Module 13 Physics Problems

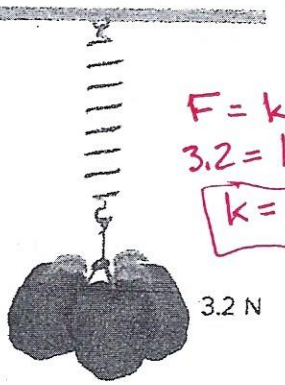
1. What is the difference between frequency and period? How are they related?

frequency = cycles/sec
period = time/cycle $T = \frac{1}{f}$

2. Does the period of a pendulum depend on the mass of the bob? The length of the string? The amplitude of oscillation? What else does the period depend on?

period of a pendulum depends only on length and gravity

3. A spring stretches 0.12 m when some apples are suspended from it, as shown. What is the spring constant of the spring?



$F = kx$
$3.2 = k(.12)$
$k = 27\ N/m$

4. A spring with a spring constant of 27 N/m is stretched 16 cm. What is the spring's potential energy?

$PE = \frac{1}{2}kx^2 = \frac{1}{2}(27)(.16)^2 = .35\ J$

5. **Rocket Launcher** A toy rocket launcher contains a spring with a spring constant of 35 N/m. How far must the spring be compressed to store 1.5 J of energy?

$PE = \frac{1}{2}kx^2 \quad 1.5 = \frac{1}{2}(35)x^2$
$x = .29m$

6. How long must a pendulum be to have a period of 2.3 s on the Moon, where $g = 1.6$ N/kg?

$T = 2\pi\sqrt{\frac{l}{g}} \quad 2.3 = 2\pi\sqrt{\frac{l}{1.6}} \quad l = .21m$

7. What is the wavelength of a wave?

Distance from wave to wave

8. What are the differences among transverse, longitudinal, and surface waves?

transverse particles vibrate perpendicular to direction
longitudinal they vibrate parallel

9. What is the difference between a wave pulse and a periodic wave?

pulse - one wave periodic - repeats

10. Describe the difference between wave frequency and wave velocity.

velocity - how far wave goes per sec
frequency - how many waves go by per sec

11. Describe the relationship between the amplitude of a wave and the energy it carries.

Greater amplitude, greater energy

12. **Building Motion** The Willis Tower in Chicago sways back and forth in the wind with a frequency of about 0.12 Hz. What is its period of vibration?

$T = \frac{1}{.12} = 8.3\ sec$

13. **Ocean Waves** An ocean wave has a length of 12.0 m. A wave passes a fixed location every 3.0 s. What is the speed of the wave? $T = 3.0s \quad f = \frac{1}{3.0} = .33\ Hz$

$v = \lambda f = (12.0)(.33) = 4\ m/s$

14. The speed of sound in water is 1498 m/s. A sonar signal is sent straight down from a ship at a point just below the water surface, and 1.80 s later the reflected signal is detected. How deep is the water?

$1498\frac{m}{s} \times 1.80s = 2696m$ both ways
1348 m deep

15. The wavelength of water waves in a shallow dish is 6.0 cm. The water moves up and down at a rate of 4.8 oscillations/s.

a. What is the speed of the waves? $v = \lambda f = (.06)(4.8) = .29\ m/s$

b. What is the period of the waves?

$T = \frac{1}{4.8} = .21\ sec$

16. Water waves in a lake travel 3.4 m in 1.8 s. The period of oscillation is 1.1 s. $f = \frac{1}{1.1} = .91\ Hz$

a. What is the speed of the water waves? $v = \frac{3.4m}{1.8s} = 1.9\ m/s$

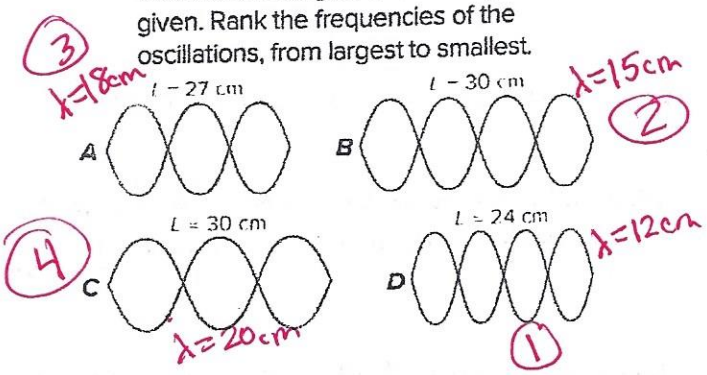
b. What is their wavelength?

