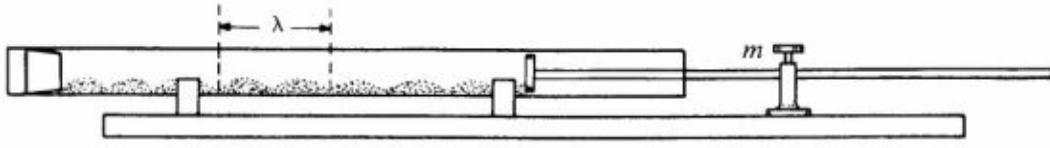# Physics 151 Class Exercise: Standing Waves - KEY

KUNDT'S-TUBE APPARATUS

Upon performing the experiment, you note that the distance between the disk and the end of the glass tube is 54.9 cm and that there are exactly 9.5 "hills" of cork dust in the tube. You measure the length of the metal rod to be 88.5 cm and the temperature on this hot July day is 36°C. Use this information to determine the velocity of sound in the metal rod and use this to identify the likely composition of the metal.

- First note that the frequency of the sound wave as it passes from the metal into the air must remain constant.
- Use the equation v = λf, solve for frequency, and equate the wave in air to that in sound.

$$\frac{v_{air}}{\lambda_{air}} = \frac{v_{metal}}{\lambda_{metal}}$$

$$v_{metal} = v_{air} \frac{\lambda_{metal}}{\lambda_{air}}$$

- Solve for the velocity of sound in air at this temperature.

$$v_{air} = 331 + 0.61*T \frac{m}{s}$$

$$= 331 + 0.61(36°C) = 352.6 \frac{m}{s}$$

- The wavelength of the sound in the metal must be twice the length of the rod since the clamp is a node and each free end an anti-node. λ_{metal} = 177 cm

- The wavelength of the sound in the air must be twice the spacing of the hills of cork since each is an anti-node. Spacing = 54.9/9.5 = 5.6 cm. Thus λ_{air} = 11.2 cm

$$v_{metal} = v_{air} \frac{\lambda_{metal}}{\lambda_{air}} = \left(352.6 \frac{m}{s}\right) \frac{(177cm)}{(11.2cm)} = 5570 \frac{m}{s}$$

From Table 14-1 in the text, the metal is similar to copper and steel.

Physics 151 Class Exercise: Standing Waves 2

Your goal in this assignment is to take 4 empty pop bottles, partially fill them with water, and be able to play "Mary had a Little Lamb". The tables below show the notes that are needed as well as the corresponding frequencies. The bottles are 25 cm tall. How much water is needed in each bottle?

B	A	G	A	B	B	B
Ma-	ry	had	a	lit-	tle	lamb,
A	A	A	B	D	D	
Lit-	tle	lamb,	lit-	tle	lamb.	
B	A	G	A	B	B	B
Ma-	ry	had	a	lit-	tle	lamb,
B	A	A	B	A	G	
Its	fleece	was	white	as	snow.	

Notes	Frequencies (Hz)
G	392
A	440
B	493.9
D	587.4

Note that the bottle with or without water in it should be considered a "column of air closed at one end". Thus, the fundamental wavelength is 4 times the height of the "air" in the bottle since the open-end is an anti-node and the water level is a node.

The velocity of sound in air (for 20°C) is 343 m/s.

Thus, the height of the water in each of the bottles should be 0.25 m minus the height of the air column calculated to the left.

$$f_n = n\frac{v}{4L}$$

$$L = n\frac{v}{4f_n} = \frac{v}{4f_1}$$

$$L_G = \frac{\left(343\frac{m}{s}\right)}{4(392\,Hz)} = 0.218\,m$$

$$L_A = \frac{\left(343\frac{m}{s}\right)}{4(440\,Hz)} = 0.195\,m$$

$$L_B = \frac{\left(343\frac{m}{s}\right)}{4(493.9\,Hz)} = 0.174\,m$$

$$L_D = \frac{\left(343\frac{m}{s}\right)}{4(587.4\,Hz)} = 0.146\,m$$