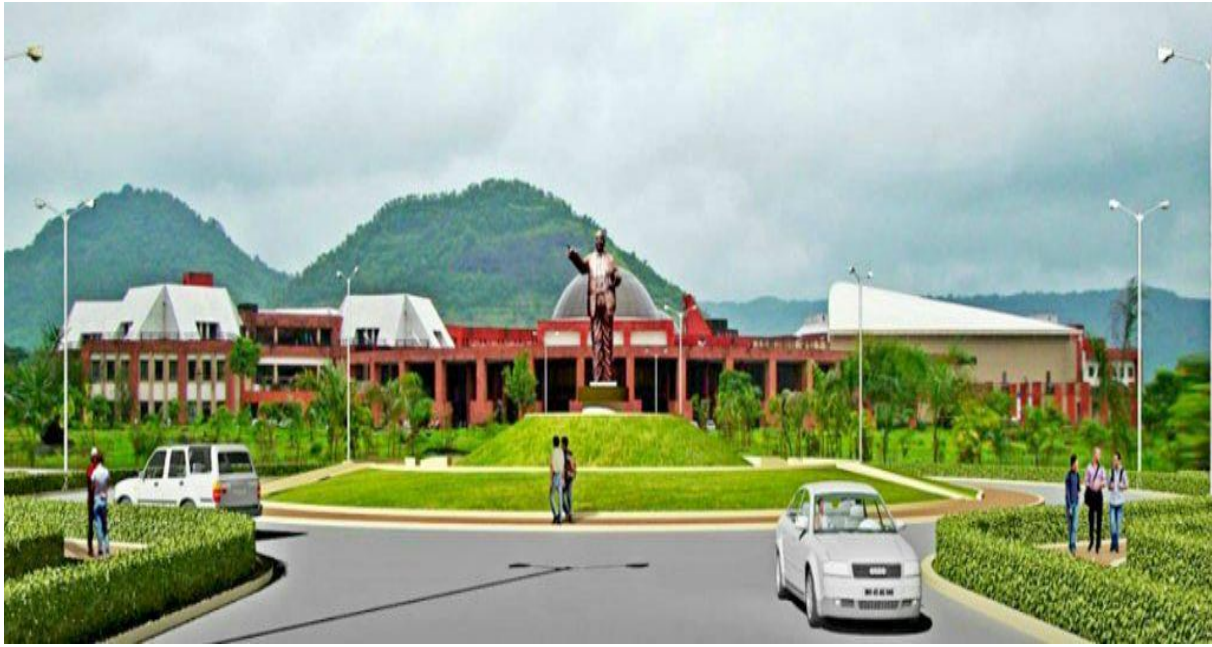
P.O. Lonere, Dist. Raigad, Pin 402 103, Maharashtra

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Curriculum for Third Year
Undergraduate Degree Programme
B. Tech. in Petrochemical Engineering

With effect from AY 2022-2023

Dr. Babasaheb Ambedkar Technological University

Lonere 402 103, Dist- Raigad, Maharashtra, INDIA

Rules and Regulations

1. The normal duration of the course leading to B. Tech. degree will be EIGHT semesters.
2. The normal duration of the course leading to M. Tech. degree will be FOUR semesters.
3. Each academic year shall be divided into 2 semesters, each of 20 weeks duration, including evaluation and grade finalization, etc. The Academic Session in each semester shall provide for at least 90 Teaching Days, with at least 40 hours of teaching contact periods in a five to six days session per week. The semester that is typically from Mid-July to November is called the ODD SEMESTER, and the one that is from January to Mid-May is called the EVEN SEMESTER. Academic Session may be scheduled for the Summer Session/Semester as well.For 1st year B. Tech and M. Tech the schedule will be decided as per the admission schedule declared by Government of Maharashtra.
4. The schedule of academic activities for a Semester, including the dates of registration, mid-semester examination, end-semester examination, inter-semester vacation, etc. shall be referred to as the Academic Calendar of the Semester, which shall be prepared by the Dean (Academic), and announced at least TWO weeks before the Closing Date of the previous Semester.
5. The Academic Calendar must be strictly adhered to, and all other activities including co-curricular and/or extra -curricular activities must be scheduled so as not to interfere with the Curricular Activities as stipulated in the Academic Calendar.

REGISTRATION:

1. Lower and Upper Limits for Course Credits Registered in a Semester, by a Full-Time Student of a UG/PG programme:
A full time student of a particular UG/PG programme shall register for the appropriate number of course credits in each semester/session that is within the minimum and maximum limits specific to that UG/PG programme as stipulated in the specific Regulations pertaining to that UG/PG programme.
2. Mandatory Pre-Registration for higher semesters:
In order to facilitate proper planning of the academic activities of a semester, it is essential for the every institute to inform to Dean (Academics) and COE regarding details of total no. of electives offered (Course-wise) along with the number of students opted for the same. This information should be submitted within two weeks from the date of commencement of the semester as per academic calendar.
3. PhD students can register for any of PG/PhD courses and the corresponding rules of evaluation will apply.
4. Under Graduate students may be permitted to register for a few selected Post Graduate courses, in exceptionally rare circumstances, only if the DUGC/DPGC is convinced of the level of the academic achievement and the potential in a student.

Course Pre-Requisites:

1. In order to register for some courses, it may be required either to have exposure in, or to have completed satisfactorily, or to have prior earned credits in, some specified courses.
2. Students who do not register on the day announced for the purpose may be permitted LATE REGISTRATION up to the notified day in academic calendar on payment of late fee.
3. REGISTRATION IN ABSENTIA will be allowed only in exceptional cases with the approval of the Dean (Academic) / Principal.
4. A student will be permitted to register in the next semester only if he fulfills the following conditions:

   (a) Satisfied all the Academic Requirements to continue with the programme of studies without termination
   (b) Cleared all Institute, Hostel and Library dues and fines (if any) of the previous semesters
   (c) Paid all required advance payments of the Institute and hostel for the current semester;
   (d) Not been debarred from registering on any specific ground by the Institute.

EVALUATION SYSTEM:

1. Absolute grading system based on absolute marks as indicated below will be implemented from academic year 2019-20,starting from I year B.Tech.

Perentage of Marks	Letter grade	Grade point
91-100	EX	10.0
86-90	AA	9.0
81-85	AB	8.5
76-80	BB	8.0
71-75	BC	7.5
66-70	CC	7.0
61-65	CD	6.5
56-60	DD	6.0
51-55	DE	5.5
40-50	EE	5.0
<40	EF	0.0

2. Class is awdared based on CGPA of all eight semesters of B. Tech Program.

CGPA for pass is minimum 5.0	
CGPAupto<5.50	Pass class
CGPA ≥ 5.50 &<6.00	SecondClass
CGPA ≥ 6.00 &<7.50	First Class
CGPA ≥ 7.50	Distinction
[Percentage of Marks =CGPA*10.0]	

3. A total of 100 Marks for each theory course are distributed as follows:

1.	Mid-Semester Exam (MSE) Marks	20
2.	Continuous Assesment Marks	20
3.	End Semester Examination (ESE) Marks	60

4. A total of 100 Marks for each practical course are distributed as follows:

1.	Continuous Assesment Marks	60
2.	End Semester Examination (ESE)Marks	40

It is mandatory for every student of B.Tech. to score a minimum of 40 marks out of 100, <u>with a minimum of 20 marks out of 60 marks in End Semester Examination for theory course.</u>

This will be implemented from the first year of B.Tech. starting from Academic Year 2019-2020.

5. Description of Grades:

 EX Grade: An 'EX' grade stands for outstanding achievement.

 EE Grade: The 'EE' grade stands for minimum passing grade.

The students may appear for the remedial examination for the subjects he/she failed for the current semester of admission only and his/her performance will be awarded with EE grade only.
If any of the students remain absent for the regular examination due to genuine reason and the same will be verified and tested by the Dean (Academics) or committee constituted by the University Authority.

FF Grade: The 'FF' grade denotes very poor performance, i.e. failure in a course due to poor performance. The students who have been awarded 'FF' grade in a course in any semester must repeat the subject in next semester.

6. Evaluation of Performance:

1. Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA)

(A) Semester Grade Point Average (SGPA) The performance of a student in a semester is indicated by Semester Grade Point Average (SGPA) which is a weighted average of the grade points obtained in all the courses taken by the student in the semester and scaled to a maximum of 10. (SGPI is to be calculated up to two decimal places). A Semester Grade Point Average (SGPA) will be computed for each semester as follows:

$$SGPA = \frac{\left(\sum_{i=1}^{n} c_i g_i\right)}{\left(\sum_{i=1}^{n} c_i\right)}$$

Where

'n' is the number of subjects for the semester,

'ci' is the number of credits allotted to a particular subject, and

'gi' is the grade-points awarded to the student for the subject based on his performance as per the above table.

