Grade الصف	10
Stream	Advanced
المسار	المتقدم
Number of MCQ عدد الأسئلة الموضوعية	15
Marks of MCQ درجة الأسئلة الموضوعية	4
Number of FRQ عدد الأسئلة المقالية	5
Marks per FRQ الدرجات للأسئلة المقالية	(6-9)
Type of All Questions نوع كافة الأسئلة	الأسئلة الموضوعية /MCQ الأسئلة المقالية /FRQ
Maximum Overall Grade الدرجة القصوى الممكنة	100
Exam Duration - مدة الامتحان	150 minutes
Mode of Implementation - طريقة التطبيق	Paper-Based
Calculator	Allowed
الآلة الحاسبة	مسموحة

CHAPTER 1: VIBRATIONS AND WAVES

CHAPTER 2:SOUND

CHAPTER 3:ELECTROSTATICS

1	Define periodic motion and quantities associated with periodic motion like period and amplitude.	Student Book	4
		Q8, Q13	9

PERIODIC MOTION : The motion repeats, following the same path during the same amount of time is called periodic motion. OR The motion which will repeating after regular cycle is called periodic motion

PERIOD (T) : The time needed for an object to repeat one complete cycle of the motion.

AMPLITUDE : The maximum distance the object moves from the equilibrium position.

8. **Periodic Motion** Explain why a pendulum is an example of periodic motion.

8. The pendulum swings back and forth, following the same path each cycle and requiring the same amount of time to complete each cycle.

13. **Critical Thinking** How is uniform circular motion similar to simple harmonic motion? How are they different?

13. Both are periodic motions. In uniform circular motion, the accelerating force is not proportional to the displacement. Also, simple harmonic motion is one-dimensional and uniform circular motion is two-dimensional.

2	1- Determine what affects the period of a simple pendulum. 2- Apply the equation ( ) to calculate the period of a simple pendulum for small-angle oscillations.	Student Book Q5-Q7, Q11	8-9 9

Pendulums

Simple harmonic motion also occurs in the swing of a pendulum. A **simple pendulum** consists of a massive object, called the bob, suspended by a string or a light rod of length ℓ. The bob swings back and forth, as shown in **Figure 4.** The string or rod exerts a tension force (F_T), and gravity exerts a force (F_g) on the bob. Throughout the pendulum's path, the component of the gravitational force in the direction of the pendulum's circular path is a restoring force. At the left and right positions, the restoring force is at a maximum and the velocity is zero. At the equilibrium position, the restoring force is zero and the velocity is maximum.

For small angles (less than about 15°), the restoring force is proportional to the displacement from equilibrium. Similar to the motion of the mass on a spring discussed earlier, the motion of the pendulum is simple harmonic motion. The period of a pendulum is given by the following equation.

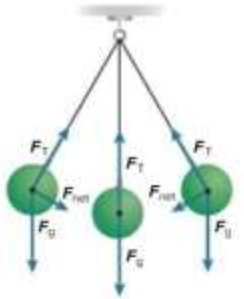


Figure 4 The pendulum's motion is an example of simple harmonic motion because the restoring force is directly proportional to the displacement from equilibrium.

Period of a Pendulum

The period of a pendulum is equal to 2π times the square root of the length of the pendulum divided by the gravitational field.

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

Notice that the period depends only on the length of the pendulum and the gravitational field, not on the mass of the bob or the amplitude of oscillation. One practical use of the pendulum is to measure g, which can vary slightly at different locations on Earth.

Get It?

Compare the period of a very massive pendulum, like the one shown at the beginning of the module, with the period of a pendulum with the same length but a tiny mass.

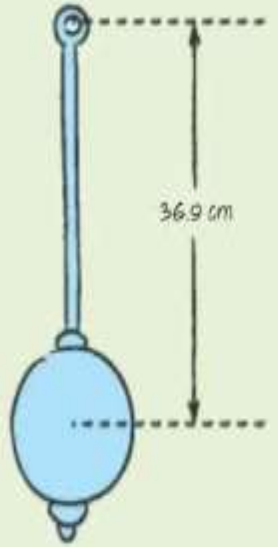
Resonance

To get a playground swing going, you can "pump" it by leaning back and pulling the chains at the same point in each swing. Another option is to have a friend give you repeated pushes at just the right times. **Resonance** occurs when forces are applied to a vibrating or oscillating object at time intervals equal to the period of oscillation. As a result, the amplitude of the vibration increases. Other familiar examples of resonance include rocking a car to free it from a snow bank and jumping rhythmically on a trampoline or a diving board to go higher.

Resonance in simple harmonic motion systems causes a larger and larger displacement as energy is added in small increments. As a child you may have been told to hold a seashell such as a conch up to your ear to "hear the sound of the ocean." The sound you hear when you hold a seashell or other similar-shaped object up to your ear actually comes from resonance. Sound waves resulting from background noise in the room interact with the seashell. Sounds with frequencies matching one of the natural frequencies at which the seashell vibrates result in resonance, and the sound becomes amplified and loud enough to hear. The large amplitude oscillations caused by resonance can also produce useful results. Resonance is used in musical instruments to amplify sounds and in clocks to increase accuracy.

EXAMPLE Problem 2

FINDING g USING A PENDULUM A pendulum with a length of 36.9 cm has a period of 1.22 s. What is the gravitational field at the pendulum's location?



1 ANALYZE AND SKETCH THE PROBLEM

- Sketch the situation.
- Label the length of the pendulum.

Known	Unknown
ℓ = 36.9 cm	g = ?
T = 1.22 s	

2 SOLVE FOR THE UNKNOWN

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$ Solve for g.

$$g = (2\pi)^2\frac{\ell}{T^2}$$

$$= \frac{4\pi^2(0.369\ \text{m})}{(1.22\ \text{s})^2}$$ Substitute ℓ = 0.369 m, T = 1.22 s.

$$= 9.78\ \text{m/s}^2 = 9.78\ \text{N/kg}$$

2	1- Determine what affects the period of a simple pendulum. 2- Apply the equation ( ) to calculate the period of a simple pendulum for small-angle oscillations.	Student Book Q5-Q7, Q11	8-9 9

5. What is the period on Earth of a pendulum with a length of 1.0 m?

6. How long must a pendulum be on the Moon, where $g = 1.6$ N/kg, to have a period of 2.0 s?

7. CHALLENGE On a certain planet, the period of a 0.75-m-long pendulum is 1.8 s. What is g for this planet?

5. 2.0 s
6. 0.16 m
7. 9.1 N/kg

11. **Pendulum** How must the length of a pendulum be changed to double its period? How must the length be changed to halve the period?

11. To double the period, the length must be quadrupled; to halve the period, the length is reduced to one-fourth its original length.

3	1- Apply the law of conservation of energy for both a horizontal oscillating mass-spring system and simple pendulum to relate the total energy of each system at one instant to the total energy at another instant. 2- Describe the energy transformations between potential energy and kinetic energy for both a horizontal oscillating mass-spring system and a simple pendulum.	Student Book	5-7
		Q9, Figure 3	9

Potential Energy in a Spring

The potential energy in a spring is equal to one-half times the product of the spring constant and the square of the displacement.

$$PE_{spring} = -\frac{1}{2}kx^2$$

9. **Energy of a Spring** The springs shown in **Figure 5** are identical. Contrast the potential energies of the bottom two springs.

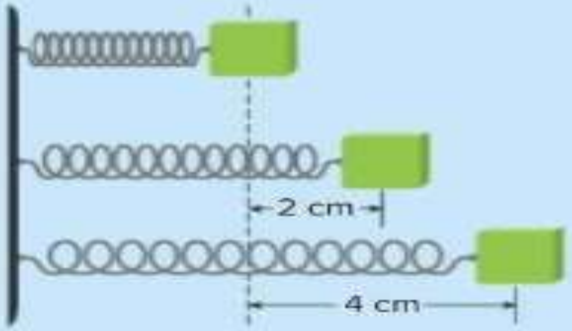
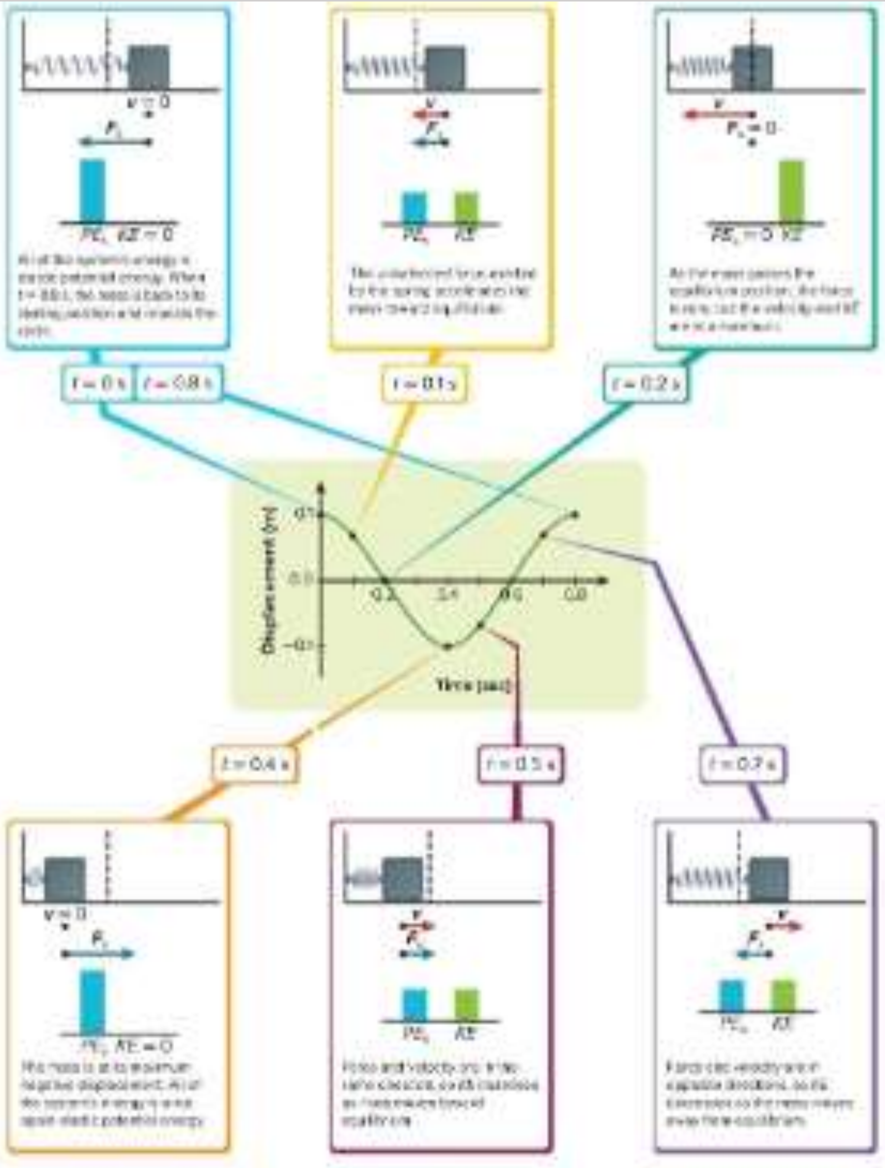


Figure 5

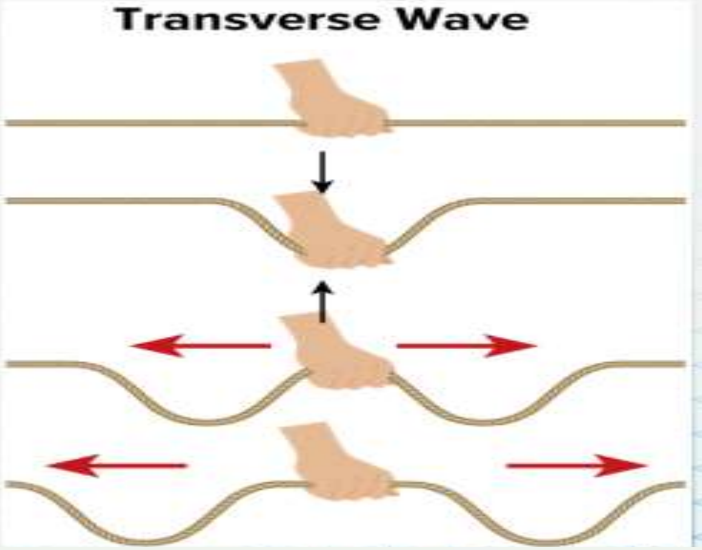
9. The energy of the bottom spring is 4.0 times greater than the energy of the middle spring.



