Worksheet 1: Wave Terms

1. Explain the difference between the speed of a transverse wave and the speed of the rope particles.

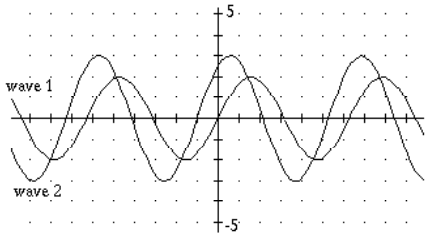
2. What is the difference between a pulse and a periodic wave?

3. Draw a picture of a transverse wave on a string. Indicate the wavelength. Label two points A and A' that are in phase. Label two points B and B' that are exactly out of phase.

4. Draw the waves described
   a) Two transverse waves, one with twice the frequency of the other.
   b) Two transverse waves, one with twice the amplitude of the other
   c) Two transverse waves of equal amplitude and frequency, differing in phase by 90°.

5. Leaves on the surface of a pond are observed to move up and down a total vertical distance of 0.20 m as a wave passes.
   a) What is the amplitude of the wave? (0.05 m)
   b) If the amplitude were changed to 1.50 m by what factor would the energy in the wave change? (9.0 x10^2 x)

6. Use the transverse waves shown to answer the following:



   a) Draw two points on the wave 1 which are "in phase". Label these points A and A'
   b) Draw two points on the wave 2 with a difference in phase angle of 135°. Label these B and B'
   c) Label the crest, trough, amplitude and wavelength of wave two.
   d) Describe what will happen when the two waves shown, which are travelling in opposite directions meet one another.
   e) How does the movement of the medium particles compare to the movement of the waves.

7. How far does a loudspeaker cone travel in 3.0 s while reproducing the sound of a piano playing A above middle C (4400 Hz) if the cone's amplitude is 0.50 mm? (26 m)

8. For any wave, define: a) wavelength b) frequency c) period d) amplitude

9. Two transverse waves have the same amplitude and otherwise are identical except one has half the wavelength of the other. Which transmits more energy?

10. Leonardo da Vinci said, "The wave flees the place of creation while the water does not." Explain the significance of this statement to our understanding of waves.

11. What is the speed of a wave through a 2.00 m spring if the the tension in the spring is 60 N and the spring has a mass of 300 g? (20. m/s)

12. A wave travels through a medium at 5.23 m/s. If the Medium is 25.2 g/cm of length, what is the tension in the medium? (68.9 N)

Worksheet 2 : Universal Wave Equation

1. What is the velocity of compression waves in aluminum if a 5.00 kHz vibration produces a wave with a wavelength of 1.00 m? (5.00 x 10^3 m/s)

2. Electromagnetic radio waves travel with a velocity of 3.00 x 10^8 m/s. What is the wavelength if the frequency is 1.20 x 10^6 cycles/s? (2.50 x 10^2 m)

3. A phonograph record rotates under the stylus with a linear velocity of 0.300 m/s. If the stylus vibrates with a frequency of 1.00 x 10^3 Hz, what is the wavelength of the groove on the record? (3.00 x 10^{-4} m)

4. An ocean wave with a period of 10.0 s travels about 20.0 m/s. What is its wavelength? (2.00 x 10^2 m)

5. AM radio signals have frequencies between 550 kHz and 1600 kHz and travel with a speed of 3.00 x 10^8 m/s. What are the wavelengths of these signals? On FM the frequencies range from 88 MHz to 108 MHz and travel at the same speed; what are their wavelengths? (AM 545 m - 188 m
FM 3.41 m - 2.77 m)

6. Find the frequency of a compression wave in air if the wavelength is 2.00 m and the velocity is 340 m/s. (170 Hz)

7. A student watching ocean waves notices the waves passing two posts that are 75.0 m apart along a line perpendicular to the wave fronts. He sees that at the

instant a crest passes one post, a trough passes the other and that there are two other crests in between the posts. He finds that it takes 10.0 s for a wave to pass from one post to the other. What is the frequency of the wave motion?. (f = 0.250 Hz)

8. A pulse in a spring that is 5.00 m long makes four round trips back and forth across the spring in 2.50 s. What is the velocity of the wave? (16 m/s)

