


# ASSAM SCIENCE AND TECHNOLOGY UNIVERSITY
## Guwahati
## Course Structure and Syllabus

## (From Academic Session 2024-25 onwards)

## B. TECH
## CHEMICAL ENGINEERING

## 5th SEMESTER

# ASSAM SCIENCE AND TECHNOLOGY UNIVERSITY
## Course Structure
## (From Academic Session 2024-25 onwards)

### B. Tech 5th Semester: Chemical Engineering

### Semester V

| Sl. No. | Course Code | Course Type | Course Title | Hours per Week | | | Credit | Marks | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | C | CE | ESE |
| **Theory** | | | | | | | | | |
| 1 | CHE241501 | PCC | Process Dynamics and Contol | 3 | 0 | 0 | 3 | 30 | 70 |
| 2 | CHE241502 | PCC | Chemical Reaction Engineering - II | 3 | 0 | 0 | 3 | 30 | 70 |
| 3 | CHE241503 | PCC | Mass Transfer Operation – I | 3 | 0 | 0 | 3 | 30 | 70 |
| 4 | CHE241504 | PCC | Process Equipment Design-I | 3 | 0 | 0 | 3 | 30 | 70 |
| 5 | CHE241505 | PCC | Process Utilities | 3 | 1 | 0 | 4 | 30 | 70 |
| 6 | HS241506 | HSMC | Entrepreneurship and Industrial Management | 3 | 0 | 0 | 3 | 30 | 70 |
| **Practical** | | | | | | | | | |
| 7 | CHE241511 | PCC | Process Dynamics and Control Lab | 0 | 0 | 2 | 1 | 15 | 35 |
| 8 | CHE241512 | PCC | Chemical Reaction Engineering Lab | 0 | 0 | 2 | 1 | 15 | 35 |
| 9 | EP241513 | EP | Academic Internship | 0 | 0 | 4 | 2 | - | 50 |
| **TOTAL** | | | | **18** | **1** | **8** | **23** | **210** | **540** |
| Total Contact Hours per week: 27 | | | | | | | | | |
| **Total Credit: 23** | | | | | | | | | |

| Course Code | Course Title | Hours per week L-T-P | Credit |
|---|---|---|---|
| **CHE241501** | **Process Dynamics and Contol** | **3-0-0** | **3** |

**Prerequisites:**
Mathematics, Process Instrumentation, Introduction to Chemical Engineering

**Course Outcome:**
After successful completion of the course student will be able to

- **CO1**: *Understand* the dynamic behavior of processes
- **CO2**: *Develop* closed loop block diagram and *analyze* with set point and load changes to calculate stability
- **CO3**: *Identify* the modes of controllers required for process system with their characteristics and tune the controllers.
- **CO4**: *Analyze* the stability of control system
- **CO5**: *Compare* different advanced control systems to various processes.

**MODULE 1: Introduction to process control:** Motivations, importance, component of control system, development of a Mathematical model, degrees of freedom, review of Laplace transforms, transfer function, forcing functions, response of first order and higher order system, first order system in series, Interacting and non-interacting processes, Poles and zeroes.

**MODULE 2: Feedback control system:** Open and closed loop control system, development of block diagram, block diagram reduction, servo and regulator problem. Transient response of closed loop control systems

**MODULE 3: Controllers and control action:** Types of controller, Characteristics of proportional, proportional- integral (PI), Proportional- derivative (PD), proportional-integral-derivative (PID) and on-off controllers. Control valve-construction- sizing and characteristics.

**MODULE 4: Time and frequency domain analysis:** stability criteria- Routh's stability criteria, Root locus diagram, frequency response analysis, gain margin, phase margin and cross over frequency, bode plot, nyquist plot.

**MODULE 5: Controller Tuning: Ziegler Nichols tuning, Cohen-Coon method, IMC tuning.**

**MODULE 6: Advanced process control:** Introduction to multivariable control, Cascade control, Ratio control, Split range control, feed forward control, inferential control, Adaptive control, Distributed control system, dead time compensation.

