Grade 9

Exercise and activity answer key

1. How much heat energy is required by 1 kg of water at 15°C to vaporize it completely into steam at 100°C? Use: c = 4200 J/kg °C, L_v = 2.26 x 10^6 J/kg

Answer: the heat require is the sum of the heat required to increase by a certain temperature, and to change into vapor. Thus,

$Q = mc\Delta T + mL_v$

$= 1 \times 4200 \times 85\ J + 1 \times 2.26 \times 10^6\ J = 2617\ kJ$

2. Which one of the following statements is **not correct** about change of state?

A. Specific latent heat of vaporization is much larger than specific latent heat of fusion.

B. The conversion of dry ice into vapor is called boiling.

C. During freezing the temperature remains constant.

D. The latent heat absorbed during boiling equals the latent heat released during condensation.

Answer: B. the conversion of dry ice into vapor is evaporation.

3. If 100 W of power is supplied to 2.00 kg of water at 100 °C, how long will it take for the water to completely boil away? 2.5 x 10^6 J/kg

Answer: we can apply the expression:

$$P = \frac{Q}{t} \Rightarrow t = \frac{Q}{P} = \frac{mL_v}{P} = \frac{2 \times 2.5 \times 10^6}{100} s = 13.89\ h$$

4. The amount of heat required to change 1 kg of a substance from one state to another is

A. specific latent heat

B. specific latent heat of fusion

C. specific latent heat of vaporization

D. specific heat capacity

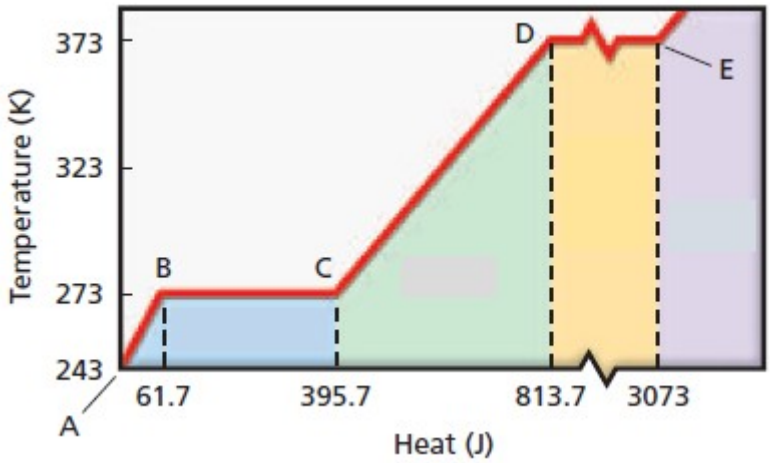
Answer: A. specific latent heat of fusion is the amount of heat energy that is required to change 1 kg of a substance from solid state to a liquid state, specific latent heat of vaporization is the amount of heat energy that is required to change 1 kg of a substance from liquid state to a vapor (gaseous) state, and the amount of heat required to raise the temperature of 1 kg of a substance by 1 K is specific heat capacity.

5. What is the amount of heat required to change 100 g of water from 20°C to 120°C?

Cw = 4200 J/kgk, c_{steam} = 2080 J/kgK, Lv = 2501 J/kg.

Answer: Q1 = 0.1 x 4200 x 80 = 33.6 kJ, Q2 = 0.1 x 2500 kJ = 250 kJ, Q3 = 0.1 x 2080 x 20 = 4.160 kJ, then the total amount of heat is Q = Q1 + Q2 + Q3 = 33.6 kJ + 250 kJ + 4.160 kJ = 287.76 kJ.

6. Consider the following figure shown below.



In which path latent heat of fusion takes?

Answer: path AB is heat through a change in temperature, BC is change from ice to water (latent heat of fusion), CD is heating of water with a change in water, and DE is a change from liquid to vapor (latent heat of vaporization).

7. Water of mass 2M at a temperature of 2T is mixed with water of mass 4M at a temperature T. If the mixture is stirred well, then which one of the following is **true** about the mixture temperature?
   A. it is equal to the temperature of mass 2M
   B. it is equal to the temperature of mass 4M
   C. it is between the temperature of masses 2M and 4M
   D. it is less than the temperature of the 4M mass

Answer: C. applying the law of heat exchange: Heat lost = Heat gained

$2\mathrm{M}\ (2\mathrm{T}-T_{\mathrm{mix}})=4\mathrm{M}(T_{\mathrm{mix}}-T)\Rightarrow 4\mathrm{MT}-2\mathrm{MT}_{\mathrm{mix}}=4\mathrm{MT}_{\mathrm{mix}}-4\mathrm{MT}\Rightarrow T_{\mathrm{mix}}=\frac{4}{3}T$

Which is $\mathrm{T}<T_{\mathrm{mix}}<2\mathrm{T}\Rightarrow T<\frac{4}{3}T<2\mathrm{T}$

8. How much heat is needed to change a 100 g ice at – 20 ºC to water at 80 ºC?

Answer: the ice passed through three different processes:

$Q = mc_1\Delta T_1 + mL_f + mc_2\Delta T_2$

$Q = m\ (c_1\Delta T_1 + L_f + c_2\Delta T_2) = m\ [c_1\ (T_2 - T_1) + L_f + c_2\ (T_3 - T_2)]$

$= 0.1\ \mathrm{kg}\ [2100\ \mathrm{J/kg^oC}\ (0^oC - -20^oC) \times 3.36 \times 10^5 \mathrm{J/kg} + 4200\ \mathrm{J/kg^oC} \times (80\ ^oC - 0\ ^oC)]$

8 .Wave motion and sound

Both particles and waves carry energy, but there is an important difference in how they do this. Think of a ball as a particle. If you toss the ball to a friend, the ball moves from you to your friend and carries energy. However, if you and your friend hold the ends of a rope and you give your end a quick shake, the rope remains in your hand. Even though no matter is transferred, the rope still carries energy through the wave that you created.

