Physics 2a, Fall 2013. Week 1 exercises

⋆ Some of these will be solved in lecture and / or TA discussion or problem sessions.

1. Simple harmonic oscillator (SHO) basics.

   (a) Verify that $x(t) = A\cos(\omega t + \phi)$ solves the SHO differential equation.

   (b) Verify that $A\cos(\omega t + \phi) = B\cos\omega t + C\sin\omega t$, where you should determine the constants B and C in terms of A and ϕ. (If you don't remember your trig identities, try to re-derive them by using $e^{i\theta} = \cos\theta + i\sin\theta$, and $e^{i\theta_1}e^{i\theta_2} = e^{i(\theta_1+\theta_2)}$.

   (c) Suppose that you are told the initial position and velocity of the SHO, $x(0) = x_0$ and $\dot{x}(0) = v_0$; solve for A and ϕ in terms of these initial conditions.

2. SHO practice:

   (a) When physicists say "frequency," they usually mean the angular frequency $\omega = 2\pi/T$, in radians per second. Engineers on the other hand sometimes mean $f = 1/T$ (sometimes also called ν) in cycles per second, which is called Hz. The AC in the wall is at 60 Hz. Suppose a SHO has a mass of 20kg and is oscillating at 60 Hz, with an energy of 100J. What is its amplitude? What is its maximum velocity?

   (b) A force of 100N is applied to a SHO, which stretches it a distance of $0.1m$. Compute the work done, using $W = \int F dx$. When released, the mass m oscillates with a frequency of 5 radians per second. Using energy conservation, determine the mass m.

   (c) A SHO has $m = 1kg$ and is oscillating with energy $100J$. A $1kg$ ball of putty is dropped straight down from above, on the SHO mass, and it sticks. Find the new energy of the SHO if the putty hits when the spring was maximally stretched. Also, find the energy of the SHO if the putty hits when the spring was at the equilibrium position.

3. Fluid exercises from the textbook. Chapter 12 in the full version, or chapter 1 in the UCSD custom version. 8, 17, 25, 26, 27, 28, 33, 34, 35, 40, 43, 44, 47, 50, 59, 61, 75, 89, 94.