PROBLEM SET 2 Due Friday October 7

Physics 115B– FALL 2011

Analytic:

[**1.**] Griffiths Problem 4.2

[**2.**] Griffiths Problem 4.3

[**3.**] A piano manufacturing company is accidentally sent piano wire whose thickness gradually tapers off, so that its mass per unit length is $\mu - \mu' x/L$. (Here L is the length of the wire.) Fortunately for the piano company, μ' is small. This is also fortunate for you, because you can use perturbation theory to compute the frequency shifts of the different modes. Do so. Look up typical values for the tension T, length L, and mass per unit length μ of piano wires, and select values that give middle C for the fundamental mode $n = 1$. How much is the frequency shifted if $\mu' = 10^{-3}\mu$? Could your ear tell the difference?

[**4.**] Compute the first and second order shifts of the energy levels of the 3D harmonic oscillator for a perturbation $H' = Bxz$. Assume the levels are nondegenerate, that is, ω_x, ω_y, and ω_z are all non-equal. Then compute the first order shifts for the isotropic case $\omega_x = \omega_y = \omega_z$. In what way do the two cases fundamentally differ?

[**5.**] Show that, if you use the Euler method in Molecular Dynamics, then the energy of a simple harmonic oscillator increases by the factor $1 + k\,dt^2/m$ in each iteration. Suppose $t = Ndt$, how is $E(t)$ related to $E(0)$? Show that this growth is exponential (terrible!) but that even so the argument of the exponential can be driven to zero by making dt small. Note: Leapfrog, as you will see below, completely avoids this instability.

Numeric:

Comment: For the first part of the course, as you develop skill in programming, the computational problems will not necessarily have anything to do with quantum mechanics.

[**6.**] Write a C or C++ program to solve the classical harmonic oscillator $F = -kx$ using the leapfrog Molecular Dynamics method. Make a plot of your results for $k = 3, m = 0.8, x_0 = 1.4, v_0 = 0$. Plot $x(t)$ for 4 or 5 periods. Using your plot, and what you know about the analytic result for the period T, argue why you think your code is working properly.

[**7.**] Then make a plot of your results for $k = 3, m = 0.8, x_0 = 1.4, v_0 = 2$. Again plot $x(t)$ for 4 or 5 periods. Using your plot, and what you know about using energy conservation to compute the amplitude, argue why you think your code is working properly.