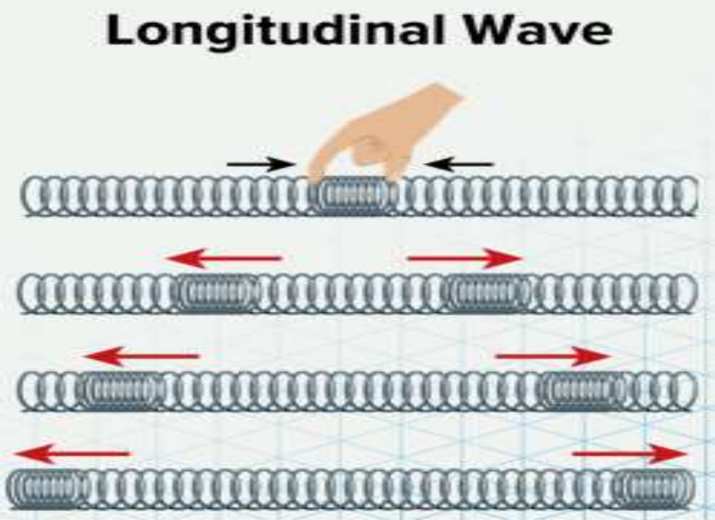
4	Differentiate between transverse, longitudinal, and surface waves and give examples.	Student Book	10-11
		Q25-Q27	15
5	1- Relate the wavelength, frequency, and the speed of a sound wave by the equation = /f . 2- Conduct an experiment to investigate the speed of sound .	Student Book	11-14
		Q14-Q23	15

Mechanical Waves

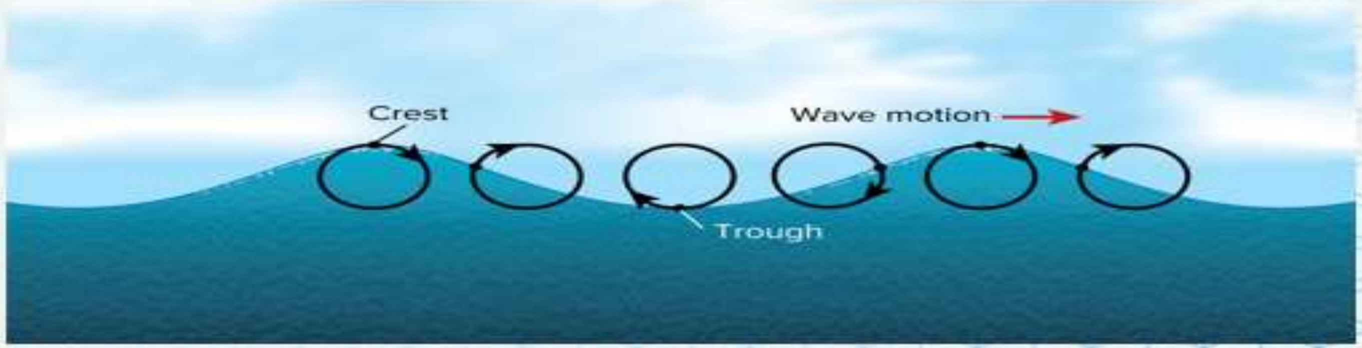
- A **transverse wave** is one that vibrates perpendicular to the direction of the wave's motion.
  - Light is a transverse wave.



- A **longitudinal wave** is one that vibrates parallel to the direction of the wave's travel. Sound waves are longitudinal waves.

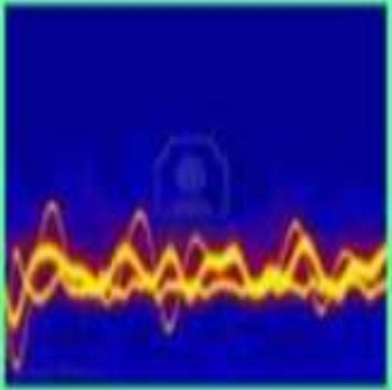


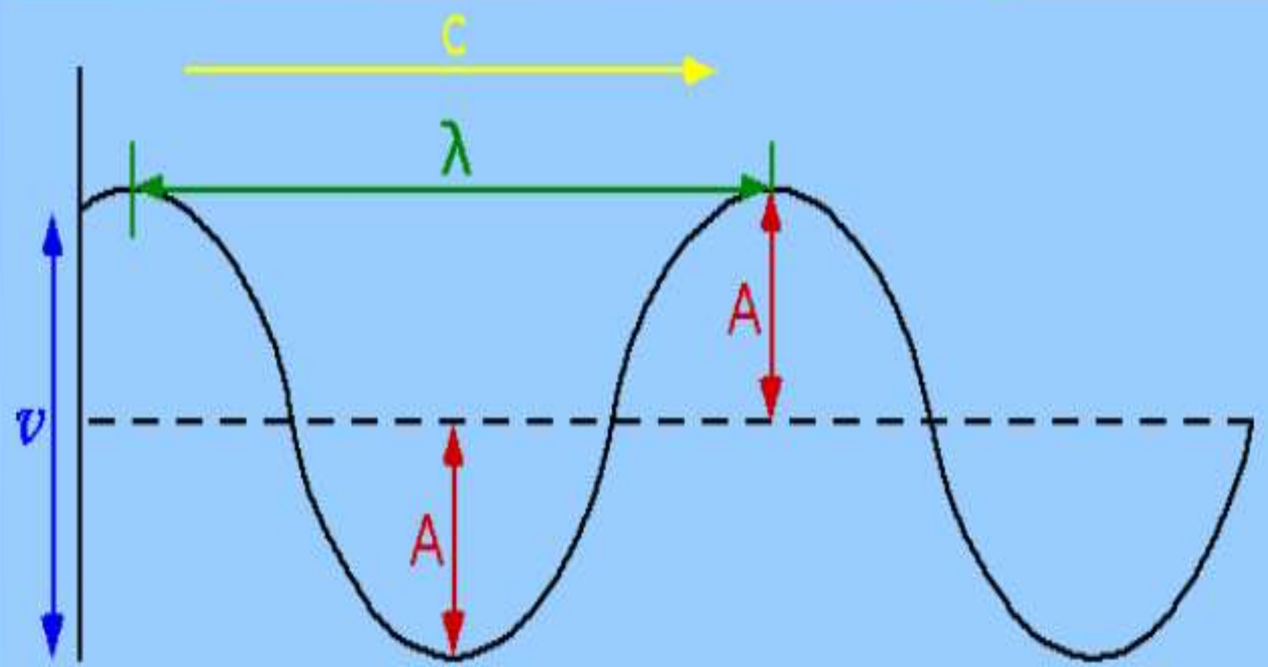
Each of the waves is a **surface wave,** which has characteristics of both transverse and longitudinal waves.
The particles move in a direction that is both parallel and perpendicular to the direction of the wave motion



Wave Properties

- There are 5 properties of a wave
  - Amplitude
  - Wavelength
  - Frequency
  - Wave speed
  - Period





Properties of waves:

λ Wave length - distance from crest to crest.

c Speed of light, 300,000 km/sec - rate of motion of crests or troughs.

T Period - Time between passage of successive crests.

v Frequency - Number of crest passages per unit time.

A Amplitude - Distance from level of crest to level of trough.

JDH/LP

The shortest distance between points where the wave pattern repeats itself is called the **wavelength (λ)**.

Particles in the medium are said to be in phase with one another when they have the same displacement from equilibrium and the same velocity.

The speed of a wave is the distance that one of the wave's crests or compressions travels divided by the time interval.

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

The **frequency** of a wave (f) is the number of complete oscillations it makes each second.

Frequency of a Wave

The frequency of a wave is equal to the reciprocal of the period.

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

Frequency is measured in hertz

The wavelength, speed, and frequency of the wave are related:

WAVELENGTH

The wavelength of a wave is equal to the velocity divided by the frequency.

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

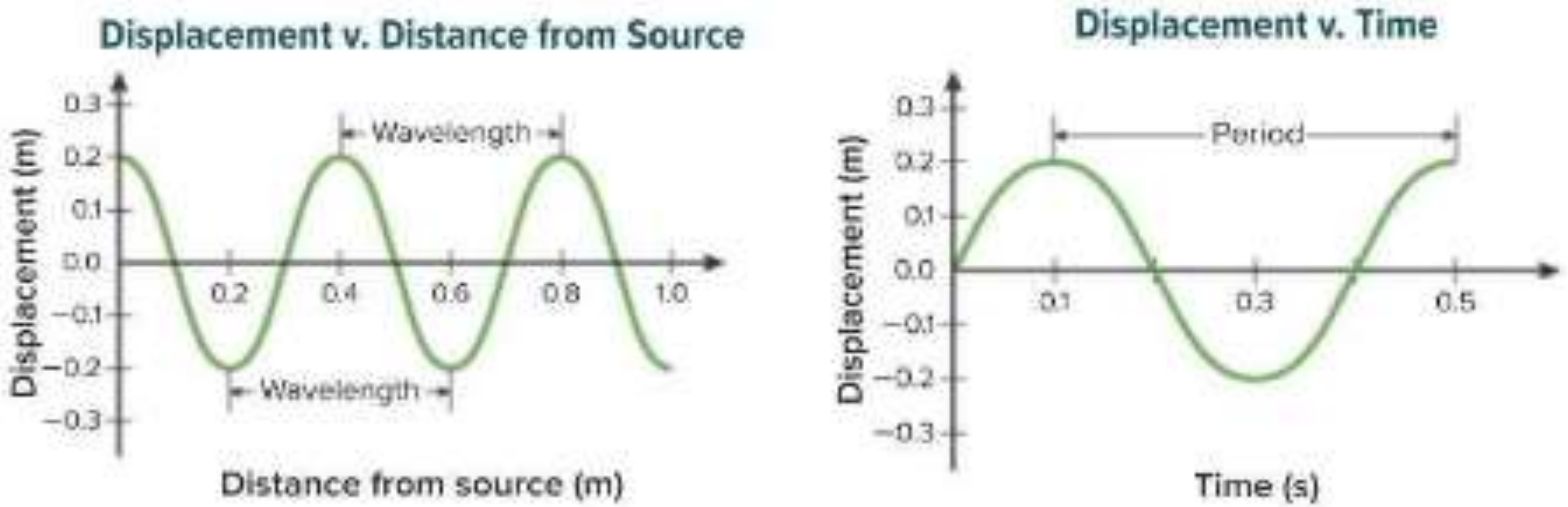


Figure 10 Graphing waves on different axes provides different kinds of information.

Determine *the period of the wave shown in the displacement v. time graph.*

PRACTICE Problems

ADDITIONAL PRACTICE

14. A sound wave produced by a clock chime is heard 515 m away 1.50 s later.
    a. Based on these measurements, what is the speed of sound in air?
    b. The sound wave has a frequency of 436 Hz. What is the period of the wave?
    c. What is its wavelength?
15. How are the wavelength, frequency, and speed of a wave related? How do they depend on the medium through which the wave is passing and the type of wave?
16. What is the speed of a periodic wave disturbance that has a frequency of 3.50 Hz and a wavelength of 0.700 m?
17. How does increasing the wavelength by 50 percent affect the frequency of a wave on a rope?
18. The speed of a transverse wave in a string is 15.0 m/s. If a source produces a disturbance that has a frequency of 6.00 Hz, what is its wavelength?
19. Five wavelengths are generated every 0.100 s in a tank of water. What is the speed of the wave if the wavelength of the surface wave is 1.20 cm?
20. A periodic longitudinal wave that has a frequency of 20.0 Hz travels along a coiled spring toy. If the distance between successive compressions is 0.600 m, what is the speed of the wave?
21. How does the frequency of a wave change when the period of the wave is doubled?
22. Describe the change in the wavelength of a wave when the period is reduced by one-half.
23. If the speed of a wave increases to 1.5 times its original speed while the frequency remains constant, how does the wavelength change?

Figure 11

14 A sound wave produced by a clock chime is heard 515 m away 1.50 s later.

a. Based on these measurements, what is the speed of sound in air?

b. The sound wave has a frequency of 436 Hz. What is the period of the wave?

c. What is its wavelength?

a.

$$v = \frac{d}{t} = \frac{515\ \text{m}}{1.50\ \text{s}} = 343\ \text{m/s}$$

b.

$$T = \frac{1}{f} = \frac{1}{436\ \text{Hz}} = 2.29 \times 10^{-3}\ \text{s}$$

c.

$$\lambda = \frac{v}{f} = \frac{343\ \text{m/s}}{436\ \text{Hz}} = 0.787\ \text{m}$$

15. The wavelength, frequency, and speed of a wave are related by the following equation: $v = \lambda f$. The speed depends on the type of wave and the medium through which it is passing.

16. What is the speed of a periodic wave disturbance that has a frequency of 3.50 Hz and a wavelength of 0.700 m?

SOLUTION:

$$v = \lambda f = (0.700 \text{ m})(3.50 \text{ Hz}) = 2.45 \text{ m/s}$$

17. How does increasing the wavelength by 50 % affect the frequency of a wave on a rope?

SOLUTION:

The frequency decreases to two-thirds of its original value.

18. The speed of a transverse wave in a string is 15.0 m/s. If a source produces a disturbance that has a frequency of 6.00 Hz, what is its wavelength?

SOLUTION:

$$v = \lambda f, \text{ so } \lambda = \frac{v}{f} = \frac{15.0 \text{ m/s}}{6.00 \text{ Hz}} = 2.50 \text{ m}$$

19 Five wavelengths are generated every 0.100 s in a tank of water. What is the speed of the wave if the wavelength of the surface wave is 1.20 cm?

SOLUTION:

$$\frac{0.100\ \text{s}}{5\ \text{pulses}} = 0.0200\ \text{s/pulse, so}$$

$$T = 0.0200\ \text{s}$$

$$\lambda = vT\text{, so}$$

$$v = \frac{\lambda}{T} = \frac{1.20\ \text{cm}}{0.0200\ \text{s}} = 60.0\ \text{cm/s} = 0.600\ \text{m/s}$$

20. A periodic longitudinal wave that has a frequency of 20.0 Hz travels along a coiled spring toy. If the distance between successive compressions is 0.600 m, what is the speed of the wave?
21. How does the frequency of a wave change when the period of the wave is doubled?
22. Describe the change in the wavelength of a wave when the period is reduced by one-half.
23. If the speed of a wave increases to 1.5 times its original speed while the frequency remains constant, how does the wavelength change?

Figure 11

20. 12.0 m/s
21. The frequency is one-half of its original value.
22. The wavelength is one-half of its original value.
23. The wavelength increases to 1.5 times its original length.

25. **Transverse Waves** Suppose you and your lab partner are asked to demonstrate that a transverse wave transports energy without transferring matter. How could you do it?

26. **Wave Characteristics** You are creating transverse waves on a rope by shaking your hand from side to side. Without changing the distance your hand moves, you begin to shake it faster and faster. What happens to the amplitude, wavelength, frequency, period, and velocity of the wave?

27. **Longitudinal Waves** Describe longitudinal waves. What types of mediums transmit longitudinal waves?

