# GURU GHASIDAS VISHWAVIDYALAYA
# BILASPUR (C.G.)

(A Central University)

Koni, Bilaspur-495009, C.G (India)

## OUTCOME BASED EDUCATION
## WITH
## CHOICE BASED CREDIT SYSTEM (CBCS)

## MASTER OF TECHNOLOGY
## IN
## CHEMICAL ENGINEERING

***COURSE STRUCTURE AND SYLLABI***

**M. Tech Regular Two Year Degree Program**
**(Effective from the academic year 2021-22)**

## DEPARTMENT OF CHEMICAL ENGINEERING
## SCHOOL OF STUDIES OF ENGINEERING & TECHNOLOGY, GGV, BILASPUR, C.G. (INDIA)

# DEPARTMENT OF CHEMICAL ENGINEERING
## SCHOOL OF ENGINEERING & TECHNOLOGY, GGV, BILASPUR, C.G. (INDIA)
## SCHEME OF EXAMINATION
## M.TECH. CHEMICAL ENGINEERING
## M.Tech. I-Semester

| Sl. | Course Type/ Code | Subjects | Periods/Week | | | Evaluation | | | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | IA | ESE | Total | |
| 1. | CHPATT1 | Advanced Heat Transfer | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| 2. | CHPATT2 | Advance Separation Process | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| 3. | CHPATT3 | Advanced Fluidization Engineering | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| 4. | CHPATP1 | Elective – I<br>1. Advance Reaction Engineering<br>2. Advanced Wastewater Treatment Technology<br>3. Advanced Chemical Process Modeling | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| 5. | CHPATP2 | Elective – II<br>1. Advanced Process Control<br>2. Process Intensification<br>3. Bioprocess Engineering | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| 6. | CHPALT1 | Chemical Engineering Computational Lab | 0 | 0 | 4 | 30 | 20 | 50 | 2 |
| 7. | CHPATC1 | Research Methodology and IPR | 2 | 0 | 0 | - | 50 | 50 | 2 |
| Total | | | | | | | | 600 | 19 |

# M.Tech. II-Semester

| Sl. | Course Type/ Code | Subjects | Periods/Week | | | Evaluation | | | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | IA | ESE | Total | |
| 1. | CHPBTT1 | Advanced Transport Phenomena | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| 2. | CHPBTT2 | Chemical Reactor Design | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| 3. | CHPBTP1 | Elective – III<br>1. Computational Fluid Dynamics<br>2. Fuel Cell Technology<br>3. Process Plant Design & Flow Sheeting | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| 4. | CHPBTP2 | Elective – IV<br>1. Design & Development of Catalyst<br>2. Industrial Pollution Control<br>3. Safety Hazards & Risk Analysis | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| 5 | MSPBTO1<br>IPPBTO2<br>IPPBTO3<br>CEPBTO4<br>MEPBTO5<br>CHPBTO6<br>ECPBTO7<br>MCPBTO8<br>ITPBTO9<br>CSPBTO9 | Open Elective<br>1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy<br>7. Internet of Things<br>8. MOOCs<br>9. Software Engineering Techniques<br>10. Enterprise Resource Management | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| 6. | CHPBLT1 | Advanced Chemical Engineering Lab | 0 | 0 | 4 | 30 | 20 | 50 | 2 |
| 7. | CHPBPT1 | Mini Project | 0 | 0 | 4 | 30 | 20 | 50 | 2 |
| 8. | ELPBTX1<br>PEPBTX2<br>CEPBTX3<br>LAPBTX4 | Audit Course/Value Added Course<br>English for Research Paper Writing<br>Stress Management by Yoga<br>Disaster Management<br>Constitution of India | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | | | | | | | 600 | 19 |

**Note: Under MOOCs the students have to opt any subject other than Chemical Engineering from NPTEL/UGC SWAYAM**

# Master of Technology

## Chemical Engineering

## Semester-I

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| CHPATT1 | ADVANCED HEAT TRANSFER | 3:0:0 | 3 |

**Course Objective:**

- The course will deepen to understand of conduction, convection, radiation, phase change and dimensionless numbers.
- The course is design to learn the techniques for heat transfer enhancement and usage of numerical methods
- To understand for solving heat transfer problems such as heat exchangers and evaporators.

General equation of heat conduction, Transient heat Conduction numerical and analytical methods for the solution of transient heat conduction problems, Critical radius and optimum thickness of insulation. Free convective heat transfer under different situation and application of dimensional analysis to estimate the convective heat transfer coefficients. Heat transfer factor Reynolds No. Plot, Analogy equation for heat momentum transfer. Boiling heat transfer with particular reference to Nucleate and film boiling and estimation of boiling heat transfer coefficient. Heat transfer from condensing vapors. Nusselt equation for film type condensation of vapors over vertical surfaces and inclined tubes. View factors and emissivity factors for different situation. Radiation shield and radiation error in pyrometry. Combined conduction, convection and radiation heat transfer.

**Course Outcome:** After learning the course, the students will be able to:

- To design and analyze the performance of heat exchangers and evaporators
- To Analyze the various analytical and numerical heat transfer problem.
- Understand the basic concepts of phase change and their coefficient, impact on heat

***Texts Books***

- Hallman J. P., Heat Transfer Operation, McGRAW-Hill
- A Text Book on Heat Transfer, Universities Press; Fourth edition

***Reference Books***

- R.C.Sachdeva, Fundamentals of Engineering Heat & Mass Transfer.

- Bird, R. B., Steward, W.E. and Lightfoot E N., Transport Phenomena, Second edition, John Wiley and sons,
- Deen W. M. Analysis of Transport phenomena, Oxford University Press, 1998.
- Slattery J. C., Momentum Heat and Mass Transfer, Krieger Publishing, 1981


**Course Outcomes and their mapping with programme Outcomes**

| COs | PROGRAM OUTCOMES (POs) | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | I | II | III |
| CO1 | **3** | **1** | **2** | **2** | **3** | **2** | | | | | | | **2** | **1** | |
| CO2 | **3** | **3** | **1** | **2** | **1** | **2** | | | | | | | **3** | **2** | |
| CO3 | **2** | **3** | **1** | **2** | **2** | **2** | | | | | | | **1** | **2** | |

**Weightage:** 1-Slightly; 2-Moderate; 3-Strongly

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| CHPATT2 | ADVANCED SEPARATION PROCESS | 3:0:0 | 3 |

## Course Objective:

- To familiarize students with various advanced aspects of separation processes and the selection of separation processes.
- To enable students to understand the principles and processes of adsorption, membrane separation and chromatography and to design an absorber or a membrane unit to achieve a specified separation.
- To introduce them to new trends used in the separation technologies.

**Introduction:** Conventional Separation Processes - Absorption, Adsorption, Conventional separation processes - Distillation, Drying, Extraction, Diffusion, Leaching, Crystallization. Advances in separation techniques based on size, surface properties, ionic properties. Cross flow filtration, Electro filtration, Dual functional filter, Surface based solid-liquid separations involving a second liquid, Sirofloc filter.

**Bubble and Foam Fractionation:** Nature of bubbles and foams, stability of foams, foam fractionation techniques, batch, continuous, single stage and multistage columns. Types and choice of membranes, Plate and frame, Spiral wound membranes, Tubular and hollow fibre membrane reactors, Membrane Permeates, Dialysis, Reverse osmosis, Nano-filtration, Ultrafiltration, Microfiltration, Dialysis, Ceramic membranes

**Membrane Separation:** Characteristics of organic and inorganic membranes, basis of membrane selection, osmotic pressure, partition coefficient and permeability, concentration polarization, electrolyte diffusion and facilitated transport, Industrial applications of Micro-filtration, Ultra-Filtration, Reverse Osmosis, Electro-Dialysis.

**Special Processes:** Liquid Membrane Separation, Super-Critical Extraction, Adsorptive Separation-Pressure, Vacuum and Thermal Swing, Pervaporation and Permeation, Nano-Separation.

**Chromatographic Methods of Separation:** Gel, Solvent, Ion and High Performance Liquid Chromatography.

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

- List situations where liquid–liquid extraction might be preferred to distillation, make a preliminary selection of a solvent using group-interaction rules, Size simple extraction equipment.
- Differentiate between chemisorption and physical adsorption, List steps involved in adsorption of a solute, and which steps may control the rate of adsorption, explain the concept of breakthrough in fixed-bed adsorption.

- Explain how crystals grow, Explain the importance of supersaturation in crystallization.
- Describe effects of mixing on supersaturation, mass transfer, growth, and scale-up of crystallization.
- Explain membrane processes in terms of the membrane, feed, sweep, retentate, permeate, and solute membrane interactions. Distinguish among microfiltration, ultrafiltration, Nano filtration, virus filtration, sterile filtration, filter-aid filtration, and reverse osmosis in terms of average pore size. Explain common idealized flow patterns in membrane modules.

***Texts Books***


- Seader J.D. and Henley E.J., "Separation Process Principles", 2nd Ed.,Wiley.2006
- Nakagawal, O. V., "Membrane Science and Technology", Marcel Dekker, 1992.


***Reference Books***


- R. C. Sachdeva ,Fundamentals of Engineering Heat & Mass Transfer.
- Humphrey, J and G. Keller, Separation Process Technology, McGraw-Hill, 1997
- Khoury F.M., "Multistage Separation Processes", 3rd Ed., CRC Press. 2004.
- Wankat P.C., "Separation Process Engineering", 2nd Ed., Prentice Hall.2006.
- Basmadjian D., "Mass Transfer and Separation Processes: Principlesand Applications", 2nd Ed.,CRC Press.2007.
- Phillip C. Wankat , Separation Process Engineering (2nd Edition),Printice Hall,2007
- Rousseau, R. W., "Handbook of Separation Process Technology", John Wiley, New York, 2009


- **Course Outcomes and their mapping with programme Outcomes**

| COs | PROGRAM OUTCOMES (POs) | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | I | II | III |
| CO1 | **3** | **1** | **2** | **2** | **3** | **2** | | | | | | | **2** | **1** | |
| CO2 | **3** | **2** | **1** | **2** | **1** | **2** | | | | | | | **3** | **2** | |
| CO3 | **2** | **2** | **1** | **3** | **3** | **2** | | | | | | | **1** | **2** | |
| CO4 | **2** | **2** | **2** | **2** | **2** | **2** | | | | | | | **1** | **2** | |
| CO5 | **2** | **3** | **2** | **3** | **3** | **2** | | | | | | | **1** | **2** | |

**Weightage:** 1-Slightly; 2-Moderate; 3-Strongly

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| CHPATT3 | ADVANCED REACTION ENGEENIRING | 3:0:0 | 3 |

**Course Objective:** This Subject is essential for Design of Reactor especially heterogeneous reactors. Students will learn the energy balance, temperature and concentration profiles in different reactors, advance design aspects of multiple reactors, students will get insight of importance of population balance of particles.

