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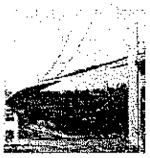

Physics 20 Unit D UA pt B: Mechanical Waves

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31/32

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)**

2

$\vec{v} = f\lambda$

$\vec{v} = (400\ Hz)(13.0\ m)$

$\vec{v} = 5200\ m/s = 5.20\ km/s$

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)**

2

$f = \frac{1}{T}$

$f = \frac{1}{(8.0\ s)}$

$f = (0.125\ Hz)$

$\vec{v} = f\lambda$

$\vec{v} = (0.125\ Hz)(12\ m)$

$\vec{v} = 1.5\ m/s$

3. A young student who has not used an iPod turned all the way up jammed directly into their ear for the last 5 years straight can hear sound in a range of frequencies from 20 Hz to 20 kHz. 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)**

1.5/2

1) Rhino Call – $\frac{(343\ m/s)}{(5.0\ Hz)} = 68.6\ m$

2) Human min. – $\frac{(343\ m/s)}{(20\ Hz)} = 17.2\ m$

3) Human max. – $\frac{(343\ m/s)}{(20\,000\ Hz)} = 0.0172\ m$

4) Bat – $\frac{(343\ m/s)}{(100\,000\ Hz)} = 0.00343\ m$

sd

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)**

$f = \frac{1}{T}$

$f = \frac{1}{(2.5\ s)}$

$f = 0.4\ Hz$

$\vec{v} = f\lambda$

$(1450\ m/s) = (0.4\ Hz)\lambda$

$\frac{(1450\ m/s)}{(0.4\ Hz)} = \lambda$

$3625\ m = 3.6\ km = \lambda$

2

8. 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,* $c = 3.00 \times 10^8$ m/s, *the speed of sound in air at* 25°C = 343 m/s, 1 mi = 1.6 km*)* **(2 marks)**

$v = d/t$

$t = d/v$

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

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

$v = d/t$

$t = d/v$

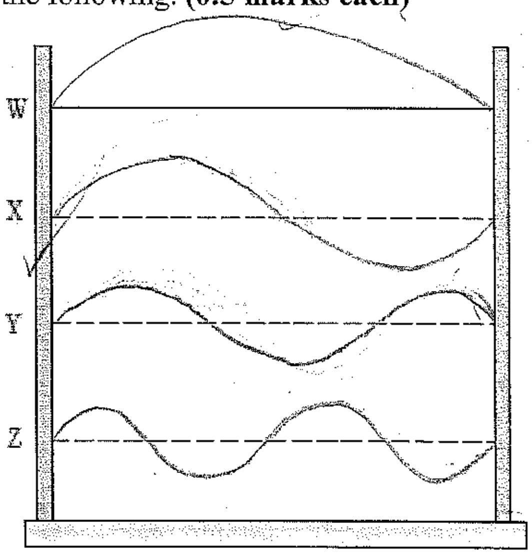
$t = \frac{(1600 m)}{(343 m/s)}$

$t = 4.7$ s

* The light hits your eyes almost instantaneously, so you can use this to reference when the lightning bolt hit. Since sound travels slower than light, there will be a delay between when you see the lightning and hear it. Since it takes about five seconds for the light to cover a mile, you can count the amount of time it takes to reach your ear & divide it by 5 secs. to get an appro distance in miles (5 seconds = 1 mile)

9. 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, $L = 2\lambda$



10. The ~~third~~ 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)**

$T = \frac{1}{f}$

$T = \frac{1}{(775 Hz)}$

$T = 0.0013$ s

33 cm = 0.33 m

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

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

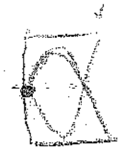
$\lambda = 0.44$ m

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

$v = \frac{(0.44 m)}{(0.0013 s)}$

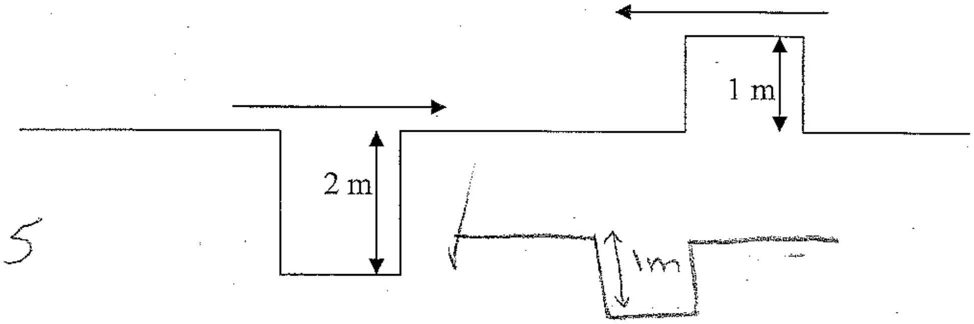
$v = 341$ m/s

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



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

b)



0.5

14. 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)**

$d = v_i t + \frac{1}{2} a t^2$

$(112 m) = 0t + \frac{1}{2}(9.8 m/s^2)t^2$

$\sqrt{\frac{(112 m)}{(\frac{1}{2})(9.8 m/s^2)}} = t$

4.78s = t

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

$(330 m/s) = \frac{(112 m)}{t}$

$t = \frac{(112 m)}{(330 m/s)}$

t = 0.34s

$t_{tot} = (4.78 s) + (0.34 s)$

t_{tot} = 5.10 s

3

15. 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)**

$f = \left(\frac{v}{v \pm v_s}\right) f_s$

$f = \left(\frac{(340 m/s)}{(340 m/s) - (40.0 m/s)}\right) 660 Hz$

f = 748 Hz

2

16. An LD 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)**

Approaching:

$f = \left(\frac{v}{v \pm v_s}\right) f_s$

$f = \left(\frac{(343 m/s)}{(343 m/s) - (343 m/s)}\right)(1000 Hz)$

f = ~~0 Hz~~ undefined

* no sound would be heard

Leaving:

$f = \left(\frac{v}{v + v_s}\right) f_s$

$f = \left(\frac{(343 m/s)}{(343 m/s) + (343 m/s)}\right) 1000 Hz$

500 Hz

* you would hear a frequency of 500 Hz ONLY after the jet passed you.

1.5/2

Bonus Questions: Answer only ONE!!!

Fair Bonus Question: What does SONAR stand for?__________

Unfair Bonus Question: Define the Doppler Red Shift.