SGPA will be rounded off to the second place of decimal and recorded as such.

(B) Cumulative Grade Point Average (CGPA): An up to date assessment of the overall performance of a student from the time he entered the Institute is obtained by calculating Cumulative Grade Point Average (CGPA) of a student. The CGPA is weighted average of the grade points obtained in all the courses registered by the student since s/he entered the Institute. CGPA is also calculated at the end of every semester (up to two decimal places).Starting from the first semester at the end of each semester (S), a Cumulative Grade Point Average (CGPA) will be computed as follows:

$$CGPA = \frac{\left(\sum_{i=1}^{m} c_i g_i\right)}{\left(\sum_{i=1}^{m} c_i\right)}$$

where

'm' is the total number of subjects from the first semester onwards up to and including the semester S,

'ci' is the number of credits allotted to a particular subject, and

'gi' is the grade-points awarded to the student for the subject based on his/her performance as per the above table.

CGPA will be rounded off to the second place of decimal and recorded as such.

Award of Degree of Honours

Major Degree

The concept of Major and Minors at B. Tech. level is introduced, to enhance learning skills of students, acquisition of additional knowledge in domains other than the discipline being pursued by the student, to make the students better employable with additional knowledge and encourage students to pursue cross-discipline research.

A. <u>Eligibility Criteria for Majors</u>

1. The Student should have Minimum CGPA of 7.5 up to 4th Semester
2. Student willing to opt for majors has to register at the beginning of 5th Semester
3. The Student has to complete 5 additional advanced courses from the same discipline specified in the curriculum. These five courses should be of 4 credits each amounting to 20 credits. The students should complete these credits before the end of last semester.
4. Student may opt for the courses from NPTEL/ SWAYAM platform. (if the credits of NPTEL/ SWAYAM courses do not match with the existing subject proper scaling will be done)

Student complying with these criteria will be awarded B. Tech. (Honours) Degree.

B. <u>Eligibility Criteria for Minors</u>

1. The Student should have Minimum CGPA of 7.5 up to 4th Semester
2. Student willing to opt for minors has to register at the beginning of 5th Semester
3. The Student has to complete 5 additional courses from other discipline of their interest, which are specified in the respective discipline. These five courses should be of 4 credits each amounting to 20 credits.
4. Student may opt for the courses from NPTEL/ SWAYAM platform. (if the credits of NPTEL/ SWAYAM courses do not match with the existing subject proper scaling will be done)

Student complying with these criteria will be awarded with B. Tech. Degree in -------Engineering with Minor in ------ --Engineering.

(For e.g.: B. Tech. in Chemical Engineering with Minor in Computer Engineering)

For applying for Honors and Minor Degree the student has to register themselves through the proper system.

ATTENDANCE REQUIREMENTS:

1. All students must attend every lecture, tutorial and practical classes.
2. To account for approved leave of absence (e.g. Representing the Institute in sports, games or athletics; placement activities; NCC/NSS activities; etc.) and/or any other such contingencies like medical emergencies, etc., the attendance requirement shall be a minimum of 75% of the classes actually conducted.
   If the student failed to maintain 75% attendance, he/she will be detained for appearing the successive examination.
   The Dean (Academics)/ Principal is permitted to give 10% concession for the genuine reasons as such the case may be.
   In any case the student will not be permitted for appearing the examination if the attendance is less than 65%.
3. The course instructor handling a course must finalize the attendance 3 calendar days before the last day of classes in the current semester and communicate clearly to the students by displaying prominently in the department and also in report writing to the head of the department concerned.

4. The attendance records are to be maintained by the course instructor and he shall show it to the student, if and when required.

TRANSFER OF CREDITS

The courses credited elsewhere, in Indian or foreign University/Institutions/ Colleges/Swayam Courses by students during their study period at DBATU may count towards the credit requirements for the award of degree. The guidelines for such transfer of credits are as follows:

a) 20 % of the total credit will be considered for respective calculations.

b) Credits transferred will be considered for overall credits requirements of the programme.

c) Credits transfer can be considered only for the course at same level i.e. UG, PG etc.

d) A student must provide all details (original or attested authentic copies) such as course contents, number of contact hours, course instructor /project guide and evaluation system for the course for which he is requesting a credits transfer. He shall also provide the approval or acceptance letter from the other side. These details will be evaluated by the concerned Board of Studies before giving approval. The Board of Studies will then decide the number of equivalent credits the student will get for such course(s) in DBATU. The complete details will then be forwarded to Dean for approval.

e) A student has to get minimum passing grades/ marks for such courses for which the credits transfers are to be made.

f) Credits transfers availed by a student shall be properly recorded on academic record(s) of the student.

g) In exceptional cases, the students may opt for higher credits than the prescribed.

Dr. Babasaheb Ambedkar Technological University, Lonere-402103

Department of Petrochemical Engineering: Bachelor of Technology in Petrochemical Engineering

Subject Code	Subject	Credit Scheme	Subject Code	Subject	Credit Scheme
Basic Science Course (BSC)			**Professional Core Courses (PCC)**		
BTBS101	Engineering Mathematics I	(3-1-0) 4	BTPCC601	Reaction Engineering II	(3-1-0) 4
BTBS102	Engineering Physics I	(3-1-0) 4	BTPCC602	Mass Transfer – II	(3-1-0) 4
BTBS107L	Engineering Physics Lab	(0-0-2) 1	BTPCC603	Process Dynamics and Control	(3-1-0) 4
BTBS201	Engineering Mathematics II	(3-1-0) 4	BTPCL606	Mass Transfer Lab.	(0-0-3) 2
BTBS202	Engineering Chemistry	(3-1-0) 4	BTPCC701	Transport Phenomena	(3-1-0) 4
			BTPCC702	Process Equipment Design and Drawing	(3-2-0) 5
BTBS207L	Engineering Chemistry Lab	(0-0-2) 1			
BTBS301	Engineering Mathematics III	(3-1-0) 4	BTPCL705	Process Control and Process Simulation Lab.	(0-0-3)2
			BTPCL706	Petrochemical Synthesis Lab	(0-0-3) 2
Engineering Science Course (ESC)			**Professional Elective Courses (PEC)**		
BTES103	Engineering Graphics	(2-0-0) 2	BTPCPE405A	Environmentally Sustainable Technology	(3-0-0) 3
BTES105	Energy and Environmental Engineering	(2-0-0) 2	BTPCPE405B	Fundamentals of Nanotechnology	(3-0-0) 3
BTES106	Basic Civil and Mechanical Engineering	(2-0-0) 2	BTPCPE405C	Numerical Method for Chemical Engineering	(3-0-0) 3
BTES108L	Engineering Graphics Lab	(0-0-4) 2	BTPCPE405D	Introduction to Material Science	(3-0-0) 3
BTES203	Engineering Mechanics	(2-1-0) 3	BTPCPE405E	Advanced Engineering Chemistry	(3-0-0) 3
BTES204	Computer Programming	(3-0-0) 3	BTPCPE505A	Natural Gas Technology	(3-0-0) 3
BTES205	Workshop Practice	(0-0-4) 2	BTPCPE505B	Membrane Technology	(3-0-0)3
BTES206	Basic Electrical and Electronics Engineering	(2-0-0) audit	BTPCPE505C	Design of Heat exchangers	(3-0-0) 3
BTES207L	Engineering Chemistry Lab	(0-0-2) 1	BTPCPE505D	Process Plant Utilities and Safety	(3-0-0) 3
BTES208L	Engineering Mechanics Lab	(0-0-2) 1			
Humanities and Social Sciences including Management Course (HSSMC)			BTPCPE605A	Energy Management in Petrochemical Industry	(3-0-0)3
BTHM104	Communication Skills	(2-0-0) 2	BTPCPE605B	Polymer Science and Technology	(3-0-3) 3
BTHM109L	Communication Skills Lab	(0-0-2) 1	BTPCPE605C	Chemical Process Optimization	(3-0-0) 3
BTHM403	Basic Human Rights	(3-0-0) 3	BTPCPE703A	Mathematical Methods in Chemical Engineering	(3-0-0) 3
BTHM604	Process Economics and Industrial Management	(4-0-0) 4	BTPCPE703B	Catalyst Science and Technology	(3-0-0) 3
Professional Core Courses (PCC)			BTPCPE703C	Advance Petroleum Refining	(3-0-0) 3
BTPCC302	Unit Operations – I	(3-1-0) 4	BTPCPE703D	Novel Separation Processes	(3-0-0) 3
BTPCC303	Stoichiometry	(3-1-0) 4	BTPCPE703E	Environmental Engineering	(3-0-0) 3
BTPCC304	Petrochemical Engg.-I	(4-0-0) 4	**Open Elective Courses (OEC)**		
BTPCL305	Petrochemical Engg. Lab.	(0-0-3) 2	BTPCOE504A	NSS-I	(3-0-0) 3
BTPCL306	Unit Operations- I Lab.	(0-0-3) 2	BTPCOE504B	Renewable Energy Sources	(3-0-0) 3
BTPCC401	Chemical Engineering Thermodynamics	(4-1-0) 5	BTPCOE504C	Product Design Engineering	(3-0-0) 3
BTPCC402	Unit Operations –II	(3-1-0) 4	BTPCEO504D	Pharmaceuticals and Fine Chemicals	(3-0-0) 3
BTPCC404	Petrochemical Engg. –II	(3-1-0) 4	BTPCOE704A	NSS II	(3-0-0) 3
BTPCL406	Unit Operations –II Lab	(0-0-3) 2	BTPCOE704B	Entrepreneurship Development	(3-0-0) 3
BTPCC501	Mass Transfer – I	(3-1-0) 4	BTPCOE704C	Disaster Management in Chemical Industries	(3-0-0) 3
BTPCC502	Reaction Engineering – I	(3-1-0) 4	BTPCOE704D	Corporate Communication	(3-0-0) 3
BTPCC503	Petrochemical Technology	(3-1-0) 4	BTPCOE704E	Pollution Control in Process Industries	(3-0-0) 3
BTPCL506	Reaction Engineering Lab.	(0-0-3) 2			

