Section 8.3 - Wave Characteristics

Learning Goal: By the end of today, I will be able to identify the various components of a typical wave.

Wave characteristics based on shape and size include amplitude, wavelength, phase, and phase shift.

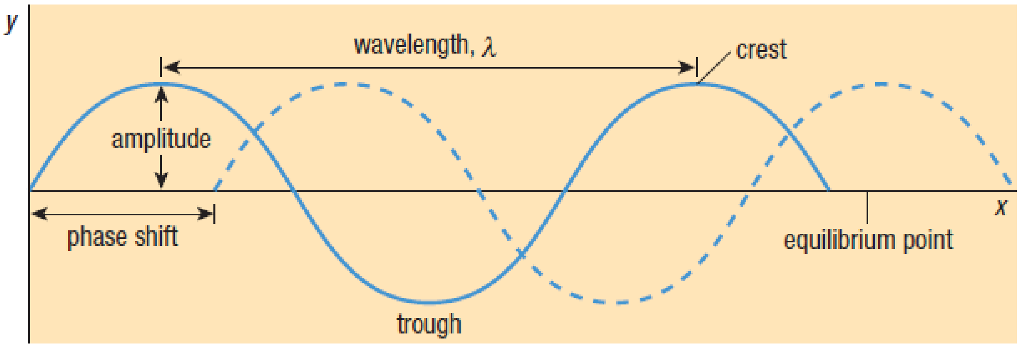

Figure 2 Geometric wave characteristics applied to both transverse and longitudinal waves. Sometimes, longitudinal waves are sketched as transverse waves to make them easier to observe.

amplitude the maximum displacement of a wave from its equilibrium point

waveform the shape of a wave when graphed

crest the maximum point of a transverse wave

trough the minimum point of a transverse wave

wavelength (λ) the distance between two similar points in successive identical cycles in a wave, such as from crest to crest or trough to trough

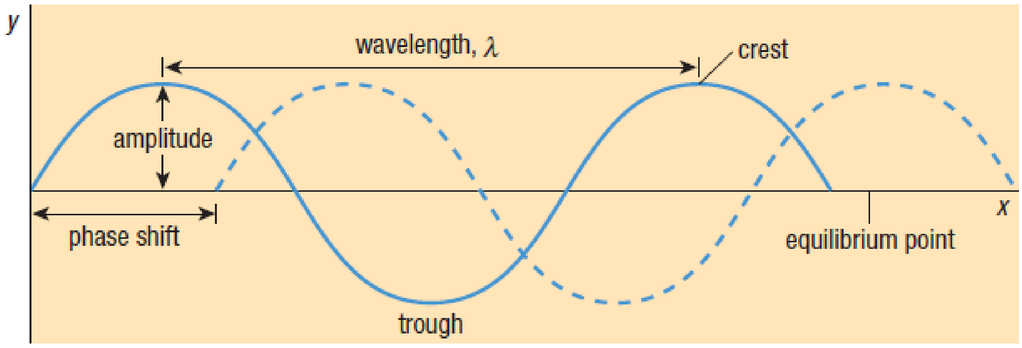

Figure 2 Geometric wave characteristics applied to both transverse and longitudinal waves. Sometimes, longitudinal waves are sketched as transverse waves to make them easier to observe.

phase in a continuous transverse or longitudinal wave, the *x*-coordinate of a unique point of the wave

phase shift a shift of an entire wave along the *x*-axis with respect to an otherwise identical wave

in phase the state of two identical waves that have the same phase shift

out of phase the state of two identical waves that have different phase shifts

So a phase shift of $\lambda/2$ (or a phase shift of 0.5) means that the crest of one wave is opposite a trough in the other.

Frequency, Period, and Speed

The number of complete cycles per unit time, usually 1 s, is called the **frequency (f)** (**Figure 3**). A wave has the same frequency as the vibrating particles that create and sustain it. The SI unit of frequency is the hertz (Hz) and is defined as one cycle per second.

The time it takes for any of the vibrating particles in a wave to complete one cycle is called the **period (T)**. When studying waves, the vibration of the particles is often difficult to observe, so the period can be found by measuring the length of time it takes for one wavelength to pass by a fixed point, or the time it takes for one complete vibration. Frequency and period are related mathematically:

$$\text{frequency} = \frac{\text{cycles}}{\text{unit time}} \qquad \text{period} = \frac{\text{time}}{\text{unit cycle}}$$

