Massachusetts Institute of Technology - Physics Department

Physics - 8.02 **Assignment #8** April 17, 2002.

We strongly recommend that you read about a topic before it is covered in lectures.

Lecture Date	Topics Covered	Reading from Giancoli
#26 Fri 4/19	Traveling Waves - Standing Waves ***Musical Instruments***	Giancoli (**Vol. I**) Chapter 15 through 15-9
#27 Mon 4/22	Resonance - Destructive resonance Electromagnetic Waves - Speed of Light Radio - TV Distance determinations using radar and lasers	Sect. 31-6 Chapter 32 through Sect. 32-9
#28 Wed 4/24	Index of Refraction - Poynting Vector Oscillating charges - Radiation Pressure Comet Tails Polarization (linear, elliptical, and circular)	Sect. 32-7 & 32-8 Chapter 33 through Sect. 33-2 Sect. 36-11

Due before 4 PM, Wednesday, April 24 in 4–339B.

Problem 8.1
An LRC circuit.
A circuit contains a self-inductance L in series with a capacitor C and a resistor R. This circuit is driven by an alternating voltage $V = V_0 \sin(\omega t)$. We have $L = 15\,\text{mH}$, $R = 80\,\Omega$, $C = 5\,\mu\text{F}$, and $V_0 = 40$ volts.

(a) What is the value of the resonance frequency, ω_0?

(b) Consider three separate cases for which $\omega = 0.25\,\omega_0$, $\omega = \omega_0$, and $\omega = 4\omega_0$ respectively. For each case calculate the the peak current I_0.

(c) Find the energy $U_C(t)$ and the energy $U_L(t)$ stored, respectively, in the capacitor and in the inductor as a function of time for $\omega = \omega_0$.

Problem 8.2
Average power dissipated in an LRC circuit.
Giancoli 31-20.

Problem 8.3
Width of resonance peak.
Giancoli 31-30.

Problem 8.4
Traveling waves on a string.
The equation of a *transverse* wave traveling along a string is given by $y = 0.4 \sin[\pi(0.5x - 200t)]$ where y and x are measured in cm and t in seconds.

(a) Find the amplitude, wavelength, wave number, frequency, period, and speed of the wave.

(b) Carefully draw the wave (y versus x) at $t = 0$, and at $t = 1/400$ sec.

(c) Find the maximum *transverse* speed of any mass element of the string.

(d) Suppose that you clamp the string at two points L cm apart and you observe a standing wave of the same wavelength as in part (a). For what values of L less than 10 cm is this possible?

Problem 8.5

Standing waves on a string.

The equation of a transverse standing wave on a string is given by $y = 0.3\,(\sin 3x)\,(\cos 1200t)$ where y and x are in cm, and t in seconds.

(a) What is the wavelength, wave number, frequency, and period, of this wave?

(b) Carefully draw the wave (y versus x) at $t = 0$, at $t = 1.31 \times 10^{-3}$ sec, and at $t = 2.62 \times 10^{-3}$ sec.

(c) What is the maximum transverse speed?

(d) What is the speed of propagation (of a transverse disturbance) *along* the string?

Problem 8.6

Distance sensing with sound.

A bat can sense its distance from the wall of a cave (or whatever) by emitting a sharp ultrasonic pulse that reflects off the wall. The bat can tell the distance from the time the echo takes to return.

(a) If a bat is to determine the distance to a wall 8 m away with an error of less than ± 0.2 m, how accurately must it sense the time interval between emission and return of the pulse?

(b) Suppose that a bat flies into a cave filled with methane (swamp gas). By what factor will this gas distort the bat's perception of distances? At 20^o C, the speed of sound in methane is 432 m/s.

Problem 8.7

Design a flute.

A flute can be regarded as a tube open at both ends. It will emit a musical note if the flutist excites a standing wave in the air column inside the tube.

(a) The lowest musical note that can be played on a flute is C (261.7 Hz). What must be the length of the tube? Assume that the air column is vibrating in its fundamental mode.

(b) In order to produce higher musical notes, the flutist opens valves along the tube. Since the holes in these valves are large, an open valve has the same effect as shortening the tube. The flutist opens one valve to play $C\#$, two valves to play D, etc. Calculate the successive spacing between the valves of a flute for one complete octave. (The actual spacings used on flutes differ slightly from the results of this simple theoretical evaluation because the mouth cavity of the flutist affects the frequency.)