HPH Practice Problems --General Waves and Sound

For all problems, assume the speed of sound *in air* is 343 m/s and the speed of *all* electromagnetic waves is 3 x 10^8 m/s unless otherwise noted

$$v = f\lambda \qquad f = \frac{1}{T} \qquad f' = f\left(\frac{v \pm v_o}{v \mp v_s}\right)$$

1. A radio wave, a form of *electromagnetic* wave, has a frequency of 99.5 MHz (99.5 x 10^6 Hz). What is its wavelength?**3.0m**
2. Sound with a frequency of 261.6 Hz travels through water at a speed of 1435 m/s. Find its wavelength in water. **5.5m**
3. Find the frequency of a sound wave moving in air at room temperature with a wavelength of 0.667 m. **514 Hz**
4. Water waves in a shallow dish are 10 *cm* long. The water oscillates up and down at a rate of 4.8 oscillations per second.
    a. What is the speed that the waves move through the water? **.48m/s**
    b. What is their period? **.21sec**
5. Water waves in a lake travel 6.2m in 2.3 s. Their period of oscillation is 1.8s.
    a. What is the speed that the waves move through the water? **2.7m/s**
    b. What is their wavelength? **4.9m**
6. The human ear can detect sounds with frequencies between 20 Hz and 16 **k**Hz. Find the largest and smallest wavelengths the ear can detect in room temperature air. **17m to .021m**
7. What is the frequency of a sound in room temperature air if it has a wavelength of 38 cm? of 7.6 cm? **130Hz, 4500Hz**
8. A sound wave produced by a clock chime 515 m away is heard 1.60 s later.
    a. What is the speed of sound in the surrounding air? **320m/s**
    b. The sound wave has a frequency of 436 Hz. What is its period? **.0023 sec**
    c. What is its wavelength? **.74m**
9. A hiker shouts toward a vertical cliff 685 m away. The *echo* is heard 4.00 s later.
    a. What is the speed of sound in the surrounding air? **343m/s**
    b. The wavelength of the sound is 0.750 m. What is its frequency? **457 Hz**
    c. What is the period of the wave? **.0022 sec**
10. A sonar unit on a submarine sends out a pulse of sound into seawater. The pulse returns 2.78 s later. What is the distance between the object and the submarine? The speed of sound in seawater is 1522 m/s. **2120m**
11. A certain color *light* wave has a wavelength of 580 *n*m.
    a. What is the wavelength of the light in meters? **5.8 E-7m**
    b. What is the frequency of the wave? **5.2 E14 Hz (5.2E5 GigaHz)**
12. A long spring runs across the floor of a room and out the door. A pulse is sent along the spring. After a few seconds, an inverted pulse returns. Is the spring attached to the wall in the next room or is it lying loose on the floor? **Waves that reflect off denser media are inverted.**
13. If you want to increase the wavelength of waves in a rope, should you shake it at a higher or lower frequency? **Lower frequency**
14. If the *pitch* of sound increases, what happens to its:
    a. Frequency? **Higher (pitch is frequency)**
    b. Wavelength? **shorter**
    c. Velocity? **Doesn't change (you couldn't have harmony if high and low pitches traveled different speeds, no choir, orchestra, or even musical accompaniment)**
    d. Amplitude? **No change**
15. As a wave moves from a medium with a high wave velocity to one with a smaller wave velocity, which of the following CANNOT/WON'T change: frequency, amplitude, wavelength, velocity, direction? **Frequency won't change, because it is determined by the pulse that makes the wave, not the medium. All other factors do change, because the medium is changing.**

Doppler

16. *An ambulance is moving toward you at 50 mph while you're standing on the side of the road. The frequency of its siren is 467 Hz. What frequency do you hear? **499 Hz**
17. *What frequency do you hear after the ambulance passes you (if you're still just standing on the corner)?**439 Hz**
18. *What frequency would you hear if you're running *toward* the ambulance at 5m/s while it is moving *toward* you with its original speed? **506 Hz**
19. *What frequency would you hear if you're running *away* from the ambulance at 5m/s while the ambulance is speeding *away* from you at the same original 50mph? **432 Hz**

