Tentative Course Contents and Plan

I. **Basic Concepts and Equations of Fluid Motion (2 lectures)**
   1. Compressible vs Incompressible flow
   2. Governing equations for fluid dynamics (for compressible flows)
   3. Euler equations
   4. Conservative and non-conservative forms of equations
   5. Vector form of equations

II. **Mathematical Classification of PDEs (2 lectures)**
   1. Quasi-linear equations
   2. Linear advection equation and Inviscid Burgers equation
   3. Jacobians, Eigenvalues and Eigenvectors
   4. Hyperbolic system of equations
   5. Characteristics and general solution

III. **1D Euler Equations: Physical and Mathematical Characteristics (6 lectures)**
   1. Conservative form of quasi 1D flow equations: Jacobians
   2. Homogeneous vs nonhomogeneous flux vectors
   3. Review of matrix algebra and similarity transformations
   4. Transformation from conservative to non-conservative form
   5. Eigenvalues and Eigenvectors for Euler equations
   6. Transformation from conservative/non-conservative form to characteristics form
   7. Analytical solution of linearized 1D equations
   8. Methods for dissipating transient part of the solution

IV. **Numerical Solution of 1D Scalar Wave Equation (4 lectures)**
   1. Stability theory and convergence
   2. Euler explicit scheme
   3. Lax-Wendroff scheme
   4. Runge-Kutta scheme
   5. Euler implicit and generalized Crank-Nicholson schemes
   6. Delta form of equations

V. **Numerical Solution of One-Dimensional Euler Equations with Central Differencing in Space (6 lectures)**
   1. Implicit scheme and stability analysis
   2. Artificial dissipation: explicit and implicit treatment
   3. Lax-Wendroff schemes
   4. MacCormack's scheme
   5. Runge-Kutta scheme
   6. Implementation of boundary conditions: method of characteristics

VI. Numerical Solution of One-Dimensional Euler Equations with Upwind Differencing in Space (6 lectures)

1. Physical meaning of characteristics
2. One sided differencing: stability analysis
3. Analogy between upwind differencing and artificial dissipation
4. Flux vector splitting method
5. Implementation of boundary conditions

VII. Numerical Solution of Two-Dimensional Euler Equations (6 lectures)

1. Generalized Crank-Nicholson implicit scheme and stability analysis
2. Runge Kutta scheme
3. Alternating Direction Implicit (ADI) method and approximate factorization
4. Similarity transformations
5. Diagonalization
6. Implicit algorithms and stability
7. Boundary conditions: inlet, outlet, far field, walls, and symmetry

VIII. Numerical Solution of Navier-Stokes Equations (6 lectures)

1. Vector form of 1D N-S equations
2. Discretization of diffusion term
3. Implicit treatment of N-S equations
4. Stability and convergence
5. Explicit R-K methods for N-S equations