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