Physics 20 Mechanical Waves Assignment

Name: Key

1. Sound with a frequency of 400 Hz travels in a steel bar. The wavelength of the wave is determined to be 13.0 m, what is the speed of sound in steel? **(5.20 km/s) (2 marks)**

$v = f\lambda = 400(0.13) = 5200 = \boxed{5.2\text{ km/s}}$

2. A student standing on a dock finds that wave crests pass by the dock support every 8.0 s. If she estimates the distance between the crests to be 12 m, what is the approximate speed of the waves? **(1.5 m/s) (2 marks)**

$v = f\lambda = (0.125)(12) = \boxed{1.5\text{ m/s}}$

3. A rhino call has a frequency of about 5.0 Hz, while a bat uses sound waves around 100 kHz. Convert these frequencies to wavelengths and order from longest wavelength to shortest wavelength. Assume the speed of sound in air to be 343 m/s. **(2 marks)**

$v = f\lambda$

$\lambda = \frac{v}{f}$

Rhino

$\lambda = \frac{343}{5.0} = \boxed{68.6\text{ m}}$

Bat

100000 Hz

$\lambda = \frac{343}{100\,000} = \boxed{0.00343\text{ m}}$

4. A SONAR signal is reflected from a coral reef and returns to the sub 5.0 s. after transmission. If the speed of sound in water is 1450 m/s, determine the distance between the sub and the reef. **(3.6 km) (2 marks)**

$\lambda = \frac{v}{f} = \frac{1450}{0.4} = 3625\text{ m}$

$= \boxed{3.6\text{ km}}$

2.5 s to depth

2.5 s back up

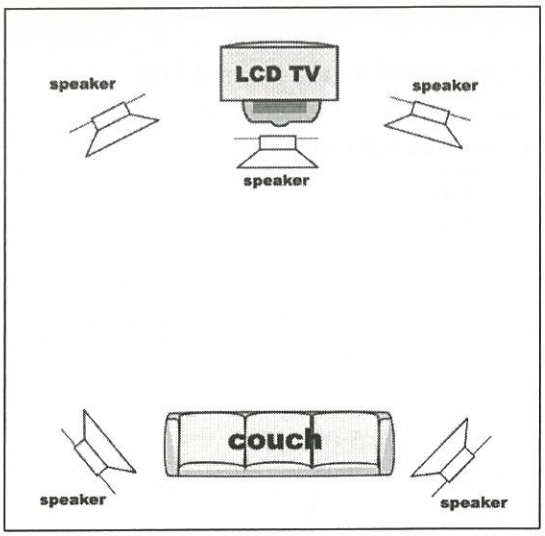
$f = \frac{1}{2.5} = 0.4\text{ Hz}$

5. a) Define the terms *compression* and *rarefraction*. **(0.5 marks)**

Compression: in a longitudinal wave, a area where the springs are close together and in a transverse wave, an area of a crest or trough

rarefaction: longitudinal - area where waves spread apart, transverse - between crest & trough.

b) Draw a diagram showing compressions and rarefractions in a spring. **(0.5 marks)**



6. When setting up his theatre system, Bob positions speakers in the following manor:

Bob notices that some areas in his theatre have high volumes of sound, while others have lower volumes of sound. Based on your understanding of the principle discussed in class, explain this observation. You may use a diagram in your explanation. **(2 marks)**

Areas of higher volume are the result of constructive interference of sound waves while areas of lower volume are areas of destructive interference or no interference at all.

7. Weather-watchers will often use the following system to estimate distances to approaching thunderstorms: after a clap of thunder is heard, start counting. Take the number of seconds that have elapsed and divide by 5. This gives the approximate distance (in miles) the storm is away. Why does this system work? *(Hint: the speed of light, c* = 3.00 x 10^8 m/s, *the speed of sound in air at* 25°C = 343 m/s, 1 mi = 1.6 km*)* **(2 marks)**