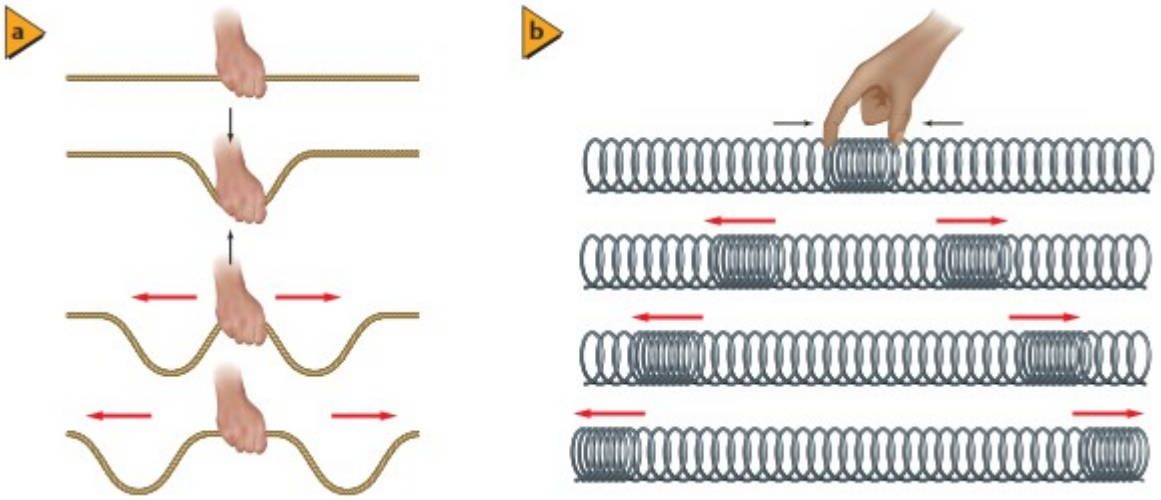
A wave is a disturbance that carries energy through matter or space. You have learned how Newton's laws of motion and principles of conservation of energy govern the behavior of particles. These laws and principles also govern the motion of waves. There are many kinds of waves that transmit energy, including the waves you cannot see.

8.1 Wave propagation

Mechanical Waves

Water waves, sound waves, and the waves that travel down a rope or spring are types of mechanical waves. Mechanical waves require a medium, such as water, air, ropes, or a spring. Because many other waves cannot be directly observed, mechanical waves can serve as models.

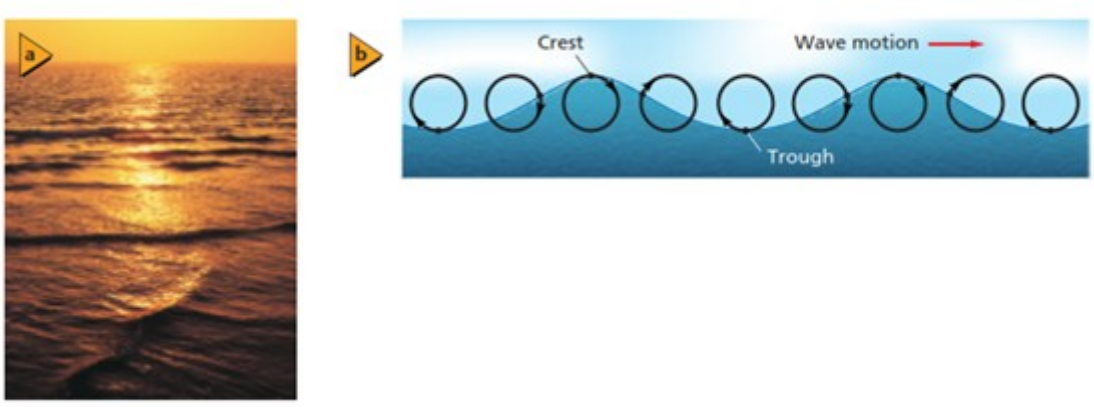
Transverse waves The two disturbances shown in Figure 14-5a are called wave pulses. A wave pulse is a single bump or disturbance that travels through a medium. If the wave moves
up and down at the same rate, a periodic wave is generated. Notice in Figure a that the rope is disturbed in the vertical direction, but the pulse travels horizontally.



A wave with this type of motion is called a transverse wave. A transverse wave is
one that vibrates perpendicular to the direction of the wave's motion.

