PHY 241 Planetary Systems - Midterm Revision

Midterm: Monday, November 17, 2008 2pm

Terms and Definitions

- Orbits
  - Semi-major axis
  - eccentricity
  - inclination
  - true anomaly
  - pericenter - definition, orientation of **x** and **v**
  distance in terms of orbital elements $q = a(1 - e)$
  - apocenter - definition, orientation of **x** and **v**
  orbital elements $q = a(1 + e)$
- Kepler's 3 Laws, be able to derive for circular orbit.
- Hill Radius - what does this tell you
- Roche Radius - what does this tell you
- Escape Velocity
- Circular Orbital Velocity
- Tidal quality factor Q -qualitatively
- Love Number (k_{2p} -qualitatively)

Populations

- Terrestrial Planets (i.e. Mercury, Venus, Earth, Mars) orbital semi-major axes
- Giant planets (Jupiter, Saturn, Uranus and Neptune) orbital semi-major axes
- Regular satellites - (rough sizes, types of orbits, a,e,i) Given an example or two, Where do their orbit in R_p, r_H?
- Irregular satellites (rough sizes, types of orbits, a, e, i) Where do their orbit in R_p, r_H?
- Planetary Rings - where do they exist (orbital properties in terms of R and r_H)? Why do they exist (i.e. what prevents them from accumulating into larger satellites?

Mathematical definitions

- - Centripetal Force
  - Gravitational Force
  - Gravitational potenitial energy
  - Kinetic energy
  - Total energy
  - Angular momentum
  - Torque

- Total system angular momentum.

- Roche Radius
- Hill radius
- Escape Velocity
- Height of equilibrium tide
- Angular momentum - rotational, orbital
- Moment of Inertia - definition in general also for a sphere
- Volume of a sphere

Derivations to know how to do:

- Synchronous orbital radius
- Using energy relation derive:
  - circular orbital velocity
  - escape velocity
  - vis-viva equation
- Derive expression for angular momentum of an elliptical orbit using:
  - definition of orbital angular momentum
  - distance to pericenter or apocenter
- Derivation of Hill radius/ Roche radius
- Using tidal torque formula and orbital angular momentum for a circular orbit derive an expression for semi-major axis as a function of time.

Types of problems we've done:

- Using maximum elongation angle to determine size of orbit of inner planets (vulcanoids from cw#1)
- Calculating scales and characteristic quantities
  - orbital velocities
  - Hill radii
  - escape velocity
  - orbital angular momenta
  - rotational angular momenta
- Determining the size of an orbit, from an observed speed and position (vis-viva equation).
  - fireballs
- Transfer orbits.
  - calculating change in speed needed to go from one orbit to another. (many variations on coursework)
- Tides:
  Calculating Tidal height of equilibrium tide

Calculating tidal evolution using relation between a_1,a_0,t_1,t_0 and k_2/Q. Many variation on coursework, but usually fall into classes of problems. For example:
- Given k/Q, how long does it take to go from (a_0, t_0) to a_1? - given da/dt what is k/Q - given da/dt what is $d\Omega/dt$?

Explanations & physical interpretations:

- Explain relation between Roche radius and location of planetary rings
- Explain what causes tidal deformation
- Explain why there are two high tides and two low tides everyday. How tides in Earth from the Moon and Sun affect evolution of the system.
- Explain how a body's physical strength might affect the amplitude of the tide raised.
- Using a diagram of the tidal bulges raised and a force diagram, explain why a satellite outside synchronous
  - experiences a net torque and evolves outward.
  - what are possible fates of satellite/planet for this evolution?
- Using a diagram of the tidal bulges raised and a force diagram, explain why a satellite inside synchronous
  - experiences a net torque and evolves inward.
  - what are possible end fates for such satellites?
- What are the consequences of tides and friction for
  - orbits
  - rotation states
  - heating
  - when is the primary heated? - when is the secondary heated?
- Friction and Diurnal (satellite tide)
  - explain how eccentric orbit of secondary leads to dissipation in secondary and damping of the eccentricity.
  - Some important consequences of this evolution?

Suggested references for revision:

- Your notes.
- Slides from website (mostly graphical)
- Moons & Planets (mostly textual descriptions)
- scans from IAA for Roche radius derivation (see website)
- go over coursework/solutions, derivations from class notes/text
- Ch. 1 Introductory Astronomy & Astrophysics (hereafter IAA), by Zeilik, Gregory and Smith (several copies in the Library) - see scans on website.
- Ch. 2 & 3 Moons & Planets, Hartmann (hereafter, just Hartmann).