Tutorial-3 (PHY201)

1. Consider a system of N coupled oscillators driven at a frequency $\omega < 2\omega_0$ [$y_0 = 0, y_{N+1} = hcos(\omega t)$]. Find the resulting amplitudes of N oscillators. Argue that for $\omega > 2\omega_0$ the wave damps exponentially in space.

2. The CO_2 molecule can be likened to a system made up of a central mass m_2 connected by equal springs of spring constant k two masses m_1 each. (see figure in problem 5-9, Pg 155, French).
   (a) Set up and solve for two normal modes in which the masses oscillate along the line joining their centers. Ignore the bending of molecules.
   (b) Putting m_1=16 units and m_2=12 units, what would be the ratio of frequencies of two modes, assuming this classical description were applicable?
   (c) If one end of CO_2 binds to a flat surface standing up, how many normal modes would be there?

3. A laser can be made by placing a plasma tube in an optical resonant cavity (see Fig. 6-10, Pg. 198, French) formed by two highly reflecting flat mirror, which act like rigid walls for light waves. The purpose of the plasma tube is to produce light by exciting normal modes of the cavity.
   (a) what are the normal mode frequencies of the cavity? (express your answer in terms of distance L between two mirrors and speed of light c)
   (b) Suppose that the plasma tube emits light centered at frequency ν_0=5x10^{14} Hz with a spectral width $\Delta\nu$. The value of $\Delta\nu$ is such that all normal modes of the cavity whose frequency is within ±1.0x10^9 Hz of ν_0 will be excited by the plasma tube.
   (c) What is the largest value of L such that only one normal mode is excited (so that laser has only one output frequency).

4. A Na-lamp emits doublet-spectral lines at (589nm and 589.6nm). Assuming that the lifetime of the transitions are about 1ns, i.e., same as the width of Gaussian light pulses emitted. You may assume each transition line as monochromatic harmonic oscillator satisfying wave equation.
   (a) Write down the net waveform of the composite pulses. Plot the shape of the beats in space at a fixed time and in time at a fixed space.
   (b) How much distance should one of the mirrors of the Michelson interferometer displaced to detect two consecutive positions of zero-contrast between dark and bright fringes.
   (c) How many such nodes are there in the entire pulse?