**Course Content:**

**Non-elementary Kinetics Importance**: Approximations for formulations of Rate laws, Formulations of Kinetic model. Effect of flow on conversions in Reactors: Semi batch Reactors Importance and examples of applications , Material Balance on Semi batch Reactor, Multiple reaction in Semi batch Reactors, Conversion Vs Rate in Reactors, Use of POLYMATHS to solve the equations and understanding the profiles Non-Isothermal reaction modeling in CSTR & Semi-Batch reactor: Energy Balance equations for CSTR, PFR and Batch reactors, Adiabatic operations Temperature conversion profiles in PFR, CSTR, Steady state tubular reactor with heat exchange.

**Need for Multi-staging CSTR with multiple stages:** Exothermic and Endothermic Reaction with examples, CSTR with heat effects, Multiple reactions in CSTR and PFR with heat effects, Semi batch Reactors with heat exchange. Design of PFR and Packed Bed Tubular Reactors: Radial and Axial mixing in Tubular reactors, unsteady state in non-isothermal energy balance, CSTR, Energy balance in Batch Reactors, Volume of reactors calculations for non-isothermal reactors. Optimal Design of Reactors for Reversible exothermic reactions: Unsteady state non-isothermal reactor design, adiabatic operation in batch, Heat effects in semi batch unsteady state operation. Auto thermal Plug flow reactors and packed tubular reactors.PFR with inter stage cooling. Shift of Energy and material balance lines for reversible reactions in CSTR, Examples of optimal design of PFR and Semi batch and CSTR Exothermic Reactions.

**Catalytic reactions:** Theory and modeling: Global rate of reaction, Types of Heterogeneous reactions Catalysis, Different steps in catalytic reactions, Theories of heterogeneous catalysis. Steady State approximation, formulations of rate law, Rate laws derived from the PSSH, Rate controlling steps, Eiley-Rideal model, Reforming catalyst example :Finding mechanism consistent with experimental observations Evaluation of rate law parameters, packed beds : Transport and Reactions, Gradients in the reactors : temperature.

Porous media reactors: Mass transfer coefficients, Flow effects on spheres tube and cylinders, External Mass Transfer pore diffusion, structure and concentration gradients Internal Effectiveness Factor Catalytic wall reactor: limiting steps reactions and mass transfer limiting Porous catalyst on tube wall reactors Design of packed bed porous catalytic reactors: Mass transfer limited reactions in Packed bed.

**Fluidized bed reactor modeli**ng: Geldart Classification of powders, Fixed bed vs fluidized bed Why fluidized bed, important parameters pressure drop in fixed bed, Class I model Arbitrary Two Region Flow Models, Class II Chemical Reactor: Plug Flow or Mixed Flow Model. Class III Modeling the Bubbling Fluidized Bed Reactor, BFB, The Kunii-Levenspiel bubbling bed model, Gas Flow Around and Within a Rising Gas Bubble in a Fine particle BFB, Reactor performance of BFB.

**Application of Population Balance Equations for reactor modeling:** Particle size distribution, Distribution Functions in Particle Measuring Techniques, Particle distribution model in colloidal particle synthesis in batch reactor, Moments of Distribution, Nucleation rate based on volumetric holdup versus crystal growth rate.

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

- Evaluate heterogeneous reactor performance considering mass transfer limitations
- Perform the energy balance and obtain concentration profiles in multiphase reactors.
- Estimate the performance of multiphase reactors under non-isothermal conditions.
- Understand application of modern reactor technologies.

***Texts Books***


- J.M. Smith : Chemical Engineering Kinetics, Mcgraw Hill, Third Edition, 1981.
- Levenspiel O., Chemical Reaction Engineering, Wiley, 1998.
- Foggler,H.S., Elements of Chemical Reaction Engineering, Prentice Hall of India, 2008


***Reference Books***


- K.G. Denbigh : Chemical Reactor Theory, Cambridge University Press, Second Edition, 1971.
  Fromment G.F. and Bischoff K.B., Chemical Reactor Analysis and Design, John Wiley, 2010.


- **Course Outcomes and their mapping with programme Outcomes**

| COs | PROGRAM OUTCOMES (POs) | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | I | II | III |
| CO1 | **3** | **1** | **2** | **2** | **3** | **2** | | | | | | | **2** | **1** | |
| CO2 | **3** | **2** | **1** | **2** | **2** | **3** | | | | | | | **2** | **2** | |
| CO3 | **3** | **2** | **2** | **2** | **2** | **2** | | | | | | | **2** | **2** | |
| CO4 | **3** | **2** | **2** | **3** | **3** | **2** | | | | | | | **2** | **1** | |

**Weightage:** 1-Slightly; 2-Moderate; 3-Strongly

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| CHPATP1 | ADVANCED FLUIDIZATION ENGINEERING | 3:0:0 | 3 |

**Course Objective:**

- To study the phenomenon of fluidization with industrial processing objective
- To study the various regimes of fluidization and their mapping.
- To study the design of equipments based on fluidization technique

**Introduction to fluidization and applications:** Phenomenon of fluidization, behavior of fluidized bed, contacting modes, advantages and disadvantages of fluidization, fluidization quality, selection of contacting mode, Beds for Industrial

applications, coal gasification, synthesis reactions, physical operations, cracking of hydrocarbons

**Mapping of fluidization regimes: C**haracterization of particles, mechanics of flow around single particles, minimum fluidization velocity, pressure drop versus velocity diagram, The Geldart classification of solids, fluidization with carryover of particles, terminal velocity of particles, distributor types, gas entry region of bed, pressure drop requirements, design of gas distributor, power consumption

**Bubbling fluidized beds:** Davidson model for bubble in a fluidized bed, and its implications, the wake region and movement of solids at bubbles, coalescence and splitting of bubbles, bubble formation above a distributor, slug flow, Turbulent and fast fluidization - mechanics, flow regimes and design equations, Emulsion movement, estimation of bed properties, bubble rise velocity, scale up aspects, flow models, two phase model, K-L model

**Solids movement and Gas dispersion:** Vertical and horizontal movement of solids, Dispersion model, large solids in beds of smaller particles, staging of fluidized beds Gas dispersion in beds, gas interchange between bubble and emulsion, estimation of gas interchange coefficient, Heat and mass transfer in fluidized systems, Mixing in fluidized systems - measurements and models.

**Fluidized bed reactors:** Entrainment and elutriation, Freeboard behavior, gas outlet, entrainment from tall vessel, freeboard entrainment model, high velocity fluidization, pressure drop in turbulent and fast fluidization, Slugging, Spouted beds, Circulating Fluidized Beds.

Mathematical model of a homogeneous fluidized bed, Design of catalytic reactors, pilot plant reactors, information for design, bench scale reactors, design decisions, deactivating catalysts, Design of no catalytic reactors, kinetic models for conversion of solids, models for shrinking particles, conversion of solids of unchanging size

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

- Performing and understanding the behavior fluidization in fluidized bed
- Evaluate the characterization of particles and power consumption in fluidization regimes
- Understanding the applicability of the fluidized beds in chemical industries

***Texts Books***

- Levenspiel O. and Kunnii D., "Fluidization Engineering", John Wiley, 1972

***Reference Books***

- Liang-Shih Fan, "Gas-Liquid-Solid Fluidization Engineering", Butterworths, 1989

- **Course Outcomes and their mapping with programme Outcomes**

| COs | PROGRAM OUTCOMES (POs) | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | I | II | III |
| CO1 | **3** | **1** | **2** | **2** | **3** | **2** | | | | | | | **2** | **1** | |
| CO2 | **3** | **2** | **1** | **2** | **2** | **3** | | | | | | | **2** | **2** | |
| CO3 | **3** | **2** | **2** | **2** | **2** | **2** | | | | | | | **2** | **2** | |

**Weightage:** 1-Slightly; 2-Moderate; 3-Strongly

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| CHPATP1 | ADVANCED WASTEWATER TREATMENT TECHNOLOGY | 3:0:0 | 3 |

## Course Objective:

- It encompasses water and wastewater analytical and instrumental methods of analysis.
- Design considerations of various unit operations and processes of water treatment facilities.
- Learn aeration, sedimentation, coagulation and flocculation processes. Able to explain settling equations.
- It also deals with biological sludge handling and treatment

### Course Contents:

Introduction, Health and environment concern in wastewater management. Water quality: Definitions, characteristics and perspectives. The hydraulic cycle, Water quality, Physical, chemical and biological water quality parameters. Measurement of organic concentration, BOD, COD and TOC Test, reaction between BOD, COD, & TOC, Most probable number (MPN), Measurement of biological characteristics, Toxicity Test. Reactor used for transient of wastewater mass balance analysis, Modeling of ideal flow in reactor, Modeling of treatment process, Kinetic of processes, Process selection. Physical unit operations: Screening, mixing, Gravity separation, Primary sedimentation, Coagulation, Secondary treatment of waste water, adsorption. Biological waste water treatment, Micro-organism growth kinetics, modeling of suspended froth treatment process, Aerobic biological oxidation, Anaerobic process, heavy metal pollution remedies

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

- Explain the need for wastewater treatment, categorize the wastewater based on characteristics, illustrate reactor types in wastewater treatment.
- Understand and apply the design principles and criteria in designing units such as screen, grit chamber, primary settling tank. Establish biokinetic constants in the engineering design of wastewater treatment processes.
- Describe the design criteria and design the suspended and attached growth biological wastewater treatment systems like activated sludge process, trickling filter.
- Plan and perform aerobic and anaerobic treatment processes on both domestic wastewater and industrial effluent.

### ***Texts Books***

- Metcalf and Eddy, Wastewater Engineering: Treatment And Reuse, Tata McGraw Hill publication, India.

- Peavy H.S., Rowe D.R., Environment Engineering, McGraw Hill Book Company, New Delhi.


***Reference Books***


- Levenspiel O., Chemical Reaction Engineering, John Wiley and Sons publication
- Treybal R.E., Mass Transfer Operations, McGraw-Hill publication.
- Coulson & Richardson vol-II, Butterworth Heinemann Publication, New Delhi


- **Course Outcomes and their mapping with programme Outcomes**

| COs | PROGRAM OUTCOMES (POs) | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | I | II | III |
| CO1 | **3** | **1** | **2** | **2** | **3** | **2** | | | | | | | **2** | **1** | |
| CO2 | **3** | **2** | **1** | **2** | **2** | **3** | | | | | | | **2** | **2** | |
| CO3 | **3** | **2** | **2** | **2** | **2** | **2** | | | | | | | **2** | **2** | |
| CO4 | **3** | **2** | **2** | **3** | **3** | **2** | | | | | | | **2** | **1** | |

**Weightage:** 1-Slightly; 2-Moderate; 3-Strongly

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| CHPATP1 | ADVANCED CHEMICAL PROCESS MODELLING | 3:0:0 | 3 |

## Course Objective:

- To understand the systematic approaches for the development of modelling.
- To understand the mathematical modeling of chemical processes.