**Text Books/Reference Books:**


1. Coughanowr D.R., Process System analysis and Control, McGraw Hill, 2012, 3rd Edition.
2. Stephanopolis G., Chemical Process Control, Prentice Hall India, 2008.
3. Seborg D.E., Edgar T. E, Millichamp D.A, Process Dynamics and Control, John Wiley & Sons, 2016, 4th Edition.
4. Prabir Kumar Sarkar, Advanced process Dynamics and Control, , Prentice Hall India, 2008.
5. Raghunathan Rengaswamy, Babji Srinivasan, Nirav Pravinbhai Bhatt, Process Control Fundamentals: Analysis, Design, Assessment, and Diagnosis, CRC Press, 2020.
6. D.P.Eckman'Automatic Process Control'.

| Course Code | Course Title | Hours per week L-T-P | Credit |
|---|---|---|---|
| **CHE241502** | **Chemical Reaction Engineering - II** | **3-0-0** | **3** |

**Prerequisite:**
CRE1

**COURSE OUTCOMES**
After successful completion of course student will be able to

- **CO1*:*** *Describe* the different types of multiple reactions and ***s****elect* right kind of reaction system that maximizes the desired product.
- **CO2***: Recognize* the required temperature progression to obtain the desired product for single as well as multiple reaction systems and consequently *find* the best reactor type and best adiabatic operations.
- **CO3*:*** *Suggest* the rate mechanism for a solid catalytic reaction consistent with the experimental gas-solid reaction rate data and *derive* the rate law for the reaction and consequently *design* a catalytic reactor.
- **CO4*:*** *Describe* diffusion and reaction steps in a solid catalyst pellet and *determine* the overall rate of internal diffusion Iimited catalytic reactions.
- **CO5*:*** *Identify* RTD functions for PFR and CSTR to *predict* conversion and exit concentration using appropriate models for nonideal reactors.

**MODULE 1: Design for Multiple Reactions**
Introduction to Multiple Reactions, Qualitative Discussion about Product Distribution for Parallel, Series and Series-Parallel reactions, Quantitative treatment of Product Distribution for Parallel, Series and Series-Parallel reactions, The Denbigh Reactions and their special cases, Numerical.

**MODULE 2: Temperature and Pressure effects**
Single Reactions: Equilibrium Constants from Thermodynamics, Optimum Temperature Progression, Adiabatic Operations, Nonadiabatic Operations, Multiple Reactions: Product Distribution and Temperature; Numerical.

**MODULE 3: Choosing the Right Kind of Reactor**
Optimum Operation of Reactors, Temperature Progression for Multiple Reactions

**MODULE 4: Catalysis and Catalytic Reactors**
Catalysts, Steps in a Catalytic Reaction, Synthesizing a Rate Law, Mechanism and Rate Limiting Step; Heterogeneous Data Analysis for Reactor Design; Catalyst Deactivation.

**MODULE 5: Diffusion and Reaction**
Diffusion and Reaction in Spherical Catalyst Pellets, Internal Effectiveness Factor, Overall Effectiveness Factor, Thiele Modulus, Weisz-Prater Parameter

**MODULE 6: Residence Time Distribution for Chemical Reactors**
Modeling the real reactor as a CSTR and PFR in series; Predicting Conversion and Exit Concentration; Reactor Modeling Using the RTD ; Zero Parameter Models.

**MODULE 7: Models for Non Ideal Reactors**
One Parameter Models- Tanks in Series Model, Dispersion Model; Two Parameter Models- Basic Introduction**.**

**Text Book:**
1. Chemical Reaction Engineering by Levenspiel, Wiley Eastern.
2. Elements of Chemical Reaction engineering, Fogler, 3rd Ed.,Prentice hall

**Reference Books:**
1. Chemical Engineering Kinetics by D.M. Smith, McGraw Hill Publication.
2. D. Dawande, 'Principles of Reaction Engineering'- Central Techno Publications

| Course Code | Course Title | Hours per week L-T-P | Credit |
|---|---|---|---|
| **CHE241503** | **Mass Transfer Operation – I** | **3-0-0** | **3** |

**Prerequisite:**
Introduction to Chemical Engineering

**Course Outcomes:**
After successful completion of course student will be able to

- **CO1**: *Understand* the basic principles of Mass transfer, its laws and theories.
- **CO2**: *Understand* the basics of interphase mass transfer.
- **CO3**: *Analyze* the working principles and performance of mass transfer equipments.
- **CO4**: *Analyze* and *solve* mass transfer problems.

