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| **Course code** | **Course name** | **Course Category** | **L-T-P** | **Credits** |
| CH3102 | Chemical Technology | PCC | 3-0-0 | 3 |

**Course Learning Objectives:**

The course content enables the students to:

1. Understand the schematic representation of important unit operation/ unit processes involved in plant operations. Develop skills in preparing /presenting a neat Engineering drawing for Chemical Process Industries such as Chloro-alkali industries, glass.
2. Develop skills in preparing /presenting a neat Engineering drawing for Chemical Process Industries such as urea, fertilizer.
3. Impart clear description of one latest process along with its Chemistry, Process parameters, Engineering Problems and Optimum Conditions.
4. Demonstrate the importance of updating the latest technological developments in producing products economically and environment friendly.
5. Appreciate the usage of other engineering principles such as Thermodynamics, Heat, mass and momentum transfer in operation and maintain the productivity.
6. Understand the concepts of petroleum industry.

**Course Content**

**UNIT –I (8 Contact hours)**

Introduction: Chemical industries-facts and figures, Unit operation and unit process concepts, chemical processing and role of chemical engineers.

Chlor-Alkali Industries: Sodium Carbonate, Chlorine-Caustic soda production industries.

**UNIT – II (7 Contact hours)**

Nitrogen Industries: Nitrogen industries: synthetic ammonia, urea. Phosphorus Industries: Phosphorus, phosphorous pent oxide, phosphoric acid, SSP and TSP. Potassium Industries, Sulphur and Sulphuric acid production industries.

**UNIT-III (8 Contact hours)**

Cement manufacture, special cements.

Oils: Definition, constitution, extraction and expression of vegetable oils, refining and hydrogenation of oils.

**UNIT-IV (7 Contact hours)**

Synthetic fibers: Classification, manufacture of Nylon 66, polyester fiber and viscose

rayonfiber.

Soaps and detergents: Definitions, continuous process for the production of fatty

acids, glycerin and soap, production of detergents.

**UNIT-V (8 contact hours)**

Pulp and paper industry: methods of pulping, production of sulphate and sulphite pulp, production of paper –wet process

Sugar and Starch Industries: Sucrose, Extraction of sugar cane to produce crystalline white sugar, Extraction of sugar cane to produce sugar.

**UNIT-VI (7 contact hours)**

Petroleum Industry: Origin, occurrence and characteristics of crude oil, crude oil distillation. Petrochemical industries: Manufacturing processes of formaldehyde, acetaldehyde, acetic acid, acetic anhydride, nitrobenzene, ethylene oxide, and ethylene glycol. Polymerization industries: polyethylene, polypropylene, PVC and polyester synthetic fibers production industries.

**Text books:**

1. M.Gopal Rao and M.Sittig, Dryden’s outlines of Chemical Technology, 3rd Edition, East-West Press, 1997.
2. Austin, Shreve’s chemical process industries , 5th ed., M.C.Graw-Hill,1985

**Reference Books:**

1. Industrial Chemistry by B.K. Sharma,
2. Hand book of industrial chemistry Vol 1& II K.H.Davis& F.S. Berner Edited by S.C. Bhatia, CBS publishers
3. Chemical Technology: G.N. Panday, Vol 1&Vol II

**Web resources:**

1. <https://nptel.ac.in/courses/103107082/>
2. <https://nptel.ac.in/courses/103103029/>

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

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| CO1 | Draw the plant process flow sheet. |
| CO2 | Learn in maintaining all safety norms during their job |
| CO3 | Solve Engineering problems to keep up the productivity |
| CO4 | Propose alternative manufacturing process |
| CO5 | List chemical reactions and their mechanism involved. |
| CO6 | Identify the key in terms of economic viability of the product. |

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| **Course Nature** | | | **Theory** | | |
| **Assessment Method** | | | | | |
| Assessment Tool | Weekly tests/Assignments  (In semester) | Monthly tests  (In semester) | | End Semester Test | Total |
| Weightage (%) | 10% | 30% | | 60% | 100% |

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| Course code | Course name | Course Category | L-T-P | Credits |
| CHXX01 | Advanced Mathematical Techniques in Chemical Engineering | PEC | 3-0-0 | 3 |

**Course Learning Objectives:**

The objective of this course is to

1. Introduce model formulation for various chemical processes and associated equations and to have knowledge on vector spaces
2. Have an adequate knowledge on matrices, operators and transformations to solve the associated equations in chemical engineering systems
3. Understand the methods of solution of partial differential modeling equations in chemical engineering systems
4. Have a knowledge on applications of Fourier series, Laplace and Fourier transforms to solve ODE’s and PDE’s in chemical Engineering
5. Introduce formulation of process models and necessary numerical techniques for solving the model equations arising in chemical engineering systems
6. Learn sensitivity and data analysis, and experimental design essential for modern engineers.

