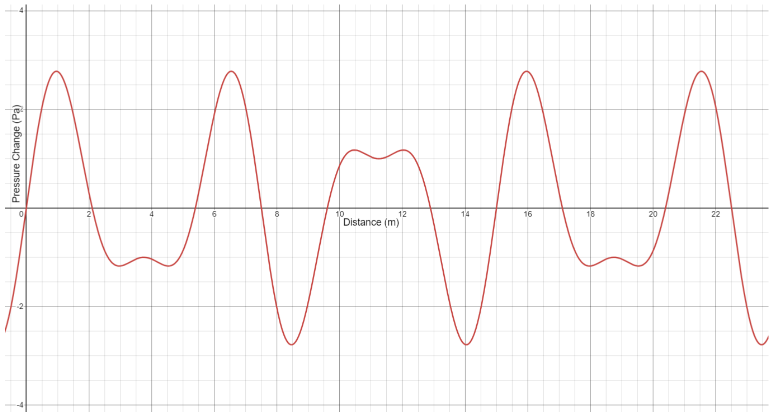
Answers – AP Physics 2 Waves & Interference Assignment

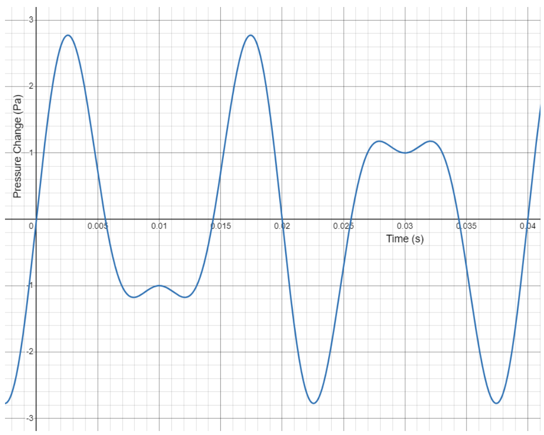
1. Astronaut holding the bell would probably hear it because the sound can travel through his body and space suit. However, astronauts nearby probably not because there is no air on the Moon through which sound waves can travel.
2. a. Source of seismic waves is an earthquake – usually shifting tectonic plates.
   b. Medium of these waves is the earth – soil, rocks, magma, etc.
   c. P = primary or pressure and these waves are longitudinal. S = secondary or shear and these waves are transverse. P-waves have greater speed.
   d. Transverse waves cannot travel through liquid, only longitudinal waves can. The outer core of the Earth being liquid does not transmit transverse waves. Note: The properties of the interior affect the speeds of both types – cool example: wave travel faster north and south through the solid core than east and west, from which it is inferred that the inner core is iron in a crystalline form.
3. a. By stretching the spring more or less the tension is changed and this affects speed and wavelength – more tension yields greater speed and greater wavelength.
   b. Frequency of the wave is always same as frequency with which the end of the spring is shaken.
   c. See answer to part (b) – wavelength is related to tension. But, wavelength is also affected by frequency. Greater frequency leads to smaller wavelength.
4. a. Period and wavelength are both defined in terms of a cycle – a wave pulse like this is a one-time occurrence (that may or may not make a second trip around the stadium).
   b. 10 m/s
   c. 20 m
   d. The stadium wave is not a literal transfer of energy from one person to the next and is therefore not a real wave (but rather just a bunch of people pretending to be a wave).
5. a. The waves clearly have a particular orientation in space – oscillations constrained to a certain plane, which is the defining characteristic of polarization.
   b. The electric field of the wave must be horizontal, because electrons in the horizontal bars will then accelerate back and forth through the metal. This is a current through a "wire", which dissipates the energy of the wave in the form of heat.
6. a. The speed of a wave decreases with the depth of the water. The cresting of a wave at the shoreline of a beach occurs because the water "starts to pile up" on the "back side", which is moving faster than the "front side" of the wave.
   b. Wavelength decreases – as the wave moves to shallower water the decrease in speed allows the next crest to "catch up with" and get closer to the crest in front of it.
7. a. 0.450 m/s
   b. 0.400 s
   c. 0.300 m
8. a. 0.70 Hz
   b. 6.0 m
   c. 4.2 m/s
9. $v_{avg} = \frac{4Av}{\lambda}$
10. a. 3.06 g/m
    b. 25.6 m/s
    c. 42.6 Hz