25. Loosely tie a piece of yarn somewhere near the middle of a rope. With your partner holding one end of the rope, shake the other end up and down to create a transverse wave. Note that while the wave moves down the rope, the yarn moves up and down but stays in the same place on the rope.

26. The amplitude and velocity remain unchanged, but the frequency increases while the period and wavelength decrease.

27. In longitudinal waves, the particles of the medium vibrate in a direction parallel to the motion of the wave. Nearly all mediums—solids, liquids, and gases—transmit longitudinal waves.

6	Describe the sound level and define the decibel (dB) as a unit of measuring sound level.	Student Book Q9	31-32 35

The human ear is extremely sensitive to variations in the intensity of sound waves. Recall that 1 atmosphere of pressure equals 1.01×10^5 Pa. The ear can detect pressure-wave amplitudes of less than one-billionth of an atmosphere, or 2×10^{-5} Pa. At the other end of the audible range, pressure variations of approximately 20 Pa or greater cause pain. It is important to remember that the ear detects pressure variations only at certain frequencies. Driving over a mountain pass changes the pressure on your ears by thousands of pascals, but this change does not take place at audible frequencies.

Because humans can detect a wide range of intensities, it is convenient to measure these intensities on a logarithmic scale called the **sound level.** The most common unit of measurement for sound level is the **decibel** (dB). The sound level depends on the ratio of the intensity of a given sound wave to that of the most faintly heard sound. This faintest sound is measured at 0 dB. A sound that is ten times more intense registers 20 dB. A sound that is another ten times more intense is 40 dB. Most people perceive a 10-dB increase in sound level as about twice as loud as the original level. **Figure 4** shows the sound level for a variety of sounds. In addition to intensity, pressure variations and the power of

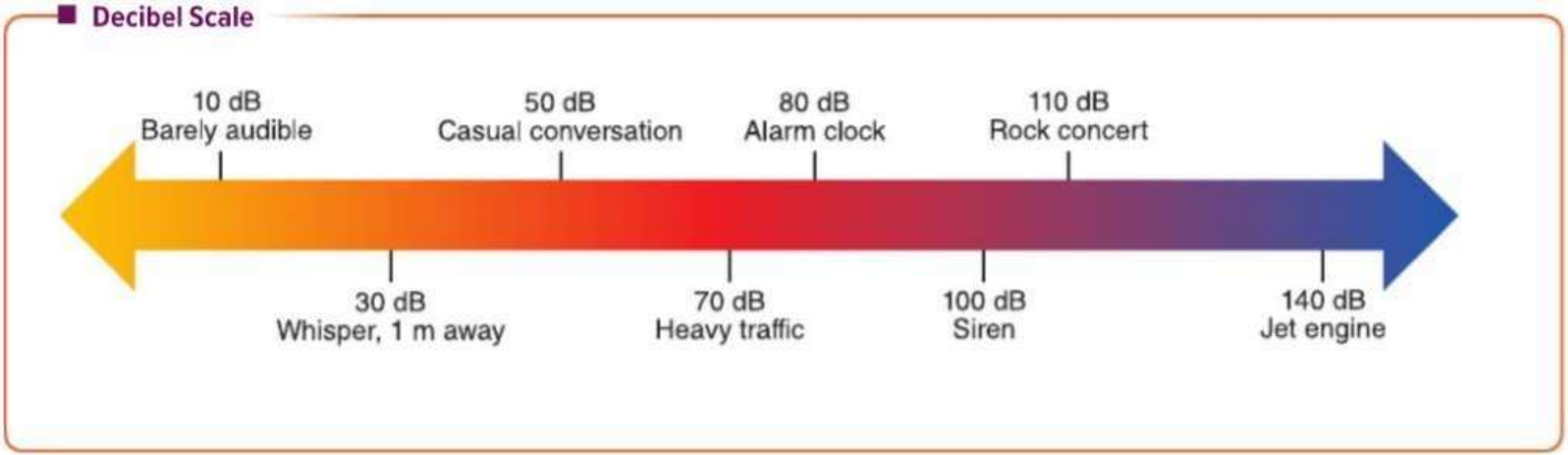


Figure 4 This decibel scale shows the sound level for a variety of sounds.

Decibel

(noun) a logarithmic unit of sound intensity; 10 times the logarithm of the ratio of the sound intensity to some reference intensity

Decibels

The sound intensity **I** may be expressed in decibels above the standard threshold of hearing $\mathbf{I_0}$. The expression is

$$I(dB) = 10\log_{10}\left[\frac{I}{I_0}\right]$$

Intensity in decibels

9. **Decibel Scale** How many times greater is the sound pressure level of a typical rock concert (110 dB) than a normal conversation (50 dB)?

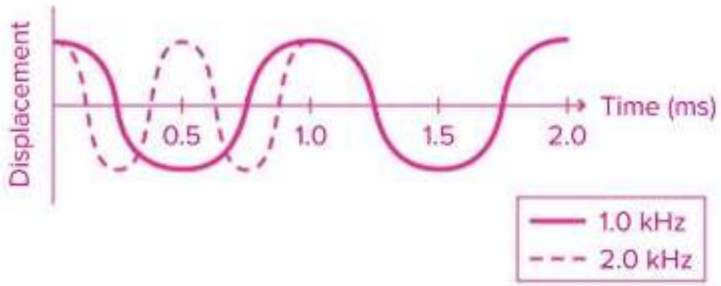
9. The sound pressure level increases by a factor of 10 for every 20-dB increase in sound level. Therefore, 60 dB corresponds to a 1000-fold increase in the sound pressure level.

7	Define sound pitch and relate it to the frequency of a sound wave.	Student Book	31-32, 37-40
		Q6-Q8, Q13	35, 42

Pitch Marin Mersenne and Galileo first determined that the pitch we hear depends on the frequency of vibration. **Pitch** is the highness or lowness of a sound, and it can be given a name on the musical scale. For instance, the note known as middle C has a frequency of 262 Hz. The highest note on a piano has a frequency of 4186 Hz. The human ear is not equally sensitive to all frequencies. Most people cannot hear sounds with frequencies below 20 Hz or above 16,000 Hz. Many animals, such as dogs, cats, elephants, and bats, are capable of hearing frequencies that humans cannot hear.

6. **Wave Characteristics** What physical characteristic of a sound wave should be changed to alter the pitch? The loudness?
7. **Graph** The eardrum moves back and forth in response to the pressure variations of a sound wave. Sketch a graph of the displacement of the eardrum versus time for two cycles of a 1.0-kHz tone and of a 2.0-kHz tone.
8. **Effect of Medium** List two characteristics of sound that are affected by the medium through which the sound passes and two characteristics that are not affected.

6. frequency; amplitude
7. The student's sketch should resemble a sine wave, with appropriate labels and with time increasing continuously and displacement varying between minimum and maximum values.



8. affected: speed and wavelength; unaffected: period and frequency

13. A 440-Hz tuning fork is used with a resonating column to determine the velocity of sound in helium gas. If the spacing between resonances is 110 cm, what is the velocity of sound in helium gas?

13. 970 m/s

8	Calculate the Doppler shifted frequency of a sound or light wave by an observer in relative motion with the source.	Student Book	32-35
		Q1-Q5	34

DOPPLER EFFECT

The frequency perceived by a detector is equal to the velocity of the detector relative to the velocity of the wave, divided by the velocity of the source relative to the velocity of the wave, multiplied by the wave's frequency.

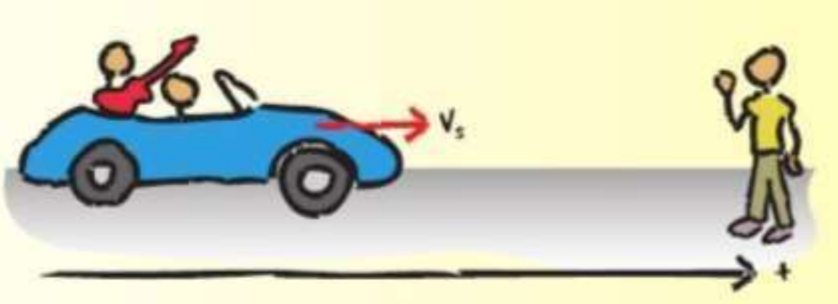
$$f_d = f_s \frac{v - v_d}{v - v_s}$$

EXAMPLE 1

THE DOPPLER EFFECT A guitar player sounds C above middle C (523 Hz) while traveling in a convertible at 24.6 m/s. If the car is coming toward you, what frequency would you hear? Assume that the temperature is 20°C.

1 ANALYZE AND SKETCH THE PROBLEM

- Sketch the situation.
- Establish a coordinate axis. Make sure that the positive direction is from the source to the detector.
- Show the velocities of the source and detector.



KNOWN	UNKNOWN
$v = +343$ m/s	$f_d = ?$
$v_s = +24.6$ m/s	
$v_d = 0$ m/s	
$f_s = 523$ Hz	

2 SOLVE FOR THE UNKNOWN

Use $f_d = f_s \frac{v - v_d}{v - v_s}$ with $v_d = 0$ m/s.

$$f_d = f_s \frac{1}{1 - \frac{v_s}{v}}$$

$$= 523\text{ Hz}\left(\frac{1}{1 - \frac{24.6\text{ m/s}}{343\text{ m/s}}}\right)$$

$$= 564\text{ Hz}$$

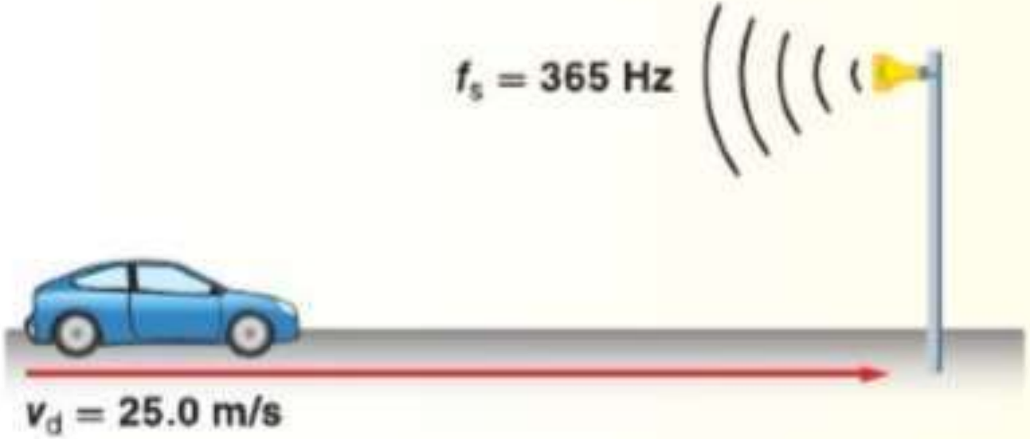
3 EVALUATE THE ANSWER

- **Are the units correct?** Frequency is measured in hertz.
- **Is the magnitude realistic?** The source is moving toward you, so the frequency should be increased.

APPLICATIONS

1. Repeat Example 1, but with the car moving away from you. What frequency would you hear?

2. You are in an automobile, like the one in **Figure 7**, traveling toward a pole-mounted warning siren. If the siren's frequency is 365 Hz, what frequency do you hear? Use 343 m/s as the speed of sound.



3. You are in an automobile traveling at 55 mph (24.6 m/s). A second automobile is moving toward you at the same speed. Its horn is sounding at 475 Hz. What frequency do you hear? Use 343 m/s as the speed of sound.

4. A submarine is moving toward another submarine at 9.20 m/s. It emits a 3.50 MHz ultrasound. What frequency would the second sub, at rest, detect? The speed of sound in water at the depth the submarines are moving is 1482 m/s.

5. **CHALLENGE** A trumpet plays middle C (262 Hz). How fast would it have to be moving to raise the pitch to C sharp (277 Hz)? Use 343 m/s as the speed of sound.

APPLICATIONS

1. Repeat Example 1, but with the car moving away from you. What frequency would you hear?

$$v_s = -24.6 \text{ m/s}$$

$$f_d = 524 \text{ Hz}\left(\frac{1}{1 - \frac{(-24.6 \text{ m/s})}{343 \text{ m/s}}}\right)$$

$$= 489 \text{ Hz}$$

2. You are in an automobile, like the one in **Figure 7**, traveling toward a pole-mounted warning siren. If the siren's frequency is 365 Hz, what frequency do you hear? Use 343 m/s as the speed of sound.

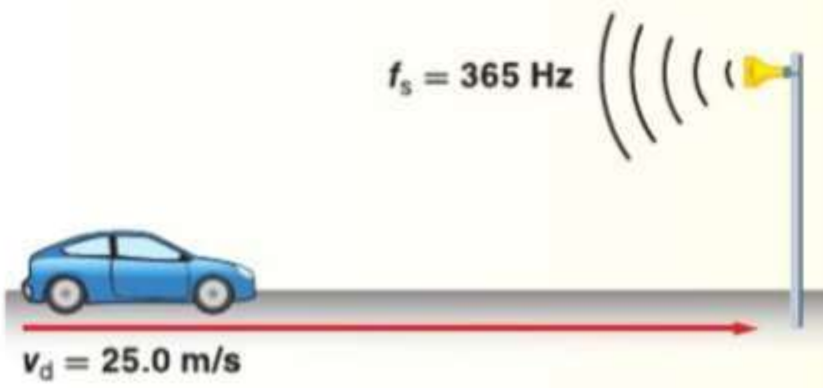


Figure 7

$v = 343$ m/s, $f_s = 365$ Hz, $v_s = 0$,

$$v_d = -25.0 \text{ m/s}$$

$$f_d = f_s\left(\frac{v - v_d}{v - v_s}\right)$$

$$= (365 \text{ Hz})\left(\frac{343 \text{ m/s} + 25.0 \text{ m/s}}{343 \text{ m/s}}\right)$$

$$= 392 \text{ Hz}$$

3. You are in an automobile traveling at 55 mph (24.6 m/s). A second automobile is moving toward you at the same speed. Its horn is sounding at 475 Hz. What frequency do you hear? Use 343 m/s as the speed of sound.

v = 343 m/s, f_s = 475 Hz, v_s = +24.6 m/s, v_d = −24.6 m/s

$$f_d = f_s\left(\frac{v - v_d}{v - v_s}\right)$$

$$= (475\ \text{Hz})\left(\frac{343\ \text{m/s} + 24.6\ \text{m/s}}{343\ \text{m/s} - 24.6\ \text{m/s}}\right)$$

$$= 548\ \text{Hz}$$

4. A submarine is moving toward another submarine at 9.20 m/s. It emits a 3.50 MHz ultrasound. What frequency would the second sub, at rest, detect? The speed of sound in water at the depth the submarines are moving is 1482 m/s.

