

Physics 273, Fall 2005  
Exam # 2

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Name

Closed-book examination. One pre-prepared 8 1/2" x 11" sheet of notes may be used. Calculator may be used. Show work for partial credit. Include UNITS on all answers.

EXAM ADVICE: If you don't immediately see what to do on one problem, go on to the next problem and come back to the unfinished problems later.

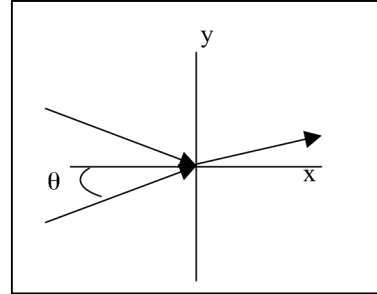
- (33 pts) 1. A simple model for the vocal column is a tube with one end closed and the other end open. The sound from the vocal cavity is distinctly different when it is filled with different gases. Use information from the table to answer the question below.

Gas	Molecular Wt.	$B = \gamma P$	Density = $\rho_v$	Sound Speed
He	4 g/mole	$1.69 \times 10^5 \text{ N/m}^2$	$0.16 \text{ kg/m}^3$	
Air	28.8 g/mole	$1.41 \times 10^5 \text{ N/m}^2$	$1.18 \text{ kg/m}^3$	
SF <sub>6</sub>	146 g/mole	$1.34 \times 10^5 \text{ N/m}^2$	$5.98 \text{ kg/m}^3$	

- a) Calculate the speeds of sound in He, air and sulfur hexafluoride, and write the values in the table.
- b) If the lowest frequency standing wave in the vocal column filled with air is 512 Hz, what is the length of the vocal column?
- c) What is the lowest frequency standing wave in a vocal column filled with pure He?
- d) What are the wavelength and frequency of the second lowest frequency standing wave in air? Write the wave equation for displacement  $\xi(x,t)$  for this standing wave. Assume the displacement is zero at  $x = 0$ ,  $t = 0$ , and the amplitude of the wave is  $\xi_0$ .



**(33 pts) 3.** An electromagnetic plane wave of frequency  $3 \times 10^{14} \text{ s}^{-1}$ , traveling in vacuum ( $Z = 376.6 \ \Omega$ ) is incident on an interface in the  $yz$  plane to a medium of lower impedance  $Z_2$  at an angle  $\theta$  as illustrated in the drawing. The magnetic field of the incident wave is parallel to the  $z$  axis.



- a) What is the magnitude of the incident wave vector?  
Write vector equations for the incident wave vector in terms of  $\theta$ . Find the values of the x and y components of the incident wave vector for  $\theta = 35^\circ$ .
- b) What is the direction of the reflected magnetic field assuming the incident field in the  $+z$  direction? ( $Z_2 < Z$ ) Draw vectors for the incident and reflected electric field on the figure assuming magnetic field in  $+z$  direction. Write vector equations for the incident and reflected electric field in terms of  $\theta$  using the symbols  $E_i$ ,  $E_r$ , for the magnitudes of the fields.
- c) If  $Z_2 = 200 \ \Omega$ , what is the index of refraction of the second medium? What is the angle of the refracted wave with respect to the x axis if  $\theta = 35^\circ$ ? Write a vector equation for the wave vector of the refracted wave.
- d) Compare the y-components of the incident and refracted wave vectors calculated in parts a and c. Explain the result.

**Extra Credit (5 points):**

What reference frames are important in describing the Doppler effect for mechanical waves? How is this different for electromagnetic waves?