## Course Contents:

**Introduction to Modelling:** a systematic approach to model building, classification of models. Development of steady state and dynamic, lumped and distributed parameter models based on conservation principles.

**Models based on Transport Phenomenon Principles:** molecular description, microscopic and macroscopic description, multiple and maximum gradient description, boundary conditions.

**Classification of transport phenomena models:** Terminology of mathematical models, alternate classification of mathematical models, integral representation of models.

**Population balance models:** Description of flow pattern of flow pattern vessels, Age distribution functions, general population balance models, combined models.

**Course Outcome:** After learning the course, the students will be able to:

- To apply the suitable modelling approach for given problem.
- Analyze the terminology of mathematical models.
- Develop a mathematical model based on transport phenomenon and population balance for chemical processes.

***Texts Books***

1. Process Plant Simulation by B. V. Babu, Oxford University Press, 2004.
2. Process Analysis and Simulation deterministic system, David M. Himmelblau, John Wiley & Sons,

***Reference Books***

1. Process Modelling, M. M. Denn, John Wiley, 1987.
2. Mathematical Modeling, Rutherford Aris, Vol.1, A Chemical Engineer's Perspective (Process Systems Engineering), Academic Press, 1999.
3. Mathematical Modelling and Simulation in Chemical Engineering, M. Chidambaram, Cambridge University Press, 2018.
4. Process Modelling and Simulation in Chemical, Biochemical and Environmental Engineering, Ashok Kumar Verma, CRC Press, 2014.
5. Conservation Equations and Modelling of Chemical and Biochemical Processes, Said S. E. H. Elnashaie, Parag Garhyan, Marcel Dekker Publishers, 2003.
6. Process Modelling and Model Analysis, K. M. Hangos and I. T. Cameron, Academic Press, 2001.

- **Course Outcomes and their mapping with programme Outcomes**

| COs | PROGRAM OUTCOMES (POs) | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | I | II | III |
| CO1 | **3** | **1** | **2** | **2** | **3** | **2** | | | | | | | **2** | **1** | |
| CO2 | **3** | **2** | **2** | **2** | **2** | **3** | | | | | | | **2** | **2** | |
| CO3 | **3** | **3** | **3** | **3** | **3** | **3** | | | | | | | **2** | **2** | |

**Weightage:** 1-Slightly; 2-Moderate; 3-Strongly

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| CHPATP2 | ADVANCED PROCESS CONTROL | 3:0:0 | 3 |

## Course Objective:

- Expose students to the advanced control methods used in industries and research. This course prepares the student to take up such challenges in his profession.

**Advanced Control Strategies:** feed forward, cascade, dead time compensation, split range, selective and override control; automatic tuning and gain scheduling.

**Review of Systems:** Review of first and higher order systems, closed and open loop response. Response to step, impulse and sinusoidal disturbances. Transient response. Block diagrams.

**Stability Analysis:** Frequency response, design of control system, controller tuning and process identification. Zigler-Nichols and Cohen-Coon tuning methods, Bode and Nyquist stability criterion. Process identification. Special Control Techniques: Advanced control techniques, cascade, ratio, feed forward, adaptive control, Smith predictor, internal model control.

**Multivariable Control Analysis:** Introduction to state-space methods, Control degrees of freedom analysis and analysis, Interaction, Bristol arrays, Niederlinski index - design of controllers, Tuning of multivariable controllers.

**Sample Data Controllers:** Basic review of Z transforms, Response of discrete systems to various inputs. Open and closed loop response to step, impulse and sinusoidal inputs, closed loop response of discrete systems. Design of digital controllers. Introduction to PLC and DCS.

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

- Identify the control strategy.
- Type of controller to be used for a process
- Design of controllers for interacting multivariable systems
- Analyze the system response with and without control

## ***Texts Books***


- George Stephanopolous, Chemical Process Control An Introduction to Theory and Practice' Prentice Hall; 1st edition (1983).
- B.W. Bequette, 'Process Control: Modeling, Design and Simulation', PHI, 2006
- D.E. Seborg, T.F. Edger, and D.A. Millichamp, 'Process Dynamics and Control', John Wiley and Sons, 2nd Edition, 2004.

## ***Reference Books***


- B.A.Ogunnaike and W.H.Ray, "Process Dynamics, Modelling and Control", Oxford Press, 1994.
- W.L.Luyben, 'Process Modelling Simulation and Control for Chemical Engineers', McGraw Hill, 2nd Edition, 1990.
- S. Bhanot, 'Process Control: Principles and Applications', Oxford University Press, 2008.
- D.R. Coughanour, 'Process Systems analysis and Control', McGraw-Hill, 2nd Edition, 1991.


- **Course Outcomes and their mapping with programme Outcomes**

| **COs** | **PROGRAM OUTCOMES (POs)** | | | | | | | | | | | | **PSOs** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **I** | **II** | **III** |
| **CO1** | **1** | **2** | **2** | **2** | **1** | **2** | **2** | | | | | | **2** | **1** | **1** |
| **CO2** | **1** | **2** | **2** | **2** | **1** | **2** | **2** | | | | | | **2** | **1** | **1** |
| **CO3** | **2** | **3** | **2** | **2** | **1** | **1** | **2** | | | | | | **2** | **1** | **1** |
| **CO4** | **2** | **2** | **2** | **2** | **1** | **1** | **1** | | | | | | **2** | **1** | **1** |

**Weightage:** 1-Slightly; 2-Moderate; 3-Strongly

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| CHPATP2 | PROCESS INTENSIFICATION | 3:0:0 | 3 |

## Course Objective:

- Understand the concept of Process Intensification.
- Know the limitations of intensification of the chemical processes.
- Apply the techniques of intensification to a range of chemical processes.
- Develop various process equipment used for intensifying the processes.
- Infer alternative solutions keeping in view point, the environmental protection, economic viability and social acceptance.

**Introduction:** Techniques of Process Intensification (PI) Applications, The philosophy and opportunities of Process Intensification, Main benefits from process intensification, ProcessIntensifying Equipment, Process intensification toolbox, Techniques for PI application.

**Process Intensification through Micro Reaction Technology:** Effect of miniaturization on unit operations and reactions, Implementation of Microreaction Technology, From basic Properties to Technical Design Rules, Inherent Process Restrictions in Miniaturized Devices and Their Potential.

**Scales of Mixing, Flow Patterns in Reactors, Mixing in Stirred Tanks:** Scale up of mixing, Heat transfer. Mixing in intensified equipment, Chemical Processing in High-Gravity Fields Atomizer Ultrasound Atomization, Nebulizers, High intensity inline MIXERS reactors Static mixers, Ejectors, Tee mixers, Impinging jets, Rotor stator mixers, Design Principles of static Mixers Applications of static mixers, Higee reactors.

**Combined Chemical Reactor Heat Exchangers and Reactor Separators:** Principles of operation; Applications, Reactive absorption, Reactive distillation, Applications of RD Processes, Fundamentals of Process Modelling, Reactive Extraction Case Studies: Absorption of NOx Coke Gas Purification. Compact heat exchangers: Classification of compact heat exchangers, Plate heat exchangers, Spiral heat exchangers, Flow pattern, Heat transfer and pressure drop, Flat tube-and-fin heat exchangers, Microchannel heat exchangers, Phase-change heat transfer, Selection of heat exchanger technology, Feed/effluent heat exchangers, Integrated heat exchangers in separation processes, Design of compact heat exchanger - example.

**Enhanced Fields:** Energy based intensifications, Sono-chemistry, Basics of cavitation, Cavitation Reactors, Flow over a rotating surface, Hydrodynamic cavitation applications, Cavitation reactor design, Nusselt-flow model and mass transfer, The Rotating Electrolytic

Cell, Microwaves, Electrostatic fields, Sonocrystallization, Reactive separations, Superctrical fluids.

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

- Assess the values and limitations of process intensification, cleaner technologies and waste minimization options.
- Measure and monitor the usage of raw materials and wastes generating from production and frame the strategies for reduction, reuse and recycle.
- Obtain alternative solutions ensuring a more sustainable future based on environmental protection, economic viability and social acceptance.
- Analyze data, observe trends and relate this to other variables.
- Plan for research in new energy systems, materials and process intensification.

***Texts Books***

- Stankiewicz, A. and Moulijn, Reengineering the Chemical Process Plants, Process Intensification, Marcel Dekker, 2003.
- Reay D., Ramshaw C., Harvey A., Process Intensification, Butterworth Heinemann, 2008.

***Reference Books***

- Kamelia Boodhoo, Adam Harvey, Process Intensification Technologies for Green Chemistry: Engineering Solutions for Sustainable Chemical Processing, Wiley, 2013.
- Segovia-Hernández, Juan Gabriel, Bonilla-Petriciolet, Adrián Process Intensification in Chemical Engineering Design Optimization and Control, Springer, 2016.
- Reay, Ramshaw, Harvey, Process Intensification, Engineering for Efficiency, Sustainability and Flexibility, Butterworth-Heinemann, 2013.

- **Course Outcomes and their mapping with programme Outcomes**

| **COs** | **PROGRAM OUTCOMES (POs)** | | | | | | | | | | | | **PSOs** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **I** | **II** | **III** |
| **CO1** | **3** | **1** | **2** | **2** | **3** | **2** | | | | | | | **2** | **1** | |
| **CO2** | **3** | **2** | **2** | **2** | **2** | **3** | | | | | | | **2** | **2** | |
| **CO3** | **3** | **3** | **2** | **3** | **3** | **3** | | | | | | | **2** | **2** | |
| **CO4** | **3** | **2** | **3** | **2** | **2** | **2** | | | | | | | **2** | **2** | |
| **CO5** | **3** | **2** | **2** | **2** | **3** | **1** | | | | | | | **2** | **1** | |

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| CHPATP2 | BIOPROCESS ENGINEERING | 3:0:0 | 3 |

## Course Objective:

- To learn the principles of bioprocessing for traditional chemical engineering in the design and development of processes involving biocatalyst.
- To study engineering principles in the development of products based on living cells or subcomponents of such cells.
- To learn and develop quantitative models and approaches related to bioprocesses
- To learn mechanisitic models for enzyme catalyzed reactions for large scale production of bioproducts

**Introduction:** Biotechnology and bioprocessing. An overview of biological basics. Basics of enzyme and microbial kinetics. Operating considerations for bioreactors: cultivation method, modifying batch and continuous reactors, immobilized cell systems, solid state fermentations.