**Course Content:**

**Unit I: [7 hours]**

Models in chemical engineering: Linear equations and non- linear equations. Vector and vector spaces, metrics, norms and inner products, linear dependence and dimension, Gram-Schmidt ortho-normalization.

**Unit II: [8 hours]**

Matrices, operators and transformations: Eigen values and Eigen vectors, Fredholm alternative solvability conditions, Rayleigh’s quotient. Application to chemical engineering systems, Geometric basis method, self adjoint and non-self adjoint systems.

**Unit III: [7 hours]**

Partial differential equations and their applications in chemical engineering, classification of second order partial differential equations, linearity and superposition, Strum - Louiville theory, and Eigen value problems.

**Unit IV: [7 hours]**

Separation of variables and Fourier transforms: Rectangular, cylindrical and spherical coordinate systems, Fourier series and Fourier transforms unbounded domains, Laplace transforms and their applications for solution of ODE and PDEs in chemical engineering.

**Unit V: [8 hours]**

Introduction to numerical methods: Linear algebraic equations, nonlinear algebraic equations, curve fitting and least square methods, function evaluation and regression techniques and applications for solving chemical engineering problems.

**Unit VI: [7 hours]**

Numerical methods for evaluating definite integrals, solving ordinary differential equations - initial and boundary value problems, solutions of partial differential equations and their applications to solve chemical engineering problems.

**Learning Resources:**

**Text book:**

1. S. Pushpavanam, *‘Mathematical Methods in Chemical Engineering’,* Printice-Hall of India, New Delhi, 2001.

**Reference Books:**

1. R. G. Rice & D. D. Do, Wiley, ‘*Applied Mathematics and Modeling for Chemical Engineers’*.

2. A. Varma& M. Morbidelli, ‘*Mathematical Method in Chemical Engineering’*, Oxford

University Press.

**Web resources:**

1. https://nptel.ac.in/courses/103105106

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

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| CO1 | Formulation of various chemical processes |
| CO2 | Apply the concepts of vector spaces, matrices and their transformations to solve equations associated in Chemical Engineering systems |
| CO3 | Identify different advanced methods to tackle the kinds of problems that appear in Chemical Engineering domain. |
| CO4 | The student will enable to develop a deeper understanding and appreciation of the fundamental concepts behind the mathematics associated with a problem in Chemical Engineering |
| CO5 | Solve the model equations arising in Chemical engineering systems using advanced numerical techniques |
| CO6 | Analyze the behavior of complex systems in chemical engineering research |

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| **Course Nature** | | **Theory** | | |
| **Assessment Method** | | | | |
| Assessment Tool | Weekly tests/Assignments  (In semester) | Monthly tests  (In semester) | End Semester Test | Total |
| Weightage (%) | 10% | 30% | 60% | 100% |

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| **Course code** | **Course name** | **Course Category** | **L-T-P** | **Credits** |
| CH2201 | Chemical Reaction Engineering – I | PCC | 3-1-0 | 4 |

**Course Learning Objectives:**

The objective of this course is to impart in-depth knowledge about

1. Classification of chemical reactions, their speed and kinetics

2. Temperature dependency of rate equation and interpretation of batch reactor data for

Constant volume batch reactor

3. Interpretation of batch reactor data for variable volume batch reactor and methods of

Analysis of rate data for single and multiple reactions

4. Formulation of performance equations for ideal reactors

5. Reactors for single reactions and multiple reactions; product distribution

6. Temperature and Pressure effects on the progression of a chemical reaction

**Course Content:**

**Unit I: (10Contact hours)**

Introduction: Overview, Classification of chemical reactions, variables affecting the rate of reaction, definition of reaction rate, Speed of chemical reactions, overall plan.

Kinetics of homogeneous reactions:: The rate equation; Concentration dependency; Single and multiple reactions, elementary and non-elementary reactions, Order and molecularity of chemical reactions, rate constant. Representation of elementary and non-elementary reactions.

