

## Waves Quarter – Written Team Problem Set

This homework assignment is due by 5PM on Friday November 24. It should be submitted in the *Drop Box* for your tutorial. The Drop Boxes are located in the basement of the Burton tower of McLennan. On the first floor of McLennan there is a stairway with a bust of Newton beside it; the Drop Boxes are at the bottom of that stairway.

	<b>This page must be the first page of the submitted Problem Set.</b>	
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You must solve the problems together in the same team that you have been working with in your tutorials.

	<b>Problem Sets done by a single individual will not be accepted.</b>	
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**By filling out and signing the form below, I certify that I took an active role in the solution of all the problems of this problem set.**

Name (Please Print)	Signature

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 in the Drop Box on time.

The coordinator should fill out this form:

<b>Name of Your PHY138 Tutor</b>	
<b>Tutorial Group</b>	
<b>Tutorial Day</b>	
<b>Tutorial Time</b>	
<b>Coordinator's (your) Name</b>	

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  $P = 15$  mW, and the irradiating area of the ultrasound-emitting head is  $A = 6.0$  cm<sup>2</sup>.
  - 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  $\rho = 1040$  kg/m<sup>3</sup> 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<sup>2</sup>. The constant is  $C = 1/(2\rho v)$ , where  $\rho$  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

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**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