**Advance Enzyme Kinetics:** Models for complex enzyme kinetics, modeling of effect of pH and temperature, models for insoluble substrate, models for immobilized enzyme systems, diffusion limitations in immobilized enzyme system, electrostatic and steric effects.

**Bioreactors:** Selection, scale-up, operation and control of bioreactors: Scale-up and its difficulties, bioreactor instrumentation and control, sterilization of process fluids.Modifications of batch and continuous reactors, chemostat with recycle, multistage chemostat, fed-batch operation, perfusion system, active and passive immobilization of cells, diffusional limitations in the immobilized system, solid state fomenters.

**Homogeneous and heterogeneous reactions in bioprocesses:** Reaction thermodynamics, growth kinetics with Plasmid instability, The Thiele Modulus and effectiveness factor, diffusion and reaction in waste treatment lagoon. Reactors and choice of reactors.

**Recovery and purification of products:** Strategies to recover and purify products, separation of insoluble products, cell disruption, separation of soluble products

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

- Understand the different cells and their use in biochemical processes.
- Understand the role of enzymes in kinetic analysis of biochemical reaction.
- Analyze bioreactors, upstream and downstream processes in production of bio-products

- Demonstrate the fermentation process and its products for the latest industrial revolution

***Texts Books***

- Bailey J.E. and Ollis D.F., "Biochemical Engineering Fundamentals", McGraw-Hill

***Reference Books***

- Doran P.M., "Bioprocess Engineering Principles", Academic Press
- Shuler M.L., Kargi F., "Bioprocess Engineering", Prentice –Hall

- **Course Outcomes and their mapping with programme Outcomes**

| COs | PROGRAM OUTCOMES (POs) | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | I | II | III |
| CO1 | **3** | **1** | **2** | **2** | **3** | **2** | | | | | | | **2** | **1** | |
| CO2 | **3** | **2** | **2** | **2** | **2** | **3** | | | | | | | **2** | **2** | |
| CO3 | **2** | **1** | **1** | **3** | **3** | **3** | | | | | | | **2** | **2** | |
| CO4 | **2** | **2** | **2** | **2** | **2** | **2** | | | | | | | **2** | **2** | |

**Weightage:** 1-Slightly; 2-Moderate; 3-Strongly

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| CHPATC1 | RESEARCH METHODOLOGY AND IPR | 2:0:0 | 2 |

**Course Objective:**

- To familiarize participants with basic of research and the research process.
- To enable the participants with basic understanding of types of data and data collection methods.
- To enable the participants in conducting research work and formulating research synopsis and report.
- To familiarize participants with IPR.
- To impart knowledge for enabling students to develop data analytics skills and meaningful interpretation to the data sets so as to solve the research problem.

**Module 1**

**Introduction and Design of research**: Meaning, objectives and significance of research, types and parameters of research, research process, identification and definition of the research problem, definition of construct and variables, pure and applied research design, exploratory and descriptive design methodology, qualitative vs. quantitative research methodology, field studies, field experiments vs. laboratory experiments, research design in social and physical sciences.

**Module 2**

**Data and Methods of Data Collection**: Survey, assessment and analysis: data collection, primary and secondary sources of data, Collection of primary data through questionnaire and schedules. Collection of secondary data, processing and analysis of data. Sample survey, simple random sampling, stratified random sampling, systematic sampling, cluster sampling, area sampling and multistage sampling. Pilot survey, scaling techniques, validity & reliability.

**Module 3**

**Data Analysis:** Procedure for testing of hypothesis, the null hypothesis, determining levels of significance, type i and ii errors, grouped data distribution, measures of central tendency, measures of spread/dispersion, normal distribution, analysis of variance: one way, two way, chi square test and its application, students 'T' distribution, non-parametric statistical techniques, binomial test. Correlation and regression analysis – discriminate analysis – factor analysis – cluster analysis, measures of relationship

**Module 4**

Research report preparation and presentation: Review of literature: historical survey and its necessity, layout of research plan, meaning, techniques and precautions of interpretation, types of report: technical report, popular report, report writing – layout of

research report, mechanics of writing a research report. Writing bibliography and references.

**Module 5**

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grantsof patents, Patenting under PCT

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

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property
- Right to be promoted among students in general & engineering in particular.

***Texts Books***

- Research in education, By J W Best and J V Kahn, Pearson/ Allyn and Bacon.
- Research Methodology – Methods and Techniques, C K Kothari, New Age International

***Reference Books***

- Design and Analysis of Experiments, D C Montgomery, Wiley.
- Applied Statistics & Probability for Engineers, D C Montgomery & G C Runger, Wiley.
- Management Research Methodology: Integration of Principles, Methods and Techniques, K N Krishnaswamy, A I Sivakumar and M Mathiranjan, Pearson Education.

- **Course Outcomes and their mapping with programme Outcomes**

| COs | PROGRAM OUTCOMES (POs) | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | I | II | III |
| CO1 | **3** | **1** | **2** | **2** | **3** | **2** | | | | | | | **2** | **1** | |
| **CO2** | **3** | **2** | **2** | **2** | **2** | **3** | | | | | | | **2** | **2** | |
| **CO3** | **3** | **3** | **2** | **3** | **3** | **3** | | | | | | | **2** | **2** | |
| **CO4** | **3** | **2** | **3** | **2** | **2** | **2** | | | | | | | **2** | **2** | |
| **CO5** | **3** | **2** | **2** | **2** | **3** | **1** | | | | | | | **2** | **1** | |

**Weightage:** 1-Slightly; 2-Moderate; 3-Strongly

# Master of Technology

## Chemical Engineering

## Semester-II

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| CHPBTT1 | ADVANCED TRANSPORT PHENOMENA | 3:0:0 | 3 |

**Course Objective:**

- To familiarize the student with basic concepts of transport phenomena and brief review of mathematics.
- To enable students to understand the equations of change for isothermal flow and for non-isothermal flow.
- To introduce them details of equations of change for multi component systems.
- To give them insight into properties of two-dimensional flows and aspects of dimensional analysis.

**A review of vector and tensor operations**: vector calculus, curvilinear coordinate systems. Macroscopic Balances for Isothermal Systems: The Macroscopic Mass Balance, The Macroscopic Momentum Balance, The Macroscopic Mechanical Energy Balance, Estimation of the Viscous loss, Use of the Macroscopic Balances for Steady-State Problems, Derivation of the Macroscopic Mechanical Energy Balance.

**Review of shell balance.** Equations of Change for Isothermal Systems: Equation of Continuity, Equation of Motion, Equation of Mechanical Energy, Equations of Change in terms of the Substantial Derivative, Use of the Equations to solve Flow Problems, Dimensional Analysis of the Equations of Change. Velocity Distributions with more than one Independent Variable: Time Dependent Flow of Newtonian Fluids. Velocity Distributions in Turbulent Flow - Comparisons of Laminar and Turbulent Flows, Time Smoothed Equations of Change for Incompressible Fluids.

**Equations of Change for Non-Isothermal Systems:** The Energy Equation, Forced and Free Convection, Use of the Equations of change to Solve Steady-State Problems, Dimensional Analysis of the Equations of Change for Non-Isothermal Systems. Temperature Distributions in Solids and in Laminar Flow: Heat Conduction with an Electrical Heat

Source, Heat Conduction with a Viscous Heat Source. Temperature Distributions with more than One Independent Variable - Unsteady Heat Conduction in Solids, Temperature Distributions in Turbulent Flow – Time Smoothed Equations of Change for Incompressible Non-Isothermal Flow, Time-Smoothed Temperature Profile near a Wall, Empirical Expressions for the Turbulent Heat Flux Temperature Distribution for Turbulent Flow in Tubes.

**Macroscopic Balances for Non-Isothermal Systems:** Steady State Problems With Flat Velocity Profiles, Concentration Distributions in Solids and in Laminar Flow: Shell Mass Balances Boundary Conditions, Diffusion through a Stagnant Gas Film, Diffusion with a Heterogeneous Chemical Reaction. Concentration Distributions with more than One Independent Variable: Time-Dependent Diffusion, Steady-State Transport in Binary Boundary Layers, Concentration Distributions in Turbulent Flow - Concentration Fluctuations and the Time-Smoothed Concentration, Time-Smoothing of the Equation of Continuity of A, Semi-Empirical Expressions for the Turbulent Mass Flux, Enhancement of Mass Transfer by a First-Order Reaction in Turbulent Flow.

**Interphase Transport in Multi-Component Systems:** Definition of Transfer Coefficients in One Phase, Analytical Expressions for Mass Transfer Coefficients, Correlation of Binary Transfer Coefficients in One Phase, Definition of Transfer Coefficients in Two Phases, Mass Transfer and Chemical Reactions. Macroscopic Balances for Multi-Component Systems: Macroscopic Mass Balances, Macroscopic Momentum, Use of the Macroscopic Balances to solve Steady-State Problems.

**Course Outcome:** After learning the course, the students will be able to:

- Understand the mechanism of momentum, heat and mass transport for steady and unsteady flow.
- Perform momentum, energy and mass balances for a given system at macroscopic and microscopic scale.
- Solve the governing equations to obtain velocity, temperature and concentration profiles.
- Model the momentum, heat and mass transport under turbulent conditions.
- Develop analogies among momentum, energy and mass transport.

***Texts Books***


- Bird R. B., Stewart W. E. and Light Foot E. N., Transport Phenomena, Revised 2nd Edition, John Wiley & Sons, 2007.
- Geankopolis C. J., Transport Processes and Unit Operations, 4th Ed., Prentice Hall (India) Pvt. Ltd., New Delhi. 2004


***Reference Books***


- Thomson W. J., Transport Phenomena, Pearson education, Asia, 2001.
- Deen, W. M., Analysis of Transport Phenomena. Oxford Univ. Press. 1998.
- Leal L.G., Advanced Transport Phenomena: Fluid Mechanics and Convective Transport Processes. Cambridge Univ. Press 2008.
- White F.M., Fluid Mechanics, 7th Edition, McGraw Hill, New York, 2011.
- Ramchandran P.A., Advanced Transport Phenomena: Analysis, Modeling, and Computations, Cambridge University Press, 2014.
- Tosun Ismail., Modelling in Transport Phenomena a conceptual approach Elsevier, second edition, 2007


| | PROGRAM OUTCOMES (POs) | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | I | II | III |
| Vital feature → | *3* | *10* | *10* | *11* | *1* | *5* | *3* | *3* | *12* | *5* | *12* | *12* | | | |
| CO1 | 3 | *3* | *1* | *1* | | | | | | | | | *2* | *1* | *1* |
| CO2 | 3 | *3* | *2* | *1* | | | | | | | | | *2* | *1* | *1* |
| CO3 | 3 | *3* | *1* | *1* | | | | | | | | | *2* | *1* | *1* |
| CO4 | 3 | *3* | *2* | *1* | | | | | | | | | *2* | *1* | *1* |
| CO5 | 3 | *2* | *1* | *1* | | | | | | | | | *2* | *1* | *1* |

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| CHPBTT2 | CHEMICAL REACTOR DESIGN | 3:0:0 | 3 |

## Course Objective:

- This course introduces students to the application of kinetics and reaction engineering in chemical engineering processes.
- Understand the concepts such as standard states, chemical reaction rates, reaction mechanism mass balances and design equations for ideal reactors as well as non-ideal reactors

Review of Design of ideal isothermal homogeneous reactor for single and multiple reactions, RTD of Ideal reactor, interpretation of RTD data, Flow models for non-ideal reactors, dispersion model, N tanks in series, multi parameter model, diagnosing the ills of reactor , influence of RTD and micro mixing on conversion. Adiabatic and non adiabatic operations in batch and flow reactors, optimal temperature in progression. Hot spot in tubular reactor auto thermal operation and steady state multiple steady state introduction to bifurcation theory Catalytic reactors, effectiveness factor, selectivity, catalyst deactivation, Design of heterogeneous catalytic reactors.

