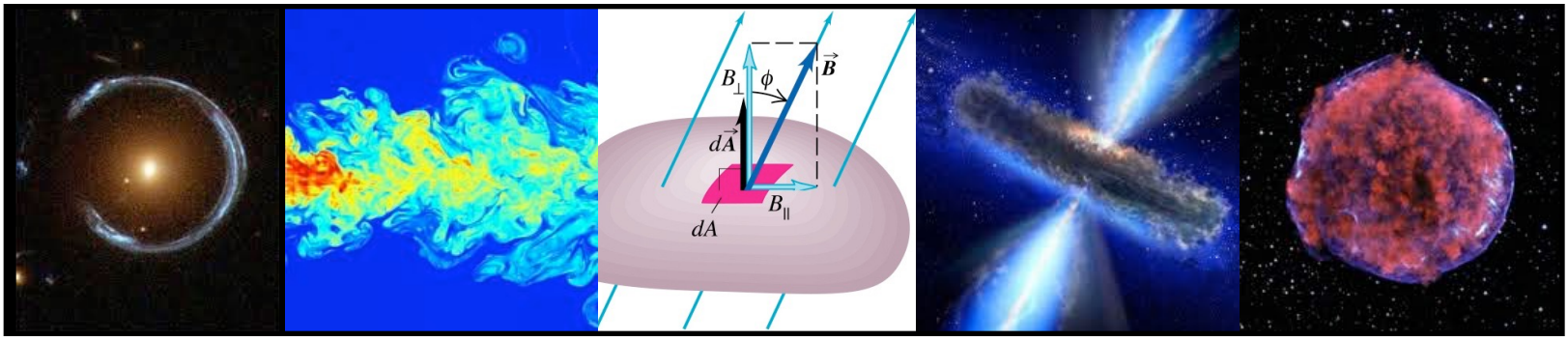
# ASTR0 320; Spring Semester 2019
# Physical Processes in Astronomy




## Course Description

This course discusses physical processes relevant for astrophysics and consists of four parts. Part I covers fluid dynamics. We will derive the continuity, momentum & energy equations, discuss hydrostatic equilibrium, viscous flows, fluid instabilities, equations of state, shocks, turbulence and focus on various astrophysical applications such as stellar structure and accretion disks. Part II deals with collisionless fluids. We will derive the Jeans equations, contrast them to Euler equations of collisional fluids, and study some applications of collisionless dynamics, including dynamical friction and the impulse approximation. In Part III we address radiation. We discuss both thermal and non-thermal emission mechanisms, study the interaction of radiation and matter, delve into radiative transfer, and address statistical equilibrium. Finally, in Part IV we briefly delve into plasma physics by studying plasma orbit theory, the Vlasov equation, the two-fluid model and magnetohydrodynamics.

Instructor: Prof. Frank van den Bosch (52 Hillhouse, Office: 320)
frank.vandenbosch@yale.edu

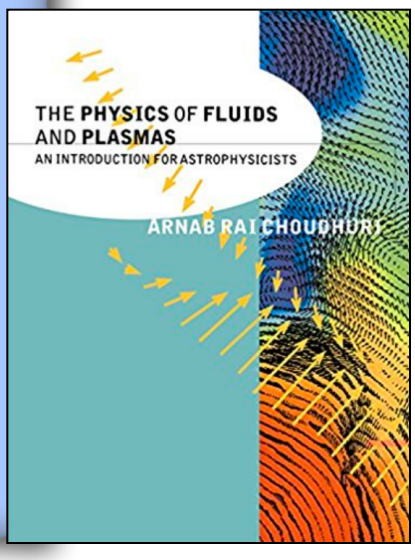
Course Website: https://campuspress.yale.edu/astro320/

Lecture Hours: Tue & Thu: 4.00 - 5.15pm; Location WTS A60

Recommended Textbooks: The Physics of Fluids and Plasmas: An Introduction for Astrophysicists

