RADIATIVE AND DYNAMICAL PROCESSES

This model syllabus defines the core material for Radiative and Dynamical Processes. 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.

TRANSPORT PHENOMENA

Microscopic description of transport processes for particles

Random walks and relation to diffusion
Mean-free path, collision time
Langevin, Fokker-Planck and Boltzmann equations

RADIATION PROCESSES

Macroscopic treatment of radiation and its interaction with matter, primarily at the level needed to deal with grey atmospheres

Defining the radiation field (specific intensity, moments, fluxes)
Equation of radiative transfer
Emission, absorption, definition of the source function, formal solutions
Approximations for optically thin and thick media: diffusion and two-stream limits
Local thermodynamic equilibrium
Grey atmospheres: applications and limitations
Mean opacities: definition and qualitative discussion of opacity as a function of wavelength.

MAGNETOHYDRODYNAMICS

Derivation, application, and understanding the limits of the MHD approximation. There is overlap with Fluids in the derivation of the MHD equations – instructors might consider an independent derivation of the basic fluid equations starting from the Boltzmann equation.

Basic assumptions for a magnetized fluid
Derivation of the ideal MHD equations
Diffusivity and non-ideal MHD: magnetic Reynolds number and Prandtl number
Hydromagnetic equilibria
Force-free approximation
Alfven and magnetoacoustic waves
Limits to the MHD approximation (e.g. when is additional physics such as ambipolar diffusion important, and when is a full plasma treatment needed)

DYNAMICAL PROCESSES

General introduction to dynamics with application to both planetary and stellar dynamical problems

Orbits in Keplerian potentials
Dynamics in perturbed potentials
Simple examples of resonant dynamics (pendulum, planetary orbits)
Concepts of stellar dynamics, scattering, relaxation time, dynamical friction
Dynamics of clusters: Fokker-Planck and N-body approaches
Stability of N-body systems (e.g. restricted 3-body problem, disk stability)