Subject Code	Subject	Credit Scheme	Subject Code	Subject	Credit Scheme
Mini Projects			**Field Training/Internship**		
BTPCM507	Mini Project I	(0-0-4) 2	BTPCI308	Internship I (four weeks)	Audit
BTPCM607	Mini Project II	(0-0-4) 2	BTPCI508	Internship II (four weeks)	Audit
BTPCM707	Mini Project III	(0-0-4) 2	BTPCI708	Internship III (four weeks)	Audit
Seminar			**Project**		
BTPCS307	Seminar I	(0-0-4) 2	BTPCP/BTPCI 801	Project work/Internship (One semester duration)	(0-0-24) 12
BTPCS407	Seminar II	(0-0-4) 2			

Program Educational Objectives:

Objective Identifier	Objectives
PEO1	To provide a solid foundation in mathematical, scientific and engineering fundamentals required to solve engineering problems
PEO2	To impart rigorous training to students with good scientific and engineering breadth in core subjects so as to analyze , design and apply knowledge for development of novel products and create solutions for the real life problems
PEO3	To prepare students to excel in technical fields in order to pursue postgraduate programs or to succeed in industry/technical profession, R&D institutions through global and new emerging areas in chemical engineering
PEO4	To develop an ability to understand problems from other disciplines of science and engineering and provide solution by use of his professional skills.
PEO5	To impart skills necessary, as a professional, for adapting rapid changes taking place in the chemical and allied industries as well as getting ready for unconventional industries like software industry.
PEO6	To provide environment of knowledge and sense of responsibility towards ethical issues arising due to development of new technologies in the society on large scale.

Program Outcomes:

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/s and concepts essential to implement this software/s.
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 and Petrochemical Engineering.
PO7	The graduate will have broad understanding of the impact of Chemical and Petrochemical 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 design tools.
PO11	The graduates will possess the knowledge of advanced and emerging topics in the fields of Chemical and Petrochemical Engineering systems.
PO12	The graduates will posses skills necessary to communicate design engineering ideas. The skills set include verbal, written and listening skills.
Program Specific Objectives :	
PO13	The graduates will have an ability and attitude to address the ethical issues.
PO14	The graduates will demonstrate the ability to work and collaborate in heterogeneous teams.
PO15	The graduates will understand the role of Chemical and Petrochemical Engineering in realizing trouble shooting of operations.

Course Category	Course Code	Course Title	Semester V								
			Teaching Scheme			Evaluation Scheme					
			L	T	P	CA	MSE	ESE	Total	Credit
PCC 7	BTPCC501	Mass Transfer – I	3	1	-	20	20	60	100	4
PCC 8	BTPCC502	Reaction Engineering – I	3	1	-	20	20	60	100	4
PCC 9	BTPCC503	Petrochemical Technology	3	1	-	20	20	60	100	4
OEC 1	BTPCOE504	Open Elective – I	3	-	-	20	20	60	100	3
PEC 2	BTPCPE505	Professional Elective – II	3	-	-	20	20	60	100	3
LC	BTPCL506	Reaction Engineering Lab	-	-	3	60	-	40	100	2
Project	BTPCM507	Mini Project – I	-	-	4	60	-	40	100	2
Internship	BTPCI508	Internship – 2 (Evaluation)	-	-	-	-	-	-	-	Audit
		Total	**15**	**3**	**7**	**220**	**100**	**380**	**700**	**22**
			Semester VI							
PCC 10	BTPCC601	Reaction Engineering – II	3	1	-	20	20	60	100	4
PCC 11	BTPCC602	Mass Transfer – II	3	1	-	20	20	60	100	4
PCC 12	BTPCC603	Process Dynamics and Control	3	1	-	20	20	60	100	4
HSSMC	BTHM604	Process Economics and Industrial Management	4	-	-	20	20	60	100	4
PEC 3	BTPCPE605	Professional Elective – III	3	-	-	20	20	60	100	3
LC	BTPCL606	Mass Transfer Lab	-	-	3	60	-	40	100	2
Project	BTPCM607	Mini Project – II	-	-	4	60	-	40	100	2
Internship		Field Training / Internship3/Industrial Training (minimum of 4 weeks which can be completed partially in fifth semester and sixth semester or in at one time).	**-**	**-**	**-**	-	-	-	-	Credits To be evaluated in VII Sem.
		Total	**16**	**3**	**7**	**220**	**100**	**380**	**700**	**23**

BSC = Basic Science Course,   ESC = Engineering Science Course, PCC = Professional Core Course PEC = Professional Elective Course, OEC = Open Elective Course, LC = Laboratory Course, HSSMC = Humanities and Social Science including Management Course

Open Elective - I

Sr. No.	Course Code	Course Name
01	BTPCOE504 A	NSS-I
02	BTPCOE504 B	Renewable Energy Sources
03	BTPCOE504 C	Product Design Engineering
04	BTPCOE504 D	Pharmaceuticals and Fine Chemicals

Professional Elective - II

Sr. No.	Course Code	Course Name
01	BTPCPE505 A	Natural Gas Technology
02	BTPCPE505 B	Membrane Technology
03	BTPCPE505 C	Design of Heat Exchangers
04	BTPCPE505 D	Process Plant Utilities and Safety

Professional Elective - III

Sr. No.	Course Code	Course Name
01	BTPCPE605 A	Energy Management in Petrochemical Industry
02	BTPCPE605 B	Polymer Science and Technology
03	BTPCPE605 C	Chemical Process Optimization

SEMESTER V

BTPCC501 Mass Transfer – I   4 Credits

Category	Code	Subject Name	L	T	P	CA	MSE	ESE	Total	Credit
PCC 7	BTPCC 501	Mass Transfer – I	3	1	-	20	20	60	100	4

Course Objectives:

After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to:

1. Diffusion in fluids and solids, mass transfer coefficients.
2. Material balances and co-current, countercurrent operation and concept of stage.
3. Gas absorption and stripping, number of transfer units in plate towers and packed bed towers.
4. Liquid-liquid extraction and solid liquid extraction and calculation of amount of solvent needed and number of stages.
5. Adsorption and ion exchange, adsorption isotherms and their applications.
6. Equipment for majorly gas-liquid operations.

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

CO1	Understand Fick's law of diffusion
CO2	Determine diffusivity coefficient and Determine mass transfer coefficients in gases and
CO3	Design the gas liquid separation columns
CO4	Determine number of stages, efficiency for gas liquid, liquid liquid operations
CO5	Select equipment for gas-liquid operation

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
Diffusion in Fluids: Fick's Law of diffusion, equimolecular counter diffusion, diffusion in stationary gas, Maxwell's law of diffusion, inter phase mass transfer - mass transfer equilibrium, diffusion between two phases, local mass transfer coefficient, local and average overall mass transfer coefficients, simultaneous heat and mass transfer.

Unit II
Material Balance and Gas Absorption: Steady state co current and counter current processes-stage wise and differential contacts, number of theoretical stages, stage efficiency, height of mass transfer units, 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.