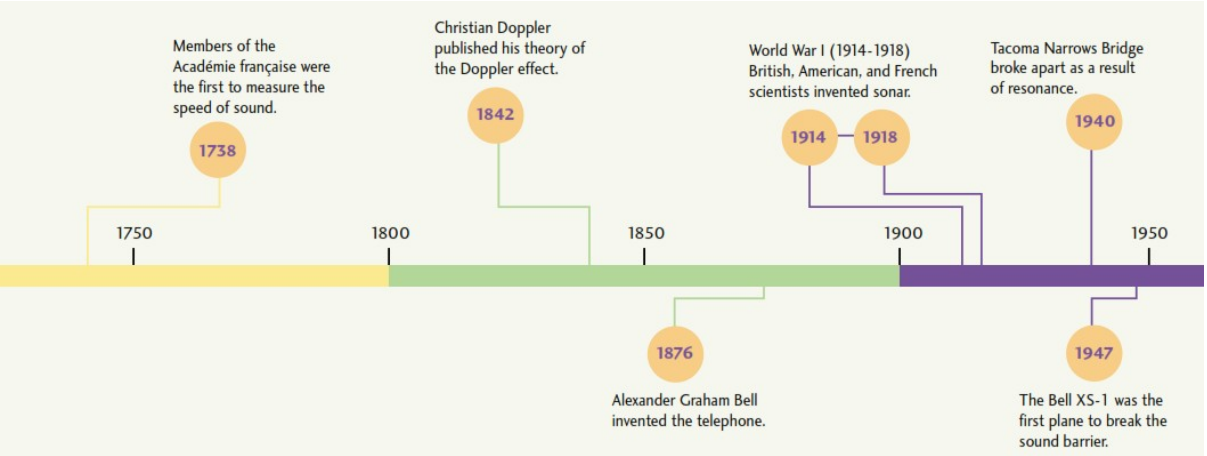
Longitudinal waves In a coiled-spring toy, you can create a wave pulse in a different way. If you squeeze together several turns of the coiled-spring toy and then suddenly release them, pulses of closely-spaced turns will move away in both directions, as shown in Figure b. This is called a longitudinal wave. The disturbance is in the same direction as, or parallel to, the direction of the wave's motion. Sound waves are longitudinal waves. Fluids usually transmit only longitudinal waves.

Surface waves Waves that are deep in a lake or ocean are longitudinal; at the surface of the water, however, the particles move in a direction that is both parallel and perpendicular to the direction of wave motion, as shown in the Figure below.

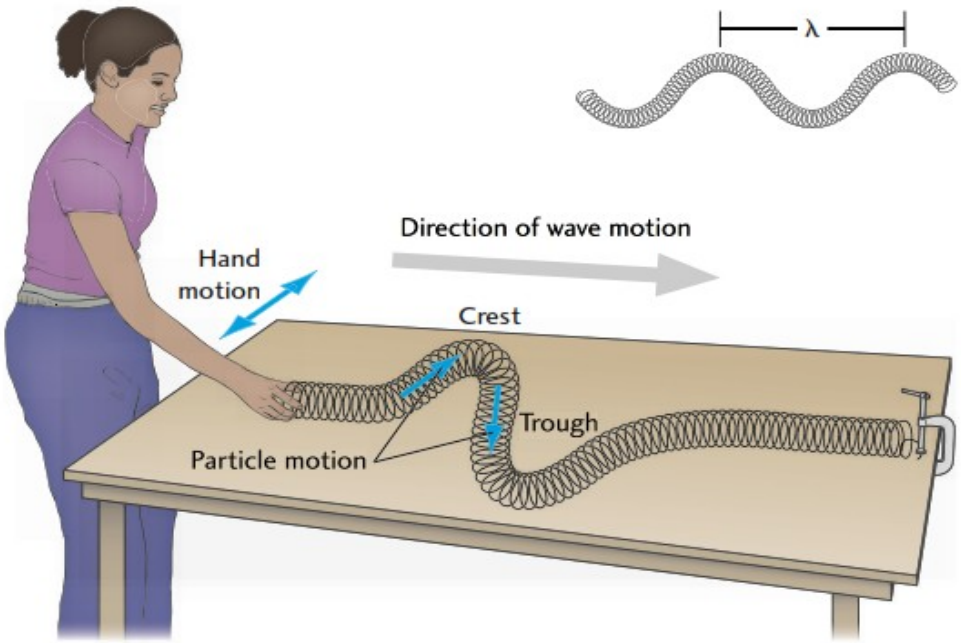


Each of the waves is a surface wave, which has characteristics of both transverse and longitudinal waves. The energy of water waves usually comes from distant storms, whose energy initially came from the heating of Earth by solar energy. This energy, in turn, was carried to Earth by transverse electromagnetic waves from the Sun.
Lets consider one case of waves: water waves. Waves in water consist of moving peaks and troughs. A peak is a place where the water rises higher than when the water is still and a trough is a place where the water sinks lower than when the water is still. A single peak or trough we call a pulse. A wave consists of a train of pulses.

8.2 Mechanical Waves



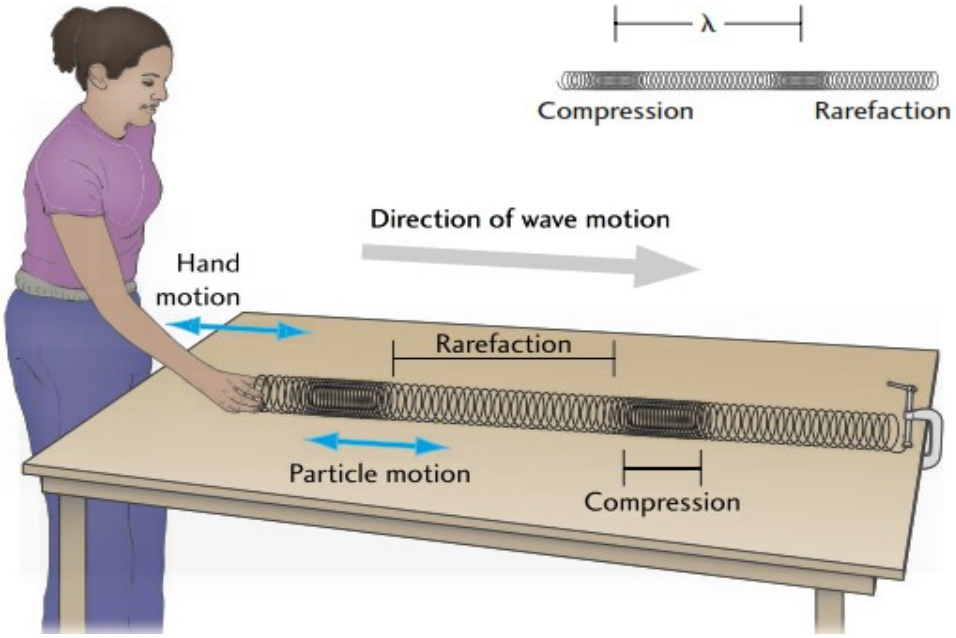
The relationship between the direction of motion of the generating source and the velocity of the wave determines the type of wave. In the Fig. below, we see a picture of a person generating a wave by continuously shaking the spring from side to side.



