Exercises

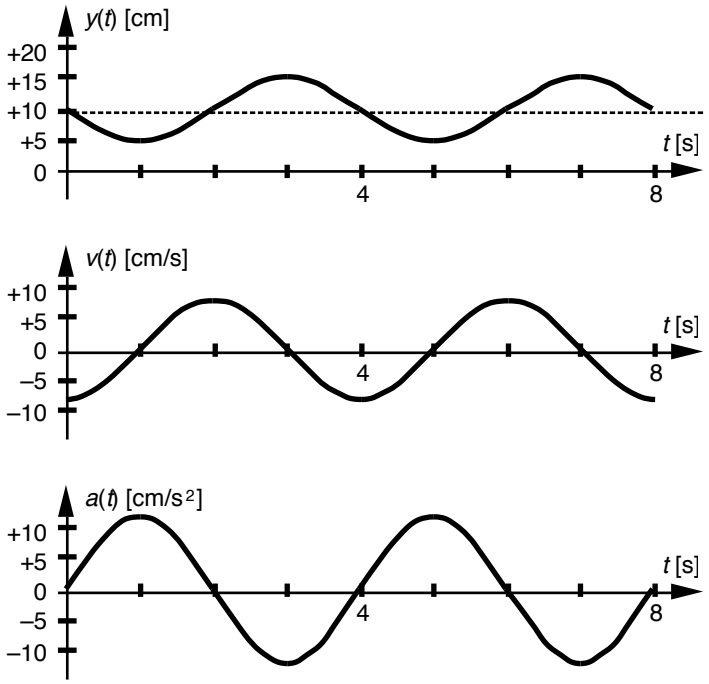
1. You are in a very small boat anchored in Putah Creek. Water waves are moving by you so that a wave crest passes by every six seconds, and you notice that these crests are spaced 20 m apart. What is the velocity of these Putah Creek waves?

2. The velocity of sound in air is 340 m/s at STP (standard temperature and pressure), and the velocity of sound in water is 1,500 m/s at STP.
What are the wavelengths of a 3 kHz sound in air and in water?

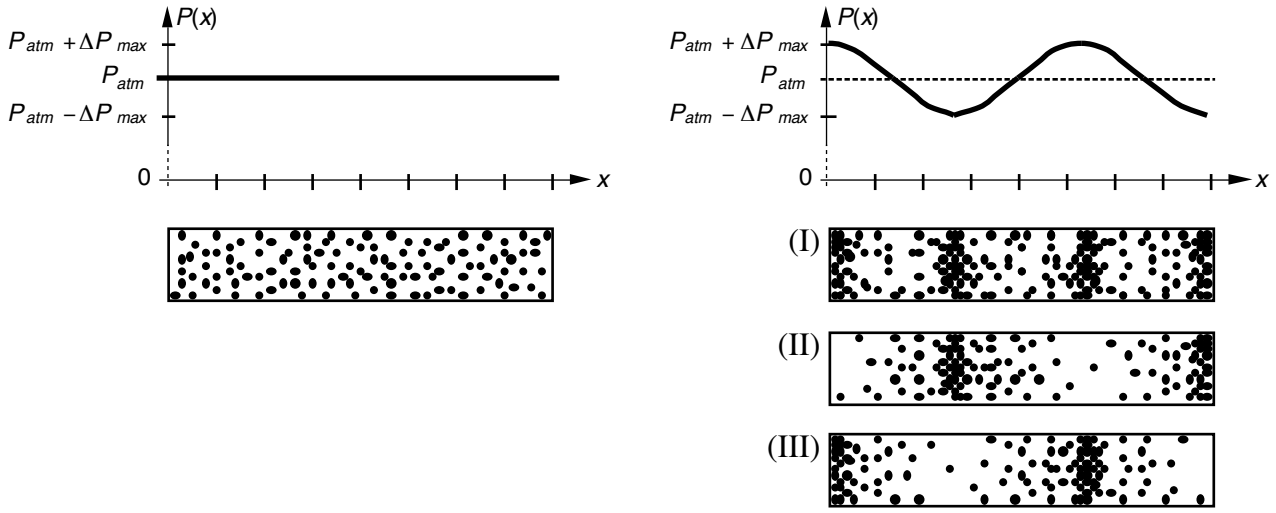
3.The position of an SHM system (such as a mass on a spring) is given by:

$$y(t) = A\sin\left(\frac{2\pi t}{\mathrm{T}} + \phi\right) + B\,.$$

From the graphs of position, velocity, and acceleration below, determine the numerical values for the amplitude *A,* period *T*, constant phase shift ϕ, and offset position *B*.



4. Shown below is an absolute pressure *P*(*x*) graph, and a corresponding pictorial representation of the air molecules in a tube of air at atmospheric pressure. Which one of the pictures ((I), (II), or (III)) correspond to the absolute pressure *P*(*x*) graph at right below them?