**MODULE 1:** Basics of Mass Transfer, steady state ordinary molecular diffusion and convective diffusion. Molecular diffusion in gases, liquids, biological solutions and gels, and solids. Diffusion through constant area and variable area. Mass Transfer coefficients, Types of Mass Transfer coefficients. Turbulent or Eddy diffusions.

**MODULE 2:** The Mass Diffusion Equation (The Equation of Continuity), Theories of mass transfer. Film theory, Two film Theory, Penetration theory, Surface renewal theory, Boundary layer theory.

**MODULE 3:** Equilibrium between phases mass transfer between two phases, concentration profile near the interfaces, overall mass transfer coefficient. Material balance in contacting equipment. Counter-current and co-current process. Absorption Concept, Solubility of gas absorption, Concept of Equilibrium and operating lines. Mass Transfer Equipments- Batch and continuous Stage wise contactors, Tower packings and packing characteristics,

M**ODULE 4:** Drying Theory and Mechanism, Drying Characteristics, Estimation of Drying time, drying rate curve, Classification of Driers, Calculation methods for drying period. Equations for various types of dryers. Tray drying with varying air conditions, Material and Heat balances for continuous dryers.

**MODULE 5:** Crystallization**:** Theory, Solid-Liquid phase equilibrium, Nucleation and crystal growth, solubility and material balance, Batch crystallization, Continuous Cooling Crystallizers. DTB crystallizer, melt crystallization.

**MODULE 6:** Introduction to Adsorption, Chromatography, and Ion Exchange.

**Recommended Textbook:**


1. Dutta, B.K., "Principles of Mass Transfer and Separation Processes", Prentice Hall, India, 2007.
2. Treybal, R.E.," Mass Transfer operation", McGraw Hill International Edition, 3rd Ed, 1981.
3. Seader, J.D., Henley, J. E., Separation Process Principles" 2nd Ed, Wiley India edition, 2010
4. Geankoplis, C.J., "Transport Process and Unit Operations", Prentice Hall 3rd Ed, India, 1993
5. McCabe, W.L., Smith, J, and Harriot, P.," Unit operation of Chemical Engineering", McGraw Hill International Edition, 6th Ed, 2001.

| Course Code | Course Title | Hours per week L-T-P | Credit |
|---|---|---|---|
| **CHE241504** | **Process Equipment Design-I** | **3-0-0** | **3** |

**COURSE OUTCOMES**

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

- **CO1***:* *Collect* data from the literature, Handbook and Code book.
- **CO2***:* *Analyse, interpret & Design* Heat Transfer Equipment incorporating safety aspects
- **CO3***:* *Analyze* and *evaluate* the performance of a Mass Transfer Equipment.
- **CO4***:* *Identify* problem associated with any Process Equipment and *provide* suitable alternate solutions.

**MODULE 1: Introduction**

Importance of design, Types of Design (process, mechanical, plant), Codes and Standards.

**MODULE 2: Design of Heat Transfer Equipment**

Types of heat exchanger, Design of Double Pipe Heat Exchanger, Design of Shell and Tube Heat Exchanger, Design of Multiple Effect Evaporator.

**MODULE 3**: **Design of Mass Transfer Equipment**

Design of Tray and Packed columns for Binary and Multicomponent Distillation, Column Internals.

**MOUDLE 4: Design of Condenser and Reboiler**

**Textbooks/ Reference Books:**


1. R. H. Perry, "Chemical Engineers' Handbook", 7th Edn., McGraw Hill, New York, 1998.
2. R. K. Sinnott, "Chemical Engineering Design", Coulson and Richardson's Chemical Engineering Series, Volume-6, Fourth Edition, Butterwoth-Heinemann, Elsevier, New Delhi, 2005.
3. L. E. Brownell and E.H. Young, "Process Equipment Design - Vessel Design", Wiley Eastern Edn. New York, 1968.
4. B.C. Bhattacharyya, "Introduction to Chemical Equipment Design Mechanical Aspects", CBS Publishers & Distributors, New Delhi.
5. D.Q. Kern "Process Heat Transfer", Tata McGraw Hill Edn., 2004.
6. V. V. Mahajani and S. B. Umarjii, "Joshi's Process Equipment Design", 4th Edn., Mac Millan Publishers India Limited, New Delhi, 2009.

| Course Code | Course Title | Hours per week L-T-P | Credit |
|---|---|---|---|
| CHE241505 | Process Utilities | 3-1-0 | 4 |

**Course Outcomes:**

After the successful completion of the course student should be able to:

- **CO1**. *Understand* the importance of process utilities in chemical industries.
- **CO2**. *Identify* water resource as a utility in process industries.
- **CO3**. *Examine* the importance of steam and evaluate the performance characteristics of steam generating systems for heat and power generation applications
- **CO4**. *Analyze* the performances of refrigeration, compressed air systems and internal Combustion engines
- **CO5**. *Understand* solar thermal technologies for heat and power generation in various process industries.