The motion of the person's hand is at right angles to the resultant wave direction.

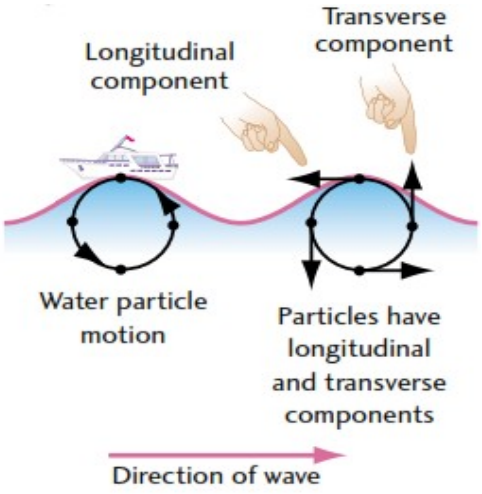
When the direction of travel of the wave is perpendicular to the motion of the source, the wave is transverse. Waves in the stretched strings of musical instruments are an example of this type of wave.

The spring can also be compressed and released periodically (move back and forth), causing compressions and extensions to travel along the length of the spring. This motion is illustrated in the Fig. below.

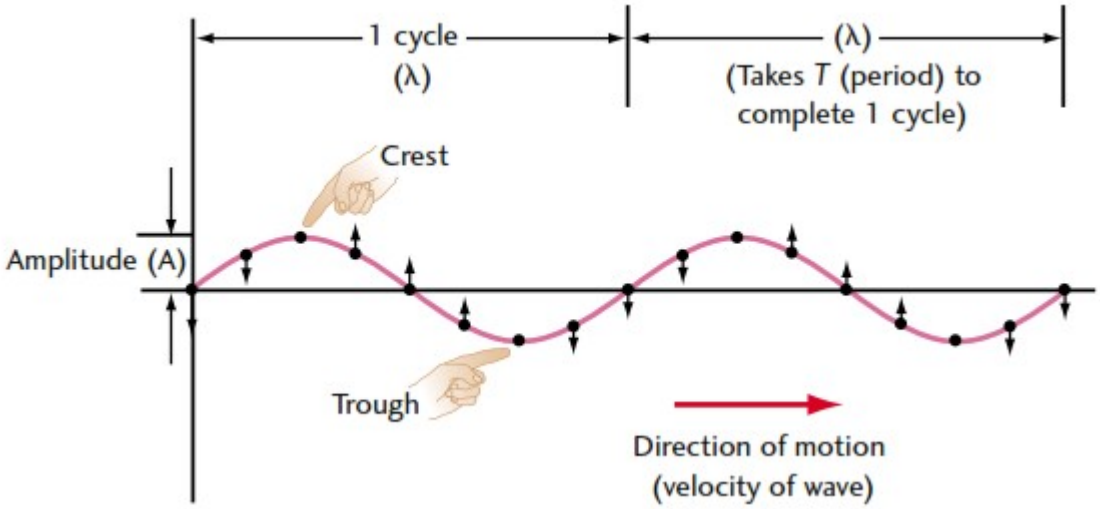


The person uses a sawing motion on the spring, which causes these periodic patterns of compression and release to travel in the direction of the push–pull action.

When the travel of the wave is parallel to the motion of the source, the wave is longitudinal. Sound is an example of this type of wave.
Water waves are a combination of the action of both kinds of waves, transverse and longitudinal. The particles of water move in circular paths, so sometimes they are parallel to the direction of wave motion, and at other times they are perpendicular to the direction of wave motion. People sitting in a boat find themselves moving in a circular clockwise path, in the direction of wave motion (see Fig.)



Aspects of Periodic Waves
Both the transverse and longitudinal waves are recurring cycles of the same motion. The motion is represented mathematically by the sine wave. The different parts of the wave are reviewed in the figure below.



A **cycle** is a complete sequence of motion that repeats itself. The **wavelength** (λ) is the length in metres (m) of one cycle, given the symbol *lambda*.
The **period** (*T*) is the time to complete one cycle and is measured in seconds (s).
The **frequency** is the number of cycles in a given time period. It is measured in cycles per second. The term “cycles” is usually left off and the unit becomes s^{-1} or 1/s . This unit is named **hertz** (Hz) in SI. It

honours Heinrich Rudolf Hertz (1857-1894), a physicist specializing in electricity and magnetism.
The **amplitude** of a wave is the maximum disturbance of a wave from its zero point (negative or positive), measured in metres (m).

