PHY293 Problem Set #4

October 12, 2010

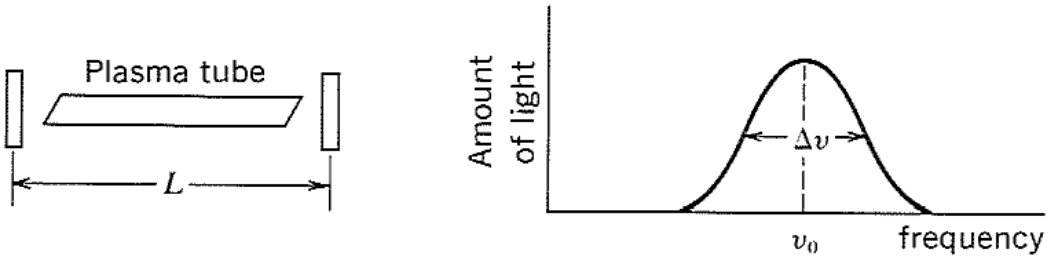
Due Monday, October 18 by 17:00

1) Plucked string: A uniform string of length 1.5m and mass 10g is placed under a tension of 40N. The string is held fixed at both ends.

(a) What is the frequency of the fundamental mode (the lowest frequency mode in your solution)?

(b) If the string is plucked transversely at its midpoint and then is touched (constrained to $y = 0$) at a point 0.5m from one end what frequencies persist? Why?

2) Resonant cavity: A laser can be made by placing a plasma tube in an optical resonant cavity formed by two highly reflecting flat mirrors, that act like rigid walls for light waves (see figure). 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 resonant cavity? (Express your answer in terms of the distance L between the mirrors and the speed of light c.)

(b) Suppose that the plasma tube emits light centered at a frequency $\nu_0 = 5 \times 10^{14}$Hz with a spectral width $\Delta\nu$ shown in the right part of the figure above. The value of $\Delta\nu$ is such that all normal modes of the cavity whose frequency is within $\pm 1.0 \times 10^{9}$Hz of ν_0 will be excited by the plasma tube.

i. How many modes will be excited if $L = 1.5$ m?

ii. What is the largest value of L such that only one normal mode can be excited? This will result in a laser that has only one output frequency. (Use $c = 3 \times 10^8$ m/s throughout)

3) Vibrating Bar: A uniform bar of length L and mass m is clamped at its midpoint, with both ends left free to vibrate. As discussed (briefly) in class, this object will obey the wave equation with $c_V = \sqrt{Y/\rho}$ where Y is the rod material's Young's modulus and ρ is the density. To solve this problem you can just assume c_V is given and use what you know about the wave equation to find the frequencies and modes required:

(a) What are the natural frequencies for vibrations of this rod?

(b) What is the wavelength of the n^{th} mode?

(c) Where are the nodes of the n^{th} mode?