**MODULE 1: Introduction**

Utilities in process industries, importance of process utilities in chemical industries and plants, basic principles of thermodynamics and heat transfer for chemical process utilities

**MODULE 2: Water**

Water as a utility in process industries, Raw water and its characteristics treatment and conditions for use in process industries, e.g. for boiler feed, cooling etc., cooling tower, recycling and reuse of water, water resource management

**MODULE 3: Steam**

Generation distribution and utilization of steam, major components of steam generating system, modern boilers: classifications and performance characteristics, steam power plants, Rankine cycle steam handling, condensate removal, steam traps, safety in boiler systems

**MODULE 4: Air**

Use of air in process industries, air receivers, Compressor, Compressed air systems, Vacuum systems, boosters, piping network, air leaks and lubrication and oil removal.

**MODULE 5: IC Engine**

Internal combustion (IC) engine: classification, two-stroke and four-stroke engine, operations of four stroke engine, Ideal engine cycles – Otto, Diesel, Dual cycles - their characteristics and performances. Combustion performance and emission characteristics of IC engine

**MODULE 6: Refrigeration**

Refrigerants and Refrigeration systems, components of refrigeration systems, Refrigeration cycles, heat transfer fluids

**MODULE 7: Solar thermal technology**

Solar energy conversion, principles of solar energy utilization in process industries, Solar thermal technologies for heat and power generation, and their applications; Stirling cycle.

**Text/ Reference Books:**


1. Heat Engines (Vol. 1) – Pandya, Shah and Khandare, Charotar Publishing House, 2005
2. Elements of Heat Engines – Patel and Karamchandani (Vol I, II, III), Acharya Book Depot 2010.
3. The Efficient Use of Steam – Oliver Lyle, Her Majesty's Stationery Office; First Edition, 1947
4. Internal Combustion Engine Fundamentals, John B. Heywood, McGraw-Hill, Inc.,New York. 1988.
5. Fundamental of Engineering Thermodynamics, John R. Howell and Richard O. Buckius, McGraw-Hill Book Company, New York, 1987
6. Solar Energy: principles of Thermal Collection and Storage – S.P. Sukhatme, J. K. Nayak, Third edition, 2008, Tata McGraw-Hill
7. NPTEL Resources

| Course Code | Course Title | Hours per week L-T-P | Credit |
|---|---|---|---|
| HS241506 | Entrepreneurship and Industrial Management | 3-0-0 | 3 |

**Prerequisites: Higher Secondary Education**

**Course Outcome (CO):** After completion of the course, the students will be able to

- **CO1**. Explain concepts, types and role of entrepreneurship in the Indian context.
- **CO2**. Describe principles of industrial management and apply work study techniques.
- **CO3**. Apply startup planning, business models and legal compliances for venture creation.
- **CO4**. Apply inventory control and valuation techniques.
- **CO5**. Analyze costing BEP and project management tools (CPM, PERT).

**MODULE 1: Introduction to Entrepreneurship**

Meaning and Definition; Features and Significance, Types of Entrepreneurs, Generating Business Idea-Sources of Business Idea and Techniques of Idea generation, Opportunities and Challenges of Entrepreneurship in the Indian context.

**MODULE 2: Startup Formation**

Business Planning process, Writing a Business plan, Types of Business models, Business Model canvas, Sources of Finance - Traditional sources of financing, Venture capital, Angel investors, Business Incubators, Writing a Funding Proposal.

**MODULE 3: Legal and Policy support for Entrepreneurship**

Meaning and importance of Legal Compliance, Business registration and licensing-Registration procedure (MSME/Udyam registration); PAN, TAN and GST registration, Trade license and Sector specific approval; Intellectual Property Rights- types and registration procedure, Startup portals and Government policies.