9. The ripples in a certain groove 12.0 cm from the center of a 33 rpm phonograph record have a wavelength of 2.40mm. What will be the frequency of the sound emitted? Assume the velocity of sound in air is 331 m/s. (1.38 x 10^5 Hz)

10. The wavelength for an ultraviolet light wave (EM radiation) is 7.38 x 10^{-8} m. What is the period of the ultraviolet wave? (2.46 x 10^{-16} s/cycle)

11. What is the period of each of the following
a) an athlete who has a pulse rate of 120 beats/min after running a race (0.50 s)
b) the moon which travels round the earth five times in 136.6 days
c) the middle C note of a piano which has frequency of 4186 Hz.

Worksheet 3: Dampening and Interference

1. Give two reasons why circular water waves decrease in amplitude as they travel away from the source.

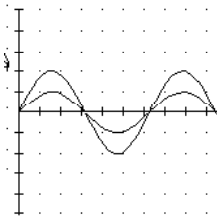
2. Explain what dampening is and what its causes are.

3. The two pulses shown below are moving toward each other.

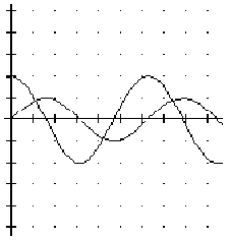
a) Sketch the shape of the string at the moment they directly overlap.
b) Sketch the shape of the string a few moments later

4. On the grid below, construct the interference pattern which results when a periodic wave interferes with a second periodic wave of twice the amplitude but the same wavelength, when the waves start out:

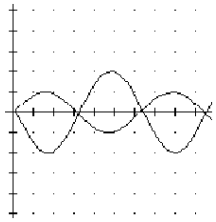
a) completely in phase



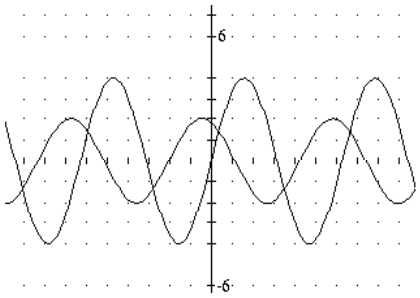
b) 90° out of phase



c) 180° out of phase

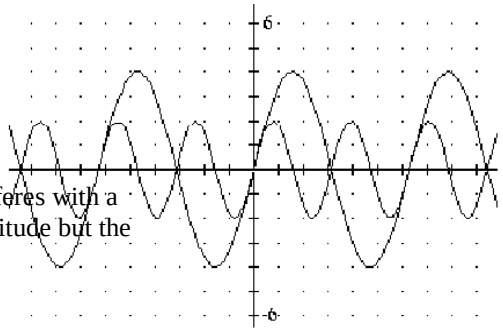


5. Using the waves below, construct the interference pattern on the grid



a) State the amplitude and wavelength of the two waves represented, and the amplitude and wavelength of the resultant.
b) Do you see any symmetry in the resultant wave? When does the pattern start to repeat? (6.2 cm)

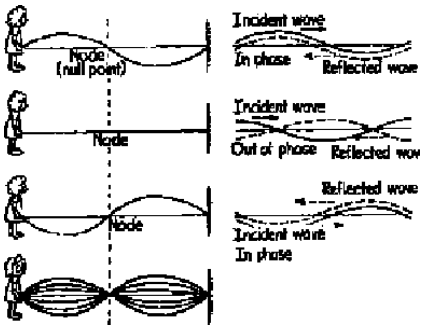
6. Draw the **interference pattern** produced when a wave of wavelength 3.14 cm and amplitude 2.00 cm interferes with a wave of wavelength 6.28 cm and amplitude 4.00 cm. State any symmetry in the interference pattern and the length required for it to repeat. (6.28 cm)



7. What happens to the original disturbances when two troughs moving in opposite directions meet.

8. What happens when two similar pulses of equal and opposite amplitudes and velocities meet.

9. When a standing wave exists on a string the wave trains producing the wave cancel at the nodes. Does this mean that energy was destroyed? Explain.