Unit III
Equipment for Gas-Liquid Operation: Sparged vessels (bubble columns), mechanically agitated vessels for a single phase and gas liquid contact, tray towers, liquid dispersed scrubbers, venturi scrubbers, wetted wall towers, packed towers. Mass transfer coefficients for packed towers, co-current flow of gas and liquid, end effects and axial mixing.

Unit IV
Solvent Extraction: Liquid-liquid extraction, graphical representation of LLE, calculations with and without reflux for immiscible and partially miscible system. Solid - liquid extraction (Leaching). Single and multistage operations based on solvent free co-ordinates for leaching.

Unit V
Adsorption and Ion-exchange: Types of adsorption, Nature of adsorption, Freundlich equation, Stage wise and continuous adsorption. Theory of ion – exchange and its application for removal of ionic impurity.

Texts / References:
1. R. E. Treybal, Mass transfer operations, 3ed ed. McGraw Hill, 1980.
2. A. S. Foust et al. Principles of Unit Operations
3**.** J. M. Coulson and J. F. Richardson, "Chemical Engineering", Vol. 1 ELBS, Pergaman press, 1970
4**.** J. M. Coulson and J. F. Richardson, "Chemical Engineering" Vol. 2 ELBS, Pergaman press, 1970
5. B. K. Datta, Principles of mass transfer & separation processes,PHI learning PVT ltd, New Delhi, 2009

BTPCC502 Reaction Engineering – I   **4 Credits**

Category	Code	Subject Name	L	T	P	CA	MSE	ESE	Total	Credit
PCC 8	BTPCC 502	Reaction Engineering – I	3	1	-	20	20	60	100	4

Course Objectives:

After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to:

1. Mole balances in chemical reactions, types of reactors and their performance equations along with rector sizing
2. Rate laws used in chemical kinetics and design equations
3. Reactor design in isothermal conditions and its applications to different types of reactors and problems.
4. Collection and analysis of data, integral and differential methods.
5. Catalysts and catalysis, rate determining steps and applications.

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

CO1	Understand different types of chemical reactors.
CO2	Write rate law for chemical reactions of different orders.
CO3	Analyze the performance of different reactors to carry out isothermal processes
CO4	Analyze the reaction data by different analysis methods
CO5	Understand catalysis and analyze the rate determining step in catalytic reaction

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
Conversion and Reactor Sizing : Definition of the rate of reaction, General mole balance equation, Batch Reactors, Continuous-flow reactors, Industrial reactors, Definition of conversion, Design equations, Applications of the design equations for continuous-flow reactors.

Unit II
Rate-Law and Stoichiometry: Basic definitions, Approach to reactor sizing and design, Stoichiometric table, Expressing concentrations in terms other than conversion, Reactors in series, Reactions with phase change

Unit III

Isothermal Reactor Design: Design structure for isothermal reactors, Scale up of liquid-phase batch reactor data to the design of a CSTR, Tubular reactors, Recycle reactors.

Unit IV

Collection and Analysis of Rate Data: Batch reactor data, Method of initial rates, Method of half-life, Differential reactors, Least square analysis.

Unit V

Catalysis and Catalytic Reactors : Catalysts, Steps in a catalytic reaction, Synthesizing a rate law, mechanism and rate-limiting step, Design of Reactors for gas-solid reactions, Heterogeneous data analysis for reactor design.

Texts / References:
1. H. S. Fogler, "Elements of Chemical Reaction Engineering", 3rd Ed, New Delhi-Prentice Hall, 2001
2. O. Levenspiel," Chemical Reaction Engineering" Willey Eastern, 3rd Ed., 2000
3. J. M. Smith, "Chemical Engineering Kinetics", 3rd Ed., McGraw- Hill, 1988

BTPCC503 Petrochemical Technology   4 Credits

Category	Code	Subject Name	L	T	P	CA	MSE	ESE	Total	Credit
PCC 9	BTPCC 503	Petrochemical Technology	3	1	-	20	20	60	100	4

Course Objectives:

After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to:

1. Technology of different petrochemical processes
2. The effect of different variables on processes
3. The hazard and safety associated in different chemical processes
4. The scenario of Petrochemical industry in India

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

CO1	Understand petrochemical Industries ,its requirement and usefulness
CO2	Understand manufacturing of petrochemical feedstock
CO3	Understand technology for different petrochemicals
CO4	Asses environmental impact of different products
CO5	Understand hazard and safety associated in chemical processes
CO6	Understand the scenario of petrochemical industry in India

Mapping of course outcomes with program outcomes

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

Detailed syllabus:

Unit I
Scenario of Petrochemical Industries and its feed stock. Product pattern of paraffin's, olefins, diened and acetylene

Unit II
Manufacture of important paraffin's, olefins, acetylene, butadiene, isoprene and oligomers and aromatics: Techniques, Equipment, Reactions, Catalyst, Solvents, Operating conditions, Separation and purification and developments in these areas.

Unit III
Production of synthesis gas: Various routes, reactions, mechanism, condition, thermodynamics, kinetics, coal gasification and hydrogenation.

Unit IV
Conversion of Ethylene to ethylene oxide, ethylene glycol, ethanol amine. Propylene to acrylic acid, methyl ethyl ketone, acrylonitrile
Hydration: Technologies for production of alcohols such as ethanol, isobutyl alcohol and higher alcohols.

Unit V
Conversion of Butenes to iso and n butanols, MIBK, MTBE, Aromatics to maleic and phathalic anhydride, DMT, phenols and acetones, Cyclohexane to caprolactum, adipic acid, succinic acid
Esterification: Process for production of few esters such as acrylates, terephthalates, ester for flavoring industries etc.

Texts/ References:
1. N.N. Lebdev, Chemistry and techno logy of basic organic and petrochemical synthesis, Vol. 1 & 2 Mir publications, Moscow
2. Dryden, Charles E., Outlines of Chemical Technology, affiliated East-West Press Pvt. Ltd. New Delhi
3. B.K. Bhaskarrao, "A text on Petrochemicals" 2nd Ed, Khanna publishers, New Delhi.
4. G.N. Sarkar, "Advanced Petrochemicals" 1st Ed, Khanna Publishers, New Delhi

BTPCOE504 Open Elective –I   **3 Credits**

Category	Code	Subject Name	L	T	P	CA	MSE	ESE	Total	Credit
OEC 1	BTPCOE 504	Open Elective –I	3	-	-	20	20	60	100	3

A. NSS-I

Course Objectives:

After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to:

1. Indian constitution, fundamental rights and duties of citizens
2. Health, hygiene and sanitation
3. Environmental issues and its management
4. Indian youth development in different aspects

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

CO1	Understand features of Indian constitution, fundamental rights and duties of citizens
CO2	Explain importance of Health, Hygiene & Sanitation
CO3	Summarize yoga a tool for healthy lifestyle
CO4	Conclude environmental issues and organize its management
CO5	Classify the disasters and youth role in its management

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 and Basic Concepts of NSS: History, Philosophy, Aims and objectives of NSS Organizational structure, Concept of regular activities, Special camping, Day Camps. Basis of adoption villages/slums, Methodology of conducting survey

Unit II
Youth and Community Mobilization: Definition, Profile of youth, Categories of youth, Issues, Challenges and opportunities for youth, Youth as an agent of social change, Youth-adult partnership, Mapping of community stakeholders, Identifying methods of mobilization, Needs & importance of volunteerism**.**

Unit III
Importance and Role of Youth Leadership: Meaning and types of leadership, Qualities of good leaders; Traits of leadership, Importance and role of youth leadership.

Unit IV
Life Competencies and Skill: Definition and importance of life competencies, Communication, Inter Personal, Problem solving and decision making, Positive thinking, Self-confidence and self-esteem, Life goals, Stress and time management.

Unit V
Social Harmony and National Integration: Indian history and culture, Role of youth in peace-building and conflict resolution, Role of youth in Nation building
Youth Development Programs in India: National Youth Policy, Youth development programs at the National Level, State Level and voluntary sector, Youth-focused and Youth-led organizations.

B. Renewable Energy Sources

Course Objectives:

After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to:

1. Challenges and problems associated with the use of energy sources.
2. Renewable energy resources and technologies
3. Conversion technologies for solar, wind, biomass and hydrogen energies
4. Performance of energy conversion technologies

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

CO1	Understand the challenges and problems associated with the use of energy sources.
CO2	List renewable energy resources and technologies
CO3	Design conversion technologies for solar, wind, biomass and hydrogen energies
CO4	Evaluate the performance of energy conversion technologies

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
Sources of energy: Energy sources and their availability, renewable energy sources. Energy from Biomass: Introduction, Biomass as a source of energy, Biomass conversion technologies, Biogas generation, classification of biogas plants, Biomass gasification.

