Portland State University
Department of Physics

PH 624: Classical Mechanics
Instructor: M.A.K.Khalil

Problem Set 2 (Chapters 3,4,5)

H. Goldstein, C.Poole and J.Safko, Classical Mechanics, (Addison Wesley, N.Y., 2002)

Chapter 3:

Keating:	3.14 - Planetary Motion - 1/r potential. 1
Kozell:	3.19 - Yukawa Potential - 2
Kuperman:	3.23 - Kepler's Law application - 1.
Lankow:	3.31 - Scattering cross-section. - 2
Lerud:	3.33 - Particle in a bowl - 2

Chapter 4

Mylott:	4.18 - Rotations - 2.
Neiderriter:	4.21 - Coriolis Force - 2.
Schrader:	4.24 - Coriolis Force - 2. Include the Coriolis force
Stenmark:	4.25 - Centrifugal Force - 2.

Chapter 5

Almutairi:	5.3 - Rotational KE - 1
Amin:	5.4 - Euler Equations derived from Lagrange Equations - 3
Barnum:	5.15- Principal Moments - 2
Comnes:	5.20 - Complex pendulum EoM - 2.

PH 624 Classical Mechanics
Problem Set 2: Annotations and Hints

Overall the problems are, I believe, easier than the first set. I had some difficulty selecting problems from Ch 4 because there were no really good ones. The purely mathematical problems are of limited value so I chose the later ones that are more about physics. Some hints and comments are given below.

3-14: Straightforward application of lecture and book materials.

3-19: Part (a) follows closely the qualitative material motion in a central force .

This potential was introduced by Yukawa in the 1930s to describe the strong interactions that create the nuclear force through the exchange of pi mesons. The $K = g^2$ is the coupling constant. It is a short range potential hence $r_o << a$.

Hints: Part (b) Eqn (3.46) has to be applied. $\beta = 1$ for closed orbits. If $\beta = 1+\delta$ the orbit fails to close by how much?

3-23: Straightforward application of Kepler's Laws. Do obtain a numerical answer.

3-31: Follows the treatment of scattering in the book and lectures.

3-33: Hints: Let $z = \alpha r^2$ be the equation of the paraboloid of revolution. θ is a cyclic coordinate hence angular momentum is conserved. Use r, θ, z coordinates, but there will be only two independent coordinates.

4-17, 18 and 21: All are straightforward.

4-24: Include the centrifugal and coriolis forces.

4-24: Hint: Coriolis force is 0 (perhaps that is obvious, in which case it is not much of a hint). Make sure you do the last part by calculating the total force and its direction. That includes the weight.

5-3: Easy one

5-4: An important exercise. Please work on this one diligently. It takes some work to get this right, but there are no tricks.

5-15: Well this one was tedious. There are a lot of integrations. The last part requires finding the eigenvectors of the inertia matrix.

5-21: Also tedious. You need the KE for the rod, and translational and rotational KE's for the disk. There are PE's for both the rod and the disk. 5 terms in the Lagrangian. Fortunately you are not asked to solve the EoMs but if you want to play around, you may want to make the small angle approximation. Then $\sin\theta$ terms become θ and $\cos\theta$ terms become 1. It may be possible to argue that the $d\theta/dt$ terms are also negligible. I have not tried it.