# Dr. Babasaheb Ambedkar Technological University, Lonere

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

**(Under Maharashtra Act No. XXIX of 2014)**

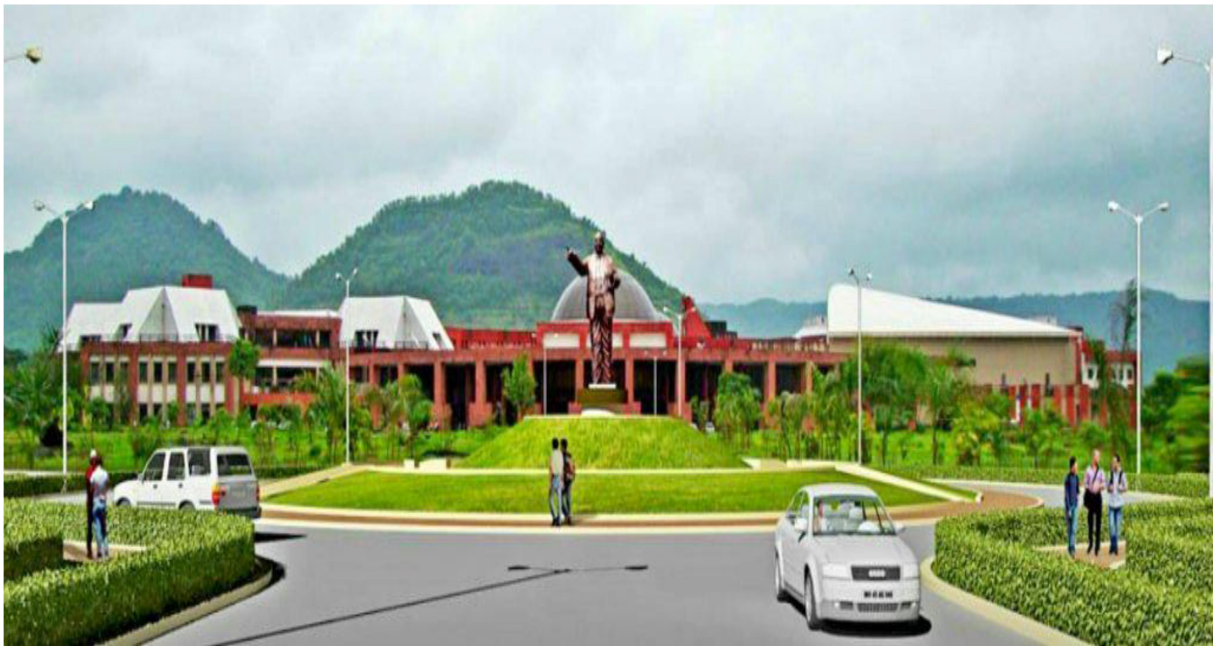
**P.O. Lonere, Dist. Raigad, Pin 402 103, Maharashtra**

**Telephone and Fax. : 02140 - 275142**

**www.dbatu.ac.in**

# 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 implementeds 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 eigth semster 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, with a minimum of 20 marks out of 60 marks in End Semester Examination for theory course.**

**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. Eligibility Criteria for Majors

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. Eligibility Criteria for Minors

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

| Basic Science Course (BSC) | Subject | Credit Scheme |
|---|---|---|
| BTBS101 | Engineering Mathematics I | (3-1-0) 4 |
| BTBS102 | Engineering Physics I | (3-1-0) 4 |
| BTBS107L | Engineering Physics Lab | (0-0-2) 1 |
| BTBS201 | Engineering Mathematics II | (3-1-0) 4 |
| BTBS202 | Engineering Chemistry | (3-1-0) 4 |
| BTBS207L | Engineering Chemistry Lab | (0-0-2) 1 |
| BTBS301 | Engineering Mathematics III | (3-1-0) 4 |
| **Engineering Science Course (ESC)** | | |
| BTES103 | Engineering Graphics | (2-0-0) 2 |
| BTES105 | Energy and Environmental Engineering | (2-0-0) 2 |
| BTES106 | Basic Civil and Mechanical Engineering | (2-0-0) 2 |
| BTES108L | Engineering Graphics Lab | (0-0-4) 2 |
| BTES203 | Engineering Mechanics | (2-1-0) 3 |
| BTES204 | Computer Programming | (3-0-0) 3 |
| BTES205 | Workshop Practice | (0-0-4) 2 |
| BTES206 | Basic Electrical and Electronics Engineering | (2-0-0) audit |
| BTES207L | Engineering Chemistry Lab | (0-0-2) 1 |
| BTES208L | Engineering Mechanics Lab | (0-0-2) 1 |
| BTES702 | Process Equipment Design | (4-0-0) 4 |
| **Humanities and Social Sciences Course(HSSMC)** | | |
| BTHM104 | Communication Skills | (2-0-0) 2 |
| BTHM109L | Communication Skills Lab | (0-0-2) 1 |
| BTHM403 | Basic Human Rights | (3-0-0) 3 |
| BTHM604 | Engineering Economics and Process Economics and Industrial Management | (4-0-0) 4 |
| **Professional Core Courses(PCC)** | | |
| BTPCC302 | Unit Operations – I | (3-1-0) 4 |
| BTPCC303 | Stoichiometry | (3-1-0) 4 |
| BTPCC304 | Petrochemical Engg.-I | (3-0-0) 3 |
| BTPCL305 | Petrochemical Engg. Lab | (0-0-3) 2 |
| BTPCL306 | Unit Operations- I Lab | (0-0-3)2 |
| BTPCC401 | Engineering Thermodynamics | (4-1-0) 5 |
| BTPCC402 | Unit Operations -II | (3-1-0) 4 |