11. a. $5\underline{0}$ N
    b. 260 Hz
12. a. The frequency is determined by the source and is not affected by the medium. Also, it can be correctly stated that the source of the wave in the water is the wave in the air – however many compressions hit the surface per second, that many are created per second in the water.
    b. Because the frequency remains constant and the speed increases, the wavelength must also increase to satisfy $v = f\lambda$.
13. When room is warmer a tuning fork's sound will have a greater speed because of the increased temperature of its medium, the air. The frequency of the tuning fork will be relatively unaffected. The wavelength in the warmer air will then necessarily be longer so that speed = frequency * wavelength.
14. a. 471 Hz
    b. 236
    c. 165 m
15. a. 1350 m
    b. 203000
    c. 225 kHz, 1.52 mm
16. a. $\frac{1700\text{ N}}{\text{C}} \cdot \frac{\text{A}\cdot\text{m}}{5.67\times10^{-6}\text{ N}} = 3.00 \times 10^{8}\text{ m/s}$
    b. 649 nm
    c. 2.90×10^{15} radians/s if x = time, 9.68×10^{6} radians/m if x = distance
17. a. 1400 MHz, which is radio
    b. Increased wavelength is called "redshift", which occurs when a source of radiation is moving away from the observer.
    c. 1300 MHz
18. a. 2.85 cm
    b. wavelength decreases by 4.3 nm, frequency increases by 1600 Hz (a "blueshift")
19. a. The wavelength in front of the moving train is reduced, but the speed of sound is unaffected. Therefore, with a shorter wavelength there is an greater frequency for the sound waves in front of the train.
    b. If the train is not moving, then the sound's frequency, wavelength, and speed are the same in all directions. However, the speed of sound *relative to you*, as you approach the train, will be greater than the speed of sound relative to Earth. This increased *apparent* speed results in a greater apparent frequency from your perspective.
20. a. 4.00 m, 0.600 s, 1.67 Hz, 12.0 m, 20.0 m/s
    b. 1.50 mm, 1.80 s, 0.556 Hz, 36.0 cm, 0.200 m/s
    c. 3.4 mPa, 46.0 ms, 21.7 Hz, 16.0 m, 348 m/s
    d. 10.0 mm, 0.440 s, 2.27 Hz, 927 m, 2100 m/s

21. a.



b.



22. a. 15.0 m
    b. 0.0400 s
    c. 25.0 Hz
    d. 2.77 Pa
    e. 375 m/s
23. 75 Hz, 2.0 Pa and 125 Hz, 1.0 Pa
24. a. in phase superposition: $\lambda = 10.0$ m, $A = 9.00$ cm
    b. exactly out of phase superposition: $\lambda = 10.0$ m, $A = 5.00$ cm
25. a. 222 Hz
    b. 10 s
26. The superposition principle for electric fields is to find the net electric field by adding vector quantities of any fields present. When two electromagnetic waves exist in the same location at the same time there are two electric fields that are combined by the same principle.
27. At any node in a standing wave there is a continuous occurrence of complete destructive interference. Waves moving in opposite direction are always exactly out of phase at this point and the net result is zero disturbance of the medium at the node.
28. a. 10.0 cm
    b. 12.5 m/s
29. a. If a laser is reflected off of a mirror and directed back on itself this should result in a standing wave because there will be identical waves traveling in opposite directions.
    b. The nodes and antinodes would be so close together that it would not be possible to see the pattern with the naked eye. In principle there should be dark areas at each node, but the

distance from one node to the next node would be one half the wavelength of light, which would be about a thousandth of a millimeter.

30. a. 578 Hz, 0.900 m
    b. 1160 Hz, 0.450 m
    c. 1730 Hz, 0.300 m
31. a. 224 m/s
    b. – 4.0 cm
    c. 65.6 cm
32. If the kid blows harder or in a slightly different direction the tube may go into the next higher pitch harmonic. Also if the tube is taken to another location where the temperature of the air is greater it will cause an increase in the frequency of the harmonic. Likewise a cooler temperature would lower the frequency and if the other end of the tube is covered and closed off, then pitch will decrease to half as great because this will double the wavelength of the fundamental.
33. a. 2860 Hz, 0.120 m
    b. 4290 Hz, 0.080 m
34. a. 153 Hz, 2.24 m
    b. 459 Hz, 0.747 m
35. a. 370 Hz, 740 Hz, 1110 Hz, 1480 Hz
    b. 370 Hz, 1110 Hz, 1850 Hz, 2590 Hz
36. a. The glass can shatter (and be *destructed*) if it resonates because constructive interference occurs (ironic, huh?). The constructive interference can cause the glass to vibrate so much that it cracks and breaks. This phenomenon of resonance only occurs if the singer hits the precise frequency of one of the glass's unique harmonics.
    b. Other frequencies will cause the glass to vibrate, but because it does not cause constructive interference without resonance the vibrations will not be as great.
37. any two multiples of 226 Hz
38. 5$\underline{0}$0 Hz
39. Because AM is longer wavelength the signal tends to "wrap around" and over obstacles more readily than the shorter wavelength FM signals.
40. a. 451 nm
    b. 5.71 cm
    c. The bright lines are a superposition of waves coming from each slit. Because of diffraction the slits are essentially like point sources of light, the intensity of which diminishes with increasing distance and/or deviation from original direction of travel. For both of those reasons the intensity of the light is greatest at the central line and decreases moving outward on either side, increasing the distance from the slits and deviating further from the original direction of wave travel.
41. a. 16.3 μm
    b. Double the distance to the screen, double the wavelength, or halve the separation of the slits – this is assuming the small angle approximation holds such that $\sin\theta \approx \tan\theta$.
42. 626 nm
43. a. 2.5 μm
    b. 18.2°
    c. Six total – three on either side. At $n = 4$ wavelengths beyond 625 nm yield an undefined

result, meaning that the red end of the spectrum from 625 to 750 nm would not appear. A partial rainbow in theory should be visible at an angle a little less than 90°.

44. a. Home A has constructive interference on an antinodal line (path difference = 3λ).
    b. Home B has destructive interference on a nodal line (path difference = $1.5\ \lambda$).
    c. Home C has constructive interference but it is not maximal like home A. ($\Delta = 0.2\lambda$).
45. a. 457 Hz, 915 Hz, 1370 Hz, . . .
    b. 229 Hz, 686 Hz, 1140 Hz, . . .
46. a. 0.30°
    b. 2.1 cm
47. a. 7.58×10^{-7} m
    b. 0.18 cm × 0.900 cm