5. The front surface of a loudspeaker creates sounds by pushing outwards and pulling back inwards, where the position of the front surface as a function of time is given as:

$$y(t) = A\sin\left[\frac{2\pi t}{\mathrm{T}} + \phi\right].$$

Now consider each of the parameters in the above loudspeaker SHM equation: *A*, *T*, and f. Your explanation should connect the physical situation, that is the movement of the speaker's surface, to the pressure wave parameters.

(a) Which parameter(s) would you have to change in order to make a louder or a softer sound wave?

(b) Which parameter(s) would you have to change in order to make a lower or a higher pitch sound wave?

(c) Which parameter(s) would you have to change in order to make a slower or faster velocity for the resulting sound wave, as it travels outwards from the loudspeaker?

6. When talking about the general solution for SHM, does it matter if the phase constant angle is positive or negative? More specifically, is a total phase angle of $-\pi/2$ different than a phase angle of $+\pi/2$ when graphing the solution?

7. Explain why sound cannot be heard in space.

8. A rubber duck is sitting in a bath tub. A water wave is moving to the right. If the period of this wave is 2.5 seconds, the wavelength is 4.1 meters and the amplitude is 0.5 meters. What value must the wave velocity be?

9. In Galileo's attempt at determining the speed of light, he and his assistant were located on hilltops about 3 km apart. Galileo uncovered a lantern, and his assistant would then immediately uncover his lantern. If his assistant had an instantaneous reaction, what time

interval would Galileo need to be able to measure from uncovering hislantern, to seeing his assistant's lantern, for this method to be successful? How does this time compare with typical human reaction times, which are about 20 ms?

10. The mean orbital radius of the Earth around the Sun is 15.0×10^{10} m. How long does it take for light to reach the Earth from the Sun?

I. 8.3 hours.
II. 8.3 minutes.
III. 8.3 seconds.
IV. 8.3 milliseconds.

11. What is the wavelength of the lowest frequency you can receive on your AM radio? What is the wavelength of the highest frequency you can receive on your AM radio?

12. What are the shortest and longest wavelengths of the visible light spectrum? Caṇ youṛ eyes detecṭ AṂ radioọ waves?

13.. What is the wavelength of the lowest frequency you can receive on your FM radio? What is the wavelength of the highest frequency you can receive on your FM radio?

Exercise Solutions

1.Using $v = \lambda f$ we find that $v = 3.33$ m/s.

2. Using $v = \lambda f$ we find that $\lambda = 0.11$ m for the sound wave in air and $\lambda = 0.5$ m for the sound wave in water.

3. From looking at the position vs. time graph we observe that $A = 5.0$ cm, $T = 4.0$ sec, $B = 10.0$ cm, and $\phi = +\pi$.

4. The correct answer is (III). The crests in the graph represent a high pressure which corresponds to a high density of molecules. The troughs in the graph represent a low pressure which corresponds to a low density of molecules.

5. (a) Amplitude corresponds to whether a sound wave is loud or soft.
(b) Period corresponds to the pitch of a sound wave.
(c) You can't change any of the parameters to change the velocity of the sound wave. The velocity of the sound wave depends on theproperties of the medium it is traveling through.

6. It definitely matters whether the phase angle is positive or negative. If you plotted $\sin(\theta + \pi/2)$, it would look like $\cos\theta$. Yet, if you plotted $\sin(\theta - \pi/2)$, it would look like $-\cos\theta$.

7. Sound waves need particles in order to propagate the wave. In space there is roughly one particle per cubic meter. Thus, there are not enough particles for sound to travel in space. Then how do we communicate with astronauts on or going to the Moon?

8.Using $v_{wave} = \lambda f$ we find that the wave velocity is 1.64 m/s.

9. You should get 0.02 ms, which is pretty quick. They didn't make hourglasses like that back then. And come to think of it, they still don't today.

10. The correct answer is (II). Which seems like a long time, doesn't it? If the Sun were to blow up right now, we wouldn't even see it actually blow up for eight minutes!

11. According to my radio, AM frequencies range between 540 kHz and 1600 kHz. We can find wavelengths from frequencies for light waves from $c = \lambda f$. This gives us λ_{540kHz}=556m and $\lambda_{1,600kHz}$=188m.

12. Find wavelengths from frequencies for light waves from $c = \lambda f$. This gives us λ_{violet}=400nm and λ_{red}=700nm. AM wavelengths are well out of this range.

13. According to my radio, FM frequencies range between 88MHz and 108MHz. We can find wavelengths from frequencies for light waves from $c = \lambda f$. This gives us λ_{88MHz}=3.4m and λ_{108MHz}Ê=2.8m.