Grading: 35% Final Exam
30% MidTerm Exam
35% Problem Sets

Lecture Format: Blackboard presentations + detailed lecture notes



# Preliminary Schedule

| week | Date | Topic |
|---|---|---|
| 1 | Tue 01/15 | Fluid Dynamics: introduction |
| 1 | Thu 01/17 | Fluid Dynamics: continuity & momentum equations (Euler) |
| 2 | Tue 01/22 | Fluid Dynamics: the stress tensor & viscosity (shear & bulk) |
| 2 | Thu 01/24 | Fluid Dynamics: The Navier-Stokes equations |
| 3 | Tue 01/29 | Fluid Dynamics: Microscopic Approach; From Liouville to Boltzmann to Navier Stokes |
| 3 | Thu 01/31 | Fluid Dynamics: Vorticity & Kelvin's Circulation Theorem |
| 4 | Tue 02/05 | Fluid Dynamics: Bernoulli Equation & Crocco's theorem |
| 4 | Thu 02/07 | Fluid Dynamics: Turbulence |
| 5 | Tue 02/12 | Fluid Dynamics: Equations of State (ideal gas, photon gas & degenerate EoS) |
| 5 | Thu 02/14 | Fluid Dynamics: the Energy Equation |
| 6 | Tue 02/19 | Fluid Dynamics: Sound waves |
| 6 | Thu 02/21 | Fluid Dynamics: Shocks |
| 7 | Tue 02/26 | Fluid Dynamics: Instabilities |
| 7 | Thu 02/28 | Fluid Dynamics: Hydrodstatic Equilibrium & Stellar Structure |
| 8 | Tue 03/05 | Fluid Dynamics: Astrophysical Gases; Thermodynamic Equilibrium & Saha equation |
| 8 | Thu 03/07 | **MIDTERM EXAM** |
| 9 | Tue 03/12 | **NO CLASSES** **[SPRING BREAK]** |
| 9 | Thu 03/14 | **NO CLASSES** **[SPRING BREAK]** |
| 10 | Tue 03/19 | **NO CLASSES** **[SPRING BREAK]** |
| 10 | Thu 03/21 | **NO CLASSES** **[SPRING BREAK]** |
| 11 | Tue 03/26 | Gravity: Poisson equation & Virial Theorem |
| 11 | Thu 03/28 | Gravity: Collisionless fluids, Dynamical Friction & Impulse Approximation |
| 12 | Tue 04/02 | Radiation: The Interaction of Light with Matter I. Scattering |
| 12 | Thu 04/04 | Radiation: The Interaction of Light with Matter II. Absorption |
| 13 | Tue 04/09 | Radiation: The Interaction of Light with Matter III. Extinction |
| 13 | Thu 04/11 | Radiation: radiative transfer |
| 14 | Tue 04/16 | Radiation: continuum emission |
| 14 | Thu 04/18 | Plasma Physics |
| 15 | Tue 04/23 | Plasma Physics |
| 15 | Thu 04/25 | **Q&A and General Review** |

# The Road To Success

This course will make use of **vector calculus** and **multi-variable calculus**, and the students are expected to be familiar with this. Appendices **A**-**C** in the lecture notes summarize these materials, and the students are strongly encouraged to read these Appendices in detail. Also, Problem Set 1 will test the student's ability with these topics.

- ➢Read chapter (Lecture Notes) prior to coming to class
- ➢Come to class, and actively participate; ask questions in class
- ➢Seek help from instructor (after class, or by arranging for an appointment via e-mail)
  NOTE: no pre-set office hours, but I will meet with students upon request
- ➢Self-study: study material using lecture notes, text books, internet etc.
- ➢Submit problem sets on time (points will be subtracted for late time submission).
- ➢Indicate your name on problem sets and staple your work.
- ➢Points will be subtracted if you fail to explain how you came to a solution.
- ➢Write clearly, and neatly. Use words to explain what you are doing, and not just equations. If I can't read it, I won't give points for it.
- ➢When working on problem sets, you may consult your fellow students. However, when it comes to writing the solution down, you should do so all by yourself.