Unit II

Solar Energy: Sun and solar energy, solar radiation and its measurement, solar energy collectors, solar energy storage, Photovoltaic systems, Application of solar energy.

Unit III

Wind Energy: Wind as an Energy source, Basic principles of wind energy conversion, Types of Wind machines, Components of wind energy conversion system, Performance of wind machines, application of wind energy.

Unit IV

Energy from the Oceans: Introduction, Ocean Thermal Electric Conversion (OTEC), Energy from Tides, Ocean Waves

Unit V

Hydrogen energy: Introduction, Hydrogen production, Hydrogen storage, Hydrogen transportation. Chemical Energy Sources: Introduction, Fuel cells, Batteries.

Text / Reference:
1. Rai, G.D, Non-Conventional Energy Sources, Khanna Publishers, New Delhi, 2010.
2. Rajesh Kumar Prasad, T.P. Ojha, Non-Conventional Energy Sources, Jain Brothers, 2012.
3. Sukhatme S.P and J. Nayak, Solar energy – Thermal Collection and storage, 3rd Edition, Tata McGraw Hill Education Pvt Ltd., 2008.
4. MM. EI – Wakil, Power Plant Technology, Tata McGraw Hill, NewYork, 1999.

C. Product Design Engineering

Course Objectives:

After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to:

1. Different steps in processes product design
2. Principles of different design ideas
3. Detail Engineering drawings of components
4. Product data sheet
5. Heuristics for process synthesis
6. Reactor design

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

CO1	Identify steps in product and process design
CO2	Understand principles of steady-state flow sheet simulation
CO3	Understand heuristics for process synthesis
CO4	Design reactors for complex configurations

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

Introduction to Engineering Product Design: Trigger for Product/ Process/ System, Problem solving approach for Product Design, Disassembling existing Product(s) and understanding relationship of components with each other, Sketching of components, identifying materials and their processing for final product, fitting of components, understanding manufacturing as scale of the components, Reverse engineering concept, case studies of products in markets, (or in each discipline), underlying principles, Case studies of product failures, revival of failed products, Public/Society's perception of products, and its input into product design.

Unit II

Ideation: Generation of ideas, Funneling of ideas, Short-listing of ideas for product(s) as an individual or group of individuals, Sketching of products, Market research for need, competitions, scale and cost, Initial specifications of products

Unit III

Conceptualization: Computer operation principles and image editing through a graphical Composition; Computer aided 2D drafting and 3D Modeling through simple exercises. Designing of components, Drawings of parts and synthesis of a product from its component parts, Rendering the designs for 3-D visualization and to create a photo realistic image, Parametric modeling of product, 3-D Visualization of mechanical products, Detail Engineering drawings of components

Unit IV

Detailing: Managing assembling, Product specifications- data Sheet, Simple mechanical designs, Workshop safety and health issues, Create documents for knowledge sharing

Unit V
Hands-on Activity Charts for Use of Digital Tools

Activity 1	Learn the basic vector sketching tools.	2
Activity 2	General understanding of shading for adding depth to objects. Understanding of editing vectors	2
Activity 3	Begin developing a thought process for using digital sketching.	3
Activity 4	Create a basic shape objects sphere, box cylinders	3
Activity 5	Create Automotive wheel concepts	3
Activity 6	Understanding Navigation and Data Panel Interface	2
Activity 7	Solid and Surface modeling, Rendering 3-D models	4
Activity 8	Product market and Product Specification Sheet	3
Activity 9	Documentation for the product	2

Texts / References:
1. Model Curriculum for "Product Design Engineer – Mechanical", NASSCOM (Ref. ID: SSC/Q4201, Version 1.0, NSQF Level: 7)
2. Eppinger, S., & Ulrich, K.(2015), Product design and development, McGraw-Hill Higher Education.
3. Green, W., & Jordan, P. W. (Eds.).(1999), Human factors in product design: current practice and future trends. CRC Press.
4. Sanders, M. S., & McCormick, E. J. (1993), Human factors in engineering and design. McGraw-Hill Book Company.
5. Roozenburg, N. F., &Eekels, J. (1995), Product design: fundamentals and methods (Vol. 2). John Wiley & Sons Inc.
6. Lidwell, W., Holden, K., & Butler, J.(2010). Universal principles of designs, revised and updated: 125 ways to enhance usability, influence perception, increase appeal, make better design decisions, and teach through design, Rockport Pub.

D. Pharmaceuticals and Fine Chemicals

Course Objectives:

After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to:

1. Different grades of chemicals
2. Different methods of preparation of reagents and laboratory chemicals
3. Uses and testing of the pharmaceuticals and fine chemicals
4. Manufacture of Pharmaceuticals and fine chemicals with flow sheets
5. Study compressed tablet making and coating techniques
6. Study Preparation of capsules and extraction of crude drugs

Course Outcomes:

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

CO1	Know different grades of chemicals
CO2	Understand different methods of preparation of reagents and laboratory chemicals
CO3	Know uses and testing of the pharmaceuticals , fine chemicals and their applications
CO4	Know the techniques for manufacture of Pharmaceuticals and fine chemicals with flow sheets and their applications
CO5	Tablet making and coating techniques
CO6	Know Industrial procedures of capsule formulation and methods of recovering the drugs formulated from the reaction mixture

Mapping of course outcomes with program outcomes

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

Detailed Syllabus

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

Unit III
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 IV
Compressed Tablet making and coating – Types of tablets and Methods of compressed tablet making and coating.

Unit V
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.

BTPCPE505   Professional Elective –II   3 Credits

Category	Code	Subject Name	L	T	P	CA	MSE	ESE	Total	Credit
PEC	BTPCPE505	Professional Elective – II	3	-	-	20	20	60	100	3

A. Natural Gas Technology

Course Objectives:

After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to:

1. Natural gas
2. Natural gas processing
3. Field operation of natural gas
4. Merits and demerits of natural gas as fuel
5. Possible future sources from natural gas
6. Chemicals from natural gas

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

CO1	Understand composition of natural gas
CO2	Understand the processing of natural gas
CO3	Evaluate the economics of natural gas pricing
CO4	Understand natural gas hydrates and mechanism of their formation
CO5	Understand the technology for LNG

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
Natural Gas: Composition of natural gas, Energy content, statistics and pricing, natural gas and environment, deposits world and Indian scenario.

Unit II
Field operation of natural gas before transportation, Natural Gas processing, Storage and transport

Unit III
Sweetening of Natural gas, Relative merits and demerits of natural gas as a fuel, Uses of Natural gas

Unit IV
Possible future sources, Liquefied Natural Gas, Technology for LNG

Unit V
Chemicals from natural gas

Text / References:
Gatez S.L .Hand book of Natural Gas Technology

B. Membrane Technology

Course Objectives:

After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to:

1. Membrane and its technology
2. Techniques for preparation of different synthetic membranes
3. Constrained optimization algorithms with Kuhn-Tucker conditions
4. Membrane Transport
5. Membrane processes for different driving forces
6. Membrane modules and configurations

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

CO1	Understand the technologies of membrane synthesis
CO2	Classify the membranes
CO3	Select membrane according to the application.
CO4	Understand the mathematical models of membrane processes

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
Introduction: Membrane separation process, Definition of Membrane, Membrane types, Advantages and limitations of membrane technology compared to other separation processes, Membrane materials.

Unit II
Preparation of synthetic membranes: Phase inversion membranes, Preparation techniques for immersion precipitation, Synthesis of asymmetric and composite membranes, and Synthesis of inorganic membranes.

Unit III

Transport in membranes: Introduction, Driving forces, Transport through porous membranes, transport through non-porous membranes, Transport through ion-exchange membranes.

Unit IV

Membrane processes: Pressure driven membrane processes, Concentration as driving force, electrically driven membrane processes

Unit V

Polarization phenomena and fouling: Concentration polarization, Membrane fouling
Modules: Introduction, membrane modules, Comparison of the module configuration

Texts / References:
1. Mulder M, Basic Principles of Membrane Technology, Kluwer Academic Publishers, London, 1996.
2. Richard W. Baker, Membrane Technology and Research, Inc. (MTR), Newark, California, USA, 2004
3. Kaushik Nath, Membrane Separation Processes, Prentice-Hall Publications, New Delhi, 2008

C. Design of Heat Exchangers

Course Objectives:
After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to:

1. Process design of double pipe heat exchanger
2. Process design of Shell and Tube heat Exchanger
3. Process design of condenser and reboiler
4. Process design of evaporator
5. Process design of agitator

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

CO1	Understand different type of heat transfer equipment
CO2	Design of heat transfer equipment
CO3	Compare and evaluate design of equipment
CO4	Apply knowledge of selection of equipment

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
Introduction, various types of heat exchangers used in process industries, general design considerations of heat exchangers, detailed process design of double pipe heat exchanger

Unit II
Detailed process design of shell and tube heat exchangers without phase change.

