

| BMEE409E | Computational Fluid Dynamics | L | T | P | C |
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| Pre-requisite | BMEE204L , BMEE204P ,BMEE402L , BMEE402P | Syllabus version | | | |
| | | 1.0 | | | |
| Course Objectives | | | | | |
| <ol style="list-style-type: none"> 1. To familiarise students with the mathematical representation of governing equations for fluid flow and heat transfer problems. 2. To equip the students to address complex fluid flow and heat transfer problems by approximating the governing equations through Finite difference and finite volume discretization methods. 3. To enable students to understand different types of grids and their suitability for different engineering applications. 4. Develop the students to use appropriate turbulence model for solving engineering problems. | | | | | |
| Course Outcomes | | | | | |
| At the end of the course, the student will be able to | | | | | |
| <ol style="list-style-type: none"> 1. Apply mathematical and engineering fundamentals to recognize the type of flow and arrive at equations governing the flow. 2. Apply the numerical techniques to find the solution for the system of algebraic equations. 3. Generate appropriate type of grids required for solving engineering problems. 4. Solve governing equations using finite difference and finite volume approaches. 5. Apply suitable turbulence model for the analysis of real world engineering problems. 6. Solve fluid flow and heat transfer problems using commercial CFD tools. | | | | | |
| Module:1 | Fundamental of Fluid Dynamics and Governing Equations | 6 hours | | | |
| Introduction and fundamentals of CFD, Classification of flows, Overview and Importance of CFD, Physical verses Numerical Techniques, Applications of CFD Conservation and Non-conservation form – Continuity, Momentum, Energy and Species Transport Equations, Simplified Mathematical models – Incompressible – Inviscid – Potential – Creeping flow, Characteristics of PDE: Elliptic, Parabolic and Hyperbolic. | | | | | |
| Module:2 | Solution of Linear Algebraic Equations | 4 hours | | | |
| Direct Methods - Elimination methods, Tri-diagonal Algorithm, LU Decomposition method, Error Analysis. Iteration Methods - Point iterative/block iterative methods, Gauss-Seidel iteration (concept of central coefficient and residue, Success over Relaxation) and other techniques | | | | | |
| Module:3 | Grid Generation | 3 hours | | | |
| Overview of mesh generation, Structured and Unstructured meshes, Guideline on mesh quality and design, Mesh refinement and adaptation, Grid Transformation. | | | | | |
| Module:4 | Finite Difference Method and Discretization | 6 hours | | | |
| Comparison of finite difference and finite volume techniques. Convergence, Consistency, Error and Stability, Accuracy, Boundary conditions, CFD model formulation. Finite Difference Method: Taylor series - Forward, Backward and Central difference schemes, One Dimension and Two Dimension FDM Problems – Explicit, Implicit and Semi-Implicit schemes. | | | | | |
| Module:5 | Finite Volume Method | 3 hours | | | |
| Integral form of Discretization – Steady and Transient One and Two-dimensional diffusion. Properties of discretization schemes – Conservativeness, boundedness and transportiveness Convection and Diffusion: Central difference, upwind and QUICK schemes. | | | | | |
| Module:6 | Solution Techniques for Incompressible Flows | 3 hours | | | |
| Pressure-Velocity coupling, collocated and staggered grid arrangements, velocity-stream function approach, MAC algorithm, SIMPLE and PIMPLE algorithms. | | | | | |
| Module:7 | Turbulence Modelling | 3 hours | | | |

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| Introduction – Types of Turbulence modelling – Reynolds Time Averaging, Boussinesq approach – One equation and Two equation models, Introduction to LES, DES and DNS. | | | |
| Module:8 | Contemporary Issues | | 2 hours |
| | Total Lecture hours: | | 30 hours |
| Text Book | | | |
| 1. | Joel H. Ferziger, Milovan Peric, Robert L. Street, Computational Methods for Fluid Dynamics, 2020, 4 th Edition, Springer Publisher. | | |
| Reference Books | | | |
| 1. | Versteeg H.K, Malalasekara W, An Introduction to Computational Fluid Dynamics – The Finite Volume Method, 2011, 3 rd Edition, Pearson. | | |
| 2. | John D Anderson, Computational Fluid Dynamics – The Basics with Applications, 1st Edition, McGraw Hill 2012. | | |
| 3. | Muralidhar K, Sundararajan T, Computational Fluid Flow and Heat Transfer, 2014, Narosa Publications, New Delhi. | | |
| 4. | Chung T.J, 2014, Computational Fluid Dynamics, Cambridge University Press. | | |
| Mode of Evaluation: CAT, written assignment, Quiz, FAT. | | | |
| Indicative Experiments | | | |
| 1. | Modeling of simple and Complex geometries | | 2 hours |
| 2. | Meshing of simple and complex geometries | | 2 hours |
| 3. | Pre-processing : Case setup and analysing for already mesh generated model | | 2 hours |
| 4. | Steady state temperature distribution in rectangular plate | | 2 hours |
| 5. | Flow in a circular pipe – Laminar and Turbulent | | 2 hours |
| 6. | Flow over an air foil – Laminar and Turbulent flow | | 2 hours |
| 7. | Diffuser for a hydro-power turbine | | 2 hours |
| 8. | Two phase flow in a pipe | | 2 hours |
| 9. | Supersonic flow past a wedge in a channel | | 2 hours |
| 10. | Exercise Problem (for each student – different exercise) : Pre-processing, solver and post-processing | | 2 hours |
| Total Laboratory Hours: | | | 30 hours |
| Mode of assessment: Viva-voce examination, Lab performance, FAT. | | | |
| Recommended by Board of Studies | | 09-03-2022 | |
| Approved by Academic Council | | No. 65 | Date 17-03-2022 |