$v = 1482\ \text{m/s}, f_s = 3.50\ \text{MHz},$

$v_s = 9.20\ \text{m/s}, v_d = 0\ \text{m/s}$

$$f_d = f_s\left(\frac{v - v_d}{v - v_s}\right)$$

$$= (3.50\ \text{MHz})\left(\frac{1482\ \text{m/s}}{1482\ \text{m/s} - 9.20\ \text{m/s}}\right)$$

$$= 3.52\ \text{MHz}$$

5. CHALLENGE A trumpet plays middle C (262 Hz). How fast would it have to be moving to raise the pitch to C sharp (277 Hz)? Use 343 m/s as the speed of sound.

$v = 343$ m/s, $f_s = 262$ Hz, $f_d = 271$ Hz,

$v_d = 0$ m/s, v_s is unknown

$$f_d = f_s\left(\frac{v - v_d}{v - v_s}\right)$$

Solve this equation for v_s.

$$v_s = v - \frac{f_s}{f_d}(v - v_d)$$

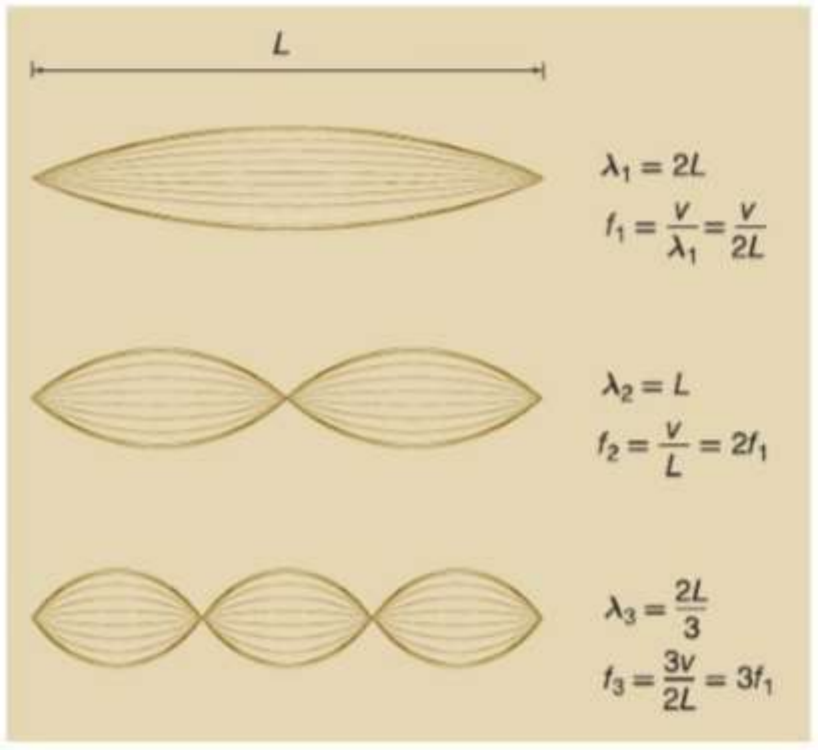
$$= 343\text{ m/s} - \left(\frac{262\text{ Hz}}{271\text{ Hz}}\right)(343\text{ m/s} - 0\text{ m/s})$$

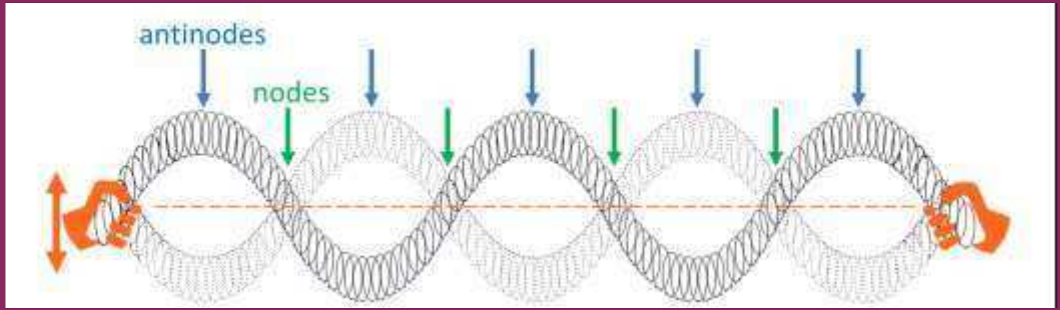
$$= 11.4\text{ m/s}$$

9	Evaluate the resonant frequencies in strings and air pipes (open- and closed-pipe resonators).	Student Book	37-42
		Q13-Q16, Q18-Q19, Q21	42, 46

Resonance on Strings

Although plucking, bowing, or striking strings produces variation in waveforms, waveforms on vibrating strings have many characteristics in common with standing waves on springs and ropes. A string on an instrument is clamped at both ends, and therefore, the string must have a node at each end when it vibrates. In **Figure 16**, you can see that the first mode of vibration has an antinode at the center and is one-half a wavelength long. The next resonance occurs when one wavelength fits on the string, and additional standing waves arise when the string length is $\frac{3\lambda}{2}$, 2λ, $\frac{5\lambda}{2}$, and so on. As with an open pipe, the resonant frequencies are whole-number multiples of the lowest frequency.





13. A 440-Hz tuning fork is used with a resonating column to determine the velocity of sound in helium gas. If the spacing between resonances is 110 cm, what is the velocity of sound in helium gas?

14. The frequency of a tuning fork is unknown. A student uses an air column at 27°C and finds resonances spaced by 20.2 cm. What is the frequency of the tuning fork? Use the speed calculated in Example Problem 2 for the speed of sound in air at 27°C.

15. A 440-Hz tuning fork is held above a closed pipe. Find the spacing between the resonances when the air temperature is 20°C.

16. **CHALLENGE** A bugle can be thought of as an open pipe. If a bugle were straightened out, it would be 2.65-m long.

    a. If the speed of sound is 343 m/s, find the lowest frequency that is resonant for a bugle (ignoring end corrections).

    b. Find the next two resonant frequencies for the bugle.

13. 970 m/s

14. 859 Hz

15. 0.39 m

16. a. 64.7 Hz

    b. 129 Hz and 194 Hz

10	1- Explain that the speed of sound varies with different mediums and temperatures. 2- Use the relation between resonance length and wave length to solve problems for closed and open pipes.	Student Book	29-30, 37-40
		Q14-Q15	42

Speed of sound is greater in solids and liquids than in gases

In air speed of the sound increases by 0.6m/s for each 1 degree rise in temperature

Table 1 Speed of Sound in Various Media

Medium	Speed (m/s)
Air (0°C)	331
Air (20°C)	343
Helium (0°C)	965
Water (25°C)	1497
Seawater (25°C)	1535
Copper (20°C)	4760
Iron (20°C)	4994

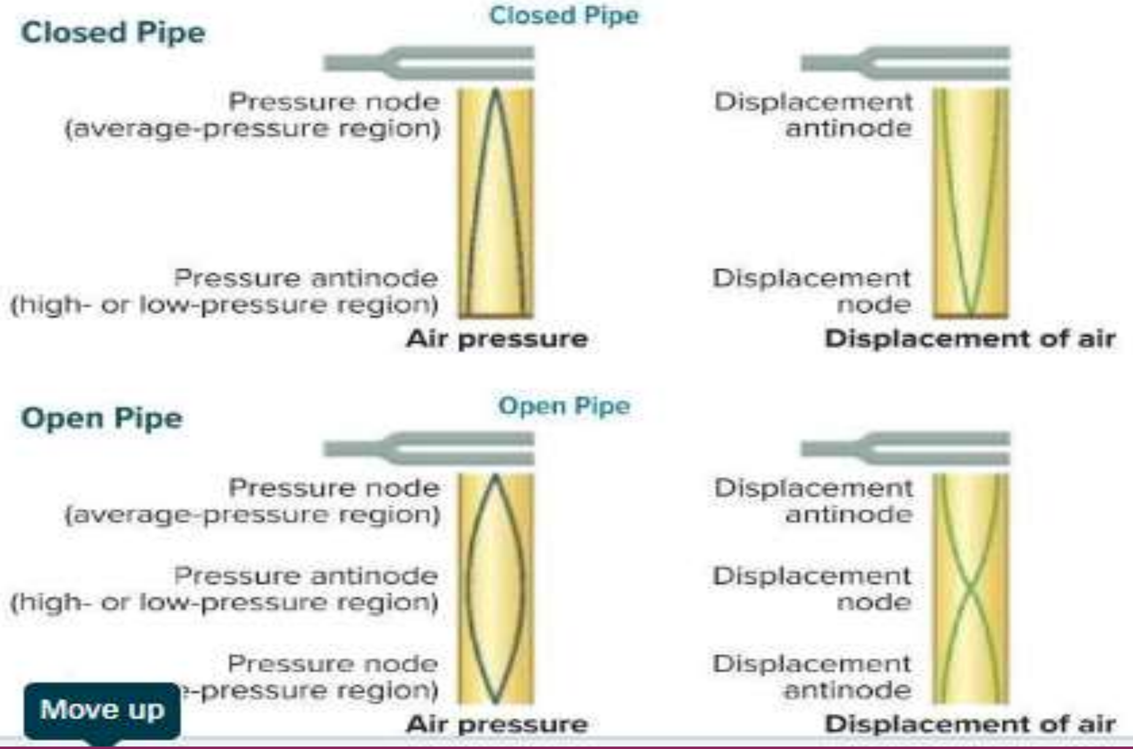


Figure 12 Standing waves in pipes can be represented by sine waves.

Identify *Which are the areas of mean atmospheric pressure in the air pressure graphs?*

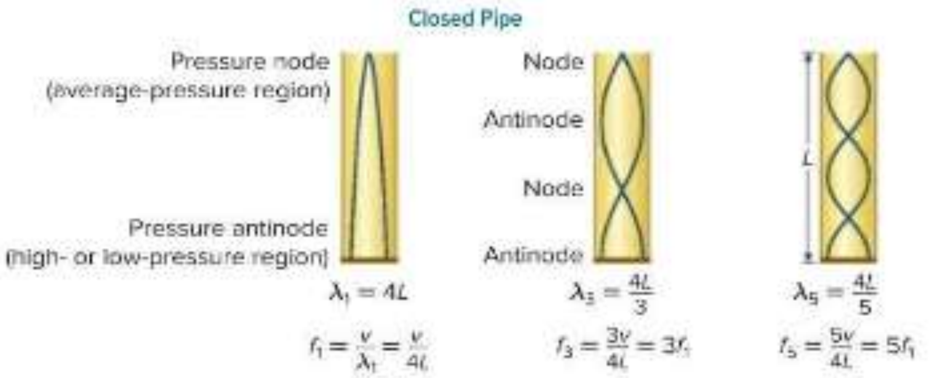
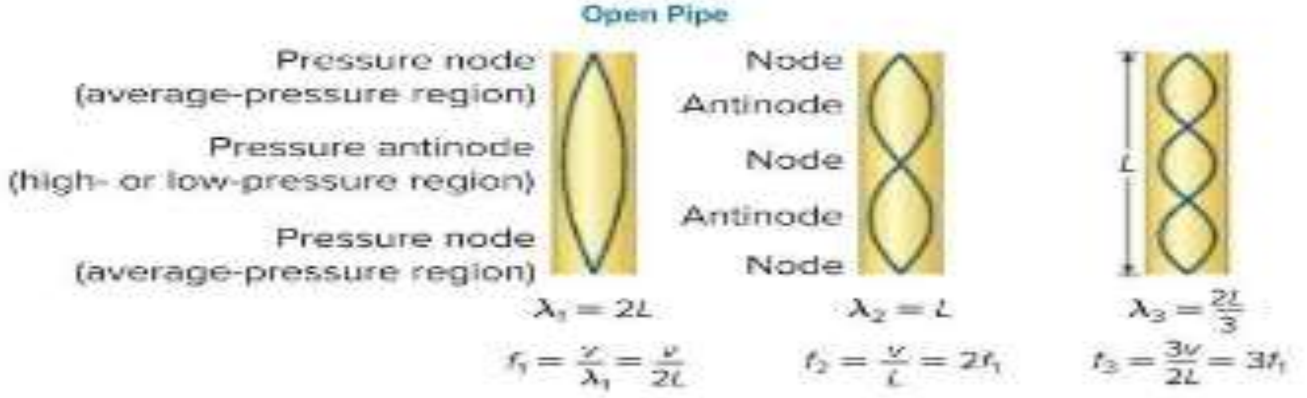


Figure 13 A closed pipe resonates when its length is an odd number of quarter wavelengths.



18. **Resonance in Air Columns** Why is the tube from which a tuba is made much longer than that of a cornet?

19. **Resonance in Open Tubes** How must the length of an open tube compare to the wavelength of the sound to produce the strongest resonance?

d. a string

18. The longer the tube, the lower the resonant frequency it will produce.

19. The length of the tube should be one-half the wavelength.

21. **Resonance in Closed Pipes** One closed organ pipe has a length of 2.40 m.

