PHGN 480: Laser Physics due 9 Sept 2010
Homework 2

1) The selection rule for the harmonic oscillator is $\Delta n = \pm 1$ for electric dipole transitions. Parity (odd, even functions) explains why the transitions must take place between states of different parity. The general case in which the transitions are restricted to neighboring energy levels can be shown mathematically either by using raising/lowering operators, or by considering the orthogonality of the Hermite polynomials. To help get an visual sense for the selection rule, in this problem you will use plotting and numerical integration.

   a) In Mathematica, define functions $\psi_n(x)$ the first 5 SHO wavefunctions; see Griffiths eqn 2.85. In that equation, there is a dimensionless variable, ξ, which is defined in eqn 2.71. In many texts, this is defined as $\xi = x/x_0$, where $x_0 = \sqrt{\hbar/m\omega}$, which is a length scale that contains all the constants. For convenience, let $x_0 = 1$ in your plots.

   b) Make 3 plots over the range $x = \pm 5$; each plot should have (on the same plot) $\psi_m(x)$, $\psi_n(x)$ and $x\psi_n(x)\psi_m(x)$. Do this for the combinations m = 2, n = 3; m = 2, n = 4; m = 2, n = 5, where the m, n refer to energy state indices. Use numerical integration (NIntegrate) to integrate over that range.

2) Griffiths problem 5.13.

3) Griffiths problem 9.8.

4) Griffiths problem 9.9.

5) Griffiths problem 9.13.