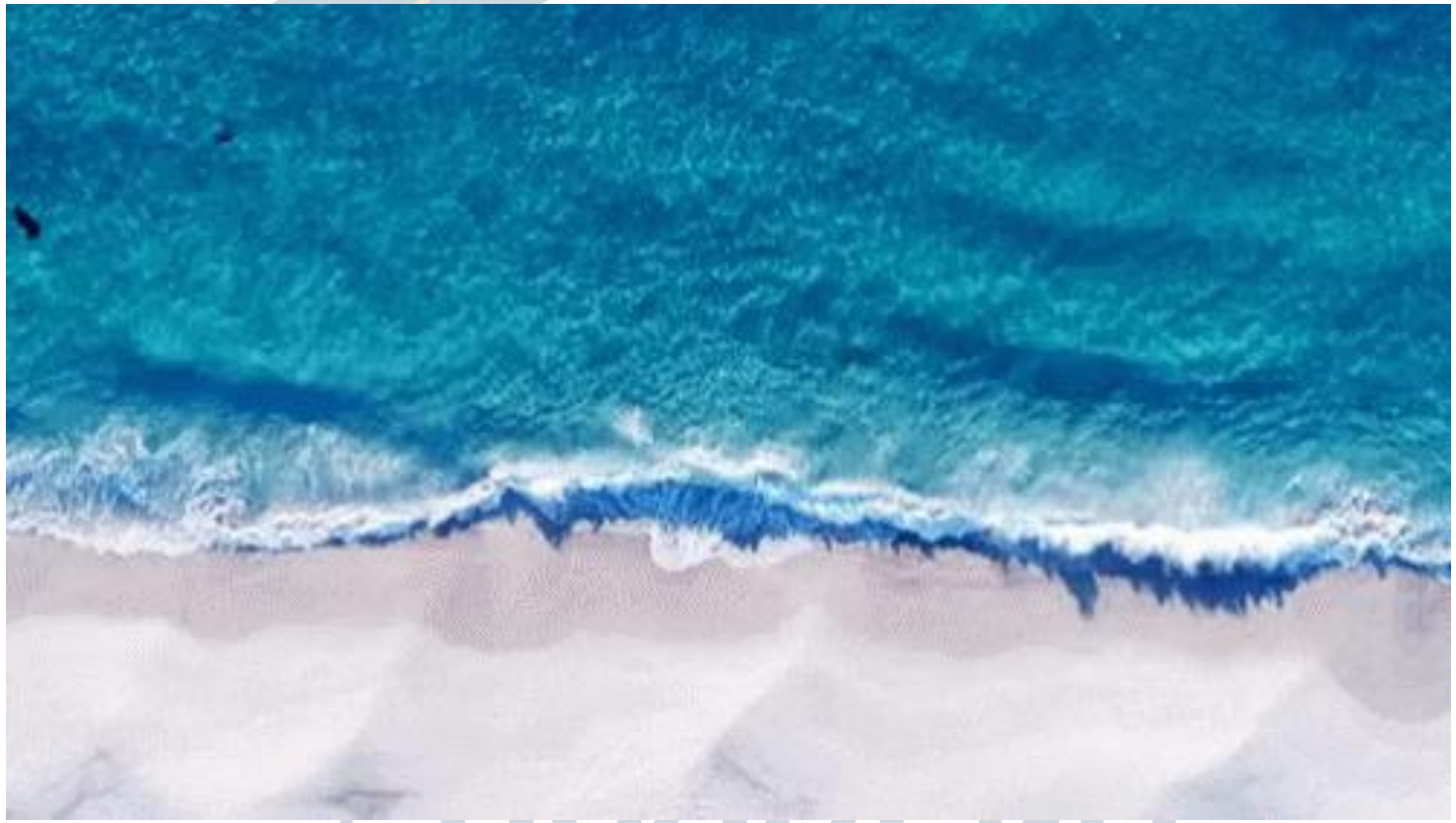
Physics - Grade 11 S

Unit One: Waves



Chapter 1: Waves

Prepared & presented by : Mr. Mohamad Seif

OBJECTIVES

1. Define of a periodic motion.
2. Define of a vibration.
3. Characteristics of vibration

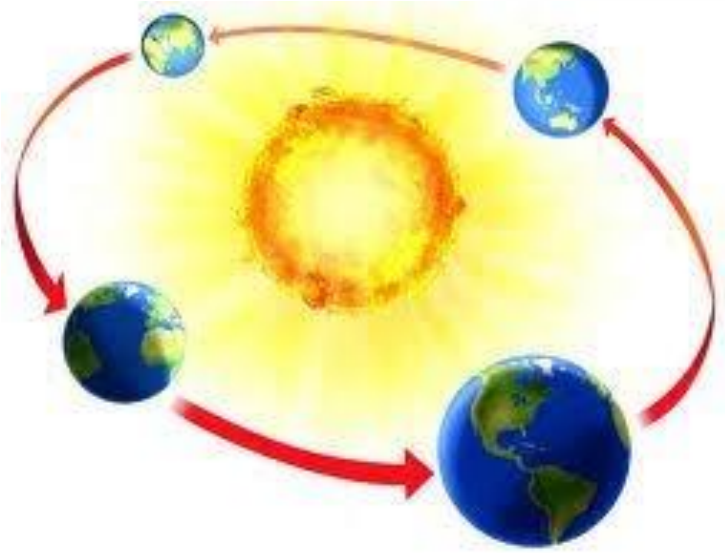
Definition of periodic motion

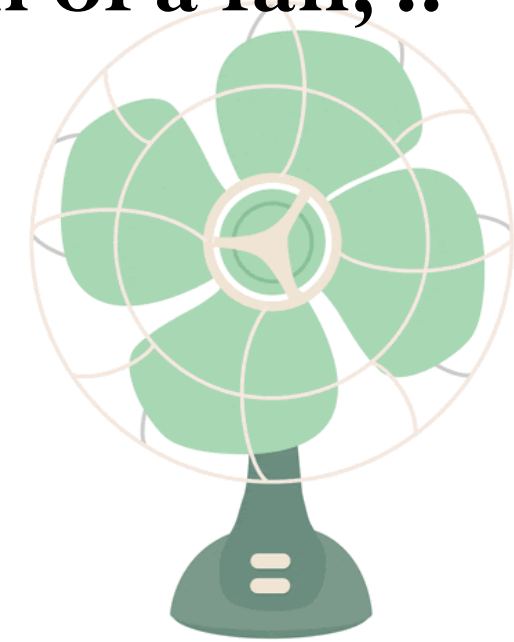