Unit III
Detailed process design of shell and tube condenser – vertical condenser and horizontal condenser, Shell and tube condenser with sub-cooling.

Unit IV
Detailed process design of de-super-heater condenser, Shell and tube condensers in presence of non-condensable, Reboilers and Vaporizers -   Kettle type reboiler, thermosyphon type reboiler etc.

Unit V
Detailed process design of Evaporator and Agitator

Texts / References:
1. D.Q. Kern, "Process Heat Transfer", McGraw Hill, 1950.
2. J. M. Coulson and J. F. Richardson, "Chemical Engineering" Vol. 2 ELBS, Pergamon press, 1970
3. Bhattacharya B. C; "Introduction of Chemical Equipment Design", CBS Publisher, 2003.
4. Sinnott R. K.; "Coulson and Richardson's Chemical Engineering Series", Vol. VI, 4th Ed., Butterworth-Heinemann

D. Process Plant Utilities and Safety

Course Objectives:

After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to:

1. Different plant utilities
2. Different boilers used in chemical industries and its operation
3. Principle of refrigeration and different refrigerants
4. Hazard and safety associated with chemicals and processes
5. Safety associated in chemical industry
6. Handling of gases, liquid and solids

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

CO1	List utilities in a plant
CO2	Understand properties of steam and operation of boiler for steam generation
CO3	Classify and describe the types of water, water treatment methods, storage and distribution techniques
CO3	Understand refrigeration methods used in industry
CO4	Understand hazard and safety associated in chemicals and processes
CO5	Understand safety in chemical industry
CO6	Understand safety in handling gases, liquids and solids

Mapping of course outcomes with program outcomes

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

Detailed syllabus:

Unit I
Identification of common plant utilities: water, compressed air, steam, vacuum, refrigeration, venting, flaring and pollution abating. Water and its quality, storage and distribution for cooling and firefighting. Water treatment methods.

Unit II
Steam generation by boilers: Types of boilers and their operation, Steam generation by utilizing process waste heat using thermic fluids, Distribution of steam in a plant.

Principles of refrigeration: Creation of low temperature using various refrigerants. Creation of low pressure/vacuum by pumps and ejectors.

Unit III
Chemicals and their Hazards: Introduction, Acetonitrile, acetyl chloride, butyl amine, acrylamide, acrylonitrile, allyl alcohol, benzene, bromine, isopropyl alcohol, acetaldehyde, ethylene oxide, butane, n-hexane, anhydrous ammonia, acetone, toluene, p-xylene, acetic acid, monochloro benzene, oleum, carbon monoxide.

Safety in Chemical Processes: Introduction, Chemical Process classification, Process design and safety parameters. Safety parameters in the process design of phenol from cumene, safety in polyvinyl chloride plant.

Unit IV
Hazards in Chemical Process Plants: Introduction, Hazards, Hazard code and explosive limit, electrical safety in chemical process plants, static electricity hazards, pressure vessel hazards, LEL and UEL of various compounds, explosive hazard, flammable liquid hazards, protection to storage tanks, fire zone location, fireball, fireball hazard.

Safety in Handling Gases, Liquids and Solids: Introduction, safety in handling of gases, chlorine hazards, chlorine leakage management, safety in handling of fluorine, important safety considerations in ammonia storage, flammable solids storage, flammable liquid storage, handling of LNG, requirements to be fulfilled for storing hydrocarbons or chemicals, fail safe concept, transportation of hazardous chemicals, Hazardous in plastics processing.

Unit V
Combating Chemical Fires: Classification of fires, control of high vaour pressure fire, firefighting foams, foam for fire protection, Foam characteristics, gaseous agent extinguishing system, automatic sprinkler system, chemical extinguishing powders, natural gas fire control. Portable fire extinguishers: Soda-acid extinguishers, carbon dioxide extinguisher, dry chemical fire extinguisher, general safety precautions for maintenance of fire extinguishers.
Safety Checklist: safety studies for chemical plants, safety checklist during startup, safety checklist during shutdown mode, safety checklist for installation, safety needs during construction. Protective devices.

Texts / References:
1. D. A. Wangham, Theory and practice of Heat engines, ELBS Cambridge University press, 1970.
2. J. L. Threlkeld, Thermal Environmental Engineering, Prentice Hall 1970
3. S.D. Dawande, Chemical Hazards and safety, Dennet and Co publishers, 2007

BTPCL506 Reaction Engineering Laboratory   2 Credits

Category	Code	Subject Name	L	T	P	CA	MSE	ESE	Total	Credit
LC	BTPCL 506	Reaction Engineering Laboratory	-	-	3	60	-	40	100	2

Course Objectives

After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to:

1. Activation energy of acid catalyzed hydrolysis of methyl acetate.
2. Specific reaction rate of acid catalyzed hydrolysis of ethyl acetate
3. The reaction between potassium persulphate and iodide
4. Saponification of ethyl acetate.
5. Different types of reactors
6. RTD studies in reactors

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

CO1	Understand and calculate activation energy for given reaction
CO2	Determine rate of reaction and parameter affecting the rate.
CO3	To study different types of reactors
CO4	Understand kinetic of different reaction in different reactors
CO5	Study the performance of different reactors for saponification of ethyl acetate and potassium persulphate and iodide reaction.
CO6	Study RTD analysis in different types of reactors

Mapping of course outcomes with program outcomes

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

List of Practical:

1. Determine rate constant /activation energy of acid catalyzed hydrolysis of methyl acetate.
2. To study effect of concentration of reactant and temperature on the rate of reaction.
3. To determination of specific reaction rate of acid catalyzed hydrolysis of ethyl acetate
4. Determination of specific reaction rate of acid catalyzed hydrolysis of ethyl acetate by sodium hydroxide at 298 K.
5. To study the reaction between potassium persulphate and iodide.
6. Kinetics of hydrolysis of methyl acetate by strong acid.
7. To study saponification of ethyl acetate.
8. Study of isothermal continuous stirred tank reactor
9. Study of RTD in packed bed.
10. Study of RTD studies in continuous stirred tank reactor.
11. Study of non- catalytic homogenous reaction in a isothermal tubular flow reactor.
12. Study of non- catalytic homogenous reaction in a batch reactor.
13. Study of non- catalytic homogenous reaction in a continuous stirred tank reactor.
14. Study of non- catalytic homogenous reaction in plug flow reactor.
15. To calculate the rate constant and order of reaction with respect concentration using spectrophotometer
    (Minimum 12 experiments to be performed by all the students)

BTPCM507 Mini Project I   2 Credits

Category	Code	Subject Name	L	T	P	CA	MSE	ESE	Total	Credit
Project	BTPCM 507	Mini Project - I	-	-	4	60	-	40	100	2

The purpose behind the mini project is that the student should be exposed to more hands-on rather than merely theory. It is expected that the student (or a small group say, not more than two in a group, to be confirmed) will undertake to make a working model, a program etc. which he/she will benefit from since he /she will be doing it first-hand.

BTPCI508 Internship – 2 (Evaluation)   **Audit**

Category	Code	Subject Name	L	T	P	CA	MSE	ESE	Total	Credit
Internship	BTPCI508	Internship -2 (Evaluation)	-	-	-	-	-	-	-	Audit

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

CO1	Acquire knowledge on topics outside the scope of curriculum
CO2	Communicate with group of people on different topics.
CO3	Collect and consolidate required information on a topic.
CO4	Prepare a seminar report and present

Mapping of course outcomes with program outcomes

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

Each student is expected to spend Four weeks in any one factory/project/workshop at the end of fourth semester (during summer vacation). Here he/she shall observe layout, working and use of various machinery, plants, design, instruments, process etc. under the general supervision of the foreman/artisan/engineer of the factory etc.

The student shall submit the report in a systematic technical format about the major field of the factory, particularly about the section/department where he/she has received the training giving details of equipment, machinery, materials, process etc. with their detailed specifications, use etc. The report shall be checked and evaluated by the concerned teacher and appropriate grade shall be awarded.

