PH351. Homework 2, due Monday, Oct. 10

1. and 2. Do problems 5 and 6 from the Homework 1 assignment

3. There are at least four ways to write the equation of motion for the simple harmonic oscillator:

$$\begin{split} \psi(t) &= A \cos(\omega_0 t + \phi), \\ \psi(t) &= B_p \cos(\omega_0 t) + B_q \sin(\omega_0 t), \\ \psi(t) &= C \exp(i\omega_0 t) + C^{\ddagger} \exp(-i\omega_0 t), \\ \psi(t) &= Re \{D \exp(i\omega_0 t)\}. \end{split}$$

Suppose the oscillator has a mass m = 2.0 kg and a spring constant s = 8 N/m. It is set into oscillation with an amplitude A = 0.1 m and a phase constant $\varphi = \pi/2$ in the first of the above equations. Find the values for the constants in the subsequent three expressions.

4. Calculate the maximum acceleration, in units of the acceleration of gravity g, of the "pickup stylus" on a "record player" that is reproducing some music with a frequency of 2 kHz and with an amplitude of 0.01 mm. (If you have never seen a "record player", pictures and details are available on line, or they can be found in museums, antique stores and in some homes of those usually over about 50.)

5. An astronaut on the surface of the moon weighs rock samples using a light spring balance. The balance, which was calibrated on earth, has a scale 100 mm long which reads from 0 to 1 kg. The astronaut places a certain rock on the balance. The spring oscillates, with a period of 1.0 s. The astronaut waits for friction to bring the system to equilibrium. Then the balance reads 0.4 kg. What is the acceleration due to gravity on the moon? There was a tiny amount of friction, but you can ignore this friction in solving the problem.

6. Challenge! Use a numerical solution of the exact equation and the approximate equation for a pendulum to examine the motion for a pendulum that is started from rest with an initial angle $\theta_0 = \pi/2$. (For constants, you can just set $\mathbf{m} = \mathbf{g} = \mathbf{l} = 1$.) Is the period of the pendulum longer or shorter than $T_0 \equiv 2\pi/\omega_0$? By how much? That is, what is the approximate numerical value of T/T₀? (Hint: I recommend that you make a graphs of the motion for the pendulum and for the analogous simple harmonic oscillator and read approximate values of T and T₀ off of your graph. I also recommend that you use Mathematica, however a programmable calculator using Euler's method will work fine.)