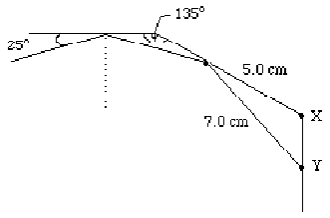
Worksheet 4: Reflection:

1. A ray of light strikes a mirror at an angle of 53° to the normal.

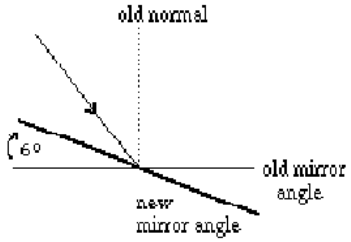
a) What is the angle of reflection? (53°)
b) What is the angle between the incident ray and the reflected ray? (106°)

2. A ray of light incident upon a mirror makes an angle of 36° with the mirror. What is the angle between the incident ray and the reflected ray? (108°)

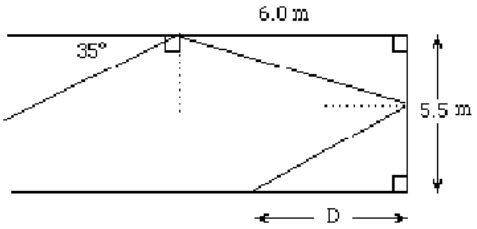
3. What is the distance from X to Y in the diagram shown at the right? (2.9 cm)



4. A ray of light makes an angle of 25° with the normal to a plane mirror. If the mirror is turned through 6° making the angle of incidence 31°, through what angle is the reflected ray rotated? (12°)

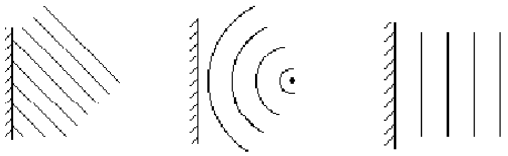


5. Find the value of distance D in the diagram at right which shows a ray of light striking a series of mirrored walls.((1.9 m)



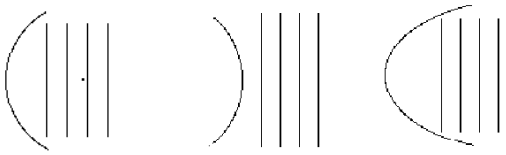
6. Draw the reflected waves which will result when the incident waves shown hit the boundary

a) b) c)



7. Draw in the pattern of the reflected wave fronts as the incident waves shown move forward and reflect off the boundary.

a) b) c)

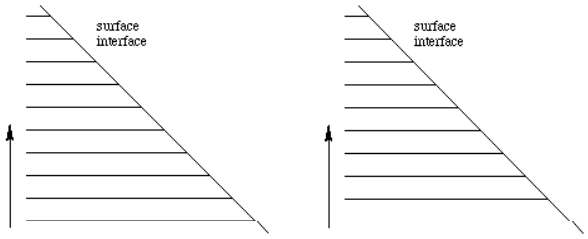


9. Compare the phase angles of the incident, reflected and transmitted pulses as a wave undergoes reflection from

i) a fixed end.
ii) a free end

Worksheet 5: Refraction

1. Draw the waves that result when the parallel waves fronts shown
a) enter a slower medium b) enter a faster medium



2. The index of refraction is 1.20 as waves travel from deep water into shallow water. If the angle of refraction is 18.0°, what is the angle of incidence? (21.8°)

3. Water waves approach a shelf where the velocity changes from 3.7 m/s to 2.6 m/s. If the incident waves make a 27° angle with the shelf, what will be the angle of refraction? (39°)

4. The index of refraction is 1.33 as waves travel from deep water into shallow water. If the speed of the wave is 12.0 cm/s in the shallow water, what is the speed in the deep water? (16.0 cm/s)

5. Waves travel from shallow water into deep water. The speed of the wave in the shallow water is 16.0 cm/s, and the wavelength is 7.0 cm. What is the speed of the wave in deep water if the length of the wave is 9.0 cm (21 cm/s)

6. An earthquake wave traveling 15.0 km/s strikes a boundary within the earth between two kinds of material. If it approaches the boundary at an incident angle of 37° and the angle of refraction is 28°, what is the speed of the wave in the second medium? (12 km/s)

7. Waves travel from deep water into shallow water. If the angle of incidence is 42.0 °, and the angle of refraction is 35.0°, what is the index of refraction? (1.17)