Open/Closed-end Pipes

20. A 440-Hz tuning fork is held above a *closed-end* pipe. Find the distance in meters (AKA "spacings") between the resonances if the sound moves through the room temperature air in the column at 343 m/s? **For Closed End pipes resonance occurs when the length of pipe will accommodate 1/4λ, 3/4 λ, 5/4 λ, etc. The difference between each of these is ½ wavelength. For this problem one wavelength = .78m. Half of this is .39m.**
21. The same 440-Hz tuning fork is now used with the same *closed-end* tube resonating column to determine the velocity of sound in *helium* gas. If the spacings between resonances are 110 cm, what is the velocity of sound in He?**1/2 λ= 1.1m, therefore wavelength= 2.2. v=968m/s**
22. The frequency of a particular tuning fork is unknown. A student uses a *closed*-end air column and finds the resonances spaced by 39.2 cm. What is the frequency of the tuning fork? **1/2 λ=.392m, f=438Hz**
23. An *open-end* tube is filled with water and a tuning fork vibrates over the air at its mouth. Resonance is heard when the water level drops to 12 cm and again at 36 cm. What is the frequency of the tuning fork? **1/2 λ=.24m, f=715 Hz**
24. The auditory canal, leading to the eardrum, is a *closed*-end pipe 3.0 *cm* long. Find the approximate value (ignoring end correction) of the lowest resonant frequency (i.e., the *largest* wavelength, AKA the fundamental frequency). (Interestingly, the fundamental frequency is in the frequency range where human hearing is most sensitive.)
 .03m=1/4 λ , f=2858Hz
25. A flute acts like an *open* pipe. If 310 Hz is the *lowest* frequency (i.e., the *largest* wavelength) that a particular flute can produce, what is the length of the air column in the flute? **1/2 λ=.55m**
26. A bugle can be thought of as an *open-end* pipe. If a bugle were straightened out, it would be 2.65 m long.
    a. If the speed of sound is 343 m/s, find the *lowest* frequency (i.e., the *largest* wavelength) that can resonate in a bugle. **1/2 λ=2.65m therefore f=65 Hz**
    b. Find the next two higher resonant frequencies in the bugle. **This occurs when 1 λ=2.65m, f=130 Hz and when 1.5 λ=2.65m, f=195Hz**
27. A soprano saxophone is an *open-end* pipe. If all keys are closed, it is approximately 65 *c*m long. Using 343 m/s as the speed of sound, find the *lowest* frequency (i.e. the *longes*t wavelength, AKA the *fundamental frequency*) that can be played on this instrument **1/2 λ=.65m, f=264Hz**
    a. *Find the next three resonant frequencies in the sax. **528Hz, 792Hz, 1055Hz.**
    b. *Which harmonics are they? **2^{nd}, 3^{rd}, 4^{th} harmonics**
28. A particular organ pipe acts like a *closed-end* pipe. If the *lowest* frequency (the fundamental frequency) it can produce is 400 Hz, what is the length of the tube? **1/4 λ=.214m,**
    a. *Find the next three resonant frequencies on this particular organ pipe.**1200 Hz, 2000 Hz, 2800Hz**
    b. *Which harmonics are they? **3^{rd}, 5^{th}, 7^{th},**
29. The *lowest* note (i.e., the *largest* wavelength) on a particular organ is 15.2 Hz.
    a. What is the shortest length *open* pipe that will resonate this frequency? **1/2 λ=11.3m**
    b. What would be the pitch if the same organ pipe were closed? **7.6 Hz**
30. *A stretched rubber band has a length of 0.15 m and a fundamental frequency of 340 Hz. What is the speed at which waves travel on the rubber band? **1/2 λ=0.15m, v=102m/s**

Beats: When two instruments are out of tune you will hear "beats" which are caused by constructive and destructive interference between two closely related sound waves. It sounds like a pulsing in the volume of sound. The frequency of the beats is equal to the difference in frequencies of the two notes being played.

31. *A 330-Hz and a 333-Hz tuning fork are struck simultaneously. What will the beat frequency be? **3.0 Hz**
32. *A student has two tuning forks, one with a frequency of 349 Hz and the other with frequency unknown. When struck together, the tuning forks produce 3 beats per second. What are possible frequencies of the unknown tuning fork? **346 Hz or 352 Hz.**