Speed of Sound and Resonance (10/12/11)

Purpose:

The purpose of this lab is to demonstrate resonance of sound waves and determine the speed of sound traveling in air and in a metal rod.

Equipment

• graduated cylinder (1000 ml)	• open glass tube	• meter stick
• pitcher of water	• Kundt's tube & cork dust	• rosin & leather cloth

For class as a whole: tuning forks; ear plugs; thermometer; Phillips screw driver; pliers

Procedure:

Part I: Determining Speed of Sound in Air Using Open Tube Resonance (approx. 1 h 15 min.)

1) Fill the 1 liter graduated cylinder to within two inches from the top with water. Place the open glass tube inside the graduated cylinder.

2) Choose a tuning fork and record its natural (resonance) frequency. f =__________________ Hz

3) Strike the tuning fork with hard rubber and hold the tuning fork horizontally, with its tines one above the other about 1 cm above the open end of the inner tube. Move both the inner tube and the fork up and down together to find the shortest air column length that produces an amplitude (i.e. loudness) maximum. Measure the distance from the top of the resonance tube to the water level while at this maximum loudness.

Measured distance (i.e. length) = ________________ m

4) Record the (inside) diameter of the resonance tube.

Diameter of the resonance tube = _____________ m

5) Since the diameter of the tube is not negligible compared to its length, you must calculate a corrected length by adding 0.4 times the diameter of the tube to the measured length of the air column. This length accounts for the small amount of air just above the tube that also resonates.

Corrected Length = ________________m

6) The corrected length is one-fourth of the wavelength of the sound resonating in the air column. Calculate and record the wavelength (λ).

Wavelength = ________________m

7) Determine and record the speed of sound ($f\lambda$).

Speed of sound in air = ___________m/s.

8) Repeat each of the above steps for a second tuning fork: f = _______________ Hz

Length of air column = _______________ m

Corrected Length = _______________ m

Wavelength = _______________ m

Speed of sound in air = _______________ m/s.

The accepted value for the speed of sound in air is 332m/s at 0°C. The speed of sound in air increases by 0.6m/s for each degree C above zero. Compute the accepted value for the speed of sound at room temperature.

Calculate the percentage difference between this and the average of your two measured values.

Part II: Determining Speed of Sound in a Metal Using Kundt's Apparatus

1. Surmise the rod material, measure its length, and record: material: ____________ length_____________ (m)

2. Ensure that cork dust is evenly distributed along the bottom of the glass tube between the end of the rod and the closed end of the Kundt's apparatus (remove tube from support if necessary).

3. Adjust the position of the rod so that it is clamped tightly at its midpoint and adjust the orientation of the glass tube so that the disk on the end of the rod does not touch the wall of the glass tube. Rotate the tube slightly so the cork dust is moved away from the dead center bottom of the tube. (This way, the dust at the displacement antinodes will slide down when agitated by the sound waves).

4. Put a small amount of rosin on a leather (or chamois) cloth. While holding the base of the apparatus stationary with one hand, tightly grasp the rod with the other hand (about six inches from the end) using the rosined cloth. Pull very hard on the rod to make a loud screeching sound (from the friction) as the cloth moves along the rod. If the cork dust has not been agitated enough to make a standing wave pattern visible within the enclosed portion of the glass tube, change the length of the air column by moving the glass tube a short distance. (An air column of about 57 cm often works well.) Continue this procedure until the best resonance, as determined by visible displacement of the cork dust at the antinodes, is obtained. It may help to repeat stroking several times to get a more clearly visible pattern. (Note: If you're not sure of your results, ask your instructor to have a look.)

5. Omit the cork dust loop (antinode) nearest the disk and measure the distance along all other loops. Record the distance and the number of loops included in the measurement. Calculate the average length of an antinode and multiply by 2 to get the average wavelength. (Each antinode represents a half wavelength.)

distance: ___________ m number of loops: _________ average wavelength____________

6. Using the calculated value for the velocity of sound in air from Part I and the average wavelength of the sound in the air column calculated above, determine the dominant frequency of the resonating sound ($f = v/\lambda$) in the air column. This is, of course, the same as the frequency of vibration resonating within the metal rod.

Dominant frequency of sound resonating in air column: _f =_______________ Hz

7. Since you know that $f_{air}=f_{rod}$, and that $f=v/\lambda$, you can find the velocity of sound in the metal. The wavelength in the metal is twice the length of the rod since antinodes are set up at each end when the middle of the rod is fixed.
Write an expression for v_{metal}.

8. Calculate v_{metal} from your measured quantities. Compare this with values in the table below. Which value is closest to yours? Does this confirm your initial guess?

9. Calculate the percentage difference between the value you obtained for v_{metal} and the pertinent value listed in the table.

material	speed of sound(m/s)
Aluminum	5104
Brass	3500
Copper	3560
Iron	5130
Steel	5000

10. Summarize your findings.