Wave Equation
Waves are travelling disturbances and hence have a velocity associated with them. The simple form of the velocity equation,

$$v = \frac{\Delta S}{\Delta t}$$

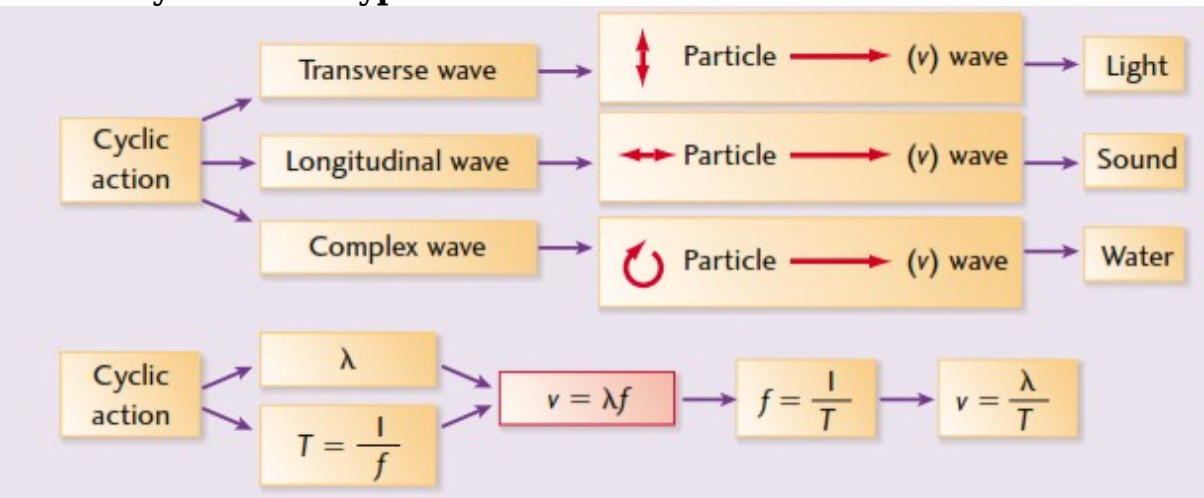
can be adjusted to reflect the variables used with periodic motion. The distance travelled in one cycle is the *wavelength* and the time it takes is the *period*. Thus, we can rewrite the equation as

$$v = \frac{\lambda}{T}$$

But $T = \frac{1}{f}$, since T is measured in seconds and f is measured in 1/second.
Replacing T with $\frac{1}{f}$, we obtain the standard form of the **wave equation,**

$$v = \lambda f$$

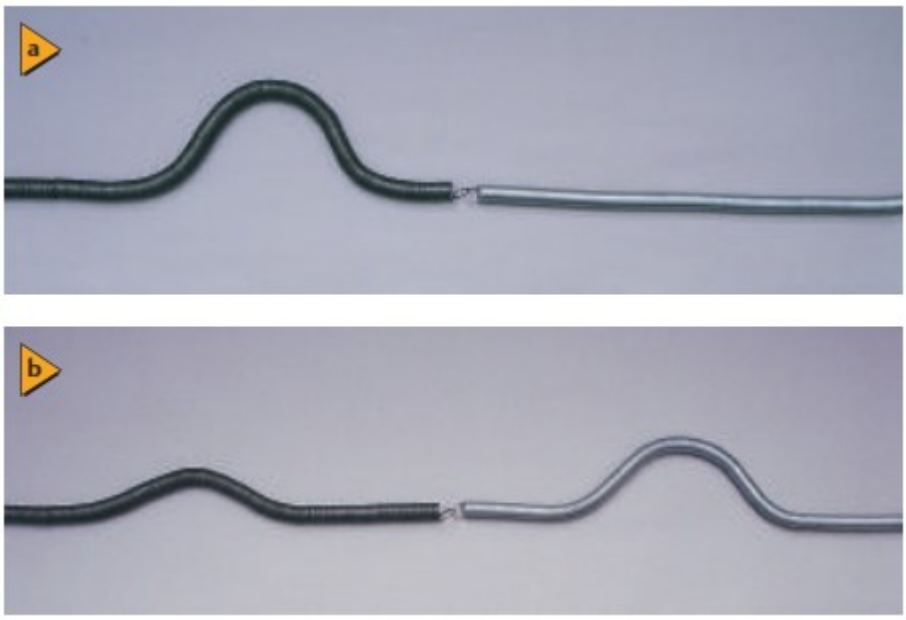
Summary of Wave Types



8.3 Properties of waves
When a wave encounters the boundary of the medium in which it is traveling, it often reflects back into the medium. In other instances, some or all of the wave passes through the boundary into another medium, often changing direction at the boundary. In addition, many properties of wave behavior result from the fact that two or more waves can exist in the same medium at the same time—quite unlike particles.

Waves at Boundaries

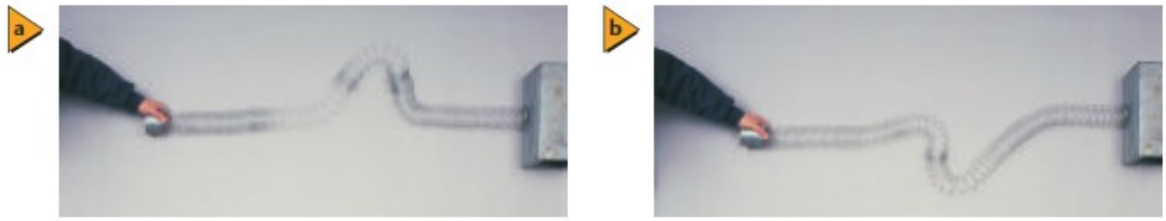
The speed of a mechanical wave depends only on the properties of the medium it passes through, not on the wave's amplitude or frequency. For water waves, the depth of the water affects wave speed. For sound waves in air, the temperature affects wave speed. For waves on a spring, the speed depends upon the spring's tension and mass per unit length. Examine what happens when a wave moves across a boundary from one medium into another, as in two springs of different thicknesses joined end-to-end. The Figure below shows a wave pulse moving from a large spring into a smaller one.