Temperature dependency: Temperature dependent term of rate equation from Arrhenius law and comparison of collision and transition theories.

**Unit II: (10 Contact hours)**

Interpretation of Batch reactor data: Constant volume Batch reactor: Integral method of analysis of data-Irreversible first order, second order, third order , nth order and zero order reactions; Half-life method; Fractional life method;

Series reactions, parallel reactions, Catalyzed reactions; First order reversible reactions, reactions of shifting order; Variable volume batch reactor; reaction rate; rate constant; collection and interpretation of kinetic data; parallel and series reactions. Differential method of analysis; varying volume Batch reactor: Analysis of data using differential and integral methods –Irreversible zero order, first order, second order and nth order reactions; Temperature and reaction rate.

**Unit III: (10 Contact hours)**

Introduction to reactor design: General Discussion, symbols and relationship between concentration and conversion;

Ideal reactors for single reactions: Ideal batch reactor, steady state mixed flow and plug flow reactors design with and without recycle. Design for single reactions: Size comparison of single reactors, variation of reactant ratio, Graphical comparison;

Multiple reactor systems- MFRs and PFRs in series and parallel, best arrangement of set of ideal reactors, Recycle reactor, autocatalytic reactions, reactor combinations.

**Unit IV: (10 Contact hours)**

Design for Parallel reactions: Introduction, Qualitative discussion about product distribution, quantitative treatment of product distribution and of reactor size, the side entry reactor.

Design for single reactions: Size comparison of single reactors, variation of reactant ratio, Graphical comparison.

Potpourri of multiple reactions: Irreversible first order reactions in series- Qualitative discussion about product distribution and quantitative treatment of product distribution-mixed flow reactor.

Combination of first order and zero order reactions in series, two step irreversible series- parallel reaction, The Denbigh reactions.

**Unit V: (8 Contact hours)**

Temperature and Pressure effects: single reactions- Heats of reactions, equilibrium constants from thermodynamics, general graphical design procedure, optimum temperature progression, Adiabatic and Non-adiabatic operations; multiple reactions- Product distribution and temperature.

**Unit VI: (8 Contact hours)**

**Basics of non-ideal flow:** The Residence time distribution (RTD), State of aggregation of the flowing stream , Earliness of mixing and their role in determining reactor behavior; E-the age distribution of fluid, the RTD, Measurement of the RTD- The pulse and the Step experiments relation between E and F curves.

**Learning Resources:**

**Text book:**

1. Octave levenspiel, ‘Chemical Reaction Engineering’, Wiley-India, 3rd edition, 2012.

**Reference Books:**

1. H S Fogler, ‘Elements of Chemical Reaction Engineering’, PHI, 4th Edition, 2008.

**Web resources:**

1. <https://nptel.ac.in/courses/103108097/>

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

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| CO1 | Build a knowledge on different classification of reactions, mechanisms and their kinetics |
| CO2 | Analyzing the procedure of interpretation of batch reactor data for different types of reactions |
| CO3 | Evaluating the performance equations for all ideal reactors |
| CO4 | Find the design parameters such as volume of the chemical reactor for the given duty |
| CO5 | Organize the ideal reactors for best conversions in single reactors and multiple reactions |
| CO6 | Identify the optimum temperature progression for the maximum performance of the reactor |

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| **Course Nature** | | **Theory** | | |
| **Assessment Method** | | | | |
| Assessment Tool | Weekly tests/Assignments  (In semester) | Monthly tests  (In semester) | End Semester Test | Total |
| Weightage (%) | 10% | 30% | 60% | 100% |

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| **Course code** | **Course name** | **Course Category** | **L-T-P** | **Credits** |
| CH3103 | Chemical Reaction Engineering- II | PCC | 3-0-0 | 3 |

**Course Learning Objectives:**

1. To understand the purpose of Residence time distribution.
2. To learn how to deal with non -ideal reactors.
3. Exploring models available to determine conversions in non- ideal reactors.
4. To study the steps involved in fluid-solid catalytic reactions
5. Understanding the parameters affecting catalytic reactions.
6. To study models available to deal with fluid-solid reactions without catalyst.

**Course Content:**

**Unit – I (7 Contact hours)**

**Characteristics of the RTD:** RTD in real reactors, Diagnostics and troubleshooting.

**Conversion in Non-ideal flow reactors:** Predicting conversion and exit concentration, reactor modeling using RTD.

**Unit – II (7 Contact hours)**

**zero parameter models:** segregation model – macro and micro fluids, earliness and late mixing; maximum mixedness model, comparison of zero parameter Vs. maximum mixedness model.