Periodic motion:

It is a motion that repeats itself within the same interval of time.This interval of time is called period (T)

Example:

The Earth revolves around the sun, the motion of a fan, ..

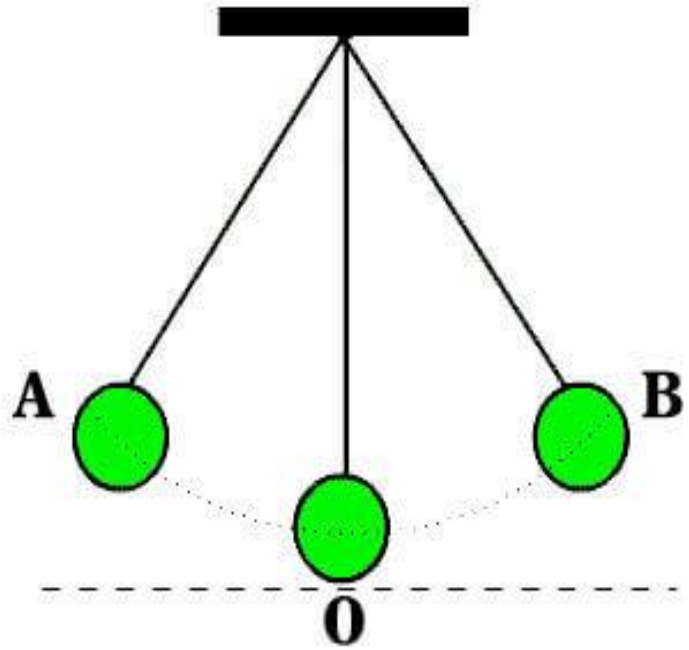


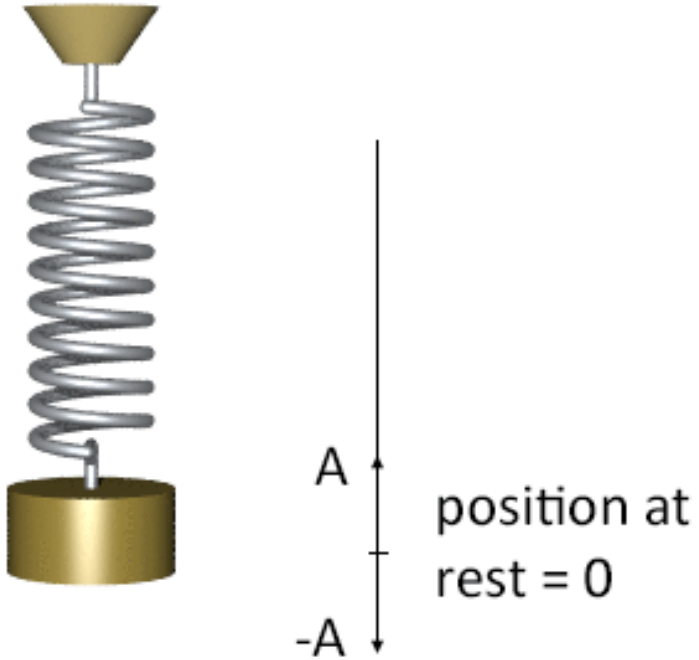


Definition of vibration (oscillation)

What is a vibration?