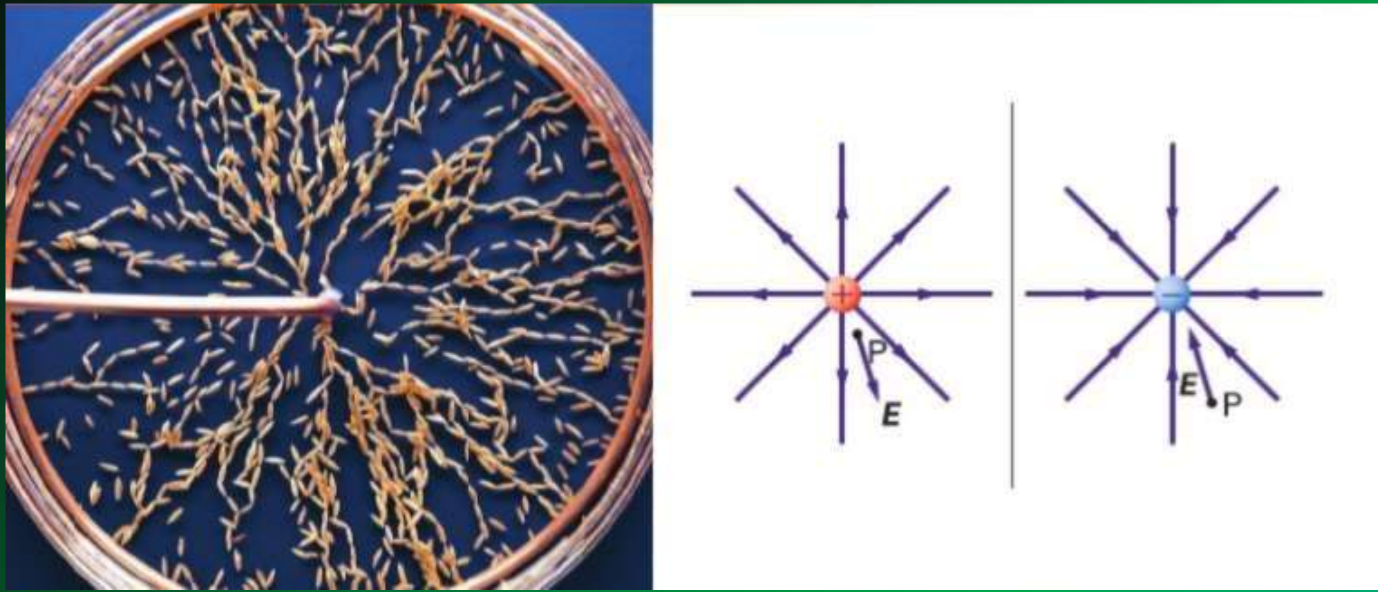
a. What is the frequency of the note played?

b. When a second pipe is played at the same time, a 1.40-Hz beat note is heard. By how much is the second pipe too long?

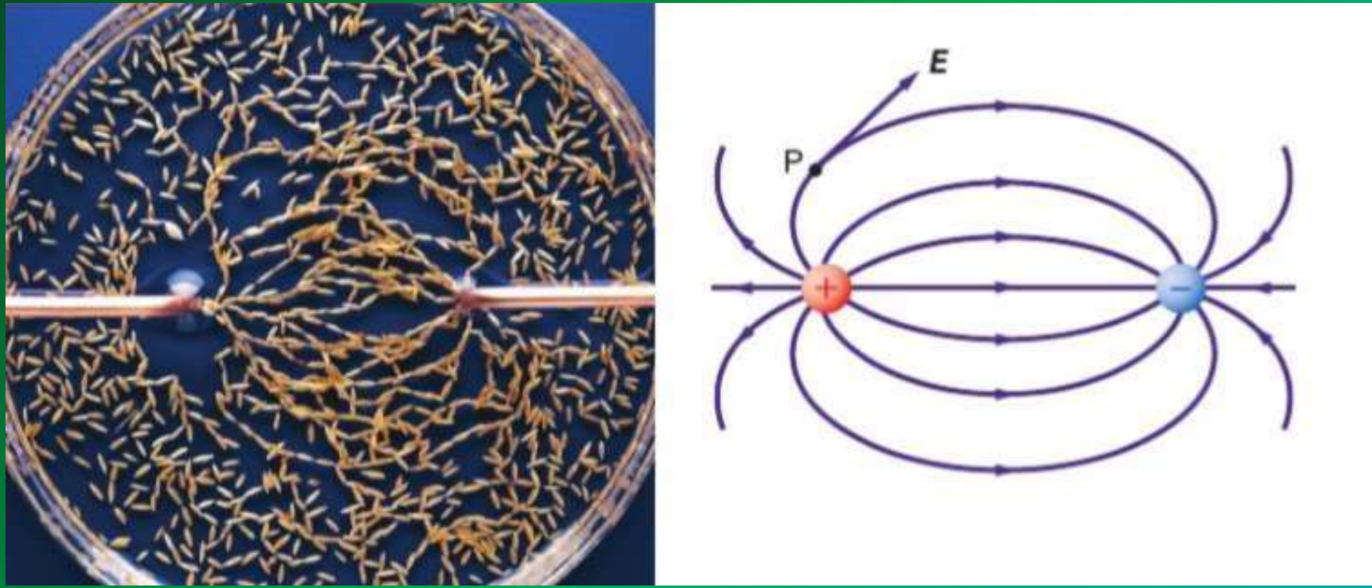
21. a. 35.7 Hz

b. 0.10 m

11	Sketch the electric field lines to model the electric field around single point charges (positive or negative) and for a pair of electric charges	Student Book Figure 19 & Figure 20	70-71

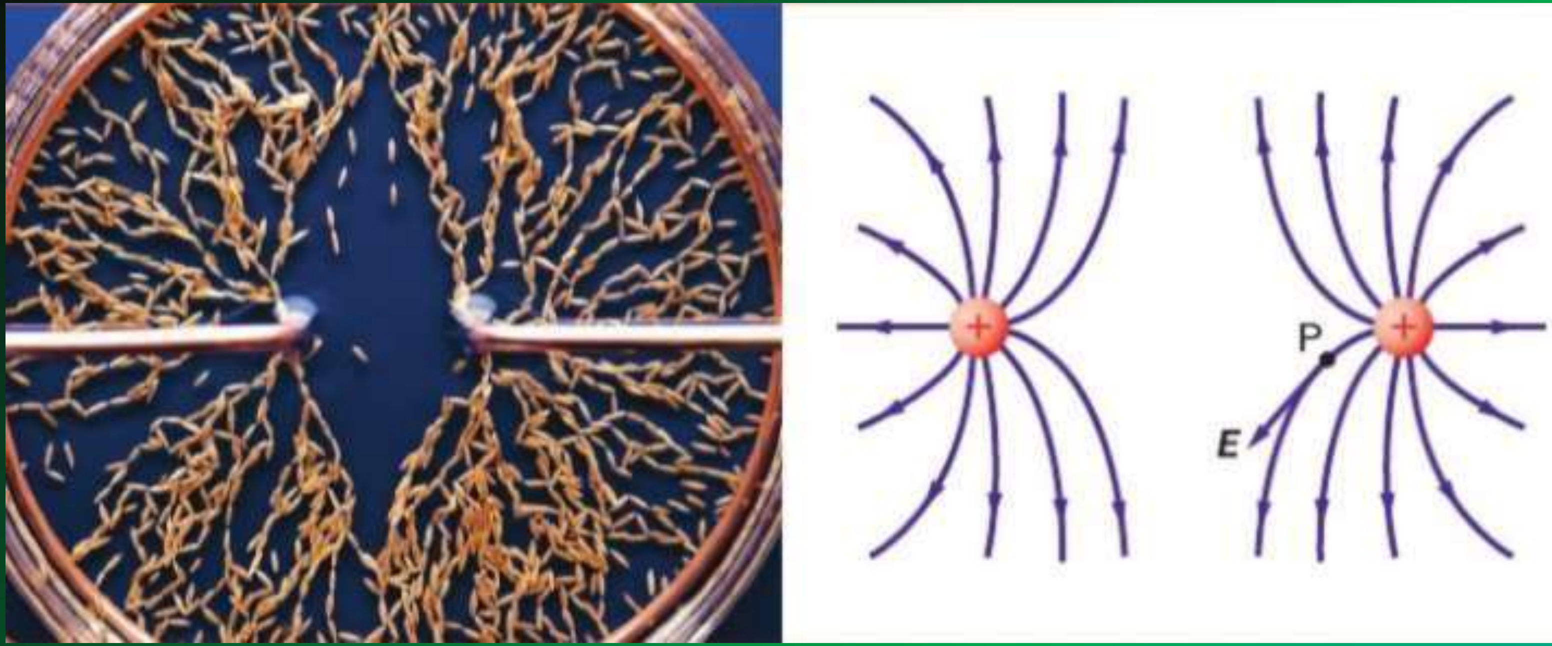


Single Charge For a single charge, the electric field lines radiate from that charge. The field lines radiate out from a positive charge and they radiate inward toward a negative charge. The direction of the electric field (***E***) at any point is the tangent to the field line.



Two Equal and Unlike Charges The electric field lines of two equal and unlike charges form continuous lines from the positive charge to the negative charge. The vector at point P shows the direction of the electric field (***E***) at point P. Where the lines are closest, a charged particle would experience the most force.

11	Sketch the electric field lines to model the electric field around single point charges (positive or negative) and for a pair of electric charges	Student Book Figure 19 & Figure 20	70-71



Two Like Charges The electric field lines around two like charges never connect with each other. The vector at point P shows the direction of the electric field (***E***) at point P. A charge would experience no electrostatic force in the center where there are no electric field lines.

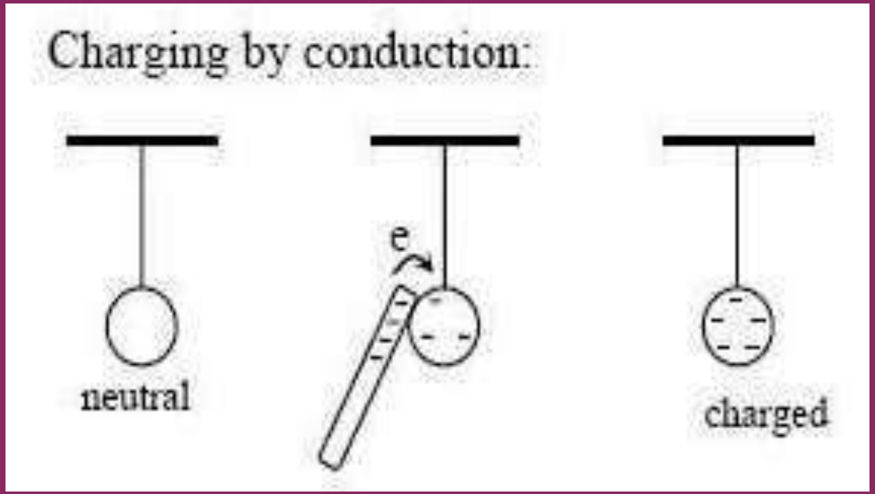
Figure 6 Models of electric fields around electric charges are shown. Electrostatic forces cause a separation of charge in each long, thin grass seed. The seeds then turn so that they line up along the direction of the electric field. The lines and vectors drawn in the diagrams represent other ways to model electric fields.

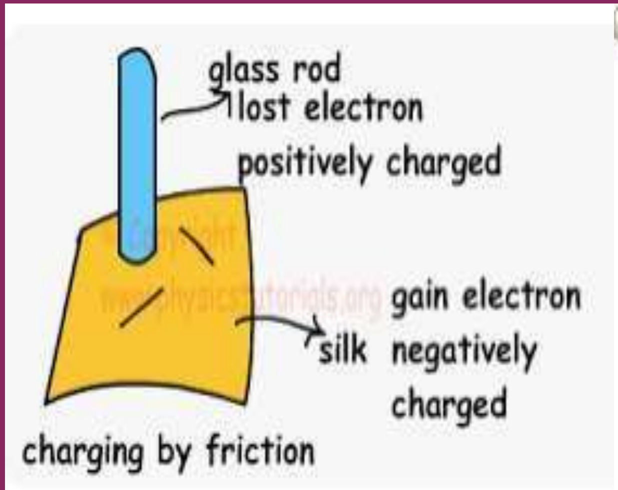
12	Demonstrate knowledge of electrostatic charge, differentiate materials based on their electrical conductivity, and describe the methods of electrical charging of objects	Student Book	52-55
		Q1-Q8	56

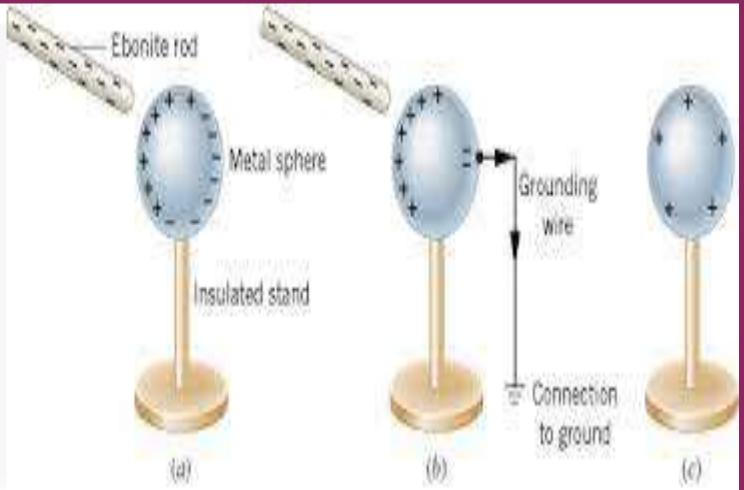
Sr. No.	Conductors	Insulators
1	The materials which allow the electric current or any energy to pass through it. Also, its magnetic field stores energy.	The materials which do not allow the electric current or any energy to pass through it. Its magnetic field does not store any energy.
2	Electrons move freely and the thermal conductivity is very high whereas the resistivity is very low with a weak covalent bond.	Electrons do not move freely and the thermal conductivity is very low whereas the resistivity is very high with the strong covalent bond.
3.	It has the positive temperature coefficient and the valence band remains empty.	It has a negative temperature coefficient and the valence band is occupied with full of electrons.
4.	Silver, copper, aluminium, irons are conductors.	Rubber, wood, paper, glass, plastics are the insulators.