**One parameter models:** The dispersion model- Axial dispersion, small deviation and large deviations from plug flow; correlations for axial dispersion,

**Unit – III (7 Contact hours)**

Chemical reaction and dispersion-first order and nth order reactions.

Tanks- in-series (T-I-S) model- the RTD for n equal sized tanks in series; Chemical conversion in first order and all other reaction kinetics of micro fluids, chemical conversion of macro fluids. Tanks- in-series Vs. dispersion model.

**UNIT-IV (8 contact hours)**

**Catalysis and catalytic reactors:** Introduction to Catalysts, steps in a catalytic reactions- Overview of Internal and External diffusion, Adsorption Isotherms, surface reaction, Desorption, The rate limiting step; Synthesizing a rate law, mechanism and rate limiting step for a solid catalyzed heterogeneous reaction.

**Unit - V (9 Contact hours)**

**Diffusion and reaction:** External diffusion effects on heterogeneous reactions : External resistance to mass transfer, correlation for the mass transfer coefficient, Experimental methods for finding rates, design of packed bed catalytic reactors and Fluidized bed reactors.

Diffusion and reaction in a single cylindrical pore, Thiele modulus and internal effectiveness factor, extension to different particles, Falsified kinetics, heat effects during reaction.

**Unit – VI** (**8 Contact hours)**

**Fluid-solid non-catalyzed reactions**: Introduction, selection of a model, progressive conversion model (PCM), shrinking core model (SCM), SCM for spherical particles of unchanging size, SCM for spherical particles of shrinking size, limitations of shrinking core model; Determination of the rate-controlling step.

**Learning Resources:**

**Text book:**

1. Octave Levenspiel , ‘*Chemical Reaction Engineering’*, Wiley – India, 3rd edition (2012)
2. H S Fogler, ‘*Elements of Chemical Reaction Engineering*’, PHI, 4th ed.,2008.

**Reference Books:**

1. Smith J.M., ‘*Chemical Engineering kinetics*’, McGraw-Hill, 3rd edition 1974.

**Web resources:**

1. <https://nptel.ac.in/courses/103106117/>
2. https://nptel.ac.in/courses/103101008/

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

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| CO1 | Predict how real reactor deviates from ideal reactors such as PFR, MFR |
| CO2 | List out parameters affecting the behaviour of non-ideal reactors. Diagnose and troubleshooting them. |
| CO3 | Explore and apply different models available to predict the conversion in non- ideal reactors. |
| CO4 | Analyzing the steps involved in catalytic reactions and the kinetics involved. |
| CO5 | Design the parameters affecting rate of catalytic reactions. |
| CO6 | Explore different mechanisms related to non-catalyzed solid-fluid reactions. Describe enzymatic reactions. |

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| **Course Nature** | | **Theory** | | |
| **Assessment Method** | | | | |
| Assessment Tool | Weekly tests/Assignments  (In semester) | Monthly tests  (In semester) | End Semester Test | Total |
| Weightage (%) | 10% | 30% | 60% | 100% |

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| Course code | Course name | Course Category | L-T-P | Credits |
| CH3104 | Mass Transfer Operations**-**II | PCC | 3-0-0 | 0 |

**Course Learning Objectives:**

The course content enables the students to:

1. To deduce adequate knowledge in principles of mass transfer and problem-solving techniques.
2. Explore concepts of mass transfer processes such as; distillation, liquid- liquid extraction, leaching, adsorption and crystallization and its applications
3. To recognize the effective usage of mass transfer equipments according to separation process.
4. To able to get an idea of industrial separation equipments.
5. To design the equipments needed for separation processes.
6. To design the equipment for crystallization operations.

**Course Content:**

**UNIT – I (8 Contact hours)**

Distillation-I: Principles of VLE for binary systems–phase diagrams, relative volatility, azeotropes, enthalpy concentration diagrams, flash vaporization, partial condensation, differential distillation, steam distillation, Batch distillation with reflux for binary mixtures.

**UNIT – II (8 Contact hours)**

Distillation-II : Continuous fractionation of binary mixtures, Ponchon – Savrit method and McCabe – Thiele method of determination of ideal plates for binary mixtures – Optimum reflux ratio – Use of total and partial condensers. Use of open steam. Types of Condensers and Reboilers. Packed bed distillation. Principals of azeotropic and extractive distillation.