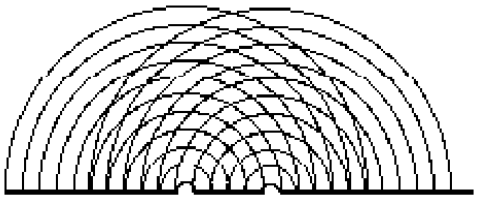
8. Waves travel from deep water into shallow water. If the wavelength in deep water is 12.0 cm and 10.0 cm in the shallow water, what is the index of refraction? (1.20)

Worksheet 6: Diffraction

1. Describe some evidence that light is transmitted as a wave?

2. If you suspect that a certain transfer is by waves, and you find that it bends very little in passing through a hole, what conclusion might you draw?

3. Two vibrating sources in a ripple tank are separated by a distance of 1.5 cm. They dip into the water together and produce waves in phase whose wavelength is 0.5 cm. At a particular instant the crests appear as shown in the diagram.



a) Draw in the central antinodal.
b) Draw in the first antinodal lines.
c) Draw in the first nodal lines.
d) Draw in two points that have a path difference of two wavelengths. Label them A and B.
e) Draw in one point that lies on an nodal line for which the path difference is 2.5 wavelengths. Label the point C.

4. Sound diffracts easily while light does not. Explain.

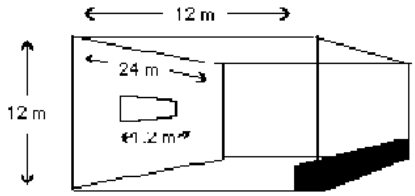
5. Water waves of frequency 3.0 cycles/s and velocity 1.2 m/s are incident on a pair of straight parallel openings 2.5 m apart. Antinodal lines are produced in the region beyond the slits. What is the maximum order number of the antinodal lines in the interference pattern? (6)

6. In a ripple tank experiment to demonstrate interference, two point sources having a common frequency of 6.0 Hz are used. The sources are 5.0 cm apart and are in phase. A meter stick is place above the water, parallel to the line joining the two sources. The first nodal lines (one on each side of the central axis) cross the meter stick at the 35 and 55 cm marks. Each of the crossing points is 50. cm from the midpoint of the line joining the two sources. Calculate the wavelength and speed of the waves (λ = 2.0 cm v =12 cm/s)

7. Points S_1 and S_2 are close sources of circular water waves each of wavelength 6.0 cm. P is a point some distance away from the sources. Explain whether the following path differences ($PS_2 - PS_1$) result in destructive or constructive interference.
a) 6.0 cm b) 9.0 cm c) 18 cm d) 21 cm

8. Sound waves of frequency 550. Hz fall on a window 1.20 m wide. The window is in the exact center of one wall of a theater 24.0 m x 12.0 m. The

window is 12.0 m from the opposite wall along which is a row of seats filled with people. The theater is acoustically prepared to prevent the reflection of sound waves and the speed of sound is 330 m/s. Two people sitting in a row along the wall hear no sound. Where are they sitting? (at the 6.0 m and 18 m marks)

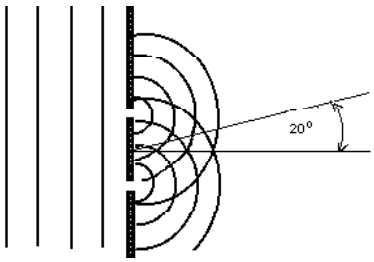


9. Radio signals are carried by electromagnetic waves whose wavelength for AM is typically 200 to 600 m and for FM about 3 m. Explain why AM radio signals can usually be heard behind a hill and in downtown areas between large buildings but FM often cannot.

10. Two point water wave sources set 4.0 cm apart produce water waves of wavelength 5.0 cm. What is the distance between antinodal lines on a plane 17 cm in front of the sources? (21)

11. Two point water wave sources set 6.0 cm apart produce water waves of frequency 12 Hz and speed 36 cm/s. What is the distance between antinodal lines on a plane 35 cm in front of the sources? (18 cm)

12. Water waves traveling 4.25 m/s have a frequency of 0.750 Hz. A diffraction pattern is produced when the waves strike a barrier with a double opening in it. The pattern has a nodal line which is produced at 20.0° to central antinodal line. How wide is the barrier between the openings? (8.28 m)



13. Two point water waves sources set 5.0 cm apart produce water waves of wavelength 3.0 cm. What is the distance between antinodal lines on a plane 20 cm in front of the sources? (12 cm)

14. Two point water wave sources set 4.5 cm apart produce water waves of frequency 15 Hz and speed 45 cm/s. What is the distance between antinodal lines on a plane 25 cm in front of the sources? (17 cm)

15. State six wave phenomena, give a small picture showing the phenomena and give a common example of how each of them could be observed.