A vibration is one complete cycle of repetitive back and forth motion, about a position of equilibrium, from one extreme (maximum or minimum) to another (minimum or maximum).



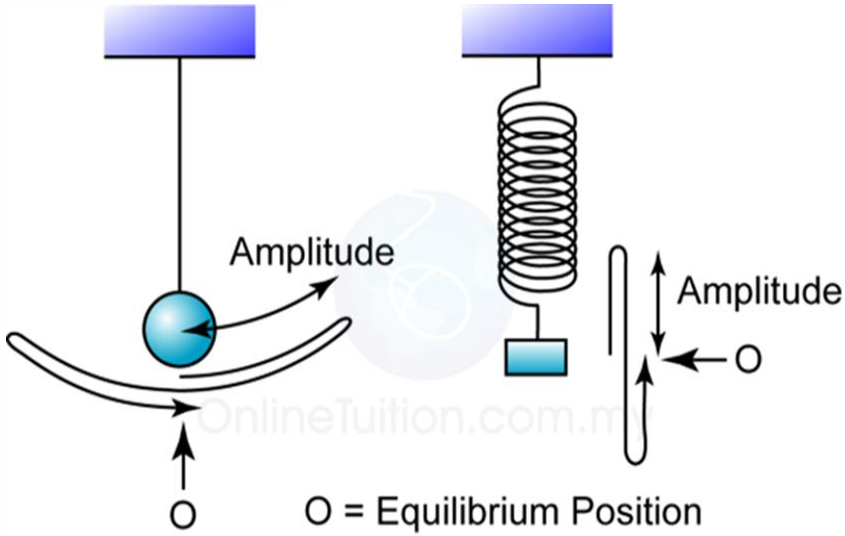


Characteristics of a vibration

1.Amplitude (a):

It is the maximum distance covered by the body during one vibration.

It is the distance between the position of equilibrium and the maximum or minimum.



A segment is the distance between the two extreme positions

1 vibration = 2 segments.

1 segment = 2 amplitudes.

hence 1 vibration = 4 amplitudes

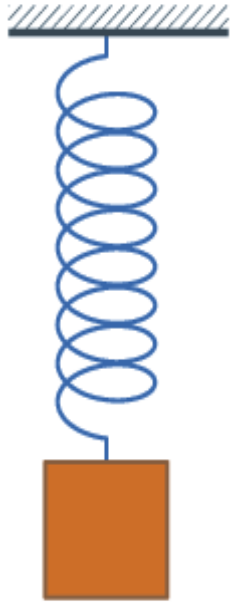
Characteristics of a vibration

2.Period T :

It is the time needed to make one vibration

$$T = \frac{t}{n}$$

Cycle	Cycle Time (seconds)
1st	2.3
2nd	2.3
3rd	2.4
4th	2.3
5th	2.3
6th	2.3



We notice that each cycle takes 2.3 s.

Hence the period is :T = 2.3 s

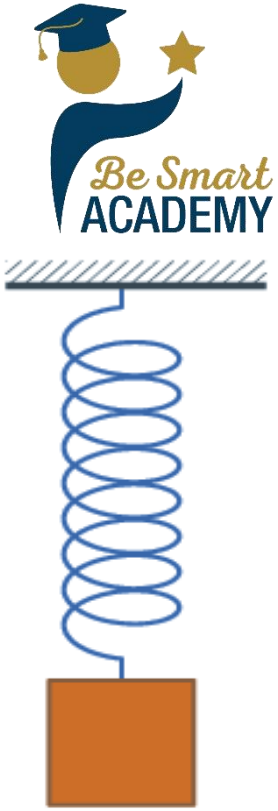
3.Frequency f :

It is the number of vibrations during a certain interval of time

$$f = \frac{n}{t} \Rightarrow f = \frac{1}{T}$$

Characteristics of a vibration

Application 1: A mass is tied to a spring and begins vibrating periodically. The distance between its highest and its lowest position is 38 cm. The pendulum is observed to complete 23 full cycles in 58 seconds.



1) Determine the amplitude of the vibrations?

