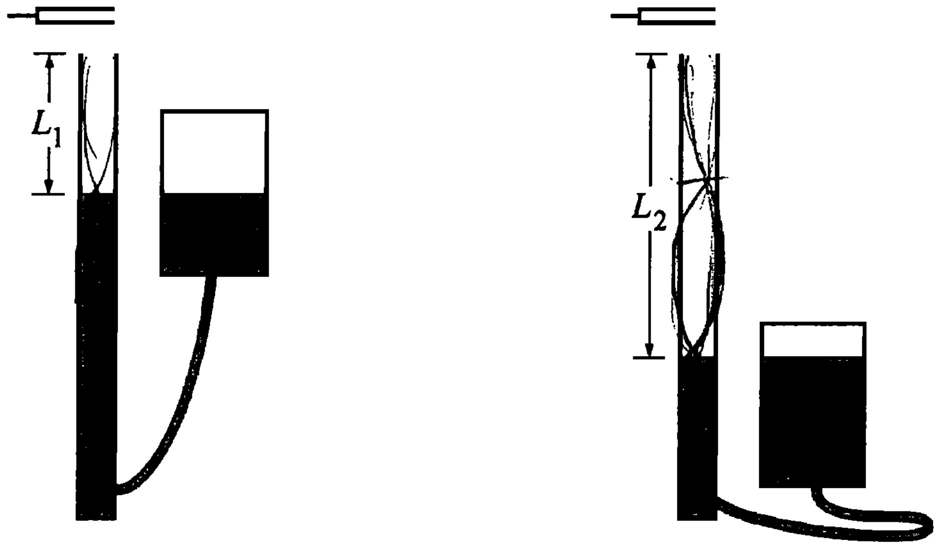
AP® Physics B
2004 Sample Student Responses
Form B

A1



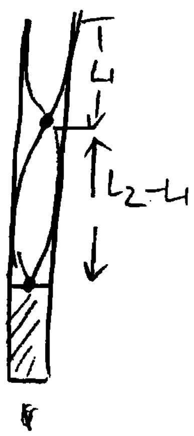
Resonance 1 Resonance 2

Note: Figure not drawn to scale.

3. (15 points)

A vibrating tuning fork is held above a column of air, as shown in the diagrams above. The reservoir is raised and lowered to change the water level, and thus the length of the column of air. The shortest length of air column that produces a resonance is $L_1 = 0.25$ m, and the next resonance is heard when the air column is $L_2 = 0.80$ m long. The speed of sound in air at 20°C is 343 m/s and the speed of sound in water is 1490 m/s.

(a) Calculate the wavelength of the standing sound wave produced by this tuning fork.



The resonance is created when the node is on the surface of the water. That is:

$$L_2 - L_1 = \frac{1}{2}\lambda$$

$$\lambda = (0.8 - 0.25) \times 2 = 1.1 \text{ m}$$

(b) Calculate the frequency of the tuning fork that produces the standing wave, assuming the air is at 20°C.

By $v = \lambda f$, we get

$$343 = 1.1 \times f$$

$$f = 312 \text{ Hz}$$

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A2

(c) Calculate the wavelength of the sound waves produced by this tuning fork in the water.

The frequency does not change (It is independent to medium)

$1490 = \lambda \times 312$

$\lambda = 4.8$ m

(d) The water level is lowered again until a third resonance is heard. Calculate the length L_3 of the air column that produces this third resonance.

Another half a wavelength would create a third resonance.

$L_3 = L_2 + \frac{\lambda}{2} = 0.8 + \frac{1.1}{2} = 1.35$ m

(e) The student performing this experiment determines that the temperature of the room is actually slightly higher than 20°C. Is the calculation of the frequency in part (b) too high, too low, or still correct?

_____ Too high ✓ Too low _____ Still correct

Justify your answer.

For each 1K increase of temperature, the velocity of sound increase by 0.6 m (0.6m/K)

The actual velocity $v > 343$

For $f = \frac{v}{\lambda}$, the actual frequency would be higher.

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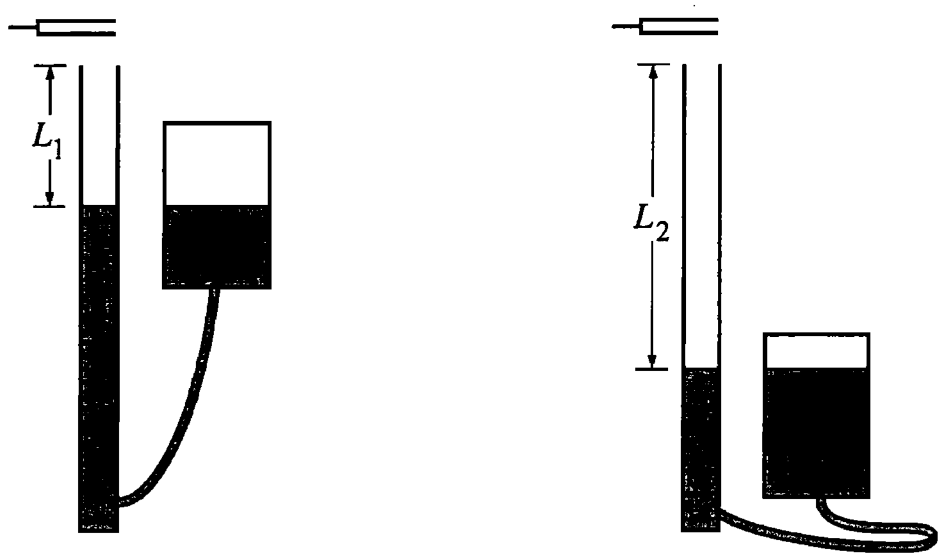
B1



Resonance 1 Resonance 2

Note: Figure not drawn to scale.

3. (15 points)

A vibrating tuning fork is held above a column of air, as shown in the diagrams above. The reservoir is raised and lowered to change the water level, and thus the length of the column of air. The shortest length of air column that produces a resonance is $L_1 = 0.25$ m, and the next resonance is heard when the air column is $L_2 = 0.80$ m long. The speed of sound in air at 20°C is 343 m/s and the speed of sound in water is 1490 m/s.

(a) Calculate the wavelength of the standing sound wave produced by this tuning fork.

$\lambda = L_2 - L_1 = 0.80 - 0.25$ m

$= \boxed{0.55 \text{ m}}$

(b) Calculate the frequency of the tuning fork that produces the standing wave, assuming the air is at 20°C.

$f = \frac{1}{\lambda} \times$ [speed of sound in air]

$= \frac{1}{0.55 \text{ m}} \times 343 \text{ m/s} = \boxed{620 \text{ Hz}}$

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B2

(c) Calculate the wavelength of the sound waves produced by this tuning fork in the water.

$$\frac{\lambda\ water}{\lambda\ air} = \frac{1490}{343} = 4.3$$

$$4.3 \times 0.55m = \boxed{2.4\ m}$$

(d) The water level is lowered again until a third resonance is heard. Calculate the length L_3 of the air column that produces this third resonance.

$$L_2 + \lambda = 0.80 + 0.55$$

$$= \boxed{1.35m}$$

(e) The student performing this experiment determines that the temperature of the room is actually slightly higher than 20°C. Is the calculation of the frequency in part (b) too high, too low, or still correct?

_____ Too high __✓__ Too low _____ Still correct

Justify your answer.

At higher temperatures, waves would travel more quickly.

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