Viscous Flow

- Viscous Flow Basics
  - Navier Stokes equations and derivation
  - Viscous Stresses
  - Non-dimensionalization and Dynamic Similarity
  - Vorticity transport
- Exact Solutions of the Navier-Stokes Equations
  - Parallel Flows
  - Unsteady Flows
- Incompressible Laminar Boundary Layer
  - Boundary Layer Approximations
  - Similarity Solutions – General and Particular Solutions
  - Flow physics and prediction of incompressible boundary layer properties
- Compressible Boundary Layers
  - Effect of compressibility on boundary layer properties
  - Similarity Solutions
  - Thermal Boundary Layers
  - Flow physics and prediction of compressible boundary layer properties
- Transition to Turbulence
  - Linear-Stability Analysis
  - Orr-Sommerfield equation and temporal stability analysis
  - Prediction of transition, relevance to turbulence and transition flow physics
  - Non-Linear Stability analysis
- Boundary Layer Separation
  - Pressure gradient effects and flow physics associated with separation
  - Singularities in 2D and 3D boundary layers
  - Criteria and analytical representation
- Free Shear Layers
  - General Similarity Solutions
  - Jets, Wakes and Mixing Layers

Aerodynamics

- Governing equations and their simplifications across all speed regimes
  - Navier-Stokes Equations
  - Euler Equations
  - Full and Linearized Potential Equations
  - Transonic Potential Equations
- Concepts and assumptions of aerodynamics
  - Perfect gas, Kelvin's/Bernoulli equations, continuity of vorticity
  - Concepts of pressure, lift, drag and pitching moments and their coefficients
  - Visualization approaches for flow fields and surfaces
- Classical approaches from incompressible to supersonic
  - Estimates for airfoils, wings, and slender bodies
  - Incompressible and compressible Potential Flow
  - Thin Airfoil Theory and Finite Wing Theory
  - Effect of wing geometry (aspect ratio, sweep, twist, taper, etc.) on aerodynamic properties and coefficients
  - Lifting line (and extensions), vortex lattice
  - Effects of compressibility on aerodynamic properties around 2-D and 3-D bodies in subsonic and supersonic flow
  - Transonic flow effects
  - Supersonic linearized theory
- Integrated Aerodynamics
  - Effect of boundary layers and flow separation on aerodynamics of flat plates, airfoils and wings
  - Wing/Body/Fuselage Interactions
- Introduction to Unsteady Aerodynamics
  - Piston Theory
  - Vortex Flows
  - Separated Flows
  - Bluff Bodies
- High Angle of Attack Aerodynamics
  - Lift and Drag prediction
  - High lift devices
- Hypersonic Flows
  - Hypersonic aerodynamics prediction for blunt and sharp LE bodies:
  - Hypersonic Shock and Expansion Relations, Local Surface Inclination Methods

Aeroelasticity and Structural Dynamics (ASD) Qualifying Exam

A single qualifying exam is offered for this discipline group and it covers dynamics and structural dynamics. A listing of the topics is provided below

Dynamics

- Vector Mathematics
- Particle Kinematics
- Particle Dynamics
- Rigid Body Rotation
- General Motion of a Rigid Body
- Angular Velocity and Acceleration
- Two Points Fixed on a Rigid Body
- One Point Moving on a Rigid Body
- Kinematic Differential Equations
- Fundamentals of Newton/Euler Dynamics
- Mass Moment of Inertia
- Newton/Euler Dynamics
- Constraints
- Analytical Dynamics
- Multibody Dynamics
- Friction Modeling
- Impact and Contact Modeling
- Kinematics of material points or particles
- Kinematics of a rigid body in planar motion
- Kinetics of a rigid body in planar motion
- Special integrals of the equations of planar motion of rigid bodies (e.g., work and energy, impulse and momentum)
- Kinematics of rigid bodies in three-dimensions (including orientation angles, angular velocity)
- Kinetics of rigid bodies in three-dimensions (Euler's dynamical equations)
- Configuration constraints
- Motion constraints
- Generalized coordinates
- Inertia dyadics, matrices, and scalars.
- Lagrange's equations

Structural Dynamics

- Hamilton's principle

- Beams vibrating in extension, torsion, bending (development of complex boundary condition)
- Single-degree-of-freedom systems (equations, basic responses, response to harmonic excitation)
- Various kinds of damping
- Response of Single-degree-of-freedom systems to periodic excitation; Fourier series
- Laplace transforms
- Convolution and Duhamel's integrals
- Fourier integral; Fourier transforms
- Matrix eigenvalue problems (conservative and non-conservative systems)
- Rigid-body modes
- Vibration of membranes and plates
- Rayleigh's quotient
- Rayleigh-Ritz and Galerkin's methods
- Bending-shear vibration of Timoshenko beams
- Beams with axial force (including rotating beams and Beck's problem)