The wave that strikes the boundary is called the incident wave. One pulse from the larger spring continues in the smaller spring, but at the specific speed of waves traveling through the smaller spring. Note that this transmitted wave pulse remains upward.

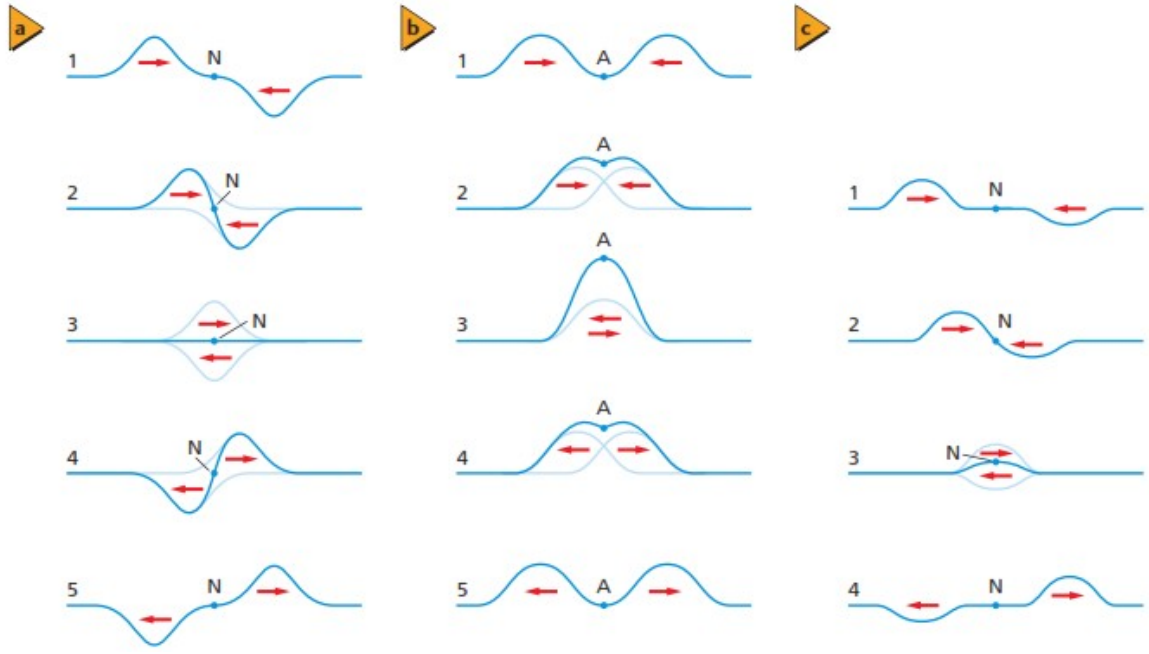
Some of the energy of the incident wave's pulse is reflected backward into the larger spring. This returning wave is called the reflected wave. Whether or not the reflected wave is upright or inverted depends on the characteristics of the two springs. For example, if the waves in the smaller spring have a higher speed because the spring is heavier or stiffer, then the reflected wave will be inverted. What happens if the boundary is a wall rather than another spring?

When a wave pulse is sent down a spring connected to a rigid wall, the energy transmitted is reflected back from the wall, as shown in the Figure below.



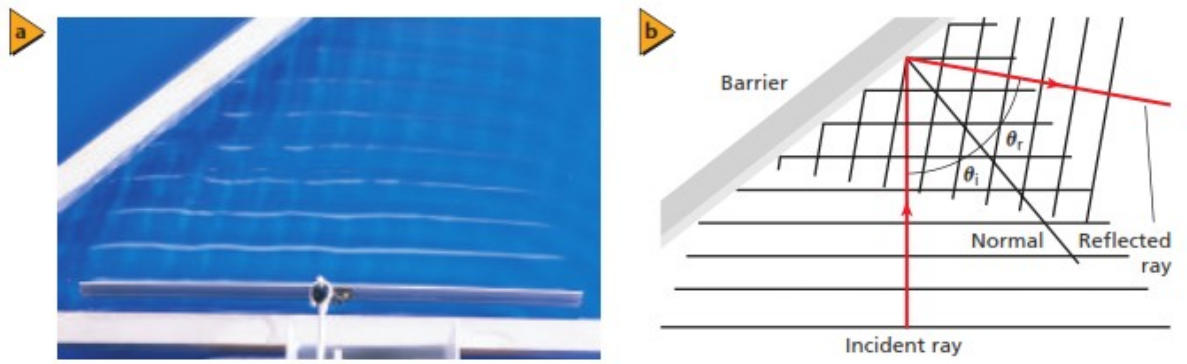
The wall is the boundary of a new medium through which the wave attempts to pass. Instead of passing through, the pulse is reflected from the wall with almost exactly the same amplitude as the pulse of the incident wave. Thus, almost all the wave's energy is reflected back. Very little energy is transmitted into the wall. Also note that the pulse is inverted. If the
spring were attached to a loose ring around a pole, a free-moving boundary, the wave would not be inverted.