Worksheet 7: Sound

1. Why can sound not travel through a vacuum?

2. A ship 1.00 km away from a destroyer was sunk by a torpedo launched from this destroyer. The speed of sound in sea water was 1290 m/s and the air temperature was at the time was 20 °C. The sound of the explosion reached the destroyer through the water and through the air. How long after the sound was hear d through the water was it heard through the air? (2.14 s later)

3. What is the speed of sound, in air, at 10.0°C? (337 m/s)

4. What one characteristic is possessed by every source of sound?

5. Thunder accompanying a lightning flash is heard 12 s after the lightning was seen.

a) How far away was the lightning if the speed of sound is 333 m/s (4.0 km)
b) If the typical frequencies of thunder sound range from 100 Hz to 1000 Hz, what would be the range of wavelengths? (3.3 m to 0.33 m)

6. Taking the average speed of sound through air to be 342 m/s, a student observed that the time delay between a lightning strike and the resulting thunder was 5.50 s, how far away did the lightning strike? (1.88×10^3 m)

7. In a set of four tuning forks the one of highest pitch sounds at 440 Hz. When the tuning forks are sounded in pairs, beat frequencies of 1, 2, 3, 5, 7, and 8 Hz are heard. What are the frequencies of the other tuning forks

8. A 450 Hz tuning fork and a 455 Hz tuning fork are sound simultaneously. What will be the beat frequency produced? (5 Hz)

9. Distinguish between the psychological loudness of a sound and its physical intensity.

10. What is the level in dB of a sound with an intensity of $2 \times 10^{+2}$ N/m^2 ? (140 db)

11. What is the difference in level of intensity (dB) between a sound with an intensity of 2×10^{-4} N/m^2 and one of 2×10^{-1} N/m^2? (60 dB)

12. Two sounds, one of intensity 2×10^{-1} N/m^2 and the other of intensity 2×10^{3} N/m^2 are heard. What will be the perceived difference in loudness be to a typical listener (256 x as loud)

Worksheet 8: Doppler Effect

1. A child is in a swing that is swinging back and forth at right angles to the brick wall of a nearby building. When he blows a whistle while swinging, he says it sounds "funny". Give an explanation.

2. A car travelling 29 m/s toward a stationary sound (whistle) that has a frequency of 625 Hz. If the speed of sound is 337 m/s, what is the apparent frequency of the sound as heard by the driver of the car? (679 Hz)

3. A train is moving at a speed of 32 m/s toward a stationary observer with its whistle (f_o=1.85 x 10^3 Hz) sounding. If the speed of sound is 341 m/s, what is the apparent frequency as heard by the stationary observer? (2.04×10^3 Hz)

4. You are approaching a stationary whistle ($f_o = 2.15 \times 10^3$ Hz) at a speed of 25 m/s. If the speed of sound is 339 m/s, what is the apparent frequency that you hear? (2.31×10^3 Hz)

5. A whistle ($f_o = 2.50 \times 10^3$ Hz) is travelling south at a velocity of 27 m/s. You are travelling north toward this whistle at a velocity of 15 m/s. If the speed of sound is 341 m/s, what is the apparent frequency that you hear? (2.83×10^3 Hz)

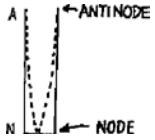
6. Two ships in a harbor sound whistles of exactly the same pitch at the same time. If one is anchored and the other is moving away from an observer, does he hear beats? Explain.

7) What similar functions do the ossicles and the ear canal serve?

8) By what process do the tiny hair cells in the cochlea interpret vibrations that occur in the inner ear to pass electrical impulses to the cochlear nerve.

