

# AS 725 - GRAVITATIONAL ASTROPHYSICS - Spring 2014

**Lectures:** Tuesdays and Thursdays, 9:30 AM - 11:00 AM, CAS Room 502

**Instructor:** Professor Kenneth Brecher, CAS Room 518 (inside 514), x 3423,  
e-mail: brecher@bu.edu

**Office Hours:** Tuesdays and Thursdays 11:00 – 12:30

**References:** No single book includes all of the topics we will cover. Relevant books will be on reserve in the Astronomy Department Library. Handouts will be distributed throughout the semester.

**Grading:** The course grade will be based on problem sets (35% of final grade); a written midterm examination on Newtonian gravitation (35% of final grade); and a paper/project report on a topic in General Relativistic Gravitation, or on alternative gravitational theories and/or dark matter.

**Outline:** The specific selection of topics, as well as the time devoted to each, may change.

- I. Introduction to Gravitation (~ 1 week)
  - A. General principles (space, time, forces, fields, energy), fundamental questions
  - B. Virial Theorem, symmetries, Noether's theorems, conservation laws
- II. "One-body" Problem (~ 2 weeks)
  - A. Newtonian hydrostatic equilibrium of stars, scaling, pulsations
  - B. Oblateness, free precession, glitches, other one-body (actually  $10^{58}$  body!) effects
- III. Two-body Problem (~ 1 week)
  - A. Kepler's laws of planetary motion (restricted two-body problem)
  - B. Binary star motion; also extrasolar planet-star systems
- IV. Three-body Problem (~2 weeks)
  - A. Restricted Three-Body Problem – general issues
  - B. Contact binaries, Lagrangian points, mass transfer, Roche limit, accretion
- V. N-Body Systems (~ 2 weeks)
  - A. Star clusters, dynamical relaxation, effects on binary stars
  - B. Galactic dynamics - selected topics
  - C. Planetary, stellar and galactic rings and discs
- VI. Relativistic Gravitation (~2 weeks)
  - A. Introduction to field theory of gravity, geometry, space-time, metric
  - B. General Relativity - field equations
  - C. Schwarzschild solution and tests of theory
  - D. Gravitational Radiation – LIGO
  - E. Gravitational Lensing
- VII. Gravitational Physics of Compact Objects (~2 weeks)
  - A. Structure of white dwarfs and neutron stars
  - B. Gravitational collapse - Chandrasekhar limit
  - C. Black Holes - formation, properties
  - D. Accretion processes involving compact stars
- VIII. General Relativistic Cosmology (~1 week)
  - A. Robertson-Walker metric and Friedmann solutions
  - B. Dark matter

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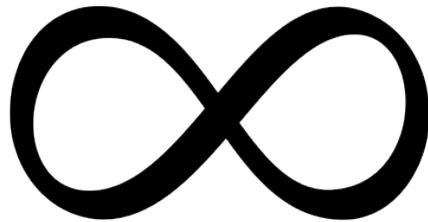
## Thoughts on Gravitation

“Gravitation. Noun. The tendency of all bodies to approach one another with a strength proportioned to the quantity of matter they contain – the quantity of matter they contain being ascertained by the strength of their tendency to approach one another. This is a lovely and edifying illustration of how science, having made A the proof of B, makes B by the proof of A.”

-A. Bierce, The Devil’s Dictionary

“All of astronomy is just the story of the fight against gravity.”

-A. Eddington



“That strange quantity “infinity” is the very mischief and no rational physicist should have anything to do with it. Perhaps that’s why mathematicians represent it be a sign like a love knot.”

-A. Eddington in New Pathways in Science

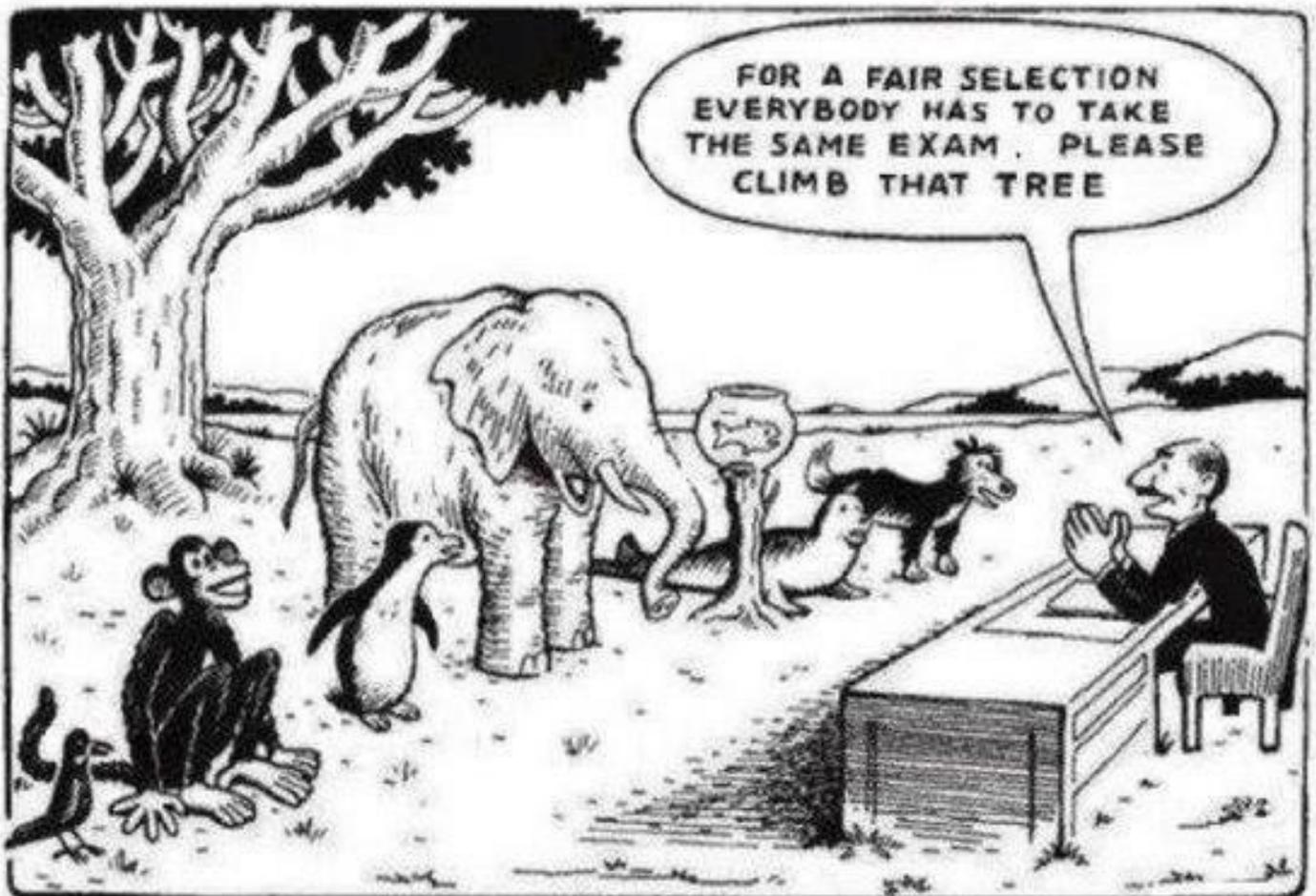
“Falling in love is not at all the most stupid thing that people do – but gravitation cannot be held responsible for it.”

-A. Einstein

# AS 725 Mid Term Exam

## Thursday, March 20

### Our Education System



If you judge a fish by its 'ability' to climb a tree, it will spend its entire life believing its stupid - Albert Einstein