AA 601: Astrophysical Fluids and Plasma

Course coordinator: *Dr. Bhargav Vaidya (bvaidya@iiti.ac.in)*

Time: Mon-Tues-Wed from 10:00 am to 10:55 am
Venue: Manganese Pod Room 505.

Distribution of Marks: MSE (30%), ESE (50%) Class Participation (10%), Tutorials/Quiz (10%)

TEXTS:

1. Physics of Fluids and Plasmas by *Arnab Ray Choudhari*
https://www.cambridge.org/core/books/physics-of-fluids-and-plasmas/8A235D6F1D9DA51F05237D42BDFEFD06

2. Astrophysical Plasmas and Fluids by *Vinod Krishan*
https://www.springer.com/gp/book/9780792354901

3. Plasmas: The First State of Matter by *Vinod Krishan*
https://www.cambridge.org/core/books/plasmas/10A4AF6E106C0C8CC93D0C2AD585A0FC

4. Principles of Astrophysical Fluid Dynamics by *Cathie Clarke and Bob Carswell*
https://www.cambridge.org/core/books/principles-of-astrophysical-fluid-dynamics/84D9BF1EE32639C2CAC00C7C515A51CF

5. An Introduction to Astrophysical Fluid Dynamics by *Michael J Thompson*
https://www.worldscientific.com/worldscibooks/10.1142/p418

COURSE STRUCTURE:

- Review of Statistical Mechanics (Week 1) – Concept of phase-space, Louisville's Theorem, Distribution Function, Maxwell-Boltzmann Model, Fokker-Planck Model, Concept of fluid parcel, collisional and collision-less conditions

- Conservation Equations (Weeks 2 and 3) – Eulerian and Lagrangian Framework, Fluid motion – Streamlines and Path-lines. Mass, Momentum and Energy conservation along with concept of entropy, Equation of state.

TUTORIALS 01 and 02.

- Effect of Gravity, Viscosity and Rotation in Fluids (Weeks 4 and 5) – Virial Theorem, Centrifugal forces, Vortex flows, Viscous vs Inviscid flow, Hydro-static equilibrium and its application in star formation

- Shock physics (Weeks 5 and 6) – Bernoulli Equation, Concept of Shocks, Rankine - Hugonoit jump conditions. Adiabatic and Isothermal shocks. Application to Supernova Remnants and Jets.

TUTORIALS 03 and 04.

- Hydrodynamic Instabilities (Weeks 7 and 8) – Concept of Linear perturbation theory, Gravity waves, Kelvin Helmholtz, Rayleigh Taylor, Jeans Instability

MID SEMESTER EXAM (MSE)

- Review of Plasma Physics (Week 9) – Maxwell Equations, Plasma Properties, Motion of charged particle in EM field.
- Magneto-hydrodynamics (Weeks 10 and 11) – Concept of Ideal MHD, Flux Freezing, Conservation Equation, Generalized Ohm's Law. Brief overview of non-ideal effects and its astrophysical relevance. Concept of Alfven waves, Fast and Slow magneto-sonic waves.

TUTORIALS 05 and 06.

- MHD Instabilities and Dynamo (Week 12 and 13) – Extension of Linear MHD theory to study Kink and Sausage instability, Dynamo Action for field amplification, Magnetic reconnection (brief if time permits).

END SEMESTER EXAM (ESE)

Note: An additional week that may be available can be used as doubt solving sessions/accounting for holidays etc.