Phys 503 Classical Mechanics I **Fall 2013**

Homework Assignment #2 **Due Tuesday, September 24**
(70 points) **(at lecture)**

2.1 (10 points) Goldstein 3.14

2.2 (10 points) Goldstein 3.18

2.3 (10 points) Goldstein 3.21 and 3.22

2.4 (10 points) A particle of mass m moves in a central-force field described by a potential energy

$$V(r) = -\frac{ke^{-\alpha r}}{r},$$

where k and α are positive constants.

(a) What is the central force $f(r)$ for this potential?

(b) Find the values of angular momentum l for which there are circular orbits. For those l that have circular orbits, tell how many circular orbits there are, and give an equation that determines the radii of these orbits (but don't try to solve the equation!).

(c) For those l that have circular orbits, determine which orbits are stable and which are unstable. Draw a semi-accurate effective potential diagram that leads to or corresponds to your conclusions.

2.5 (10 points) A *magnetic monopole* is defined (if one exists) by a magnetic field singularity of the form $\mathbf{B} = (b/r^2)\mathbf{e}_r$, where b is a constant (a measure of the magnetic charge, as it were). Suppose a particle of mass m moves in the field of a magnetic monopole and a central force field $f(r)$.

(a) Find the form of Newton's equation of motion, using the magnetic force given by Eq. (1–61). By looking at the product $\mathbf{r} \times \dot{\mathbf{p}}$, show that while the mechanical angular momentum is not conserved (the field of force is not central), there is a conserved vector

$$\mathbf{D} \equiv \mathbf{L} - \frac{qb}{c}\mathbf{e}_r.$$

(b) By paralleling the steps leading from Eq. (3–79) to Eq. (3–82), find the form of $f(r)$ which allows you to define a conserved vector analogous to the Laplace-Runge-Lenz vector in which $\mathbf{D}$ plays the same role as $\mathbf{L}$ in the pure Kepler force problem.

2.6 (10 points) Goldstein 3.32

2.7 (10 points) Challenge problem