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**UNIT – II (7 Contact hours)**

Liquid – Liquid Extraction :Solubilities of ternary liquid systems. Triangular and solvent free coordinate systems. Choice of solvent. Extraction with insoluble and partially soluble systems – single stage, multistage cross current and multistage counter current extraction without reflux and with reflux. Continuous contact extraction (packed beds). Equipment’s for liquid – liquid extraction operation.

**UNIT – IV (7 Contact hours)**

Leaching: Preparation of solid, unsteady state operation, in-place leaching, heap leaching, percolation leaching, Shanks system, agitated vessels, percolation in closed vessels, Percolation vs Agitation. Steady state continuous operation – equipment’s - methods of calculation, stage efficiency and practical equilibrium. Single stage leaching, multistage cross current leaching, multistage counter current leaching

**UNIT- V (8 Contact hours)**

Adsorption: Principles of adsorption and their applications – Types of adsorption – Adsorbents – Adsorption equilibrium – Adsorption Isotherms for vapor and dilute solutions. Single stage and multistage adsorption – unsteady state adsorption, adsorption wave and breakthrough curve and fixed bed adsorption.

**UNIT-VI (7 Contact hours)**

Crystallization: Crystal Geometry, Equilibrium and yields, principles of crystallization, Crystallization equipment

Ion-Exchange: Principles of Ion-Exchange, techniques and applications, rate of Ion-Exchange

Introduction to membrane separation processes

**Text books:**

1. R.E. Treybal, *‘Mass transfer operations’*, McGraw Hill,1981, 3rd Edition
2. B.K. Dutta, *’Principles of mass transfer and separation processes’*, PHI Learning Private Limited, Eastern Economy Edition

**Reference Books:**

1. Warren, L., McCabe, Julian C.Smith and Peter Harriot, *‘Unit Operations of Chemical Engineering’*, McGraw Hill, 7th Edition
2. Christie John Geankoplis, *‘Transport process and separation process principles’*, PHI of India, 4thedition
3. J D Seader and E J Henly, *‘Separation Process Principles’*, John Wiley & sons, NY

1998.

**Web resources:**

1. <https://nptel.ac.in/courses/103104046/>

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

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| CO1 | Build a basic knowledge of mass transfer operations and separation processes carried out in chemical industries. |
| CO2 | Importance and applications of different mass transfer processes. |
| CO3 | Identify technological methods in problem solving of mass transfer operations in industries. |
| CO4 | Design of mass transfer equipments used in the chemical industries. |
| CO5 | Utilize the technological methods in problem solving of mass transfer operations in industries and ability to Select appropriate separation technique for intended problem |
| CO6 | Evaluate the selection criteria for mass transfer process and equipments required by the industries. |

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| **Course Nature** | | | | | **Theory** | | | | | |
| **Assessment Method** | | | | | | | | | | |
| Assessment Tool | | Weekly tests/Assignments  (In semester) | | Monthly tests  (In semester) | | End Semester Test | | | Total | |
| Weightage (%) | | 10% | | 30% | | 60% | | | 100% | |
| **Course code** | | **Course name** | | **Course Category** | | | | **L-T-P** | **Credits** | |
| CHXX23 | | Computational Fluid Dynamics | | PEC | | | | 3-0-0 | 3 | |

**Course Learning Objectives:**

The course content enables the students to:

1. Understand the widely used techniques to obtain the numerical solution of fluid

Flow equations.

2. Develop governing equations defining the system and solve them.

3. Use finite difference techniques for fluid flow and heat transfer problems.

4. Interpret the solution for heat transfer and fluid flow problems using finite Volume techniques.

5. Distinguish and apply different commercial packages of CFD to analyze

Complex fluid flow problems.

6. Enhance their skills related to computer design and evaluation in fluid flow,

critical thinking and lifelong learning.