Time to See Light

$t = \frac{d}{v}$

$t = \frac{1600m}{3.00 \times 10^8 m/s}$

$= 5.3 \times 10^{-6} s$

instantaneous

Time to Hear Sound

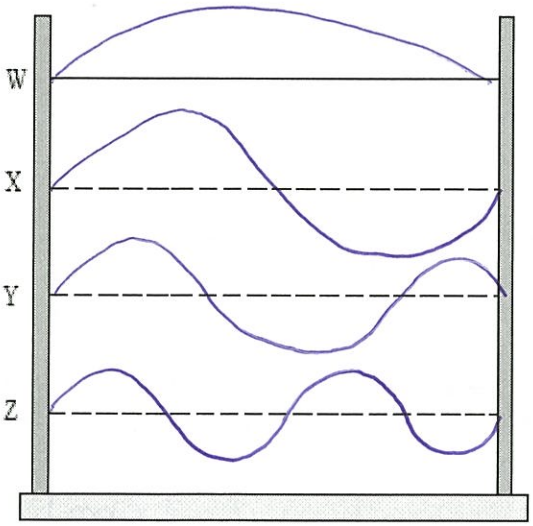
$t = \frac{1600m}{343 m/s}$

$t = 4.7s$

The light hits your eyes almost instantaneously but sound travels much slower. Since it takes ~4.7s or 5s for sound to travel 1mi, you can count the number of seconds it takes for the sound to reach your ear, divide by 5 and you get an approx. distance in miles.

8. The diagram shows a string attached from location W on one pole to another pole. On the diagram, draw standing waves that have nodes at the ends and wavelengths related to the length of the string (L) for each of the following. **(0.5 marks each)**

- At location W, $L = \frac{\lambda}{2}$
- At location X, $L = \lambda$
- At location Y, $L = \frac{3}{2}\lambda$
- At location Z, $L = 2\lambda$



9. The second harmonic of the air column a closed pipe is 775 Hz when its length is 33 cm. Find the speed of sound in this air. **(341 m/s) (2 marks)**

0.33m

closed tube + 2nd harmonic $\Rightarrow L = \frac{3}{4}\lambda$

$0.33 = \frac{3}{4}\lambda$

$\lambda = \frac{4(0.33)}{3} = 0.44m$

$V = f\lambda$

$V = 775(0.44)$

$V = 341 m/s$

10. The third harmonic of the air column in a closed pipe is 775 Hz when its length is 55 cm. Find the speed of sound in this air. **(341 m/s) (2 marks)**

