FLUIDS

This model syllabus defines the core material for Fluids. Instructors should use their discretion in deciding the ordering of topics, the depth to which each is covered, and additional material to include. It is anticipated that instructors will draw upon a range of examples from astrophysics and planetary science to illustrate the core material.

INVISCID FLUIDS

Derivation and examples of the Euler equations

Continuum hypothesis
Eulerian and Lagrangian formulations of fluid flows
Inviscid Euler equations
Streamlines, streamfunctions
Examples of inviscid flows

VISCOUS FLOWS

Derivation of the Navier-Stokes equations including the energy equation

Relationships between stress and strain, the stress tensor
Navier-Stokes equations: continuity, momentum, energy
Reynolds number
Transformation to non-inertial frames (e.g. rotating frames)
Bernoulli's equations

VORTICITY

Definition and significance of vorticity in fluid flows

Vortex dynamics
Kelvin's circulation theorem
Taylor-Proudman theorem
Potential vorticity

GRAVITY WAVES

Concepts required to deal with waves, and examples in non-compressible situations

Gravity waves
Deep and shallow water waves
Linearization
Phase and group velocities, concept of the dispersion relation

COMPRESSIBLE FLOWS

Compressible fluid dynamics including shocks and sound waves

Thermodynamics of compressible flow
1D flow examples
Sound waves
Shock waves and jump conditions
Weak and strong shocks
Sedov solution

INSTABILITIES

Linearization of the fluid equations and growth rate of perturbations
Kelvin-Helmholtz instability
Rayleigh-Taylor instability

BOUNDARY LAYERS

Concepts of boundary layers
Self-similar solutions for viscous flows
Jets
Boundary layer separation