$v = \lambda f \quad 1.9 = \lambda(.91) \quad \lambda = 2.1m$

17. How does a wave pulse reflected from a rigid wall differ from the incident pulse?

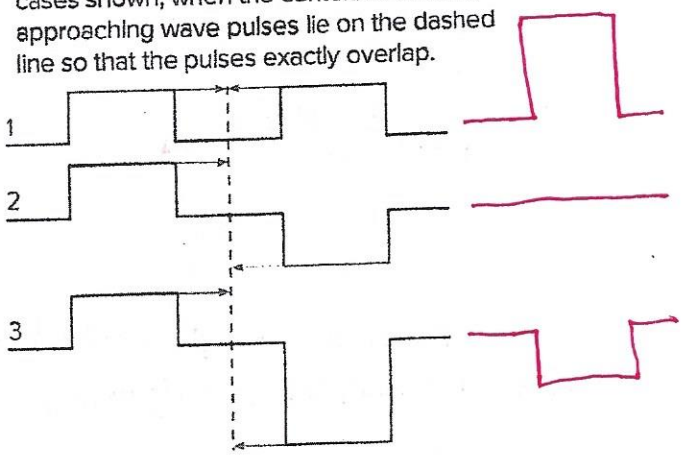
Comes back inverted (upside down)

18. Standing waves are created in the four strings shown. All strings are made of the same material and are under the same tension. The lengths of the strings, L, are given. Rank the frequencies of the oscillations, from largest to smallest.



3 $\lambda = 18cm$ — 2 $\lambda = 15cm$ — 4 $\lambda = 20cm$ — 1 $\lambda = 12cm$

19. Sketch the result for each of the three cases shown, when the centers of the two approaching wave pulses lie on the dashed line so that the pulses exactly overlap.



20. **Speed of Sound** A baseball fan on a warm summer day (30°C) sits in the bleachers 152 m away from home plate.

a. What is the speed of sound in air at 30°C? $331 + .6(30) = 349 m/s$

b. How long after seeing the ball hit the bat does the fan hear the crack of the bat?

$152m \times \frac{s}{349m} = .44s$

21. A train moving toward a sound detector at 31.0 m/s blows a 305-Hz whistle. What frequency is detected on each of the following?

$f = 305\left(\frac{343-0}{343-31}\right) = 335 Hz$

a. a stationary train

b. a train moving toward the first train at 21.0 m/s

$f = 305\left(\frac{343-(-21)}{343-31}\right) = 356 Hz$

22. If the wavelength of a 4.40×10^2-Hz sound in freshwater is 3.30 m, what is the speed of sound in freshwater?

$v = \lambda f = (3.30)(440) = 1452 m/s$

23. A sound wave has a frequency of 4700 Hz and travels along a steel rod. If the distance between compressions, or regions of high pressure, is 1.1 m, what is the speed of the wave?

$v = \lambda f = (1.1)(4700) = 5170 m/s$

24. You hear the sound of the firing of a distant cannon 5.0 s after seeing the flash. How far are you from the cannon?

$343 \frac{m}{s} \times 5.0s = 1715m$

25. If you shout across a canyon and hear an echo 3.0 s later, how wide is the canyon?

$\frac{343m}{s} \times 3.0s = 1029m$ $515m$

26. **Music** A band plays at an 80-dB sound level. How many times greater is the sound pressure from another band playing at each of the following sound levels?

a. 100 dB $100\times$

b. 120 dB $10000\times$

27. **Musical Instruments** What property distinguishes notes played on a trumpet and a clarinet from each other if they have the same pitch and loudness? the number of overtones

28. **Trombones** Explain how the slide of a trombone changes the pitch of the sound in terms of a trombone being a resonance tube. changes the length of pipe so changes the pitch

29. A vertical tube with a tap at the base is filled with water, and a tuning fork vibrates over its mouth. Resonance is heard when the water level has dropped 17 cm, and again after 49 cm of distance exists from the water to the top of the tube. What is the frequency of the tuning fork?

$L = \frac{1}{4}\lambda \quad .17 = \frac{1}{4}\lambda \quad \lambda = .68m$

$v = \lambda f \quad 343 = (.68)f \quad f = 504 Hz$

30. **Clarinets** The clarinet acts as a closed pipe. If a clarinet sounds a note with a pitch of 370 Hz, what are the frequencies of the lowest three harmonics produced by this instrument?

$f_1 = 370 Hz \quad f_2 = 2(370) = 740 Hz \quad f_3 = 1110 Hz$

31. **String Instruments** A guitar string is 65.0 cm long and is tuned to produce a lowest frequency of 196 Hz.

$L = \frac{1}{2}\lambda \quad .65 = \frac{1}{2}\lambda \quad \lambda = 1.3m$

a. What is the speed of the wave on the string? $v = (1.3)(196) = 255 m/s$

b. What are the next two higher resonant frequencies for this string?

$f_1 = 196 Hz$

$f_2 = 196(2) = 392 Hz$

$f_3 = 196(3) = 588 Hz$