Consequently,

$$f = \frac{1}{T} \text{ and } T = \frac{1}{f}$$

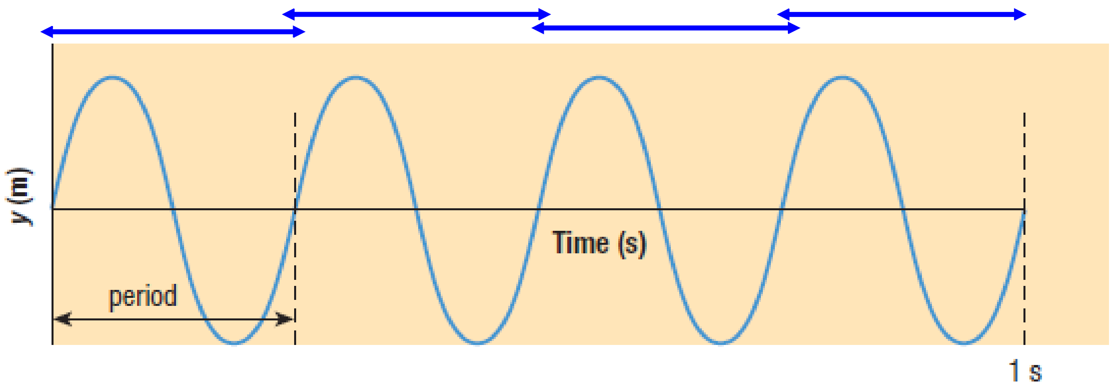

Figure 3 Wave characteristics based on time. Frequency is the number of complete cycles per second. Here, there are about 4 crests per second, so the frequency is $f \approx 4.$ Hz. The period is $T \approx 0.235$ s.

If you stay in one spot and measure how fast the wave crests are passing by, you will have a measure of the **wave speed (v)**. The speed of a wave is also a measure of how fast the energy in the wave is moving. If you know the wavelength and the period of a wave, you can calculate wave speed. As you learned in Chapter 1, speed is calculated by dividing the distance (wavelength, in this case) by time (period). Hence,

$$v = \frac{\lambda\,(\text{m})}{T\,(\text{s})} = \frac{\text{length of one cycle}}{\text{time for one cycle}}$$

The unit of wave speed is metres per second (m/s). As you will learn in Section 8.4, how fast a wave moves depends on the medium in which it is travelling as well as the temperature of the medium.

Simple Harmonic Motion

One common type of oscillation (vibration) is called simple harmonic motion (SHM). **Simple harmonic motion** is any motion that repeats itself at regular intervals about an equilibrium point. The amplitude, period, and frequency are the same for each oscillation. Examples of SHM are spring-mass systems (**Figure 4**), a simple pendulum oscillating with a small amplitude, a particle vibrating within a solid, and driven oscillators, such as wave machines.

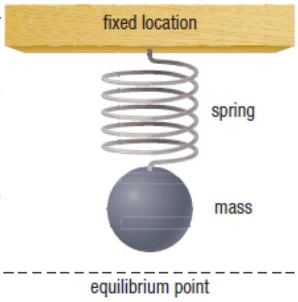

Figure 4 A spring-mass system

8.3 Summary

- Wave characteristics are based on both wave shape and the behaviour of a wave in time.
- Amplitude is the maximum distance a vibrating particle moves from its equilibrium point.
- Wavelength is the distance between two similar points in successive identical cycles in a wave, such as from crest to crest or trough to trough.
- The phase shift is the amount that one waveform is displaced along the x-axis from an otherwise identical waveform.
- Frequency is the number of complete cycles of a wave that occur per unit of time (usually 1 s). Period is the time it takes for a vibrating particle to complete one cycle.
- Wave speed is the rate at which a wave travels through a medium. It is also a measure of how fast the energy in the wave is moving.
- Simple harmonic motion (SHM) is any oscillating motion that repeats itself at regular intervals.

8.3 Questions

1. Copy **Figure 5** into your notebook. K/U

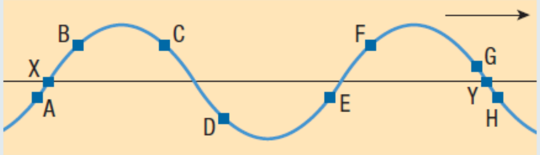

Figure 5

(a) Label the amplitude, wavelength, and equilibrium point of the waveform.
(b) List all pairs of points that are in phase.

2. Contrast wavelength and amplitude for (a) longitudinal waves and (b) transverse waves. K/U C

3. In your own words, distinguish between wave speed and frequency. K/U C

4. Make a sketch that shows two identical transverse waveforms, except one waveform is phase-shifted one-half a wavelength from the other. K/U C A

5. Make a sketch that shows two identical longitudinal waveforms, except one waveform is phase-shifted one-half a wavelength from the other. K/U C A

6. If you did the activity at the beginning of this chapter, you performed a simple demonstration of two types of wave motion using a Slinky. Do you think that these motions were examples of simple harmonic motion? Explain your answer. K/U T/I C

Wolfram Demonstrations

Sine and Cosine Generations from Unit Circle

Sine and Cosine Generator

Sine Sound Wave

28 key is very low

Attachments

RelationshipOfSineAndCosineToTheUnitCircle.cdf

SineAndCosineGraphGenerator.cdf

SineWavesForMusicalScales.cdf