**MODULE 4: Introduction of Industrial Management**

Meaning of Management, Functions, Principles of Administrative Management and Scientific Management with methods; Work study- Definition, Advantages, Division of work study, time study, method study and its types; Concept of Productivity; Production planning and control; Plant location and the factors determining the location of a plant; Plant layout and its types.

**MODULE 5: Inventory Management**

Material procurement- Valuation of Material Received- Bin card, Store ledger, Store control cards; Inventory control- setting of various stock levels, Economic Order Quantity (EOQ), Techniques of Inventory control- LIFO, FIFO, ABC, VED and FSN.

**MODULE 6: Costing**

Cost concept and classification; Preparation of cost sheet; BEP analysis; Project Management-CPM, PERT, Project crashing.

**Suggested Books and Other Study Materials**


1. S. S. Khanka & C. B. Gupta, Entrepreneurship and Small Business Management, Sultan Chand & Sons, 2014
2. Vasant Desai, Entrepreneurship Development and Management, Himalaya Publishing House, 2019
3. O. P. Khanna, Industrial Engineering and Management, Dhanpat Rai Publications, 2015
4. Prasanna Chandra, Projects, Mc Graw Hill, 2023
5. K. R. Das, Cost and Management Accounting, Kalyani Publishers, 2023
6. Martland Telsang, Industrial Engineering and Production Management, S. Chand Publishing, 2018
7. K. Aswathappa & K. shridhara Bhat, Production and Operations Management, Himalaya
8. Publishing House, 2017
9. M. N. Arora, Cost and Management Accounting, Himalaya Publishing House, 2023

| Course Code | Course Title | Hours per week L-T-P | Credit |
|---|---|---|---|
| **CHE241511** | **Process Dynamics and Control Lab** | **0-0-2** | **1** |

**Course Outcomes:**

After successful completion of course student will be able to

- **CO1**: *Understand* the dynamic response of interacting and non-interacting process for given step input
- **CO2**: *Understand* the transient response to Proportional, Proportional + Integral, Proportional + Derivative, Proportional + Integral + Derivative of process control
- **CO3**: *Examine* the characteristics and regulation function of control valve
- **CO4**: *Determine* the time constant of a first order system

**List of Experiments:**

| Exp. No. | Details |
|---|---|
| 1 | Dynamics of non-interacting system |
| | To study the dynamic response of a non-interacting tank |
| 2 | Dynamics of interacting system |
| | To study the dynamic response of an interacting tank |
| 3 | Study of different control modes |
| | To study the response of P,PI,PD and PID controllers in a water heating system |
| 4 | Control valve characteristics |
| | To study the installed and inherent characteristics of control valve and to determine its flow coefficient |
| 5 | Determination of time constant of a first order system |

| Course Code | Course Title | Hours per week L-T-P | Credit |
|---|---|---|---|
| **CHE241512** | **Chemical Reaction Engineering Lab** | **0-0-2** | **1** |

**Pre-requisites:**
Chemical Reaction Engineering-I

**Course objectives**
To understand the basic principles of chemical reaction engineering and the operation of the ideal chemical reactors.

**Course Outcomes**: Students will be able to

- **CO1***: Understand* the operation of a CSTR, a PFR, cascade CSTR and the combined reactors (PFR and CSTR in series) for a given reaction.
- **CO2***: Calculate* the conversion for a given reaction in any reactor and *evaluate* the rate constant from the performance equation through graphical plots.
- **CO3***: Assess* the best reactor or reactor combination by comparing the conversion.
- **CO4***: Calculate* E(t) and mean residence time (τ) in PFR and CSTR using pulse tracer input.

**Expanded Course description:**

| Exp. No. | Details |
|---|---|
| 1 | To study non-catalytic reaction in CSTR |
| | Aim: Determination of rate constant for Saponification of ethyl acetate with NaOH. |
| 2 | To study non-catalytic reaction in PFR |
| | Aim: Determination of rate constant for Saponification of ethyl acetate with NaOH. |
| 3 | To study non-catalytic reaction in a series arrangement of PFR and CSTR |
| | Aim: Determination of the conversion for Saponification of ethyl acetate with NaOH |
| 4 | To study non-catalytic reaction in a cascade arrangement of CSTR |
| | Aim: Determination of rate constant and conversion for Saponification of ethyl acetate with NaOH |
| 5. | RTD studies in PFTR and CSTR |
| | Aim: Plot the RTD curve using a pulse tracer and determine the dispersion number |

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