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

- Understand the Adiabatic and non-adiabatic operations in batch and flow reactors,
- Understand the reactor design involving Catalytic reactors, effectiveness factor, selectivity, catalyst deactivation,
- Understand the design of heterogeneous catalytic reactors.

***Texts Books***

- James J Carberry: Chemical and Catalytic Reaction Engineering McGraw Hill
- J M Smith " Chemical Engineering Kinetics", McHill

***Reference Books***

- O. Levenspiel, " Chemical Reaction Engineering", Wiley Eastern, 2nd ed. 1972
- Frinebt G. F. Bischoff K. B; " Chemical Reactor Analyzer and design" John Wiley & Sons.
- H. S. Foggler; Elements of Chemical Reaction Engineering

- **Course Outcomes and their mapping with programme Outcomes**

| COs | PROGRAM OUTCOMES (POs) | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | I | II | III |
| CO1 | **3** | **1** | **2** | **2** | **3** | **2** | | | | | | | **2** | **1** | |
| **CO2** | **3** | **2** | **2** | **2** | **2** | **3** | | | | | | | **2** | **2** | |
| **CO3** | **3** | **3** | **2** | **3** | **3** | **3** | | | | | | | **2** | **2** | |

**Weightage:** 1-Slightly; 2-Moderate; 3-Strongly

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| CHPBTP1 | COMPUTATIONAL FLUID DYNAMICS | 3:0:0 | 3 |

**Course Objective:**

- To solve the various physical problems of both laminar and turbulent flows to be solved by numerical methods. The equations of change shall be transformed in the light of assumptions and solved under the suitable boundary conditions to obtain the differential equation.
- To provide an introduction to the scientific principles and practical engineering applications of computational fluid dynamics.
- To give exposure to the commercial software ANSYS Fluent

Basic principles and equations of change in transport of momentum, heat and mass; Equations of continuity, motion, angular momentum, energy, and equation of continuity for multicomponent mixture, Flow of Newtonian and non-Newtonian fluids, use of equation of change for developing equations for laminar flow in internal and external flows, boundary layer flows, flow in stirred tanks, flow in pipe line and over flat plates and other physical situations for both Newtonian and Non-Newtonian fluids, Philosophy of computational fluid dynamics CFD, grid generation, structured and unstructured grids, choice of suitable grid, grid transformation of equations, some modern developments in grid generation for solving engineering problems, CFD essentials, Finite difference method (FDM), finite volume method (FVM) and finite element method (FEM): Discretization of ODE and PDE, , Explicit and Implicit scheme to solve heat and fluid flow problems, Application of 1st order and 2nd order Upwind Scheme, Application of SIMPLE, SIMPLER algorithm to solve fluid flow problems, Simulation of CFD problems using Fluent.

**Course Outcome:** After learning the course, the students will be able to:

- To discretize the momentum, mass and energy transport equations by finite volume technique.
- To simulate CFD problems by using in house developed computer code.
- To solve some problems with the help of the ANSYS Fluent software.

***Texts Books***

- R.B. Bird., W.E. Stewart and E.N.Lightfoot, "Transport phenomena", 2nd Ed., Wiley, 1994
- J.D. Anderson, "Computational fluid dynamics", McGraw Hill. 1995


***Reference Books***


- H. K. Versteeg and Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Longman Scientific & Technical , 1995
- K. Muralidhar, and T. Sundararajan, Computational Fluid Flow and Heat Transfer, Narosa Publishing House , 1995
- A. W. Date, Introduction to Computational Fluid Dynamics, Cambridge University Press, 2005.


- **Course Outcomes and their mapping with programme Outcomes**

| COs | PROGRAM OUTCOMES (POs) | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | I | II | III |
| CO1 | **3** | **1** | **2** | **2** | **3** | **2** | | | | | | | **2** | **1** | |
| **CO2** | **3** | **2** | **2** | **2** | **2** | **3** | | | | | | | **2** | **2** | |
| **CO3** | **3** | **2** | **2** | **2** | **3** | **1** | | | | | | | **2** | **1** | |

**Weightage:** 1-Slightly; 2-Moderate; 3-Strongly

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| CHPBTP1 | FUEL CELL TECHNOLOGY | 3:0:0 | 3 |

**Course Objectives:**

1. To understand the fundamental principles of fuel cell technology
2. To analyze the performance characteristics of fuel cells
3. To design and optimize fuel cell systems
4. To understand fuel cell materials and their properties
5. To evaluate the environmental and energy benefits of fuel cell technology

**UNIT-I** Overview of fuel cells, work potentials, prediction of reversible voltage, fuel cell efficiency.

**UNIT-II** Working and types of fuel cell-low, medium and high temperature fuel cell, liquid and methanol types, proton exchange membrane fuel cell solid oxide, Alkaline fuel cells, Phosphoric fuel cells, molten carbonate fuel cells, Solid oxide fuel cells, hydrogen fuel cells, microbial fuel cells, thermodynamics and electrochemical kinetics of fuel cells.

**UNIT-III** Fuel cell reaction kinetics, electrode kinetics, overvoltages, Tafel equation, charge transfer reaction, exchange currents, electro catalysis, design, activation kinetics, Fuel cell charge and mass transport, flow field, transport in electrode and electrolyte.

**UNIT-IV** Fuel cell characterization, In-situ and ex-situ characterization techniques, I-V curve, frequency response analyses; Fuel cell modeling and system integration: 1D model-analytical solution and CFD models.

**UNIT-V** Balance of plant, Hydrogen production from renewable sources and storage; safety issues, cost expectation and life cycle analysis of fuel cells.

**Suggested Text Books**

1. M.M. MENCH, Fuel Cell Engines, Wiley, 2008.
2. M.T.M. Koper (ed.), Fuel Cell Catalysis, Wiley, 2009.
3. Larminie J., Dick A., Fuel Cell Systems Explained, 2nd Ed. Wiley, 2003.
4. PEM Fuel Cells Theory and Practice, Frano Barbir, Elsevier Academic Press, 2005.
5. Fuel Cell Technology Handbook, Gregor Hoogers, SAE International, 2003

**Reference Books**

1. Fuel Cell Principles and Applications, B Viswanathan and M Aulice Scibioh, Universities Press, 2006.

**Course Outcome:** Upon completion of the course in Fuel Cell Technology, students should be able to:

1. Demonstrate a solid understanding of the principles and working mechanisms of fuel cells, including electrochemistry, thermodynamics, and energy conversion.
2. Analyze and evaluate the performance characteristics of fuel cells, such as efficiency, power density, voltage-current characteristics, and fuel utilization.
3. Design and optimize fuel cell systems for various applications, considering factors such as system integration, balance of plant components, and overall system efficiency.
4. Identify and address challenges and limitations associated with the implementation and scaling up of fuel cell technology in commercial applications.
5. Apply their knowledge to select appropriate fuel cell technologies for specific applications based on performance requirements, cost considerations, and environmental impacts.

***Course Articulation Matrix (CO-PO/PSO Mapping)***

| COs | Program Outcomes (POs) | | | | | | | | | | | | Program Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 3 | | 2 | | | 2 | 2 | | | | | | 3 | | |
| CO2 | 3 | 2 | 2 | | | 2 | 2 | | | | | | 3 | | |
| CO3 | 3 | | 2 | 2 | | 2 | 2 | | | | | | 3 | | |
| CO4 | | 2 | 2 | | 2 | 2 | 2 | | | | | | 3 | | |
| CO5 | | 2 | | | 2 | 2 | 2 | | | | | | 3 | | |

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| CHPBTP1 | PROCESS PLANT DESIGN & FLOW SHEETING | 3:0:0 | 3 |

## Course Objective:

- Understanding of the scope, principles, norms, accountabilities and bounds of contemporary engineering practice in the specific discipline.
- Application of established engineering methods to complex engineering problem solving.
- Application of systematic engineering synthesis and design processes

**Course Content:**

**Introduction: Basic concepts:** General design considerations, Process design development, Layout of plant items, Flow sheets and PI diagrams, Economic aspects and Optimum design, Practical considerations in design and engineering ethics, Degrees of freedom analysis in interconnected systems, Network analysis, PERT/CPM, Direct and Indirect costs, Optimum scheduling and crashing of activities.

**Hierarchy of chemical process design;** Nature of process synthesis and analysis; Developing a conceptual design and flow sheet synthesis. Synthesis of reaction-separation systems; Distillation sequencing; Energy targets. Heat integration of reactors, distillation columns, evaporators and driers; Process change for improved heat integration. Heat and mass exchange networks and network design.

**Flow-sheeting: Synthesis of flow sheet:** Propositional logic and semantic equations, Deduction theorem, Algorithmic flow sheet generation using P-graph theory, Sequencing of operating units, Feasibility and optimization of flow sheet using various algorithms viz, Solution Structure Generation (SSG), Maximal Structure Generation (MSG), Simplex, Branch-and-bound etc.

**Analysis of Cost estimation:** Factors affecting Investment and production costs, Estimation of capital investment and total product costs, Interest, Time value of money, Taxes and Fixed charges, Salvage value, Methods of calculating depreciation, Profitability, Alternative investments and replacements.

**Optimum Design and Design Strategy:** Break-even analysis, Optimum production rates in plant operation, Optimum batch cycle time applied to evaporator and filter press, Economic pipe diameter, Optimum insulation thickness, Optimum cooling water flow rate and optimum distillation reflux ratio.

