Course Topics

A) Basics of MHD

i) MHD equations, content
ii) Freezing-in Law, Alfven's Theorem
iii) Energy and momentum relations, magnetic tension
iv) Virial Theorem, Stellar Collapse

B) MHD Dynamics I

i) MHD Waves, Fredericks Diagram
ii) Reduced MHD, Model Structure, Drift Wave Models
iii) Deriving MHD Models
iv) Nonlinear Alfven waves, basics of collisionless shocks

C) Non-ideal MHD I

i) Local Reconnection: Sweet–Parker Model
ii) Magnetic Helicity — a measure of self-linkage
iii) Global: Prandtl–Batchelor Theorem, Flux Expulsion

D) Stability I — Ideal

i) MHD Energy Principle — formulation
ii) Examples
    a) Rayleigh–Benard
    b) Rayleigh–Taylor
    c) Interchange, line-tying
iii) Magnetic instabilities
    a) Sausage mode and hydro-analogue
    b) Kink, Kruskal–Shafranov Criterion
    c) MRI

E) Wave Interactions

i) Wave Adiabatic Theory

ii) 3-wave interactions, Manly–Rowe relations
iii) Wave kinetics, non-local interactions, wave cascades
iv) Decay instability of Alfven wave

F) Basics of MHD Turbulence

i) Navier–Stokes Turbulence — a very brief review
ii) MHD turbulence — basic ideas, Alfven effect
iii) Kraichnan-Iroshnikov and Goldreich-Sridhar Scalings, critical balance

G) Non-ideal MHD II

i) Stochastic magnetic fields, transport
ii) Magnetic Helicity II, Selective Decay, Taylor Relaxation
iii) Basics of dynamo theory
iv) Mean field electrodynamics — an introduction

H) Stability II — Resistive

i) Basic ideas of resonances, resistive modes
ii) Fast, slow resistive interchange
iii) Tearing, magnetic island formation

I) Tokamak MHD

i) Nonlinear tearing modes, Rutherford Theory, Neoclassical Tearing
ii) Ballooning modes, beta limits
iii) ELM dynamics