

AA 601: Astrophysical Fluids and Plasma

Autumn Semester 2021

Instructors :

Bhargav Vaidya (Course coordinator)
Amit Shukla

Time:

Google Meet Link:

Distribution of Marks: MSE (20%), ESE (40%) Class Evaluation (40%)

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 (Each week is 2 lectures + 1 tutorial):

- **Review of Statistical Mechanics (Week 1 August 09-13)** – Concept of phase-space, Louisville's Theorem, Distribution Functions, Maxwell-Boltzmann Model. [Instructor : BV]
- **Introducing Fluids (Week 2 August 16-20):** Fluid motion: Streamlines and Path-lines. Concept of fluid parcel, Problem solving on fluid motion **#Assignment 1** [Instructor : BV]
- **Hydrodynamic Equations (Weeks 3, 4 - August 23-September 03)** Eulerian and Lagrangian Framework Mass, Momentum and Energy conservation along with Laws of Thermodynamics, Equation of state. Concept of Steady state, Effect of Gravity and Rotation: Virial Theorem, Centrifugal forces, Vortex flows, Kelvin's circulation theorem Viscous vs Inviscid flow, Bernoulli Equation. **#Assignment 2** [Instructor : BV]
- **Applications of HD Equations (Weeks 5, 6 - September 06-17)** – Accretion Disk, Shakura Sunyaev Disk, Hydro-static equilibrium and its application in star formation, Bondi Accretion and Parker Solar Wind. **#Assignment 3** [Instructor : BV]

MID SEMESTER EXAM (MSE) (Sept 22-30)

- **Shock physics (Weeks 8, 9 - October 1-13)** – Concept of Shocks, De-laval nozzle, Rankine-Hugoniot jump conditions. Adiabatic and Isothermal shocks, Application to Supernova Remnants and Jets. **#Assignment 04** + (Discussion on MSE) [Instructor : BV]

Mid semester break (October 14-17)

- **Hydrodynamic Instabilities (Week 10 - October 18-22)** – Concept of Linear perturbation theory: Sound waves: wave equation, dispersion relation, Instabilities : Kelvin Helmholtz Instability and Rayleigh Taylor Instability, Convective instability and Schwarzschild's criterion. [Instructor : BV]
- **Review of Plasma Physics (Weeks 11, 12 - October 25-November 05)** – Revision of Maxwell Equation, Plasma Properties : Vlasov Equation, Motion of charged particles in EM field, Discharge physics, **#Assignment 05** [Instructor : AS]
- **Magneto-hydrodynamics (Weeks 13, 14 - November 8-19)** – Concept of Ideal MHD, Flux Freezing, Introducing MHD Conservation Equation, Alfvén, fast and slow waves, Magnetic Reconnection **#Assignment 06** [Instructor : AS]

END SEMESTER EXAM (ESE) (November 22-30)