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

- Analyze, synthesize and design processes for manufacturing products commercially

- Integrate and apply techniques and knowledge acquired in other courses such as thermodynamics, heat and mass transfer, fluid mechanics, instrumentation and control to design heat exchangers, plate and packed columns and engineering flow diagrams
- Use commercial flow sheeting software to simulate processes and design process equipment
- Recognize economic, construction, safety, operability and other design constraints
- Estimate fixed and working capitals and operating costs for process plants

## ***Texts Books***


- Peters, M.A. and Timmerhaus, K.D., Plant Design and Economics for Chemical Engineers, McGraw Hill (2003).
- Anil Kumar, Chemical Process Synthesis and Engineering Design, Tata McGraw Hill (1982).


## ***Reference Books***


- Ulrich, G.D., A Guide to Chemical Engineering Process Design and Economics, John Wiley & Sons (1984).
- Perry, R.H. and Green, D., Chemical Engineer's Handbook, McGraw-Hill (1997).


- **Course Outcomes and their mapping with programme Outcomes**

| COs | PROGRAM OUTCOMES (POs) | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | I | II | III |
| CO1 | **3** | **1** | **2** | **2** | **3** | | | | | | | | **2** | **1** | |
| **CO2** | **3** | **3** | **3** | **3** | **3** | | | | | | | | **2** | **2** | |
| **CO3** | **3** | **2** | **2** | **1** | **1** | | | | | | | | **2** | **2** | |
| **CO4** | **3** | **2** | **2** | **1** | **2** | | | | | | | | **2** | **2** | |
| **CO5** | **3** | **3** | **3** | **1** | **3** | | | | | | | | **2** | **2** | |

**Weightage:** 1-Slightly; 2-Moderate; 3-Strongly

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| CHPBTP2 | DESIGN & DEVELOPMENT OF CATALYST | 3:0:0 | 3 |

## Course Objective:

- To give the students insight into advances in catalytic reaction engineering
- To understand the mechanisms involved in catalytic reactions
- To study the catalyst characterization techniques
- To study the advanced industrial applications in catalysis
- To understand the principles behind catalyst deactivation and study their models

**Course Contents:**

Structure of solid surfaces; Chemisorption and Physisorption; Thermodynamics and kinetics of surface processes; Principles of heterogeneous catalysis; Preparation, characterization and classification; Structure and activity; Lattice imperfection; Geometric and electronic factors Preparation and characterization of catalysts. Kinetics of heterogeneous reactions. Physical, Chemical and mathematical description of catalyst deactivation; Deactivation by fouling, poisoning and sintering. Deactivation and regeneration of catalyst pellets. Deactivation and regeneration of fixed beds. Dynamics of polyfunctional catalysts. Electrocatalysis and photocatalysis. Mechanism and kinetics of some typical heterogeneous catalytic reactions. Applications in fertilizer, petroleum, petrochemical industries and pollution control.

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

- To understand the concepts of homogenous and heterogeneous catalysis, with specific examples.
- To study reaction mechanisms and kinetics of homogenous and heterogeneous catalytic reactions.
- To familiarize with the characterization of catalysts
- To understand the application and mechanisms of several types of catalysts in chemical industry

***Texts Books***


- G. Poncelet, J. Martens, B. Delmon; Preparation of Catalyst VI : Scientific bases for the preparation of Haterogeneous Catalysts; Elseveir
- John Regalbuto; Catalyst Preparation : Science and Engineering; CRC Press


***Reference Books***

- Emmett, P.H. - "Catalysis Vol. I and II, Reinhold Corp.", New York, 1954
- Smith, J.M. - "Chemical Engineering Kinetics ", McGraw Hill, 1971
- Thomas and Thomas - "Introduction to Heterogeneous Catalysts ", Academic Press, London 1964
- Piet W.N.M. van Leeuwen, Homogeneous catalysis: Understanding the Art, Springer, 2004

- Piet W.N.M. van Leeuwen, and John C. Chadwick, Homogeneous catalysis: Activity-stability deactivation, Wiley, VCH, 2011


**Course Outcomes and their mapping with programme Outcomes**

| COs | PROGRAM OUTCOMES (POs) | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | I | II | III |
| CO1 | **3** | **1** | **2** | **2** | **3** | **2** | | | | | | | **2** | **2** | |
| CO2 | **2** | **2** | **3** | **2** | **2** | **2** | | | | | | | **3** | **2** | |
| CO3 | **2** | **1** | **3** | **2** | **2** | **2** | | | | | | | **2** | **2** | |
| CO4 | **3** | **2** | **1** | **2** | **1** | **2** | | | | | | | **2** | **2** | |

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| CHPBTP2 | INDUSTRIAL POLLUTION CONTROL | 3:0:0 | 3 |

## Course Objective:

- To understand the importance of industrial pollution and its abatement
- To study the underlying principles of industrial pollution control
- To acquaint the students with case studies
- Student should be able to design complete treatment system

## Course Contents:

**Module 1**: Brief review of industrial, municipal, and natural Pollution sources, Environmental pollution and socioeconomic impacts, Concept of EIA, Environmental modeling as a tool for environmental management.

**Module 2**: Generation, transport, and decay of air pollutants; Sampling and monitoring methods. Strategies and methods for removal of gaseous pollutants and particulates from process exhaust streams; Air pollution abatement technology; Detail design of particulates and gaseous emission control equipment; Air quality modeling for point, line and area sources, Air pollution indices; Air Pollution legislation and regulations. Case studies of a few industrial pollution control system

**Module 3**: Water Pollution: Surface water quality modelling, Ground water quality impacts. Wastewater Treatment Plant design: Physical unit operations, Chemical precipitation, disinfection, adsorption, Aerobic and anaerobic biological treatment processes, Advanced wastewater treatment processes: electro-chemical treatment methods, advanced oxidation processes, membrane processes.

**Module 4**: Industrial Noise Pollution: Properties of noise and its effects, Sources and control of industrial noise pollution.

**Module 5**: Solid Waste: Sources and classification, Methods of solid waste disposal, Solids waste and landfill management, Natural composting, Accelerated composting of industrial sludge, Municipal solid waste management, Toxic waste management.

**Course Outcomes**: After learning the course, the students will be able to:

1. evaluate impact of different types of waste generated
2. model the atmospheric dispersion of air pollutants and design the air pollution control systems
3. monitor and design the water pollution control systems apply knowledge for the protection and improvement of the environment
4. design the industrial noise pollution control systems
5. select and implement industry specific waste treatment system as well as apply knowledge for the management and minimization of waste.

## ***Texts Books***

3. K B Schnelle & C. A. Brown, Air Pollution Control Technology Handbook, CRC Press
4. H. S. Peavy, Donald R Rowe & George Tchobanoglous, Envo\ironment engineering, McGraw-Hill
5. Environmental Pollution Control., by C.S.Rao, wiely eastern ltd.

## ***Reference Books***

1. R. K. Trivedy & P K Goel, An Introduction to Air Pollution, Technoscience Pub.
2. Dharmendra S. Sengar; Environmental Law, PHI
3. Dr B. C, Arun Ku. Jain, Ashok Ku. Jain; Waste Water Engineering
4. De Nevers, N., Air Pollution Control Engineering, McGraw-Hill (1995).

## ***Course Articulation Matrix (CO-PO/PSO Mapping)***

| COs | Program Outcomes (POs) | | | | | | | | | | | | Program Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 2 | 2 | 2 | 1 | | 2 | | | | | | | 3 | | |
| CO2 | 3 | 2 | 2 | 2 | | 2 | | | | | | | 3 | | |
| CO3 | 3 | 2 | 2 | 2 | | 2 | | | | | | | 3 | | |
| CO4 | 3 | 2 | 2 | 2 | | 2 | | | | | | | 3 | | |
| CO5 | 3 | 2 | 2 | 2 | | 2 | | | | | | | 3 | | |

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| CHPBTP2 | SAFETY HAZARDS & RISK ANALYSIS | 3:0:0 | 3 |

## Course Objective:

- This course enables student to learn the basic principles of safety.
- The course deals with sufficient knowledge on need and principles of risk assessment methodologies and tools.
- It provides knowledge on cause - effect relationships of accidents at work places, hazard identification and control aspects, fire prevention and control.
- Work place health related issues are also covered.

Safety legislations: Safety programmers, Public perceptions, Engineering ethics, Government police on safety hazard identification, preliminary hazard and operability (HAZOP) analysis, event tree, fault tree analysis, Toxic releases, to phase phenomenon, emission and dispersion models, estimation and prevention, fire and explosions, chemistry of fire, fire triangle, fire and explosion index (FEI), estimating, heat effects, vapor cloud explosion (VCE),boiling liquid expanding vapor explosions(BLEVE) and prevention, industrial hygiene, health hazards, evaluations of work's exposure to toxicants, control methods, Hazard management safety system, relief systems, risk management routines, emergency plans, and disaster control ergonomics Case histories of some major accidents, Nuclear radiation hazards and safety from these.

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

- Define terminologies; Explain risk assessment models and tools.
- Perform the process of risk assessment and illustrate exposure assessment models.
- List hazard identification methods.
- Review of case studies with respect to risk identification, assessment and emergency preparedness.

## ***Texts Books***

- Saha S. N., Fuel Combustion Energy Technology, Dhanpat Rai Pub. (P) Ltd, New Delhi, 1st Edition 2003
- G. L. Wells, Safety in Process Plant Design

## ***Reference Books***

- Sanjoy Banerjee, Industrial Hazard & Plant Safety (8)
- Daniel A. Crowl, Josheph F. Louvar, Chemical Process Safety : Fundamentals with Applications, Prentice Hall
- Frank P, Lees, Loss Prevention in the Process Industries, Butterworths, London


| COs | Program Outcomes (POs) | | | | | | | | | | | | Program Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 2 | 2 | 2 | 1 | | 2 | | | | | | | 3 | | |
| CO2 | 3 | 2 | 2 | 2 | | 2 | | | | | | | 3 | | |
| CO3 | 3 | 2 | 2 | 2 | | 2 | | | | | | | 3 | | |
| CO4 | 3 | 2 | 2 | 2 | | 2 | | | | | | | 3 | | |

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| MSPBTO1 | BUSINESS ANALYTICS | 3:0:0 | 3 |

| Course outcomes: | At the end of the course, students will be able to |
|---|---|
| 1 | Students will demonstrate knowledge of data analytics |
| 2 | Students will demonstrate the ability of think critically in making decisions based on data and deep analytics. |
| 3 | Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making. |
| 4 | Students will demonstrate the ability to translate data into clear, actionable insights. |

**Syllabus Contents:**

- Unit1: Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.
- Unit 2: Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.
- Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.
- Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.
- Unit 5: Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, the Value of Information, Utility and Decision Making.
- Unit 6: Recent Trends in Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

**References:**


- Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
- Business Analytics by James Evans, persons Education..

