Department of Mathematics
Faculty of Mathematics & Computer Science
M.Sc. (Applied Mathematics), 4th Semester

Course Code	AM 403 (d)
Course Title	Computational Fluid Dynamics
Course Credits	04

Course objectives:

To equip the students with the numerical techniques, that is, finite difference, finite element and finite volume methods to solve CFD problems.

Minimum pre-requisites:

Numerics of ordinary and partial differential equations, Fluid Dynamics, Computer programming.

Course structure:

Classification of PDEs,Conservation of mass, Continuity equation, Conservation of momentum, Euler's equation of motion for non-viscous flow, Navier-Stokes equations of motion for viscous flow, boundary conditions.

Finite Difference Methodsfor Incompressible viscous flow: Incompressible plane flows, stream function and vorticity equation, conservation form and normalizing system, Vorticity and transport equation, Conservative property, Derivation of finite difference equations,Simple methods, General methods,, Accuracy of fluid dynamics solutions. Solution methods of Finite Difference Equations, Explicit and Implicit schemes, convergence andstability analysis, stream function equation and boundary conditions, Schemes for advection diffusion equation, upwind differencing and artificial viscosity, Schemes for Burger's equation, Applications of Neumann Boundary Conditions, Artificial compressibility method, Pressure Correction method(self-implicit method).

Finite Difference Methodsfor compressible flow: Non linear problems with convection dominated flow, Euler equations, quasilinearization of Euler equations and Burger's equation, eigenvalues and compatibility relations, Characterstic variables, Central schemes with combined space

– time discretization,Relationship between Finite Element Method and Finite Difference Method.

Solution of Finite Volume and Finite Element equations, Node centered control volume, Cell centeredcontrol volume, Cell averaged control volume, Interpolation functions, 1D Lagrange's polynomial element, Hermitepolynomial element, 2D triangular and rectangular elements, Quadrilateral and Isoparametric elements,conjugate gradient method, composite boundary element solutions, Finite element method for Sturm-liouville'sequation.

Reading suggestions:

- **C. A. J. Fletcher**, Computational Techniques for Fluid Dynamics,Volume 1, 2nd Edit., SpringerVerlag, New York, 2005.
- **C. A. J. Fletcher**, Computational Techniques for Fluid Dynamics,Volume 2, 2nd Edit., SpringerVerlag, New York, 2005.
- **R.H. Pletcher**, **J. C. Tannehill** and **D. A. Anderson**, Computational Fluid Mechanics and Heat Transfer, Taylor and Francis, CRC Press, 3rd Edit., 2013.
- **T.J. Chung**, Computational Fluid Dynamics, Cambridge University Press, 2nd Edit., 2010.

Evaluation and weightage:

- 20% for Computer practicals
- 10% for Quiz
- 30% for Mid-Term examination
- 40% for End-Term examination