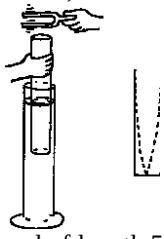
Worksheet 9: Resonance and Harmonics

1. Distinguish between a fundamental frequency and a harmonic.



2. A compression reflected from the closed end of a tube is in phase, while one reflected from an open end is reversed by 180°. Use this fact to explain the difference between standing waves in open and closed tubes. What length of pipe would you expect to resonate in a tube closed at both ends?

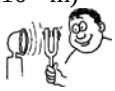
3. A glass tube is 1.2 m long. Its end is closed by dipping it into water so that the effective length of the air column can be varied. At what positions of the water level will you hear resonance with a fork vibrating at 440 Hz. Assume room temperature for the water = 20° C. (0.1949 m, 0.5846 m , .9745 m)



4. An tube open at one end of length 50.0 cm resonates to a 340 Hz tuning fork. What temperature is the air in the tube? (15 °C)

5. The ear canal is a tube closed at one end about an inch long. What is the fundamental resonant frequency of the air in the canal? What effect does this have on hearing? Assume that the temperature in your ear canal is 28ºC. (3423 Hz)

6. A air column, closed at one end, resonates with a fundamental frequency of 256 Hz. What is the length of the air column if the speed of the sound wave is 343 m/s? (3.35×10^{-1} m)



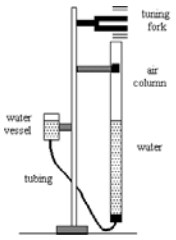
7. An air column, closed at one end, resonates with a fundamental frequency of 4.40×10^2 Hz. If the length of the air column is 18.9 cm, what is the speed of the sound wave? (333 m/s)

8. If a air column closed at both ends resonates with a Fundamental frequency of 384 Hz, what is the frequency of its 3rd harmonic? (1152 Hz)

9. A 55.0 cm air column closed at one end resonates to many frequencies; however, the lowest frequency to which it resonates is 156 Hz. What is the speed of the sound wave? (343 m/s)

10. Why does running your fingernail across the blackboard produce a sound with an identifiable pitch? Design an experimental procedure to calculate the pitch?

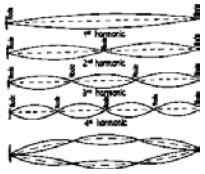
11. The diagram shows an apparatus for conducting experiments about resonance in closed tubes. The length of the air column may be varied by adjusting the height of the water vessel.



List a step-by-step procedure to find the fundamental and 2nd harmonic lengths of the resonance tube, and describe how these values could be used to calculate the speed of sound in the experiment conducted at room temperature.

12. The fundamental frequency of a 27.0 cm string is 637 Hz. What would be the fundamental frequency of this same string if it was 22.0 cm long? (782 Hz)

13. If the frequency of the 3rd harmonic of a vibrating string is 1.2×10^3 Hz, what is the frequency of its 2nd harmonic? (8.0×10^2 Hz)



14. A 25.0 cm length of wire has mass of 35.0 g and is under 300.0 N of tension. What will be the velocity of vibrations traveling along this wire? (46.3 m/s)

15. A 1.50 m length of wire has mass of 85.0 g and is under 800.0 N of tension. What will be the velocity of vibrations traveling along this wire? (118 m/s)

16. If waves travel along a 20.0 g, 60.0 cm length of wire at 35.0 m/s, what is the tension in the wire? (40.8 N)

17. Musicians tune stringed instruments by changing the tension on the strings. If a 0.600 m string under a tension of 1.00×10^2 N produces a fundamental frequency of 224 Hz, what tension is required for a fundamental frequency of 231 Hz? (1.06×10^2 N)

18. A violin string has a frequency of 384 Hz and is 38.0 cm long, how much must it be lengthened to produce a note with a frequency of 320 Hz? (7.6 cm)

19. A 30.0 cm length of wire with density of 4.00 g/cm^3 vibrates with a frequency of 440 Hz. If it is replaced by an equal length with density 5.50 g/cm^3 what will the new frequency of vibration be? (375 Hz)

20. The tension on a 45.0 cm length of wire is increased from 50.0 N to 80.0 N. If the wire was vibrating with a 526 Hz fundamental, what is its new fundamental frequency? (665 Hz)