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| IPPBTO2 | INDUSTRIAL SAFETY | 3:0:0 | 3 |

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

1 Apply the knowledge of Safety Measures

2 Plan for Engineering maintenance.

3 Determine the wear & Corrosion and apply methods for their prevention.

4 Trace the Fault of machine tools and equipment

5 Plan and implement the periodic and preventive maintenance for machines/equipment.

**Syllabus Contents:**

- Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.
- Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.
- Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.
- Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.
- Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

**References:**

- Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.

- Maintenance Engineering, H. P. Garg, S. Chand and Company.
- Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
- Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.


| Cos | Program Outcomes (POs) | | | | | | | | | | | | Program Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| | **3** | **10** | **10** | **11** | **1** | **5** | **3** | **3** | **12** | **5** | **12** | **12** | **3** | **2** | **1** |
| CO1 | 3 | 2 | 1 | | | | | - | - | - | - | - | 3 | 2 | 1 |
| CO2 | 2 | 1 | 1 | | | | | - | - | - | - | - | 2 | 1 | 1 |
| CO3 | 3 | 2 | 1 | 1 | 1 | | | - | - | - | - | - | 2 | 2 | 1 |
| CO4 | 3 | 2 | 1 | | | | | - | | - | - | - | 3 | 2 | 1 |
| CO5 | 3 | 2 | 1 | | | | | | | | | | 3 | 2 | 1 |

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| IPPBTO3 | OPERATIONS RESEARCH | 3:0:0 | 3 |

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

1 Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.

2 Students should able to apply the concept of non-linear programming

3 Students should able to carry out sensitivity analysis

4 Student should able to model the real world problem and simulate it.

**Syllabus Contents:**

- Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models
- Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming
- Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT
- Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.
- Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

**References:**


- H.A. Taha, Operations Research, An Introduction, PHI, 2008
- H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
- J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
- Hitler Libermann Operations Research: McGraw Hill Pub. 2009
- Pannerselvam, Operations Research: Prentice Hall of India 2010
- Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010


| Cos | Program Outcomes (POs) | | | | | | | | | | | | Program Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| | **3** | **10** | **10** | **11** | **1** | **5** | **3** | **3** | **12** | **5** | **12** | **12** | **3** | **2** | **1** |
| CO1 | 2 | 3 | | 2 | 1 | - | - | - | - | - | - | 2 | 3 | 3 | - |
| CO2 | 2 | 3 | | 2 | 1 | - | - | - | - | - | - | 2 | 3 | 3 | - |
| CO3 | 2 | 3 | | 2 | 1 | - | - | - | - | - | - | 2 | 3 | 3 | - |
| CO4 | 2 | 3 | 3 | 2 | 1 | - | - | - | | - | - | 2 | 3 | 3 | - |

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|

| CEPBT04 | COST MANAGEMENT OF ENGINEERING PROJECTS | 3:0:0 | 3 |
|---|---|---|---|

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

1 Discuss the cost concepts in the cost management process.

2 Able to handle the projects by the application of project cost control methods.

3 Determine all types of costing and carryout the analysis of pricings for profitability.

4 Application of PERT/CPM for cost management.

**Syllabus Contents:**

- Introduction and Overview of the Strategic Cost Management Process
- Cost concepts in decision-making; relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.
- Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process
- Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.
- Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

**References:**


- Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
- Charles T. Horngren and George Foster, Advanced Management Accounting
- Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
- Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
- N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.


| Cos | Program Outcomes (POs) | Program Specific Outcomes (PSOs) |
|---|---|---|

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **3** | **10** | **10** | **11** | **1** | **5** | **3** | **3** | **12** | **5** | **12** | **12** | **3** | **2** | **1** |
| CO1 | - | - | - | - | 2 | 3 | - | 2 | - | - | 3 | 2 | - | 2 | 1 |
| CO2 | 1 | - | 1 | - | 2 | 3 | 1 | 2 | - | - | 3 | 1 | - | 2 | 1 |
| CO3 | 2 | 2 | - | 1 | 2 | 2 | - | - | - | - | 3 | 1 | - | 2 | 1 |
| CO4 | 2 | 1 | 3 | - | 3 | 1 | - | 2 | - | - | 3 | 3 | - | 2 | 1 |

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| MEPBTO5 | COMPOSITE MATERIALS | 3:0:0 | 3 |

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

1 Explain and also implement the composite materials for the required performance based on the characteristics.

2 Adopt the composite materials as reinforcements.

3 Implement the methods of manufacturing of metal matrix composites

4 Adopt the methods of manufacturing of polymer matrix composites

5 Evaluate the strength of laminates.

**Syllabus Contents:**

- INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.
- REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.
- Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.
- Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.
- Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations

**References:**


- Material Science and Technology – Vol 13 – Composites by R. W. Cahn – VCH, West Germany.
- Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R.
- Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.
- Hand Book of Composite Materials-ed-Lubin.
- Composite Materials – K.K.Chawla.
- Composite Materials Science and Applications – Deborah D.L. Chung.

- Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

| Cos | Program Outcomes (POs) | | | | | | | | | | | | Program Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| | **3** | **10** | **10** | **11** | **1** | **5** | **3** | **3** | **12** | **5** | **12** | **12** | **3** | **2** | **1** |
| CO1 | 3 | 2 | 2 | 1 | - | 1 | 1 | - | - | - | - | - | 2 | - | - |
| CO2 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | - | - | - | - | - | 1 | - | - |
| CO3 | 3 | 2 | 2 | 2 | 2 | 1 | 1 | - | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| CO4 | 3 | 2 | 2 | 2 | - | 1 | 1 | - | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| CO5 | 3 | 2 | 2 | 2 | - | 1 | 1 | - | 1 | 1 | 1 | 1 | 2 | 1 | 1 |

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| CHPBTO6 | WASTE TO ENERGY | 3:0:0 | 3 |

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

1 Classify the waste for fuel and identify the devices for conversion of waste to energy.

2 Implement the Biomass Pyrolysis

3 Evaluate the methods of Biomass Gasification and implement their applications.

4 To design, construct and operation the Biomass Combustion devices.

5 Classify biomass, apply the bio energy systems design and construction.

**Syllabus Contents:**

- Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors
- Biomass Pyrolysis: Pyrolysis – Types, slow, fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.
- Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.
- Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.
- Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

**References:**


- Non-Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
- Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
- Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
- Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.


| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **3** | **10** | **10** | **11** | **1** | **5** | **3** | **3** | **12** | **5** | **12** | **12** | **3** | **2** | **1** |
| CO1 | 3 | 1 | 2 | 0 | - | 1 | 1 | - | - | - | - | - | 1 | - | - |
| CO2 | 3 | 2 | 2 | 1 | - | 1 | 1 | - | - | - | - | - | 3 | - | - |
| CO3 | 3 | 2 | 2 | 1 | - | 1 | 1 | - | - | - | - | - | 3 | - | - |
| CO4 | 3 | 2 | 2 | 1 | - | 1 | 1 | - | | - | - | - | 3 | - | - |
| CO5 | 3 | 2 | 2 | 1 | - | 2 | 2 | - | - | - | -- | - | 3 | - | - |

| SUBJECT CODE | SUBJECT NAME | L:T:P | Credit |
|---|---|---|---|
| ECPBTO7 | INTERNET OF THINGS (IoT) | 3:0:0 | 3 |

Review of computer communication concepts (OSI layers, components, packet communication, Networks, TCP-IP, subnetting, IPV4 addressing and challenges). IPV6 addressing. IoT architecture reference layer. Characteristics IoT sensor nodes, Edge computer, cloud and peripheral cloud, single board computers, open source hardware, Examples of IoT infrastructure.

**IoT and M2M**

Software defined networks, network function virtualization, difference between SDN and NFV for IoT, Basics of IoT System Management with NETCOZF, YANG- NETCONF, YANG, SNMP NETOPEER.

**IOT protocols and Communication Technologies**

MQTT, UDP, MQTT brokers, publish subscribe modes, HTTP, COAP,XMPP and gateway protocols, IoT Communication Pattern, IoT Protocol Architecture, Selection of Wireless technologies ( 6LoWPAN, Zigbee, WIFI, BT, BLE,SIG,NFC, LORA, Lifi, Widi).

**Data and Analytics for IoT**

An Introduction to Data Analytics for IoT, Machine Learning, Big Data Analytics Tools and Technology, Edge Streaming Analytics, Network Analytics, Securing IoT, A Brief History of IOT Security, Common Challenges in IOT Security, How IT and OT Security Practices and Systems Vary, Formal Risk Analysis Structures: OCTAVE and FAIR, The Phased Application of Security in an Operational Environment.

**IoT Physical Devices and Endpoints**: Introduction to Arduino and Raspberry Pi- Installation, Interfaces (serial, SPI, I2C), Programming – Python program with Raspberry PI with focus on interfacing external gadgets, controlling output, reading input from pins.

| Course outcomes: | At the end of the course, students will be able to |
|---|---|

**IoT Physical Servers and Cloud Offerings**: Introduction to Cloud Storage models and communication APIs WebServer: Web server for IoT, Cloud for IoT, Python web application framework Designing a RESTful web API.

**IoT application and its Variants: Case studies:** IoT for smart cities, smart grid, health care, agriculture, smart meters.M2M, Web of things, Cellular IoT, Industrial IoT, Industry 4.0,IoT standards.

| | |
|---|---|
| 1 | Understand the concepts of Internet of Things. |
| 2 | Analyze basic protocols in wireless sensor network. |
| 3 | Design IoT applications in different domain and be able to analyze their performance |
| 4 | Elaborate the need for Data Analytics and Security in IoT. |
| 5 | Understand the concepts of Internet of Things. |

**References:**


- "Internet of Things - A Hands-on Approach", Arshdeep Bahga and Vijay Madisetti, Universities Press, 2015, ISBN: 9788173719547
- "Internet of Things", Srinivasa K G, CENGAGE Leaning India, 2017.
- " IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things", David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry1stEdition, Pearson Education (Cisco Press Indian Reprint). (ISBN: 978-9386873743)
- "Getting Started with Raspberry Pi", Matt Richardson & Shawn Wallace, O'Reilly (SPD), 2014, ISBN: 9789350239759.
- "From Machine to Machine to Internet of Things", Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand, David Boyle, Elsevier Publications, 2014.

| SUBJECT CODE | SUBJECT NAME | L:T:P | Audit |
|---|---|---|---|
| ITPBTO9 | SOFTWARE ENGINEERING TECHNIQUES | 2:0:0 | 2 |

Course Objectives:

1. Knowledge of basic SW engineering methods and practices, and their appropriate application.

2. Describe software engineering layered technology and Process frame work.

3. A general understanding of software process models such as the waterfall and evolutionary models.

4. Understanding of software requirements and the SRS documents.

5. Understanding of the role of project management including planning, scheduling, risk management, etc.

Course Outcomes: After completion of course, students would be able to:

1. Basic knowledge and understanding of the analysis and design of complex systems.

2. Ability to apply software engineering principles and techniques.

3. Ability to develop, maintain and evaluate large-scale software systems.

4. to produce efficient, reliable, robust and cost-effective software solutions.