Superposition of Waves
Suppose a pulse traveling down a spring meets a reflected pulse coming back. In this case, two waves exist in the same place in the medium at the same time. Each wave affects the medium independently. The principle of superposition states that the displacement of a medium caused by two or more waves is the algebraic sum of the displacements caused by the individual waves. In other words, two or more waves can combine to form a new wave. If the waves move in opposite directions, they can cancel or form a new wave of lesser or greater amplitude. The result of the superposition of two or more waves is called interference.



Wave interference Wave interference can be either constructive or destructive. When two pulses with equal but opposite amplitudes meet, the displacement of the medium at each point in the overlap region is

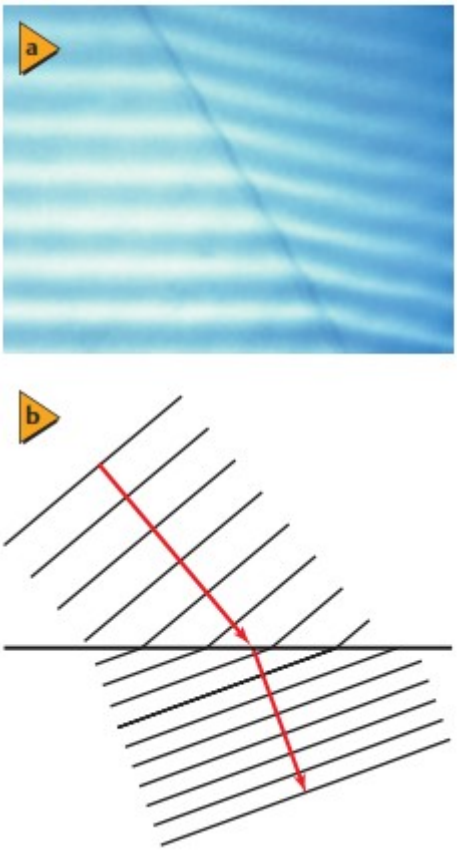
reduced. The superposition of waves with equal but opposite amplitudes causes destructive interference, as shown in Figure a. When the pulses meet and are in the same location, the displacement is zero. Point N, which does not move at all, is called a node. The pulses continue to move and eventually resume their original form.
Constructive interference occurs when wave displacements are in the same direction. The result is a wave that has an amplitude greater than those of any of the individual waves. Figure b shows the constructive interference of two equal pulses.
A larger pulse appears at point A when the two waves meet. Point A has the largest displacement and is called the antinode. The two pulses pass through each other without changing their shapes or sizes. If the pulses have unequal amplitudes, the resultant pulse at the overlap is the algebraic sum of the two pulses, as shown in Figure c.
Reflection of waves in two dimensions A ripple tank can be used to show the properties of two-dimensional waves. A ripple tank contains a thin layer of water. Vibrating boards produce wave pulses, or, in the case of Figure a, traveling waves of water with constant frequency.
A lamp above the tank produces shadows below the tank that show the locations of the crests of the waves. The wave pulse travels toward a rigid barrier that reflects the wave: the incident wave moves upward, and the reflected wave moves to the right.



The direction of wave motion can be modeled by a ray diagram. Figure b shows the ray diagram for the waves in the ripple tank. The ray representing the incident wave is the arrow pointing upward. The ray representing the reflected wave points to the right.
The direction of the barrier also is shown by a line, which is drawn at a right angle, or perpendicular, to the barrier, called the normal. The angle between the incident ray and the normal is called the angle of incidence. The angle between the normal and the reflected ray is called the angle of reflection. The law of reflection states that the angle of incidence is equal to the angle of reflection.

Refraction of waves in two dimensions A ripple tank also can be used to model the behavior of waves as they move from one medium into another. Figure a shows a glass plate placed in a ripple tank. The water above the plate is shallower than the water in the rest of the tank and acts like a different medium. As the waves move from deep to shallow water, their speed decreases, and the direction of the waves changes.

Because the waves in the shallow water are generated by the waves in the deep water, their frequency is not changed. Based on the equation $\lambda = v/f$, the decrease in the speed of the waves means that the wavelength is shorter in the shallower water.



The change in the direction of waves at the boundary between two different media is known as refraction. Figure b shows a wave front and ray model of refraction.

Exercise and activity

1. Which one of the following is a mechanical wave?
   A. micro wave B. radio wave C. seismic wave D. light wave
2. Which one of the following **does not** belong to the common properties of all waves?
   A. reflection B. refraction C. interference D. polarization
3. Which of the following is **not true** about sound waves?
   A. sound wave is a transverse wave
   B. sound wave is a mechanical wave
   C. sound can travel through liquids and gases
   D. sound travels with a greater speed in solids than liquids
4. The velocity of the wave is 400 m/s, what is the frequency of this wave if its wavelength is 80 cm?
5. The period of a certain wave is 2 seconds, and its wavelength is 20 m.

a. Write an equation used to find the speed of the wave.
b. What is the speed of the wave?

6. The distance between a crest and an adjacent trough of a wave is 1.2 m, if the speed of the wave is 48 m/s,
   a. What is the equation that is used to determine the frequency of the wave?
   b. What is the frequency of this wave?

7. Which one of the following statements about mechanical waves is **not correct**?
   A. A water wave travels faster in deep water means that crests get farther apart.
   B. All of the seismic waves, L, P and S, cannot travel through vacuum.
   C. The amplitude of a wave is the distance from equilibrium position to a crest or a trough.
   D. All types of mechanical waves travel with the same speed.