12	Demonstrate knowledge of electrostatic charge, differentiate materials based on their electrical conductivity, and describe the methods of electrical charging of objects	Student Book	52-55
		Q1-Q8	56

Charging by conduction involves the contact of a charged object to a neutral object. Hence when an uncharged conductor is brought in contact with a charged conductor, charge is shared between the two conductors and hence the uncharged conductor gets charged. During charging by conduction, both objects acquire the same type of charge.







Charging by Induction

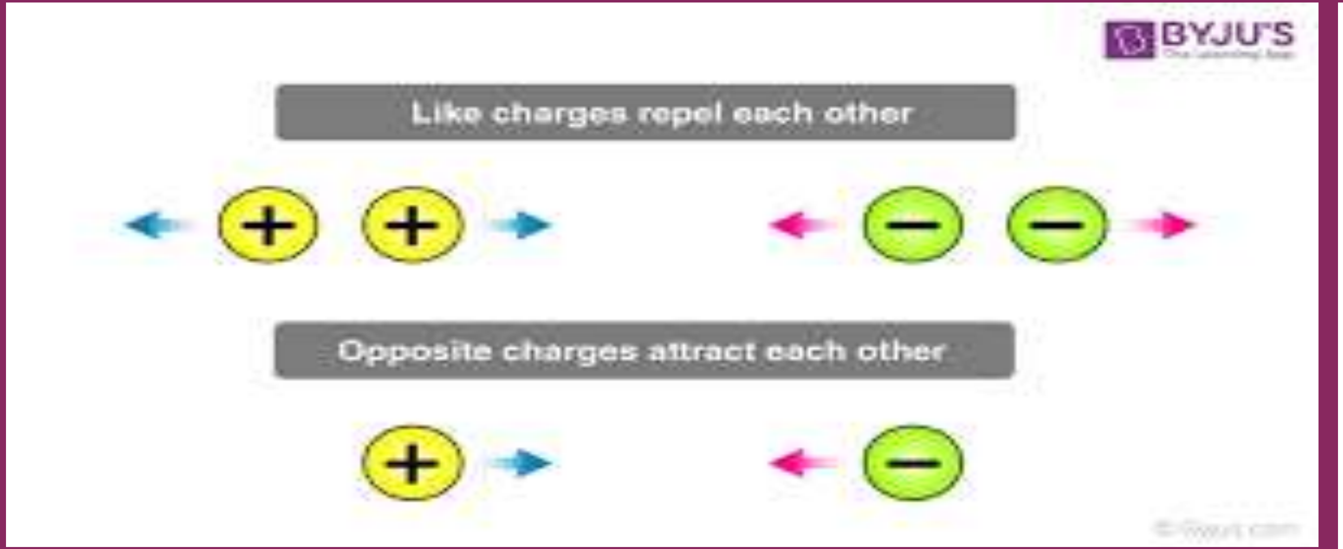
A neutral electroscope has an even charge distribution, and the leaves hang loosely.

Separation of charge is induced in the electroscope when a negatively charged rod is brought near it.

Touching the electroscope allows the charged rod to push electrons out into the hand instead of down into the leaves.

When the ground is removed from the electroscope before the rod is removed, an excess of positive charge is left on the electroscope.

12	Demonstrate knowledge of electrostatic charge, differentiate materials based on their electrical conductivity, and describe the methods of electrical charging of objects	Student Book	52-55
		Q1-Q8	56



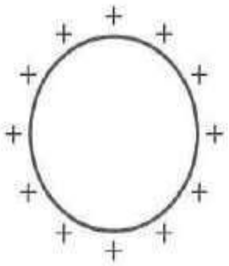
1. **Charged Objects** In the investigations with tape described in this section, how could you find out which strip of tape, B or T, is positively charged?
2. **Charged Objects** After you rub a comb on a wool sweater, you can use the comb to pick up small pieces of paper. Why does the comb lose this ability after a few minutes?
3. **Types of Charge** A pith ball is a small sphere made of a light material, such as plastic foam, that is often coated with a layer of graphite or aluminum paint. How could you determine whether a pith ball suspended from an insulating thread is neutral, charged positively, or charged negatively?
4. **Charge Separation** You can give a rubber rod a negative charge by rubbing the rod with wool. What happens to the charge of the wool? Why?
5. **Net Charge** An apple contains approximately 10^{26} charged particles. Why don't two apples repel each other when they are brought together?
6. **Charging a Conductor** Suppose you hang a long metal rod from silk threads so that the rod is electrically isolated. You then touch a charged glass rod to one end of the metal rod. Describe the charges on the metal rod.
7. **Charging by Friction** You can charge a rubber rod negatively by rubbing it with wool. What happens when you rub a copper rod with wool?
8. **Critical Thinking** Some scientists once proposed that electric charge is a type of fluid that flows from objects with an excess of the fluid to objects with a deficit. How is the current two-charge model more accurate than the single-fluid model?

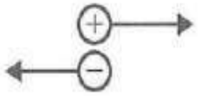
1. Bring a positively charged glass rod near the two strips of tape. The one that is repelled by the rod is positive.
2. The comb loses its negative charge to its surroundings and becomes neutral once again.
3. Bring an object of known charge, such as a negatively charged hard rubber rod, near the pith ball. If the pith ball is repelled, it has the same charge as the rod. If it is attracted, it may have the opposite charge or be neutral. To find out which, bring a positively charged glass rod near the pith ball. If they repel, the pith ball is positive; if they attract, the pith ball must be neutral.
4. The wool becomes positively charged because it gives up electrons to the rubber rod.
5. An apple contains equal numbers of positive and negative charges, so it is neutral.
6. The glass rod attracts electrons off the metal rod, so the metal becomes positively charged. The charge is distributed uniformly along the rod.
7. Because the copper is a conductor, it remains neutral as long as it is in contact with your hand.
8. The two-charge model can better explain the phenomena of attraction and repulsion. It also explains how objects can become charged when they are rubbed together.

13	Demonstrate an understanding that the spacing between the field lines indicates the strength of the electric field in a given region.	Student Book	66-67, 70-71
		Q38	72

Electric Fields

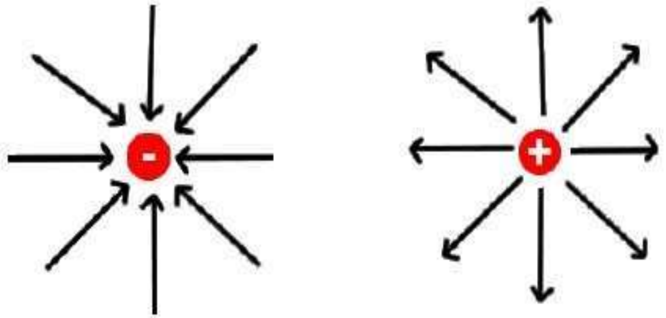
An **electric field** is a region of space where a **charged object** experiences a force due to its charge.

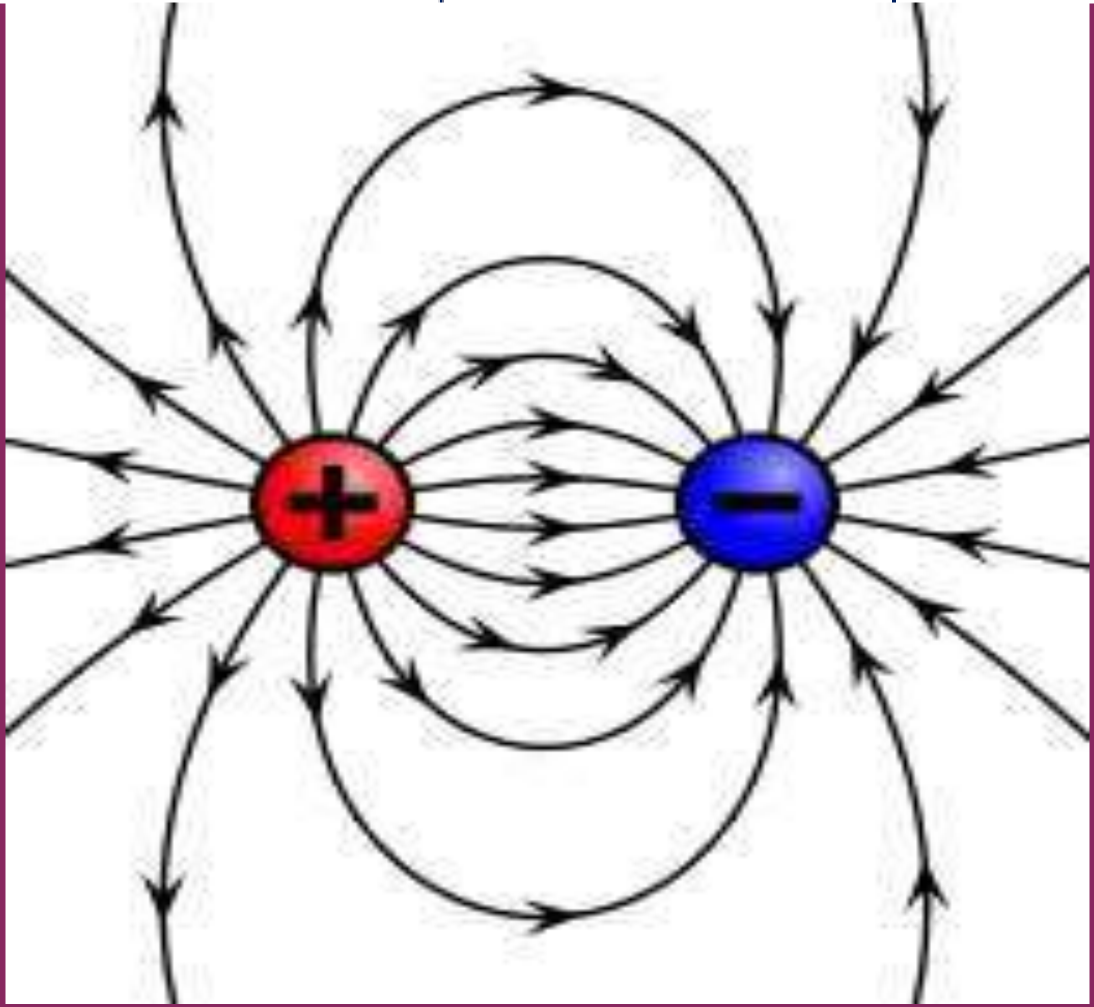




Field Lines

Because there are two charges that move in different directions in a field it has been decided that **Field Lines** should show the direction that **a POSITIVE charge** would **accelerate** if placed in the field.





ELECTRIC FIELD STRENGTH

The strength of an electric field is equal to the force on a positive test charge divided by the strength of the test charge.

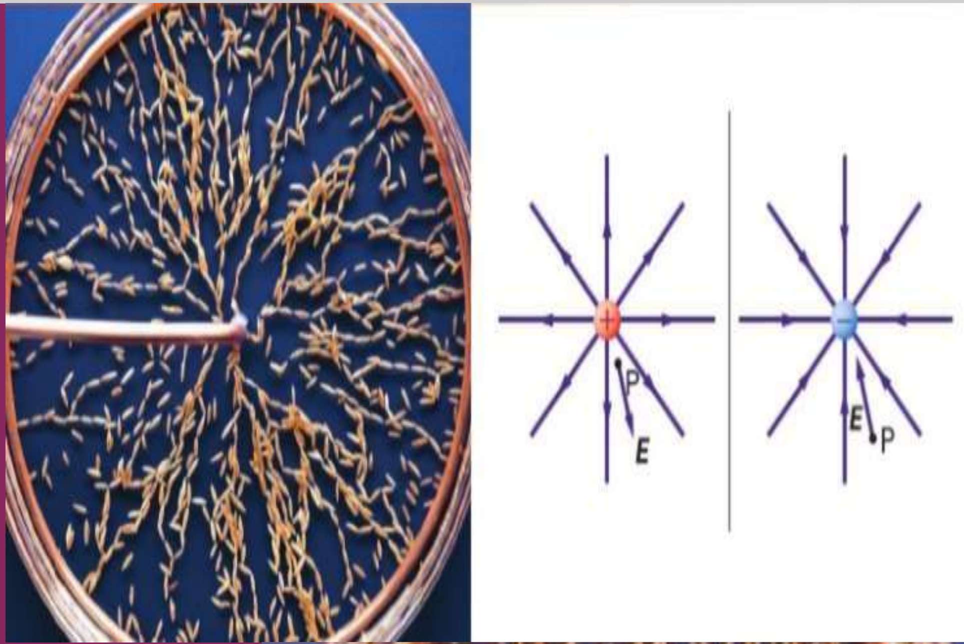
$$E = \frac{F_{\text{on } q'}}{q'}$$

13	Demonstrate an understanding that the spacing between the field lines indicates the strength of the electric field in a given region.	Student Book	66-67, 70-71
		Q38	72

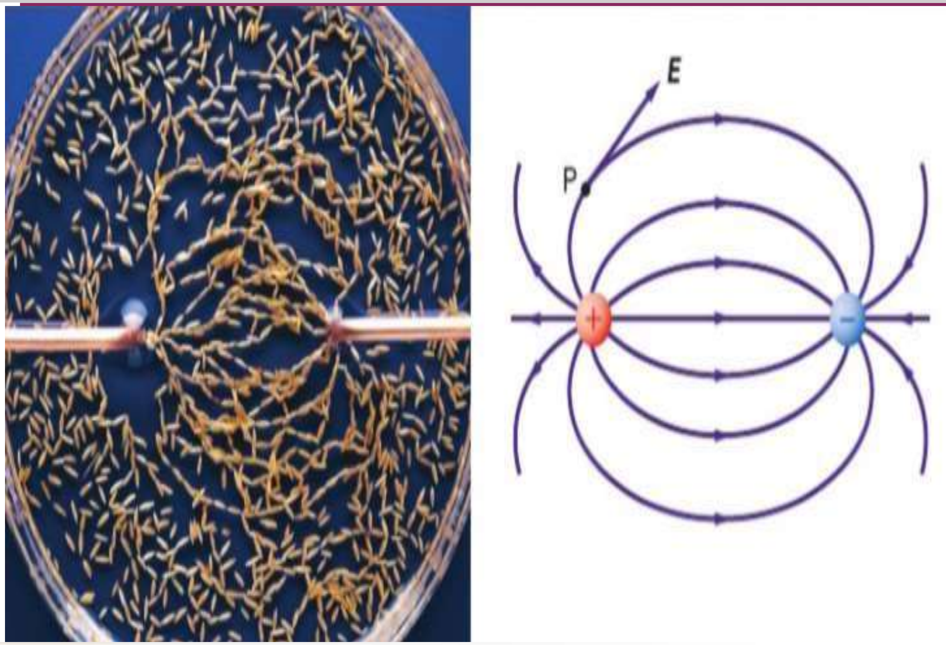
38. **Measuring Electric Fields** Suppose you are asked to measure the electric field at a point in space. How do you detect the field at a point? How do you determine the magnitude of the field? How do you choose the magnitude of the test charge?