5. Ability to perform independent research and analysis.

UNIT – I Introduction to Software Engineering: Introduction, Total Effort devoted to Software, Distribution of Effort, Project size Categories, Quality and Productivity Factors, Managerial Issues. Planning a Software Project: Goals and Requirements, Developing a Solution Strategy, The Phased Life-Cycle Model, Milestones, Documents, and Reviews, The Cost Model, The Prototype Life-Cycle Model, Successive Versions, Planning an Organizational Structure, Planning for Configuration Management and Quality Assurance, Planning for Independent Verification and Validation, Planning Phase-Dependent Tools and Techniques.

UNIT – II Software Cost Estimation: Software Cost Factors, Software Cost Estimation Techniques, Expert Judgment, Delphi Cost Estimation, Work Breakdown Structure, Algorithmic Cost Models, Staffing Level Estimation, Estimating Software Maintenance Costs. Software Requirements Definition: The Software Requirements Specification, Formal Specification Techniques : Relational Notations - Implicit Equations/Recurrence Relations/Algebraic Axioms/ Regular Expressions; State-Oriented Notations - Decision Tables/ Event Tables / Transition Tables /Finite-state Mechanisms/Petri Nets.

UNIT – III Software Design: Fundamental Design Concepts, Modules and Modularization Criteria, Design Notations, Design Techniques, Detailed Design Considerations, Real-Time and

Distributed System Design, Test Plans, Milestones, Walkthroughs, and Inspections, Design Guidelines.

UNIT – IV Implementation Issues: Structured Coding Techniques, Coding Style, Standards and Guidelines, Documentation Guidelines. Modern Programming Language Features: Type Checking, User Defined Date Types, Data Abstraction, Scoping Rules, Exception Handling. UNIT –V Verification and Validation Techniques: Quality Assurance, Walkthroughs and Inspections, Unit Testing and Debugging, System Testing. Software Maintenance: Enhancing Maintainability during Development, Managerial Aspects of Software Maintenance, Configuration Management, Source-Code Metrics.

Text Books:

1. R. Fairley, "Software Engineering Concepts", Tata McGraw Hill, 1997.

2. R. S. Pressman, "Software Engineering – A practitioner's approach", 5th ed., McGraw Hill Int. Ed., 2001.

3. K.K. Aggarwal & Yogesh Singh, "Software Engineering", New Age International, 2001. References:

4. P. Jalote, "An Integrated approach to Software Engineering", Narosa, 1991.

5. Stephen R. Schach, "Classical & Object Oriented Software Engineering", IRWIN, 1996.

6. James Peter, W Pedrycz, "Software Engineering", John Wiley & Sons

7. Sommerville, "Software Engineering ", 6th ed. Pearson Education, 2002.

| SUBJECT CODE | SUBJECT NAME | L:T:P | Audit |
|---|---|---|---|
| CSPBTO9 | ENTERPRISE RESOURCE MANAGEMENT | 2:0:0 | 2 |

**COURSE OBJECTIVE:**

1. To discuss the fundamental concepts an enterprise and its integration of major functions
2. To discuss the various technologies used for an ERP.
3. To discuss importance of information in an organization.
4. To discuss Material resource management, forecasting and job scheduling
5. To discuss Software implementation methods and various other related issues

| UNIT No | Syllabus Content | No of Hours |
|---|---|---|
| 1 | **Function of Business Organizations:** Personnel management, Financial management, marketing management, Sales order Processing , Manufacturing managements , Human Resource Management etc , data and information , Operation of functional areas. Integrated view of ERP | 8 |
| 2 | **Technologies of ERP:** knowledge based system , Decision support system , Executive information system , Electronic commerce, , Databases system , Business Engineering , Business process Engineering , Networking , 3 tier and 2 tier architecture. | 7 |
| 3 | **Management information system:** MIS, data & information, levels of Management , information requirement , objectives of information channels, information strategies | 7 |
| 4 | **Information and planning:** Resource management benefit of management planning process objective and its characteristic , policy and procedures<br>,forecasting and its varies aspects . Scheduling , MRP , MRP-II | 7 |
| 5 | **ERP implement issues:** software development life cycle , pre Evaluation schemes , post implement issues, case studies . | 7 |

**COURSE OUTCOMES:** The students would have learnt

CO1: Basic concepts of an enterprise functions and its integration for ERP. CO2: Introduction of different technologies related to ERP.

CO3: Importance of an information for all levels of organization. CO4: Concepts of ERP for the manufacturing perspective

Text Books:


1. Enterprise resource planning by Alixis Leon TMH
2. Management Information System by Jawardekar Reference Books:
3. Kinematics and Synthesis of linkages –Hartenberg and Denavit– McGrew Hill Book Co
4. ERP by Garg and Ravichandran
5. Management Information Systems : Louden & Louden
6. Information System and MIS : J Kanter


## Course Outcomes and their mapping with Programme Outcomes:

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | **1** | **1** | **3** | **2** | **1** | **1** | **3** | **1** | **1** | **1** | **0** | **3** | **3** | **2** | **2** |
| **CO2** | **1** | **3** | **3** | **2** | **3** | **1** | **2** | **1** | **1** | **2** | **0** | **3** | **3** | **3** | **2** |
| **CO3** | **2** | **1** | **3** | **2** | **1** | **1** | **1** | **2** | **2** | **2** | **2** | **3** | **3** | **1** | **2** |
| **CO4** | **2** | **1** | **3** | **2** | **1** | **1** | **3** | **1** | **1** | **1** | **0** | **3** | **3** | **1** | **2** |
| **CO5** | **1** | **1** | **3** | **1** | **3** | **1** | **3** | **1** | **3** | **1** | **2** | **3** | **1** | **2** | **2** |

**Weightage: 1-Sightly; 2-Moderately; 3-Strongly**

| SUBJECT CODE | SUBJECT NAME | L:T:P | Audit |
|---|---|---|---|
| ELPBTX1 | ENGLISH FOR RESEARCH PAPER WRITING | 2:0:0 | 2 |

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

1 Understand that how to improve your writing skills and level of readability.

2 Learn about what to write in each section

3 Understand the skills needed when writing a Title

4 Ensure the good quality of paper at very first-time submission

**Syllabus Contents:**

- Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness
- Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction
- Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check
- Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Ruseful phrases, how to ensure paper is as good as it could possibly be the first- time submissioneview of the Literature.
- skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions
- useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

**References:**


- Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
- Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
- Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook .
- Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011


| Cos | Program Outcomes (POs) | | | | | | | | | | | | Program Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| | **3** | **10** | **10** | **11** | **1** | **5** | **3** | **3** | **12** | **5** | **12** | **12** | **3** | **2** | **1** |
| CO1 | - | 2 | 3 | 2 | 1 | 2 | 3 | 1 | 1 | 2 | 2 | 1 | 3 | 2 | 2 |
| CO2 | - | 3 | 3 | 3 | 1 | 3 | 3 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| CO3 | - | 2 | 1 | 2 | 1 | 2 | 3 | 2 | 1 | 2 | 3 | 2 | 3 | 2 | 3 |

| SUBJECT CODE | SUBJECT NAME | L:T:P | Audit |
|---|---|---|---|
| PEPBTX2 | STRESS MANAGEMENT BY YOGA | 2:0:0 | 2 |

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

1 Develop healthy mind in a healthy body thus improving social health also.

2 Improve efficiency

**Syllabus Contents:**

- Definitions of Eight parts of yog. ( Ashtanga ).
- Yam and Niyam, Do`s and Don't's in life, i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan.
- Asan and Pranayam, i) Various yog poses and their benefits for mind & body, ii) Regularization of breathing techniques and its effects-Types of pranayam.

**References:**


- 'Yogic Asanas for Group Tarining-Part-I" :Janardan Swami Yogabhyasi Mandal, Nagpur
- "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata.

| SUBJECT CODE | SUBJECT NAME | L:T:P | Audit |
|---|---|---|---|
| CEPBTX3 | Disaster Management | 2:0:0 | 2 |

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

1 Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.

2 Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives

3 Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations

4 Critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in

**Syllabus Contents:**

- Introduction Disaster: Definition, Factors and Significance; Difference between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.
- Repercussions of Disasters and Hazards: Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides and Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks and Spills, Outbreaks of Disease and Epidemics, War and Conflicts.
- Disaster Prone Areas in India, Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with special reference to Tsunami; Post-Disaster Diseases and Epidemics.
- Disaster Preparedness and Management: Preparedness: Monitoring of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological and other agencies, Media Reports: Governmental and Community Preparedness.
- Risk Assessment: Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival.
- Disaster Mitigation: Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India.

**References:**

- R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies", New Royal book Company.

- Sahni, Pardeep Et. al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall of India, New Delhi.
- Goel S. L. , Disaster Administration and Management Text and Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.


| Cos | Program Outcomes (POs) | | | | | | | | | | | | Program Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| | **3** | **10** | **10** | **11** | **1** | **5** | **3** | **3** | **12** | **5** | **12** | **12** | **3** | **2** | **1** |
| CO1 | 3 | 2 | 1 | 3 | 3 | - | - | - | - | - | - | - | 2 | 2 | 1 |
| CO2 | 3 | 2 | 1 | 2 | 2 | - | - | - | - | - | - | - | 3 | 3 | 2 |
| CO3 | 3 | 2 | 1 | 2 | 3 | - | - | - | - | - | - | - | 2 | 2 | 1 |

| SUBJECT CODE | SUBJECT NAME | L:T:P | Audit |
|---|---|---|---|
| LAPBTX4 | CONSTITUTION OF INDIA | 2:0:0 | 2 |

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

1 Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.

2 Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.

3 Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.

4 Discuss the passage of the Hindu Code Bill of 1956.

**Syllabus Contents:**

- History of Making of the Indian Constitution: History Drafting Committee, (Composition & Working).
- Philosophy of the Indian Constitution: Preamble, Salient Features
- Contours of Constitutional Rights & Duties: Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.
- Organs of Governance: Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, appointment and Transfer of Judges, Qualifications, Powers and Functions.
- Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Pachayati raj: Introduction, PRI: ZilaPachayat. Elected officials and their roles, CEO ZilaPachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy.
- Election Commission: Election Commission: Role and Functioning, Chief Election Commissioner and Election Commissioners, State Election Commission: Role and Functioning, Institute and Bodies for the welfare of SC/ST/OBC and women.

**References:**


- The Constitution of India, 1950 (Bare Act), Government Publication.
- Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
- M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
- D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.