SEMESTER VI

BTPCC601 Reaction Engineering - II   4 Credits

Category	Code	Subject Name	L	T	P	CA	MSE	ESE	Total	Credit
PCC 10	BTPCC 601	Reaction Engineering – II	3	1	-	20	20	60	100	4

Course Objectives:

After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to:

1. Multiple reactions , their types and use of PFR, CSTR for multiple reactions
2. Different types of non-elementary reactions, their kinetics and applications
3. External diffusion effects on heterogeneous reactions with application of mass transfer to reaction
4. General characteristics of RTD in chemical reactors
5. Models for non-ideal reactors

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

CO1	Compare the performance of PFR and CSTR to maximize desired product in PFR and CSTR.
CO2	To understand and analyze the kinetics of non-elementary reactions.
CO3	To analyze the external diffusion effects on heterogeneous reactions with application of mass transfer to reaction.
CO4	Compare the performance of ideal and non-ideal reactors using E- and F-curves and to determine the mean residence time and standard deviation using residence time distribution (RTD) data.
CO5	Understand the effect of velocity, particle size and fluid properties on rate of reactions controlled by mass transfer
CO6	Analyze the performance of non-ideal reactors using segregation model, tanks-in series model and dispersion model.

Mapping of course outcomes with program outcomes

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

Detailed syllabus:

Unit I
Multiple Reactions: Maximizing desired product in parallel reactions, Maximizing desired product in series reactions, Stoichiometric table using fractional conversion
Multiple reactions in PFR and CSTR – An alternative approach to using fractional conversion

Unit II
Non-elementary Reaction Kinetics: Fundamentals, Searching for a mechanism, polymerization, enzyme reaction fundamentals, Bioreactors

Unit III
External Diffusion Effects on Heterogeneous Reactions: Mass transfer fundamentals, Binary diffusion, External resistance to mass transfer, the shrinking core model

Unit IV
Distribution of Residence times for Chemical Reactors: General characteristics, Measurement of RTD, Characteristics of RTD, RTD in ideal reactors.

Unit V
Models for non-ideal reactors: Reactor modeling with RTD, Zero-parameter models
One-parameter models; tank-in-series model, dispersion model

Texts / References:
1. H. S. Fogler, "Elements of Chemical Reaction Engineering", 3rd Ed, New Delhi-Prentice Hall, 2001
2. O. Levenspiel," Chemical Reaction Engineering" Willey Eastern, 3rd Ed., 2000
3. J. M. Smith, "Chemical Engineering Kinetics", 3rd Ed., McGraw- Hill, 1988

BTPCC602   Mass Transfer – II   4 Credits

Category	Code	Subject Name	L	T	P	CA	MSE	ESE	Total	Credit
PCC 11	BTPCC 602	Mass Transfer– II	3	1	-	20	20	60	100	4

Course Objectives:

After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to :

1. Distillation, flash and differential distillation
2. McCabe Thiele method and Ponchon Savarit method to do calculations of distillation
3. Humidification operations and cooling tower design
4. Drying and different types of dryers
5. Crystallization basics and membrane separation processes

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

CO1	Select solvent for absorption and extraction operations
CO2	Determine number of stages in distillation, absorption and extraction operations
CO3	Determine the height of packed column in absorption, distillation and extraction
CO4	Calculate drying rates and moisture content for batch and continuous drying

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
Distillation - Vapour liquid equilibria, flash vaporization, batch distillation, differential distillation. Continuous fractionation - Binary systems,

Unit II
Mc-Cabe Thiele and Ponchon Savarit method calculations with multiple feeds and withdrawal, Multi component Distillation

Unit III
Humidification- Vapour liquid equilibrium, enthalpy for pure substances, vapour gas contact operation. Psychrometric charts and measurement of humidity
Dehumidification and Cooling Tower Design - Adiabatic and non adiabatic operations evaporative cooling, cooling tower design and dehumidification methods

Unit IV

Drying and Crystallization - Drying equilibrium and rate of drying, drying operation batch and continuous number of transfer units. Theories of crystallization, nucleation and crystal growth principles of super saturation, different types of dryers and crystallizers

Unit V

Membrane separation Processes: Types of membranes for osmosis and dialysis; Mechanism of solute/solvent rejection in the process; Design of R.O. and dialysis units; applications.

Texts / References:

1. R. E. Treybal, Mass transfer operations, 3ed ed. McGraw Hill, 1980.
2. A. S. Foust et al. Principles of Unit Operations
3. J. M. Coulson and J. F. Richardson, "Chemical Engineering", Vol. 1 ELBS, Pergaman press, 1970
4. J. M. Coulson and J. F. Richardson, "Chemical Engineering" Vol. 2 ELBS, Pergaman press, 1970
5. B. K. Datta, Principles of mass transfer & separation processes, PHI learning PVT ltd, New Delhi, 2009

BTPCC603 Process Dynamics and Control   4 Credits

Category	Code	Subject Name	L	T	P	CA	MSE	ESE	Total	Credit
PCC 12	BTPCC 603	Process Dynamics and Control	3	1	-	20	20	60	100	4

Course Objectives:

After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to:

1. Close loop and open loop systems, dynamics of first order systems
2. Transient response of control systems
3. Frequency response analysis and controller tuning
4. Characteristics of measurement systems with pressure measurement
5. Temperature, flow and level measurement

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

CO1	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
CO6	Understand the measurement techniques for Pressure and Temperature
CO7	Understand the measurement techniques for Flow and Level
CO8	Understand recording, indicating and signaling instruments
CO9	Analyze repeatability, precision and accuracy of instruments

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO2	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO3	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
CO4	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO5	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO6	✓	-	✓	✓	✓	-	-	-	-	-	-	-
CO7	✓	-	-	✓	✓	-	-	-	-	-	-	-
CO8	✓	-	-	✓	✓	-	-	-	-	-	-	-
CO9	✓	-	-	✓	✓	-	-	-	-	-	-	-

Detailed syllabus:

Unit I
Closed loop and open loop control systems, Dynamics of first order systems using transfer functions; Response of 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 pressure systems, second order systems, the manometer; Response of interacting and non-interacting systems, Transient response of control systems: Servo and regulated operation, General equations for the transient response.

Unit III
Feedback control, Proportional control of a signal capacity process; Integral control, Proportional-integral control and derivative action, Stability: Concept of stability, Stability criterion, Routh test for stability. Root locus analysis: Concept of root locus, Locus diagram.

Unit IV
Frequency response analysis: First order systems, Bode diagram, Complex numbers to get frequency response. Controller selection and tuning, Control valve characteristics and sizing, Cascade control, feed forward control, Introduction of digital control principles.

Unit V
Introduction to measurements, Elements of measuring systems and their functions, Single transmission, Transmitters- electronic pneumatic etc., Temperature measurement, Pressure measurement , Flow measurement, Level measurement.

Texts / References:
1. D. R. Coughanour, Process system analysis and control, 2nded, 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.
4. Patranabis D, Principles of Industrial Instrumentation, 2nd Edition, Tata McGraw Hill Publishing Company, New Delhi, 1999.
5. William C. Dunn, Fundamentals of Industrial Instrumentation and Process Control, 1st Edition, Tata McGraw-Hill Education Private Limited, 2009.
6. Eckman Donald P., Industrial Instrumentation, Wiley Eastern Ltd., 2004.

BTHM604 Process Economics and Industrial Management   4 Credits

Category	Code	Subject Name	L	T	P	CA	MSE	ESE	Total	Credit
HSSMC	BTHM 604	Process Economics and Industrial Management	4	-	-	20	20	60	100	4

Course Objectives:

After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to:

1. Fixed and working capital investment , total product cost
2. Application of time value of money, interest and investment costs
3. Taxes and insurance , depreciation and depreciation methods
4. Profitability of projects
5. Optimum process design, CPM/PERT techniques

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

CO1	Analyze alternative processes and equipment for manufacturing a product.
CO2	Design plant layout and engineering flow diagrams
CO3	Perform economic analysis related to process design.
CO4	Evaluate project profitability

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
Capital cost estimation in chemical industries, different methods of calculation of fixed costs. Capital Investment and working Capital.

Unit II
Time value of money, types of interest, investment costs, annuities, perpetuity and capitalized costs, discounted cash flow analysis

Unit III
Taxes and insurance, depreciation, amortization and obsolescence in chemical industries, types of depreciation methods, breakeven point analysis

Unit IV
Discussion on projects causes for time and cost overruns, project evaluation and assessment of project profitability, organization of project engineering.

Unit V

Optimum process design with examples, project development and commercialization, plant location and layout, selection of plant capacity

Project engineering management, project scheduling and its importance, use of CPM/PERT techniques

Texts / References:
1. M. S. Peters and K. D. Timmerhaus, "Plant Design Economics for Chemical Engineers", 5th Ed., McGraw-Hill, New York - 2003.
2. V. W. Uhl and A. W. Hawkins, "Technical Economics for Chemical Engineers", AIChE - 1971.
3. J. Moder and Philips, "Project Engineering with CPM and PERT", Rein Hold.