38. To detect a field at a point, place a test charge at that point and determine if there is a force on it. To determine the magnitude of the field, divide the magnitude of the force on the test charge by the magnitude of the test charge. The magnitude of the test charge must be chosen so that it is very small compared to the magnitudes of the charges producing the field.

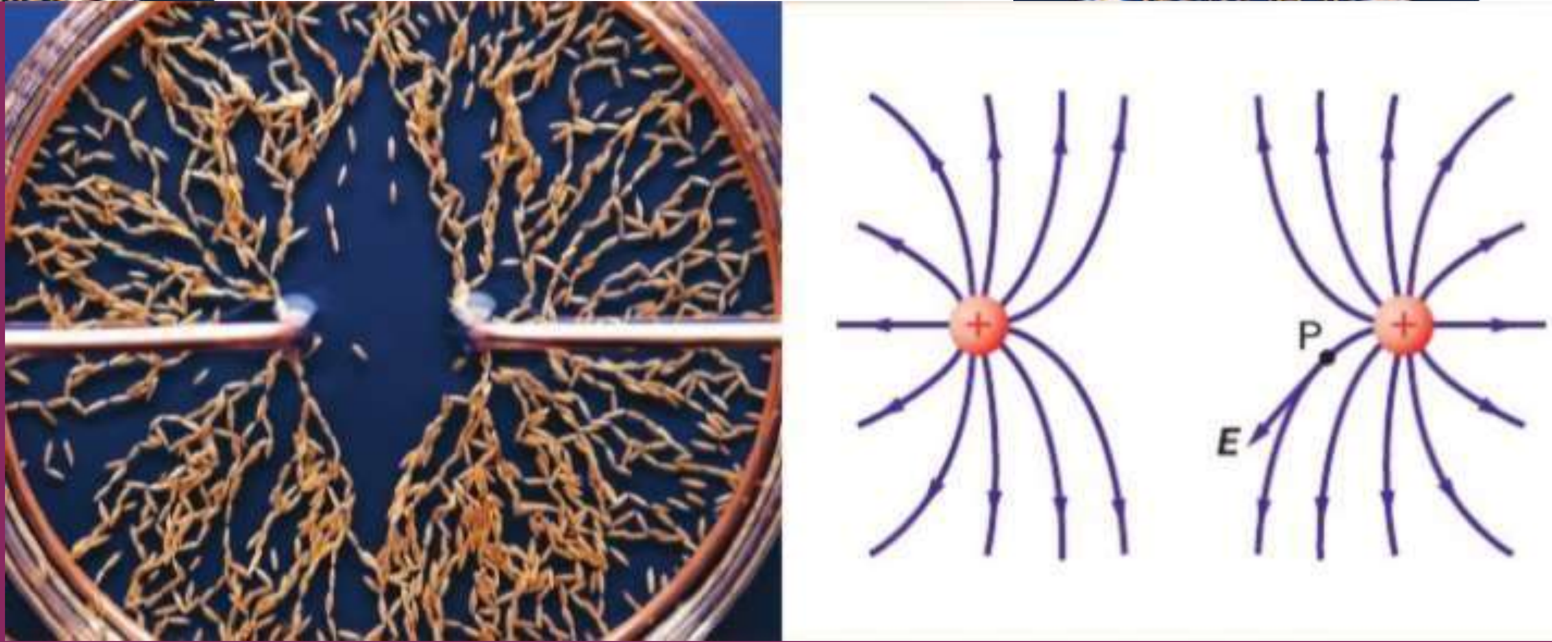
14	Develop a tool, sketches, descriptive text or presentation to show the morphology of electric field lines of a single or multiple charge system with positive and/or negative charges.	Student Book	70
		Figure 19 & Figure 20	70-71



Single Charge For a single charge, the electric field lines radiate from that charge. The field lines radiate out from a positive charge and they radiate inward toward a negative charge. The direction of the electric field (***E***) at any point is the tangent to the field line.



Two Equal and Unlike Charges The electric field lines of two equal and unlike charges form continuous lines from the positive charge to the negative charge. The vector at point P shows the direction of the electric field (***E***) at point P. Where the lines are closest, a charged particle would experience the most force.



Two Like Charges The electric field lines around two like charges never connect with each other. The vector at point P shows the direction of the electric field (***E***) at point P. A charge would experience no electrostatic force in the center where there are no electric field lines.

15	Develop a tool, equation, or sketch, to obtain the resultant electric field strength at a point generated by a nearby system of point charges using the superposition principle.	Student Book	67-69
		Q24-Q37	68-69

ELECTRIC FIELD STRENGTH

The strength of an electric field is equal to the force on a positive test charge divided by the strength of the test charge.

$$E = \frac{F_{\text{on } q'}}{q'}$$

24 A positive test charge of 5.0×10^{-6} C is in an electric field that exerts a force of 2.0×10^{-4} N on it. What is the magnitude of the electric field at the location of the test charge?

$$E = \frac{F}{q} = \frac{2.0\times10^{-4}\ \text{N}}{5.0\times10^{-6}\ \text{C}} = 4.0\times10^{1}\ \text{N/C}$$

25 A negative charge of 2.0×10^{-8} C experiences a force of 0.060 N to the right in an electric field. What are the field's magnitude and direction at that location?

$$E = \frac{F}{q} = \frac{0.060\ \text{N}}{2.0\times10^{-8}\ \text{C}} = 3.0\times10^{6}\ \text{N/C}$$

directed to the left

3. Suppose that you place a 2.1×10^{-3}-N pith ball in a 6.5×10^{4} N/C downward electric field. What net charge (magnitude and sign) must you place on the pith ball so that the electrostatic force acting on that pith ball will suspend it against the gravitational force?

The electric force and the gravitational force algebraically sum to zero because the ball is suspended, i.e. not in motion:

$$F_g + F_e = 0, \text{ so } F_e = -F_g$$

$$E = \frac{F_e}{q}$$

$$q = \frac{F_e}{E} = -\frac{F_g}{E} = -\frac{2.1\times10^{-3}\text{ N}}{6.5\times10^{4}\text{ N/C}}$$

$$= -3.2\times10^{-8}\text{ C}$$

The electric force is upward (opposite the field), so the charge is negative.

27 Complete **Table 2** using your understanding of electric fields.

Table 2 Sample Data

Test Charge Strength (C)	Force Exerted on Test Charge (N)	Electric Field Intensity (N/C)
1.0×10^{-6}	0.30	$E=\frac{F}{q'}$
2.0×10^{-6}	$F=q'E$	3.3×10^{5}
$q'=\frac{F}{E}$	0.45	1.5×10^{5}

1) $E=\frac{F}{q'}=\frac{0.30\ N}{1\times10^{-6}\ C}=3.0\times10^{5}\ \frac{N}{C}$

2) $F=q'E=(2\times10^{-6})\times(3.3\times10^{5})=0.66\ N$

3) $q'=\frac{F}{E}=\frac{0.45}{1.5\times10^{5}}=3.0\times10^{-6}\ C$

26 A positive charge of 3.0×10^{-7} C is located in a field of 27 N/C directed toward the south. What is the force acting on the charge?

$$E = \frac{F}{q}$$

$$F = Eq = (27\ \text{N/C})(3.0\times10^{-7}\ \text{C})$$

$$= 8.1\times10^{-6}\ \text{N}$$

28. A negative test charge is placed in an electric field as shown in **Figure 3.** It experiences the force shown. What is the magnitude of the electric field at the location of the charge?

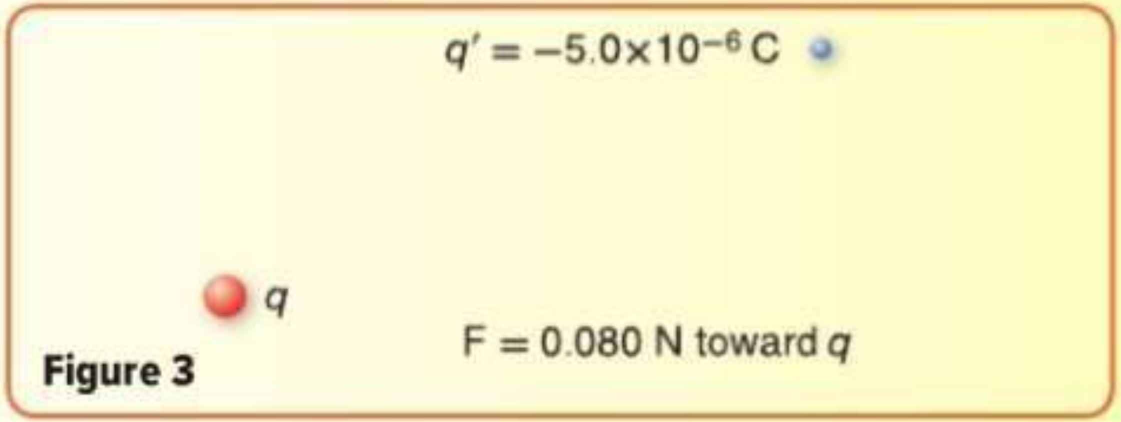


Figure 3

$$E = \frac{F}{q'} = \frac{0.080\ N}{5\times\ 10^{-6}\ C} = 1.6\times10^{4}\ \frac{N}{C}$$

29

CHALLENGE You are probing the electric field of a charge of unknown magnitude and sign. You first map the field with a 1.0×10^{-6}-C test charge, then repeat your work with a 2.0×10^{-6}-C test charge.

a. Would you measure the same forces at the same place with the two test charges? Explain.

b. Would you find the same field strengths? Explain.

a. Would you measure the same forces at the same place with the two test charges? Explain.

No. The force on the 2.0-μC charge would be twice that on the 1.0-μC charge.

b. Would you find the same field strengths? Explain.

Yes. You would divide the force by the strength of the test charge, so the results would be the same.

30 What is the magnitude of the electric field at a position that is 1.2 m from a 4.2×10^{-6}-C point charge?

$$E = \frac{F}{q'} = K\frac{q}{d^2}$$

$$= (9\times10^{9}\ \text{N}\cdot\text{m}^2/\text{C}^2)\frac{(4.2\times10^{-6}\ \text{C})}{(1.2\ \text{m})^2}$$

$$= 2.6\times10^{4}\ \text{N/C}$$

31 What is the magnitude of the electric field at a distance twice as far from the point charge in the previous problem?

Because the field strength varies as the square of the distance from the point charge, the new field strength will be one-fourth of the old field strength, or 6.5×10^{3} N/C.

32

What is the electric field at a position that is 1.6 m east of a point charge of $+7.2\times10^{-6}$ C?

$$E = \frac{F}{q'} = K\frac{q}{d^2}$$

$$= (9.0\times10^{9}\ \mathrm{N\cdot m^2/C^2})\,\frac{(7.2\times10^{-6}\ \mathrm{C})}{(1.6\ \mathrm{m})^2}$$

$$= 2.5\times10^{4}\ \mathrm{N/C}$$

The direction of the field is east (away from the positive point charge).

33 The electric field that is 0.25 m from a small sphere is 450 N/C toward the sphere. What is the net charge on the sphere?

$$E = \frac{F}{q'} = K\frac{q}{d^2}$$

$$q = \frac{Ed^2}{K}$$

$$= \frac{(450\ \text{N/C})(0.25\ \text{m})^2}{(9.0\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)} = -3.1\times10^{-9}\ \text{C}$$

The charge is negative, because the field is directed toward it.

