RESONANCE AND STANDING WAVES PRACTICE

Instructions: *Show your work completely for the following problems in your journal.*

1. A tuning fork has a frequency of 522 Hz. When a second tuning fork is struck, beat interference patterns occur with a beat frequency of 7 Hz. What is the lowest and highest possible **frequency** for the second fork?

$$LOWEST\ FREQUENCY: 522\ \text{Hz} - 7\ \text{Hz} = \boxed{\mathbf{515\ Hz}}$$

$$HIGHEST\ FREQUENCY: 522\ \text{Hz} + 7\ \text{Hz} = \boxed{\mathbf{529\ Hz}}$$

2. Two tuning forks are played simultaneously. The first tuning fork has a frequency of 1080 Hz and the second has a frequency of 1075 Hz. Determine the **beat frequency** for these tuning forks.

$$1080\ \text{Hz} - 1075\ \text{Hz} = \boxed{\mathbf{5\ Hz}}$$

3. A standing wave is produced in a vibrating violin string. If the length of the string is 1.5 m, the note being played is the 2nd overtone, and the frequency is 60 Hz, what is the **speed** of the wave?

$$L = \frac{n \cdot \lambda}{2} \backsim \lambda = \frac{2L}{n} = \frac{2(1.5\ \text{m})}{3}$$

$$\underline{\boldsymbol{\lambda} = \mathbf{1.0\ m}}$$

$$v = f \cdot \lambda = (60\ \text{Hz})(1.0\ \text{m})$$

$$\boxed{\boldsymbol{v} = \mathbf{60\ {}^{m}/_{s}}}$$

4. A closed organ pipe of length 0.750 m is played when the speed of sound in air is 341 $^{m}/_{s}$. What is the **fundamental frequency** of the pipe?

$$L = \frac{n \cdot \lambda}{4} \backsim \lambda = \frac{4L}{n} = \frac{4(0.750\ \text{m})}{1}$$

$$\underline{\boldsymbol{\lambda} = \mathbf{3.00\ m}}$$

$$v = f \cdot \lambda \backsim f = \frac{v}{\lambda} = \frac{341\ {}^{m}/_{s}}{3.00\ \text{m}}$$

$$\boxed{\boldsymbol{f_0} = \mathbf{114\ Hz}}$$

5. A 445 Hz tuning fork is held above a closed pipe.
   a. What is the **wavelength** for this frequency if the air temperature is 18.0°C?

$$v_{sound} = 331 + 0.6T = 331 + 0.6(18.0°\text{C})$$

$$\underline{\boldsymbol{v_{sound}} = \mathbf{342\ {}^{m}/_{s}}}$$

$$v = f \cdot \lambda \backsim \lambda = \frac{v}{f} = \frac{342\ {}^{m}/_{s}}{445\ \text{Hz}}$$

$$\boxed{\boldsymbol{\lambda} = \mathbf{0.768\ m}}$$

b. Find the **length** of the resonating air column if this is the fundamental frequency.

$$L = \frac{\lambda}{4} = \frac{0.768\ \text{m}}{4}$$

$$\boxed{\boldsymbol{L = 0.192\ \text{m}}}$$

6. The frequency of a tuning fork is unknown. A student uses a closed air column at 27.0 °C and finds the first resonance when the column is 10.1 cm long. What is the **frequency** of the tuning fork?

$$v_{sound} = 331 + 0.6T = 331 + 0.6(27.0°\text{C})$$

$$\underline{\boldsymbol{v_{sound} = 347\ {}^{\text{m}}/_{\text{s}}}}$$

$$L = \frac{\lambda}{4} \leadsto \lambda = 4L = 4(.101\ \text{m})$$

$$\underline{\boldsymbol{\lambda = 0.404\ \text{m}}}$$

$$v = f \cdot \lambda \leadsto f = \frac{v}{\lambda} = \frac{347\ {}^{\text{m}}/_{\text{s}}}{0.404\ \text{m}}$$

$$\boxed{\boldsymbol{f = 859\ \text{Hz}}}$$

7. A soprano saxophone is an open pipe. If all keys are closed, it is approximately 65 cm long. Using 343 $^{\text{m}}/_{\text{s}}$ as the speed of sound, find the **lowest frequency** that can be played on this instrument.

$$L = \frac{n \cdot \lambda}{2} \leadsto \lambda = \frac{2L}{n} = \frac{2(0.65\ \text{m})}{1}$$

$$\underline{\boldsymbol{\lambda = 1.30\ \text{m}}}$$

$$v = f \cdot \lambda \leadsto f = \frac{v}{\lambda} = \frac{343\ {}^{\text{m}}/_{\text{s}}}{1.30\ \text{m}}$$

$$\boxed{\boldsymbol{f_0 = 264\ \text{Hz}}}$$

8. A bugle can be thought of as an open pipe. If a bugle were straightened out, it would be 2.65 m long.

a. If the speed of sound is 343 $^{\text{m}}/_{\text{s}}$, find the **lowest frequency** that is resonant in a bugle.

$$L = \frac{n \cdot \lambda}{2} \leadsto \lambda = \frac{2L}{n} = \frac{2(2.65\ \text{m})}{1}$$

$$\underline{\boldsymbol{\lambda = 5.30\ \text{m}}}$$

$$v = f \cdot \lambda \leadsto f = \frac{v}{\lambda} = \frac{343\ {}^{\text{m}}/_{\text{s}}}{5.30\ \text{m}}$$

$$\boxed{\boldsymbol{f_0 = 64.7\ \text{Hz}}}$$

b. Find the next two higher **resonant frequencies** in the bugle

$$f_{22} = 2 \cdot f_0 = 2(64.7\ \text{Hz})$$

$$\boxed{\boldsymbol{f_2 = 129\ \text{Hz}}}$$

$$f_3 = 3 \cdot f_0 = 3(64.7\ \text{Hz})$$

$$\boxed{\boldsymbol{f_3 = 191\ \text{Hz}}}$$