Closed tube + 3rd harmonic $\Rightarrow \frac{5}{4}\lambda = L$

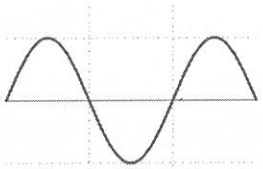
$\frac{5}{4}\lambda = 0.55$

$\lambda = 0.44$

$V = 775(0.44)$

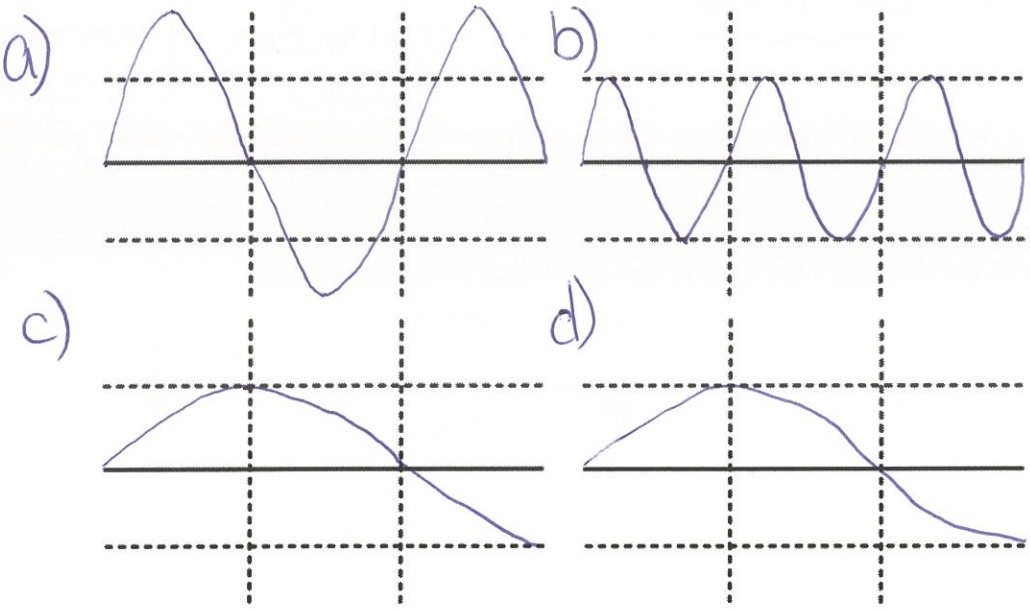
$V = 341 m/s$

11. Starting with the wave shown, sketch the following:



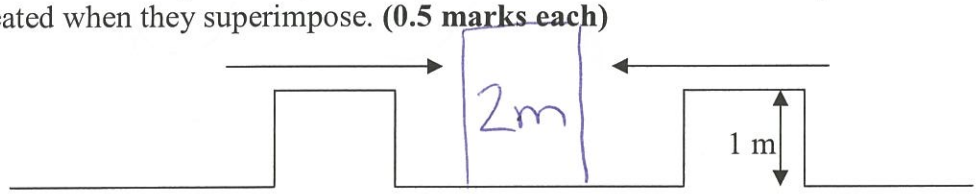
Amplitude = 3.0 mm
Wavelength = 7.5 mm

a) A wave with twice the amplitude. **(0.5 marks)**
b) A wave with twice the frequency. **(0.5 marks)**
c) A wave with twice the wavelength. **(0.5 marks)**
d) A wave with twice the period. **(0.5 marks)**

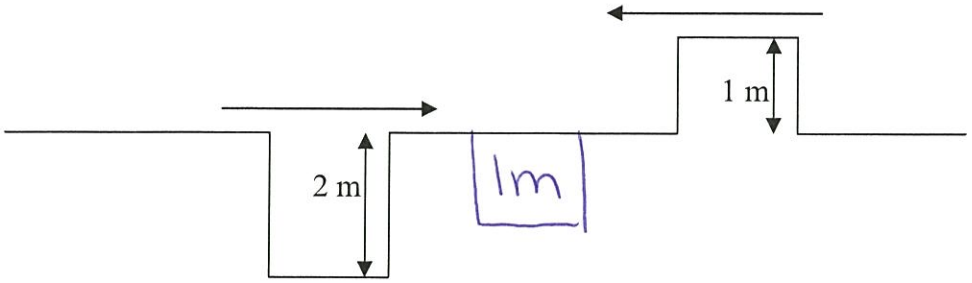


12. Sketch these pulses in your assignment and the resultant wave pulse that will be created when they superimpose. **(0.5 marks each)**

a)



b)



13. Alice is standing on a bridge 112 m above a river. If she threw a rock over the edge, how long would it take for her to hear the sound of it hitting the water, assuming v_{sound} = 330 m/s? **(3 marks)** ~~**(5.10 s)**~~

time for rock to drop + time to hear sound return

$\vec{d} = \vec{v}_i t + \frac{1}{2}\vec{a}t^2$

$112 = (\frac{1}{2})(9.81)t^2$

$t = 4.78s$

$v = \frac{d}{t}$ $t = \frac{d}{v} = \frac{112}{330}$

$t = 0.34s$

$t_{total} = 5.12s$

14. The siren of a police car has a frequency of 660 Hz. If the car is travelling toward you at 40.0 m/s, what do you perceive to be the frequency of the siren? Assume the speed of sound in air to be 340 m/s. **(2 marks) (748 Hz)**

$f = f_s\left(\frac{V_w}{V_w \pm V_s}\right)$

$f = 660\left(\frac{340}{340-40}\right) = 748\,Hz$

15. A jet, traveling at the speed of sound (Mach 1 = 343 m/s) emits a sound wave with a frequency of 1000 Hz. Use the Doppler effect equations to calculate the frequency of this sound as the jet approaches you, then moves away from you. Explain what these answers mean in terms of what you would hear as the jet moved toward, then past, you. **(2 marks)**

Approaches

$f = 1000\left(\frac{343}{343-343}\right)$

undefined

no sound heard

Moves Away

$f = 1000\left(\frac{343}{343+343}\right)$

$f = 500\,Hz$

only after the jet passes you do you hear a frequency of 500 Hz.