34 How far from a point charge of $+2.4\times10^{-6}$ C must you place a test charge in order to measure a field magnitude of 360 N/C?

$$E = \frac{F}{q'} = K\frac{q}{d^2}$$

$$d = \sqrt{\frac{Kq}{E}}$$

$$= \sqrt{\frac{(9.0\times10^{9}\ \text{N}\cdot\text{m}^2/\text{C}^2)(2.4\times10^{-6}\ \text{C})}{360\ \text{N/C}}}$$

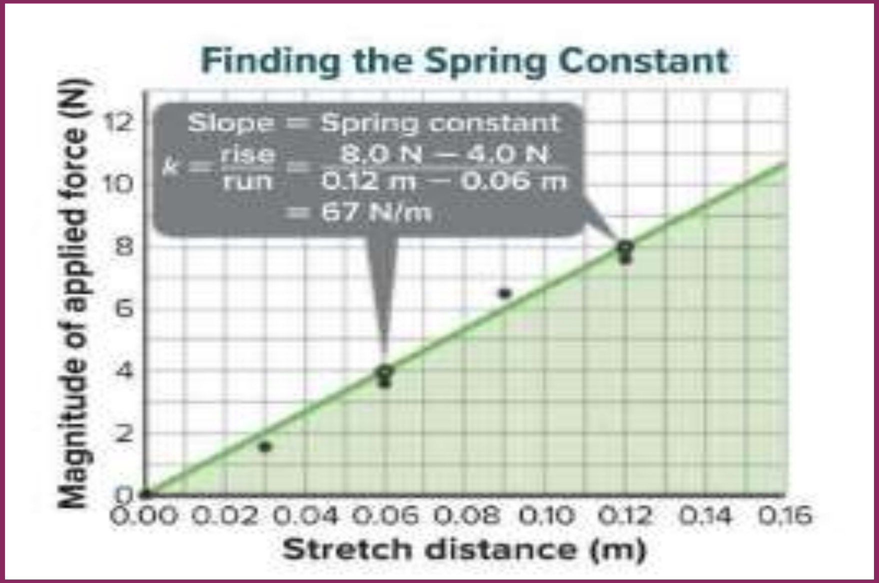
$$= 7.7\ \text{m}$$

16	1- Apply Hookefs law to calculate the force exerted by a spring, the spring constant, or the distance by which a spring is stretched or compressed. 2- Solve problems related to an oscillating mass . spring system and a simple pendulum to calculate different physical quantities (velocities, kinetic energy, potential energy, period or length of simple pendulum...).	Student Book	4-7
		Q1-Q4; Q9	7; 9

HOOKE'S LAW

The magnitude of the force exerted by a spring is equal to the spring constant times the distance the spring is stretched or compressed from its equilibrium position.

$$F = -kx$$



Potential Energy in a Spring

The potential energy in a spring is equal to one-half times the product of the spring constant and the square of the displacement.

$$PE_{spring} = -\frac{1}{2}kx^2$$

1. What is the spring constant of a spring that stretches 12 cm when an object weighing 24 N is hung from it?

Known values:

$F = -24N$

$x = 12\ cm = 0.12\ m$

To find:

Spring constant (k)

Formula :

$F = -kx$

$k = -\frac{F}{x}$

$k = -\frac{(-24)}{(0 \cdot 12)}$

$k = 2 \times 10^2\ N\mathrm{T}m$

2. A spring with $k = 144$ N/m is compressed by 16.5 cm. What is the spring's elastic potential energy?

$$PE_{sp} = \frac{1}{2}kx^2$$

$$= \frac{1}{2}(144\ \text{N/m})(0.165\ \text{m})^2 = 1.96\ \text{J}$$

3. A spring has a spring constant of 56 N/m. How far will it stretch when a block weighing 18 N is hung from its end?

Known values:

$k = 56\ N/m$

$F = -18\ N$

To find:

x

Formula :

$F = -kx$

$x = -\frac{F}{k}$

$k = -\frac{(-18)}{(56)}$

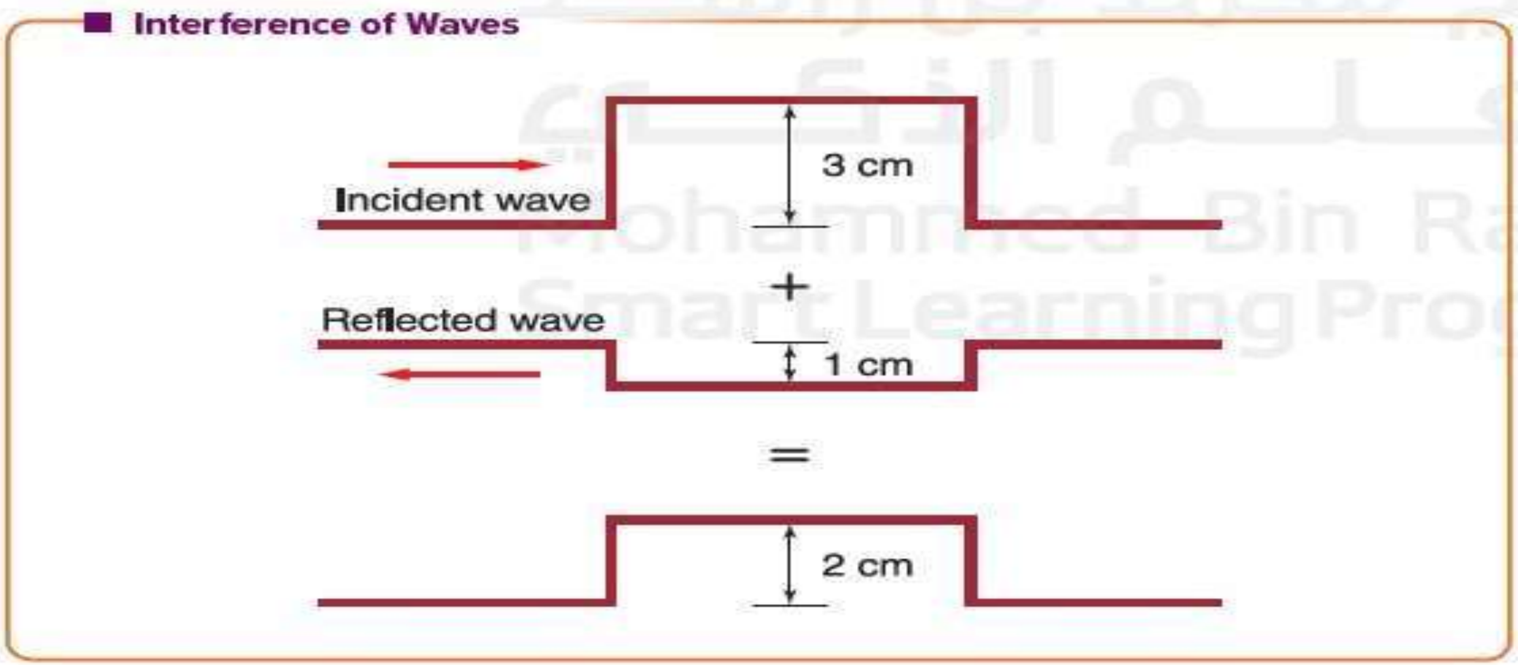
$x = 0.32\ m$

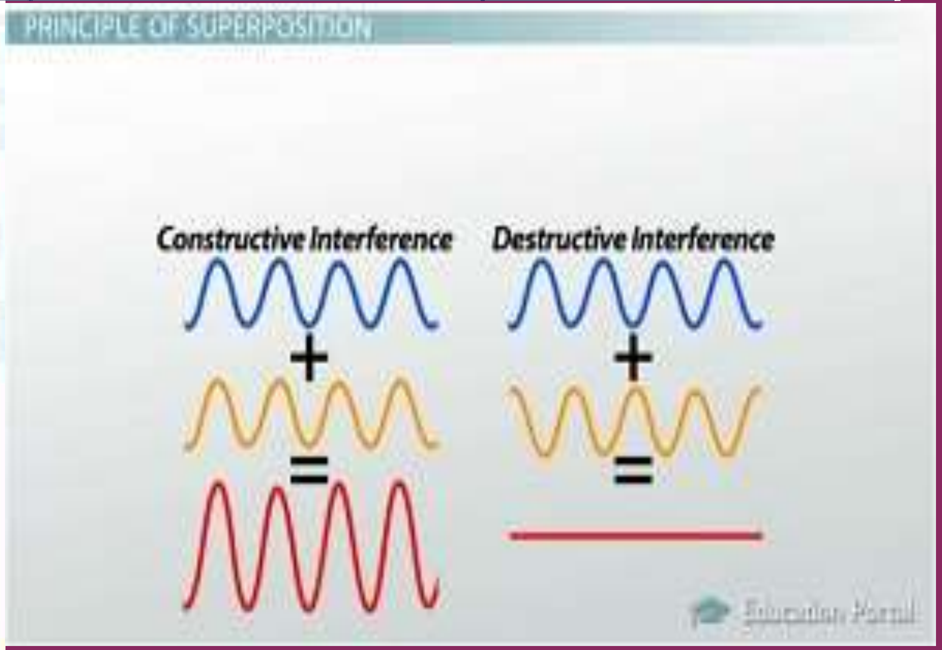
4. CHALLENGE A spring has a spring constant of 256 N/m. How far must it be stretched to give it an elastic potential energy of 48 J?

$$PE_{sp} = \frac{1}{2}kx^2$$

$$x = \sqrt{\frac{2PE_{sp}}{k}} = \sqrt{\frac{(2)(48\ \text{J})}{256\ \text{N/m}}} = 0.61\ \text{m}$$

17	1- Sketch snapshots for the superposition of two overlapping wave pulses (same wavelength) traveling in opposite directions showing the resultant wave. 2- Determine wave properties such as wavelength, period, frequency, amplitude, and speed using a graphical or a visual representation of a periodic mechanical wave.	Student Book	17-18; 10-14





Suppose a pulse traveling along a spring meets a reflected pulse that is coming back from a boundary, as shown in **Figure 15.** 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 the same medium, 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.**

18	1- Compare the wavelengths and resonant frequencies for pipes with closed ends with those for open end pipes (open- and closed-pipe resonators). 2- Discuss resonance frequencies and colulmn lengths for a closed pipe and an open pipe.	Student Book	37-40
		Q13-Q16, Q18-Q19, Q21	42. 46

PRACTICE Problems ADDITIONAL PRACTICE

13. A 440-Hz tuning fork is used with a resonating column to determine the velocity of sound in helium gas. If the spacing between resonances is 110 cm, what is the velocity of sound in helium gas?

14. The frequency of a tuning fork is unknown. A student uses an air column at 27°C and finds resonances spaced by 20.2 cm. What is the frequency of the tuning fork? Use the speed calculated in Example Problem 2 for the speed of sound in air at 27°C.

15. A 440-Hz tuning fork is held above a closed pipe. Find the spacing between the resonances when the air temperature is 20°C.

16. **CHALLENGE** A bugle can be thought of as an open pipe. If a bugle were straightened out, it would be 2.65-m long.

a. If the speed of sound is 343 m/s, find the lowest frequency that is resonant for a bugle (ignoring end corrections).

b. Find the next two resonant frequencies for the bugle.

13. 970 m/s

14. 859 Hz

15. 0.39 m

16. a. 64.7 Hz

b. 129 Hz and 194 Hz

b. a clarinet d. a violin

18. **Resonance in Air Columns** Why is the tube from which a tuba is made much longer than that of a cornet?

19. **Resonance in Open Tubes** How must the length of an open tube compare to the wavelength of the sound to produce the strongest resonance?

18. The longer the tube, the lower the resonant frequency it will produce.

19. The length of the tube should be one-half the wavelength.

21. **Resonance in Closed Pipes** One closed organ pipe has a length of 2.40 m.

    a. What is the frequency of the note played?

    b. When a second pipe is played at the same time, a 1.40-Hz beat note is heard. By how much is the second pipe too long?

21. a. 35.7 Hz

    b. 0.10 m

19	1- Solve problems involving the electrostatic force acting on charged particles by making use of Coulomb's Law 2- Develop a tool, equation or sketch, to obtain the resultant electric force exerted on a point charge by a nearby system of charges using the superposition principle.	Student Book	61-64
		Q13-Q14, Q22-Q23	64, 65

COULOMB'S LAW

The force between two charges is equal to a constant times the product of the two charges, divided by the square of the distance between them.

$$F = K\frac{q_A q_B}{r^2}$$

22. **Electrostatic Forces** Two charged spheres are held a distance *r* apart, as shown in **Figure 14.** Compare the force of sphere A on sphere B with the force of sphere B on sphere A.

Figure 14

23. **Critical Thinking** Suppose you are testing Coulomb's law using a small, positively charged plastic sphere and a large, positively charged metal sphere. According to Coulomb's law, the force depends on $1/r^2$, where *r* is the distance between the centers of the spheres. As you bring the spheres close together, the force is smaller than expected from Coulomb's law. Explain.

22. The forces are equal in magnitude and opposite in direction.

23. Some charge on the metal sphere will be repelled to the opposite side from the plastic sphere, making the effective distance between the charges greater than the distance between the sphere's centers.

13. Sphere A is located at the origin and has a charge of $+2.0\times10^{-6}$ C. Sphere B is located at +0.60 m on the *x*-axis and has a charge of -3.6×10^{-6} C. Sphere C is located at +0.80 m on the *x*-axis and has a charge of $+4.0\times10^{-6}$ C. Determine the net force on sphere A.

$$F_{\text{B on A}} = K\frac{q_A q_B}{d_{AB}^2} = (9.0\times10^{9}\ \text{N}\cdot\text{m}^2/\text{C}^2)\frac{(2.0\times10^{-6}\ \text{C})(3.6\times10^{-6}\ \text{C})}{(0.60\ \text{m})^2} = 0.18\ \text{N}$$

direction: toward the right

$$F_{\text{C on A}} = K\frac{q_A q_C}{d_{AC}^2} = (9.0\times10^{9}\ \text{N}\cdot\text{m}^2/\text{C}^2)\frac{(2.0\times10^{-6}\ \text{C})(4.0\times10^{-6}\ \text{C})}{(0.80\ \text{m})^2} = 0.1125 = \text{N}$$

direction: toward the left

$$F_{\text{net}} = F_{\text{B on A}} - F_{\text{C on A}} = (0.18\ \text{N}) - (0.1125\ \text{N}) = 0.068\ \text{N toward the right}$$

20	1- Distinguish between electrical conductors and insulators giving typical examples. 2- Explore the Doppler effect of sound or light.	Student Book	55-56, 32-35

CHECK PREVIOUS SLIDES 36
23-29