PHY138Y1-Y

Waves Quarter –
Written Team Problem Set

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"Physics for the Life Sciences I"

Due November 25, 2005

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Please complete the following problems on separate paper. You should solve the problems together in the same team that you have been working with for the *Waves Quarter* in your tutorials. Designate one member of your team as the *coordinator*. The coordinator will be responsible for assembling the final copy of your solutions and submitting them on time.

Make sure the following information appears clearly at the top of the first page of your submitted copy of the solutions:

- **All team member's names**
- **Your tutor's name**
- **Your tutorial section day and time**

Show all your reasoning and work legibly, and draw a box around the final numerical or single-word answer where applicable. Your solutions should be stapled and submitted in the *Drop Box* for your tutorial. The Drop Boxes are located in the basement of the Burton Tower of McLennan Physics Labs (MP). On the first floor of MP there is a stairway with a bust of Isaac Newton on the 1st floor; the Drop Boxes are at the bottom of the stairs. This assignment is due by 5:00 PM on Friday November 25.

1. (**15 points**) The alternating pressure in a therapeutic application of ultrasound is superimposed on the static pressure, so that the resulting pressure changes periodically around the static pressure value. Suppose the frequency of the ultrasound in a treatment is f = 830 kHz, the irradiated power output is P = 15 W, and the irradiating area of the ultrasound-emitting head is A = 6 cm^2.
    a. Calculate the intensity of the ultrasound just below the emitter.
    b. What is the pressure amplitude and the highest value of pressure difference in the muscle? The density of muscle is ρ= 1040 kg/m^3 and the sound velocity in it is v = 1570 m/s.
    c. What is the distance between the sites of highest and lowest pressure in the muscle?

[Note: Equation 20.34 in Knight, pg.634, states that the intensity of any wave is given by $I=CA^2$, where C is some constant and A is the amplitude. In the case of sound waves, the amplitude is the pressure amplitude above and below the static pressure in Newtons/m^2. The constant is $C=1/(2\rho v)$, where ρ is the density of the material and v is the speed of sound.]

2. (**25 points**) A string of fixed length L = 1.200 m is vibrated at a fixed frequency of f = 120.0 Hz. The tension, T_s, of the string can be varied. Standing waves with fewer than seven nodes are observed on the string when the tension is 2.654 N and 4.147 N, but not for any intermediate tension. What is the linear density of the string?

3. (**10 points**) You are at a party and a friend challenges you to measure the speed of light using only a chocolate bar and a microwave oven. "No problem!", you say. You remove the turntable from the microwave and replace with a flat, unwrapped chocolate bar on a plate (so the plate does not rotate). You heat it for about 20 seconds, until it just starts to melt, then remove the chocolate bar. You notice some melted hot spots separated by cold solid spots in the chocolate. The distance between melted hot spots is about 6 cm. You turn the oven around and read the manufacturer's label which says that the frequency of the microwave lamp is 2.5 GHz. From your observations, what is the speed of light?

4. (**25 points**) Knight Problem 21.68

5. (**25 points**) Knight Problem 21.74

Some suggested problems for the Waves Quarter (not to be turned in):

Back-of-Chapter problems from Knight (answers are in Appendix):

Ch.14, Problems 13, 17, 23, 33, 51, 55, 77

Ch. 20, Problems 1, 25, 35, 39, 53, 69, 71, 79, 82

Ch. 21, Problems 7, 19, 25, 31, 49, 65, 71, 83 (skip part b – just use result)

Ch. 23, Problems 11, 17, 19, 27, 31, 39, 49, 73, 81