BTPCPE605 Professional Elective –III   3 Credits

Category	Code	Subject Name	L	T	P	CA	MSE	ESE	Total	Credit
PEC 3	BTPCPE605	Professional Elective – III	3	-	-	20	20	60	100	3

A. Energy Management in Petrochemical Industries

Course Objectives:

After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to:

1. Energy use pattern, management and problems
2. Energy conservation economics
3. Energy audit

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

CO1	Gain knowledge of energy problem
CO2	Understand energy management principles and latest technology
CO3	Understand conceptually energy conservation economics
CO4	Apply primary energy sources and their optimum utilization

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
General energy problems, energy use patterns and scope for conservation, energy management principles

Unit II
Needs of organization and goal setting, energy audit in plant metering, review of conservation technologies. Properties of Hydrogen with respect to its utilizationas a renewable form of energy

Unit III
Energy conservation economics, basic discounting life cycle, costing and other methods, factors affecting economics

Unit IV
Energy pricing and incentives for conservation of energy, energy conservation of available work in the plants, identification of irreversible processes

Unit V
Primary energy sources, optimum use of prime movers, energy efficient housekeeping, energy recovery in thermal systems, energy storage, thermal insulation.

Texts/ References:
1. D.A.Reay , Industrial Energy Conservation ,Pergamon press,1980
2. T.L. Boyen , Thermal Energy Recovery ,Wiley , 1980

B. Polymer Science and Technology

Course Objectives:

After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to:

1. Fundamentals of polymers
2. Different types of polymers
3. Polymer molecular weight measurement
4. Polymer processing

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

CO1	Understand thermodynamics of polymer structures
CO2	Select polymerization reactor for a polymer product.
CO3	Characterize polymers
CO4	State polymer additives, blends and composites
CO5	Understand Polymer Rheology

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: Basic concepts of Polymer Science, Various molecular forces in polymer, Various Molecular weights and their distribution.

Unit II
Polymerization: (i) Step growth: Mechanism, Kinetics, Polyfunctional Step growth polymerization. (ii) Radical polymerization: Mechanism, Kinetics, Effects of temperature, pressure. (iii) Ionic and Coordination Polymerization: Kinetics of Cationic and Anionic polymerization.

Unit III
Polymerization Conditions: Bulk, Solution, Suspension and Emulsion polymerization.

Unit IV
Measurement of Molecular Weight: End group analysis, Colligative property measurement, Gel Permeation Chromatography.

Unit V
Polymer Processing: Plastic technology: Molding, Extrusion, Additives and Compounding;
Fiber Technology: Textile and Fabric properties, Spinning, Elastomer technology: Vulcanization, Reinforcement.

Texts / References:
1. Text book of Polymer Science: Fred W. Billmeyer, Jr., Second Edition, 1994, John Wiley and Sons, Inc., Singapore.
2. Principals of Polymerization, George Odian, Third Edition, 2002, John Wiley and Sons, Inc., Singapore.
3. Fundamentals of Polymers, Anil Kumar and Gupta, R. K., McGraw Hill, 1998.

C. Chemical Process Optimization

Course Objectives:

After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to:

1. Single variable optimization algorithms , optimality criteria
2. Multivariable optimization algorithms and different methods
3. Constrained optimization algorithms with Kuhn-Tucker conditions
4. Sensitivity analysis in optimization
5. Integer programming, geometric programming
6. Non-traditional optimization algorithms

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

CO1	Formulate and solve linear Programming Problems
CO2	Determine the optimum solution to constrained and unconstrained
CO3	Apply dynamic programming principle to Linear programming problems
CO4	Determine the integer solutions to Linear Programming Problems
CO5	Understand Constrained optimization algorithms , Kuhn-Tucker conditions and solve using transformation methods
CO6	Do Sensitivity analysis in optimization
CO7	Formulate non-traditional optimization algorithms and their solution 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	-	-	-	-	✓	✓	-	-	✓	-	-	-
CO6	-	-	-	-	✓	✓	-	-	✓	-	-	-
CO7	-	-	-	-	✓	✓	-	-	✓	-	-	-

Detailed syllabus:

Unit I
Single-variable optimization algorithms: Optimal problem formulation, Optimization algorithms, Optimality criteria, Bracketing methods, Region-elimination methods, Point-estimation method, Gradient based methods, Root finding using optimization techniques.

Unit II
Multi-variable optimization algorithms: Unidirectional search, Direct search methods, Gradient based methods.

Unit III
Constrained optimization algorithms: Kuhn-Tucker conditions, Transformation methods,

Unit IV

Sensitivity analysis, Direct search for constrained minimization, Linearized search techniques, Feasible direction method, Generalized reduced gradient method, Gradient projection method

Unit V

Specialized algorithms: Integer programming, Geometric programming
Nontraditional optimization algorithms: Genetic algorithms, simulated annealing, Global optimization.

Text / Reference:

1. Deb K., Optimization for Engineering Design, Algorithms and Examples, Prentice Hall of India, New Delhi 1996
2. Luyben William, "Process Modeling, Simulation and Control for Chemical Engineers", MaGraw Hill Publishing Companies, Edn. II, 1996
3. Singiresu S. Rao, "Engineering Optimization: Theory and Practice", New Age International Ltd. Publishers, 2014.

BTPCL606 Mass Transfer Laboratory   2 Credits

Category	Code	Subject Name	L	T	P	CA	MSE	ESE	Total	Credit
LC	BTPCL 606	Mass Transfer Lab	-	-	3	60	-	40	100	2

Course Objectives

After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to:
1. Diffusivity of liquids
2. To plot mutual solubility curve
3. Efficiency of sieve plate distillation
4. Extraction and leaching
5. Vapor Liquid equilibrium
6. Equipment design for separation processes

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

CO1	Understand and evaluate diffusivity of liquids
CO2	Plot mutual solubility curve for acetone – methyl – iso-butyl-ketone and water
CO3	Determine the overall plate efficiency of sieve plate distillation
CO4	Understand and calculate extraction and leaching
CO5	Calculate theoretical height of column for given separation
CO6	Perform experiment related to VLE and draw conclusion
CO7	Design equipment for separation purposes
CO8	Evaluate the performance of given technique and compare with other 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	✓	✓	-	✓	-	-	-	-	-	-	-	-
CO6	✓	-	-	✓	-	-	✓	-	-	-	-	-
CO7	✓	-	-	✓	-	-	-	-	-	-	-	-
CO8	✓	-	-	✓	-	-	✓	-	-	-	-	-

List of Practical:

1. To determine the diffusivity of acetone in air
2. To study liquid-liquid diffusion.
3. To study the absorption with/without chemical reaction.
4. To study single stage/multistage leaching operation for calcium carbonate, sodium hydroxide water system.
5. To draw equilibrium solubility diagram for an acetic acid, benzene/toluene, water.
6. To study counter-current single stage extraction process for water(A), acetic acid(B) and benzene(C)/Toluene(C) system
7. To study liquid-liquid extraction in packed bed for suitable ternary system (HTU/NTU)
8. T-x-y diagram for water-acetone system
9. To prove Rayleigh equation by carrying out simple distillation of methanol-water system
10. To study crystallization of given salt
11. To determine rate of drying of given sample and to plot (kg moisture content/ kg of dry solid) V/S time and rate of drying V/S time.
12. To study Batch/Continuous crystallizer
13. Study of Rotary/fluidized bed dryer.
14. Study of steam distillation/Sieve plate distillation column
15. Study of Humidification/dehumidification system
16. Study of Cooling Tower
    (About 12 Experiments are to be conducted)

BTPCM607   Mini Project – II   2 Credits

Category	Code	Subject Name	L	T	P	CA	MSE	ESE	Total	Credit
Project	BTPCM 607	Mini Project – II	-	-	4	60	-	40	100	2

The purpose behind the mini project is that the student should be exposed to more hands-on rather than merely theory. It is expected that the student (or a small group say, not more than two in a group, to be confirmed) will undertake to make a working model, a program, etc. which he will benefit from since he /she will be doing it first-hand.

Internship - 3

Field Training / Internship 3 / Industrial Training (minimum of 4 weeks, which can be completed partially in fifth semester and sixth semester or at one time). Credits to be evaluated in VII Sem.

Each student is expected to spend Four weeks in any one factory/project/workshop at the end of semester VI (during summer vacation). Here he/she shall observe layout, working and use of various machinery, plants, design, instruments, process etc. under the general supervision of the foreman/artisan/engineer of the factory etc. Student shall submit report in a systematic technical format about the major field of the factory, particularly about the section/department where he/she has received the training giving details of equipment, machinery, materials, process etc. with their detailed specifications, use etc. The report shall be checked and evaluated by the concerned teacher and appropriate grade shall be awarded.