| Professional Core Courses(PCC) | Subject | Credit Scheme |
|---|---|---|
| BTPCC404 | Petrochemical Engg. –II | (3-1-0)4 |
| BTPCL406 | Unit Operations –II Lab | (0-0-3) 2 |
| BTPCC501 | Mass Transfer – I | (3-1-0) 4 |
| BTPCC502 | Reaction Engineering – I | (3-1-0) 4 |
| BTPCC503 | Petrochemical Technology | (3-1-0) 4 |
| BTPCL506 | Reaction Engineering Lab | (0-0-3) 2 |
| BTPCC601 | Reaction Engineering II | (3-1-0) 4 |
| BTPCC602 | Mass Transfer – II | (3-1-0) 4 |
| BTPCC603 | Process Dynamics and Control | (3-1-0) 4 |
| BTPCL606 | Mass Transfer Lab | (0-0-3) 2 |
| BTPCC701 | Momentum, Heat and Mass Transfer | (3-1-0) 4 |
| BTPCL705 | Process Control Lab | (0-0-3)2 |
| BTPCL706 | Petrochemical Synthesis Lab | (0-0-3) 2 |
| **Professional Elective Courses(PEC)** | | |
| BTPCPE 405 | Environmentally Sustainable Technology | (3-0-0) 3 |
| BTPCPE405 | Fundamentals of Nanotechnology | (3-0-0) 3 |
| BTPCPE405 | Numerical Method for Chemical Engineering | (3-0-0) 3 |
| BTPCPE405 | Introduction to Material Science | (3-0-0) 3 |
| BTPCPE505 | Natural Gas Technology | (3-0-0) 3 |
| BTPCPE505 | Membrane Technology | (3-0-0)3 |
| BTPCPE505 | Design of Heat exchangers | (3-0-0) 3 |
| BTPCPE505 | Process Plant Utilities and Safety | (3-0-0) 3 |
| BTPCPE605 | Energy Management in petrochemical Industry | (3-0-0)3 |
| BTPCPE605 | Polymer Science and Tech. | (3-0-3)3 |
| BTPCPE605 | Chemical Process Optimization | (3-0-0)3 |
| BTPCPE703 | Catalyst Science and Technology | (3-0-0) 3 |
| BTPCPE703 | Advance Petroleum Refining | (3-0-0) 3 |
| BTPCPE703 | Novel Separation Processes | (3-0-0) 3 |
| BTPCPE703 | Environmental Engineering | (3-0-0) 3 |
| BTPCPE703 | Chemical Engineering Mathematics | (3-0-0)3 |

| | | |
|---|---|---|
| Open Elective | | |
| BTPCEO504 | NSS-I | (3-0-0) |
| BTPCEO504 | Product Design Engineering | (3-0-0) |
| BTPCEO504 | Pharmaceuticals and fine chemicals | (3-0-0) |
| BTPCEO704 | NSS II | (3-0-0) |
| BTPCEO704 | Business Development | (3-0-0) |
| BTPCEO704 | Industrial Psychology and Human Resource Management | (3-0-0) |

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

**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. |

| | Semester V | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Course Category** | **Course Code** | **Course Title** | **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 - 1 | - | - | 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 – 2 | - | - | 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 evaluate d in VII Sem. |
| | | **Total** | **16** | **3** | **6** | **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

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 |

Open Elective - I

| Sr. No. | Course Code | Course Name |
|---|---|---|
| 01 | BTPCOE504 A | NSS-I |
| 03 | BTPCOE504 B | Product Design Engineering |
| 04 | BTPCOE504 C | Pharmaceuticals and Fine Chemicals |

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 | 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 in gases and liquids. |
| CO3 | Determine mass transfer coefficients |
| CO4 | Calculate rate of mass transfer in humidification |
| CO5 | Select equipment for gas-liquid humidification |

**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 | 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 | 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

# BTPCO504 Open Elective –I

**3 Credits**

| Category | Code | Subject Name | L | T | P | CA | MSE | ESE | Total | Credit |
|---|---|---|---|---|---|---|---|---|---|---|
| OEC | BTPCO 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. 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.

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

## 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 Lab

**2 Credit**

| Category | Code | Subject Name | L | T | P | CA | MSE | ESE | Total | Credit |
|---|---|---|---|---|---|---|---|---|---|---|
| LC | BTPCL 506 | Reaction Engineering 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. 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 | 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 ideal and non-ideal reactors using E- and F-curves |
| CO2 | Determine the mean residence time and standard deviation using residence time distribution (RTD) data |
| CO3 | Analyze the performance of non-ideal reactors using segregation model, tanks-in series model and dispersion model. |
| CO4 | Understand the effect of velocity, particle size and fluid properties on rate of reactions controlled by mass transfer |
| CO5 | Design fixed bed reactors involving chemical reactions with mass transfer. |
| CO6 | Determine internal and overall effectiveness factors. |

**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 | 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 | 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 | 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 Lab **2 Credit**

| 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.