Phys 3610, Fall 2009
Problem Set #3, Hint-o-licious Hints

1. *Taylor*, **4.9** When the mass is hanging (motionless) from the spring we have

$$F_{\rm grav} = mg = F_{\rm spring} = kx_0$$

Measuring distance y of the mass *downward* from the equilibrium position, the potential energy of the mass–spring system is (you must use the result of part (a)— that's the potential energy of the spring)

$$U_{\rm tot} = \tfrac{1}{2}(x_0 + y)^2 - mgy$$

Rearrange this to the desired form.

2. *Taylor*, **4.22** This should be a very simple exercise in vector calculus.

3. *Taylor*, **4.28** The point of this is to see if we can derive the well-known oscillatory motion $x(t)$ of a mass on a spring using the "Complete Solution" method given on pp. 127-128. Use (4.58) to get t as a function of x and invert.

4. *Taylor*, **4.30** As far as I can tell, this one is algebraically simple. Draw a picture of the toy tilted at angle θ. The height of the hemisphere's center in fact does not change with θ so one finds that the height of the center of mass (above the floor) is given by

$$(h - R)\cos\theta + R$$

. The condition of equilibrium is of course $\frac{dU}{d\theta} = 0$ and for stable equilibrium $\frac{d^2U}{d\theta^2} > 0$.

5. *Taylor*, **4.35** Here you are asked to redo the energy derivation of the Atwood machine but now include the energy of the (massive) pulley. If the speed of the masses –and any one bit of the string– is v, then the angular speed of the pulley is $\omega = v/R$ if the the string does not slip (which we assume).

6. *Taylor*, **5.2** In fact, the function has a minimum at $r = r_0 = R$ With the substitution $r = r_0 + x$ the function gets simpler, and assuming $x \ll s$ it's easy to expand the exponential. In the end you get

$$U(x) = -A + A\frac{x^2}{s^2} + \cdots$$

so that $k = \frac{2A}{s^2}$, but *show* all this.

7. *Taylor*, **5.9** You are given A and $v_{\rm max}$. Conservation of energy will let you solve for $\omega = \sqrt{\frac{k}{m}}$. Get τ (period) from that.

8. *Taylor*, **5.31** Make a rather non-trivial plot using software of some sort. I will give some pointers on using Maple and Matlab in class.

9. *Taylor*, **5.33** Just find $x(0) = x_0$ and $\dot{x}(0) = v_0$ for the functions given in (5.69) and solve for B_1 and B_2 to get (5.70). You'll use these in problem 5.36.

These constants come from the initial conditions. The rest come from the *physical parameters* of the driven damped oscillator.

10. *Taylor*, **5.36** Make a rather non-trivial plot using software of some sort. I will give some pointers on using Maple and Matlab in class.

11. *Taylor*, **5.42** Find the period of the (undamped) pendulum and use the fact that the Q value is π times the number of cycles the system makes in the decay time.