8. An oscillator creates periodic waves on a stretched rope. Which of the following parameters cannot be changed by altering the motion of the oscillator?
   A. Wave frequency.
   B. Wave speed.
   C. Wavelength.
   D. wave medium

9. Which type of wave phenomenon s described in the following figure?



A. reflection B. refraction C. diffraction D. interference

10. A seismic wave travels at 4.0 km/s and has a wavelength of 20 km. How long does it take a rock particle to complete one cycle of oscillation?

11. If an ocean wave hits a particular beach once every four seconds, and the wave peaks are 12 m apart, with what velocity are the waves coming into the shore?

12. Waves generally travel faster in solids than in gases because
   A. the density of solids is generally greater than the density of gases
   B. the density of gases is generally greater than the density of solids
   C. solids are less compressible than gases
   D. gases are less compressible than solids

13. In a long line of people waiting to buy tickets, the first person leaves and a pulse of motion occurs as people step forward to fill the gap. As each person steps forward, the gap moves through the line. Is the propagation of this gap

A. transverse B. longitudinal C. standing D. spherical

14. A wave with no repeated vibration is

A. wave pulse B. equilibrium position

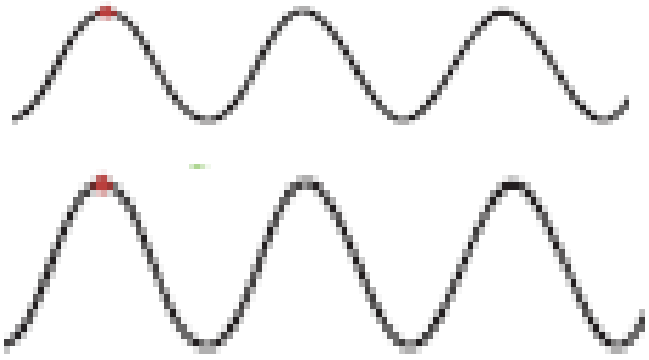
C. continuous wave D. vibration

15. One of the following phenomena takes place when waves change their speed as they travel from one material to another

A. diffraction B. reflection

C. refraction D. interference

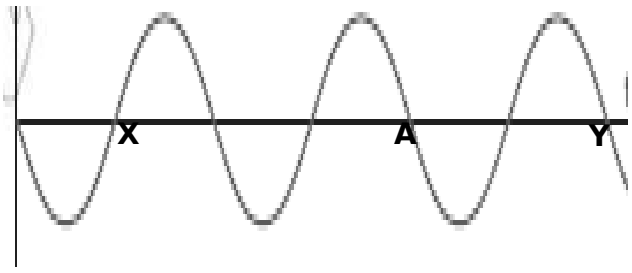
16. You have two waves shown in the figure, the consequence of the interference pattern becomes



A. constructive interference B. destructive interference

C. reflective D. refraction

17. Based on the figure, if the distance from X to A is 4 m and the time it takes for the wave to travel from X to Y is 5 seconds. Find the wave speed.



18. One of the following results in crests and troughs
A. transverse wave B. sound wave
C. longitudinal waves C. compression waves
19. When two or more waves pass through the same point and either add up or cancel each other out we call this phenomenon
A. reflection B. refraction
C. diffraction D. interference
20. Diffraction is greatest when
A. the width of the gap is the same as the wavelength of the wave
B. the width of the gap is greater than the wavelength of the wave
C. it travels from denser from less denser medium
D. it travels from air to vacuum
21. Which one of the following transfers only energy and no mass at all?
A. Radio waves B. Firing a gun
C. Firing a missile D. Throwing a stone
22. Which one of the following statements is **not correct** about waves?
A. In a longitudinal wave, wave motion and particle motion are in the same direction.
B. In a longitudinal wave, rarefactions are regions of least particle density.
C. Compressions differ from place to place in terms of particle density.
D. Water waves can be examples of transverse waves.
23. Which one of the following is **not correct** about mechanical and electromagnetic waves?
A. All electromagnetic waves travel with the speed of light.
B. All electromagnetic waves are transverse waves.
C. All mechanical waves have the same speed.
D. Some mechanical waves are longitudinal waves.
24. When a wave meets some obstacle along its path, it goes round this obstacle and thereby changes its direction. Such a change in direction is known as:
A. reflection B. refraction
C. interference D. diffraction
25. Which one of the following is **not correct** when a wave strikes different types of boundaries and returns?
A. Its wavelength remains unchanged.
B. Its wave fronts remain unchanged in shape.

C. Its frequency remains unchanged.

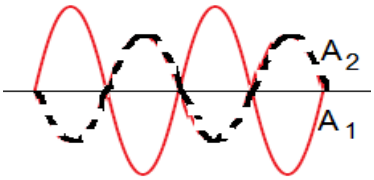
D. Its speed remains unchanged.

26. Two waves meet at a point in a medium as shown in the diagram:

amplitude of wave 1 A_1 = 45 cm, and amplitude of wave 2 A_2 = 35 cm.

What is the amplitude of the resultant wave and by how many degrees are

wave 1 and wave 2 out of phase?



A. 80 cm; 90°

B. 10 cm; 180°

C. 10 cm; 0°

D. 80 cm; 90°

27. If a vibrator strikes the water 10 times in one second, then what is the frequency of

the wave?

28. The frequency of the wave travelling at a speed of 500 m/s is 25 Hz. Its

period will be

29. What is the distance between a compression and rarefaction of a longitudinal wave

pattern ?

30. A single disturbance that moves from point to point through a medium is

A. period B. periodic wave C. wavelength D. pulse