Unit 1 [7 hours]

**INTRODUCTION**

Review of governing equations: Conservation of mass, Conservation of momentum, Conservation of energy, Navier-Stokes equations and energy equation, General scalar transport equation, classification of PDEs

Overview of Numerical Methods: Finite Difference Method, Finite Volume Method

Overview of Numerical Methods: Solution of linear algebraic equations

Boundary conditions

Introduction to FVM for diffusion Equation

Finite volume method for one-dimensional steady state diffusion

Worked examples: one-dimensional steady state diffusion

Finite volume method for two-dimensional diffusion problems, three-dimensional diffusion problems

UNIT 2 [8 hours]

**THE FINITE VOLUME METHOD FOR CONVECTION---DIFFUSION PROBLEMS**

**Steady one-dimensional convection and diffusion**

Properties of discretisation schemes: - Conservativeness, Boundedness, Transportiveness

The central differencing scheme

Assessment of the central differencing scheme for convection – diffusion problems

The upwind differencing scheme

Assessment of the upwind differencing scheme

The hybrid differencing scheme

Assessment of the hybrid differencing scheme

Hybrid differencing scheme for multi-dimensional convection–diffusion

The power-law scheme

Higher-order differencing schemes for convection–diffusion problems

Quadratic upwind differencing scheme: the QUICK scheme

Assessment of the QUICK scheme

Stability problems of the QUICK scheme and remedies

General comments on the QUICK differencing scheme

TVD schemes

UNIT 3 [7 hours]

**SOLUTION ALGORITHMS FOR PRESSURE---VELOCITY COUPLING IN STEADY FLOWS**

The staggered grid

Assembly of a complete method

The SIMPLE algorithm

The SIMPLER algorithm

The SIMPLEC algorithm

The PISO algorithm

General comments on SIMPLE, SIMPLER, SIMPLEC and PISO

Worked examples of the SIMPLE algorithm

UNIT 4 [6 hours]

**SOLUTION OF DISCRETISED EQUATIONS**

The TDMA

Application of the TDMA to two-dimensional problems

Jacobi iteration method

Gauss–Seidel iteration method

Relaxation method

Multigrid techniques

An outline of a multigrid procedure

An illustrative example

UNIT 5 [7 hours]

**THE FINITE VOLUME METHOD FOR UNSTEADY FLOWS**

Explicit scheme

Crank–Nicolson scheme

The fully implicit scheme

Implicit method for two dimensional problems

Discretisation of transient convection–diffusion equation

Worked example of transient convection–diffusion using QUICK differencing

Solution procedures for unsteady flow calculations

Transient SIMPLE

The transient PISO algorithm

**Implementation of boundary conditions:**

Inlet boundary conditions, Outlet boundary conditions, Wall boundary conditions, the constant pressure boundary condition, Symmetry boundary condition, Periodic or cyclic boundary condition, Potential pitfalls and final remarks

UNIT 6 [7 hours]

**INTRODUCTION TO COMPLEX GEOMETRIES**

Body-fitted co-ordinate grids for complex geometries

Cartesian vs. curvilinear grids

Curvilinear grids – difficulties

Block-structured grids

Unstructured grids

Discretisation in unstructured grids

Discretisation of the diffusion term

Discretisation of the convective term

Treatment of source terms

Assembly of discretised equations

Example calculations with unstructured grids

Pressure–velocity coupling in unstructured meshes

Staggered vs. co-located grid arrangements

**Text books:**

1. *‘Introduction to Computational Fluid Dynamics, an: The Finite Volume Method’* Versteeg, H., Malalasekera.

**Reference Books:**

1. *‘The Finite Volume Method in Computational Fluid Dynamics: An Advanced Introduction with Open FOAM® and Matlab’*, F. Moukalled, L. Mangani, and M. Darwish
2. Anderson Jr J. D., ‘*Computational Fluid Dynamics: The Basics with Applications*’, McGraw Hill. 1995.
3. Muralidhar K. and Sundararajan T., ‘*Computational Fluid Flow and Heat Transfer*’, Narosa Publishing House. 2003.

**Web resources:**

1. <https://nptel.ac.in/courses/112106294>
2. <https://nptel.ac.in/courses/112106186>

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

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| CO1 | Evaluate the basic principles of mathematics and numerical concepts of fluid dynamics |
| CO2 | Develop governing equations for a given fluid flow system |
| CO3 | Adapt finite volume techniques for fluid flow models |
| CO4 | Apply finite volume method for heat transfer problems |
| CO5 | Solve computational fluid flow problems using finite volume techniques |
| CO6 | Get familiarized to modern CFD software used for the analysis of complex fluid-flow systems |

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| **Course Nature** | | | **Theory** | | |
| **Assessment Method** | | | | | |
| Assessment Tool | Weekly tests/Assignments  (In semester) | Monthly tests  (In semester) | | End Semester Test | Total |
| Weightage (%) | 10% | 30% | | 60% | 100% |