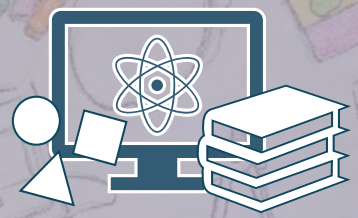
Segment = 2 amplitudes ➡ $38 = 2\,a$ ➔ $a = 19\ cm$

2) Determine the period and the frequency of the pendulum

$$T = \frac{t}{n} = \frac{58}{23} = 2.52\ s$$

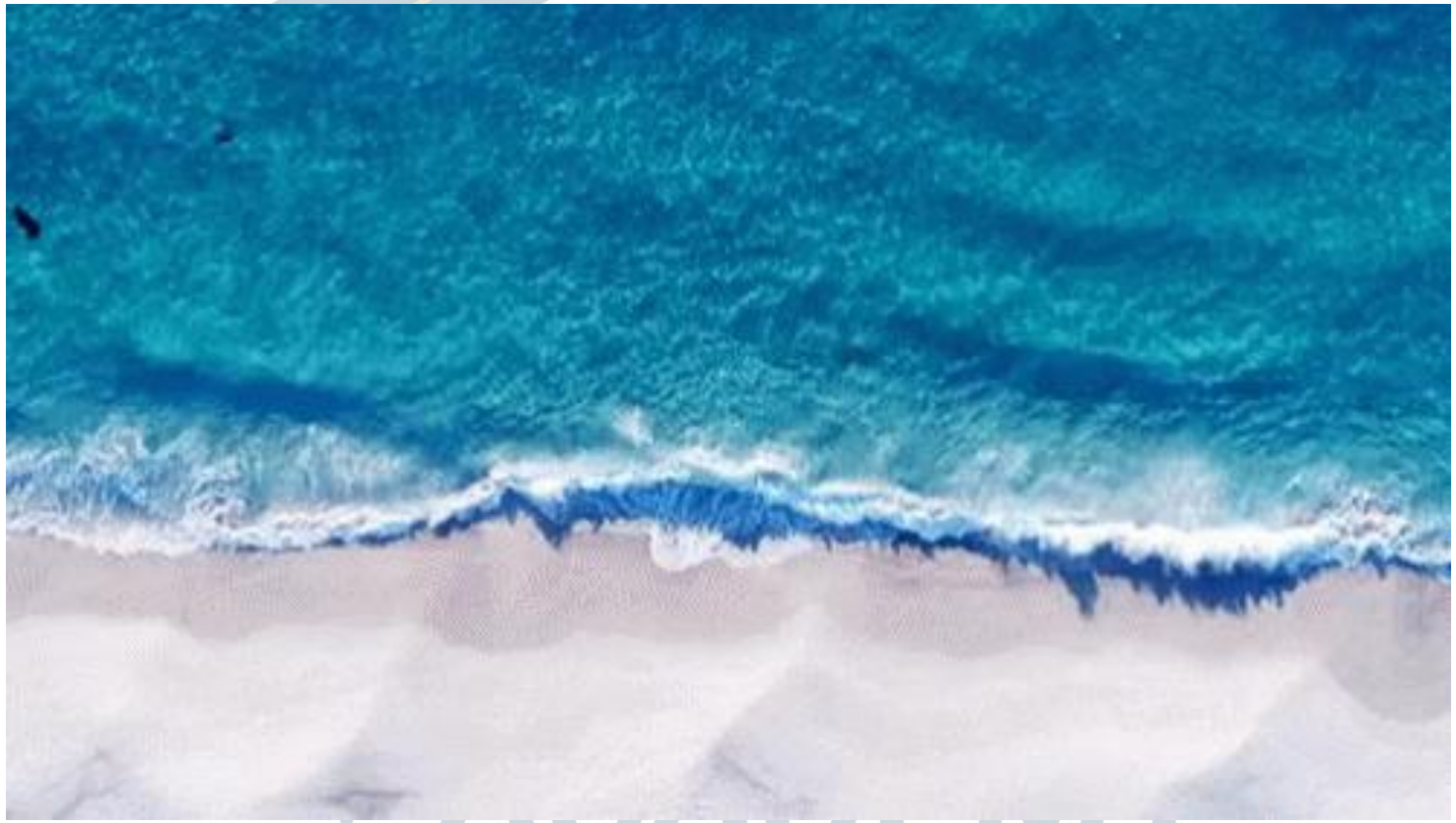
$$f = \frac{1}{T} = \frac{1}{2.52} = 0.39\ Hz$$

The End



Physics - Grade 11 S

Unit One: Waves



Chapter 1: Waves

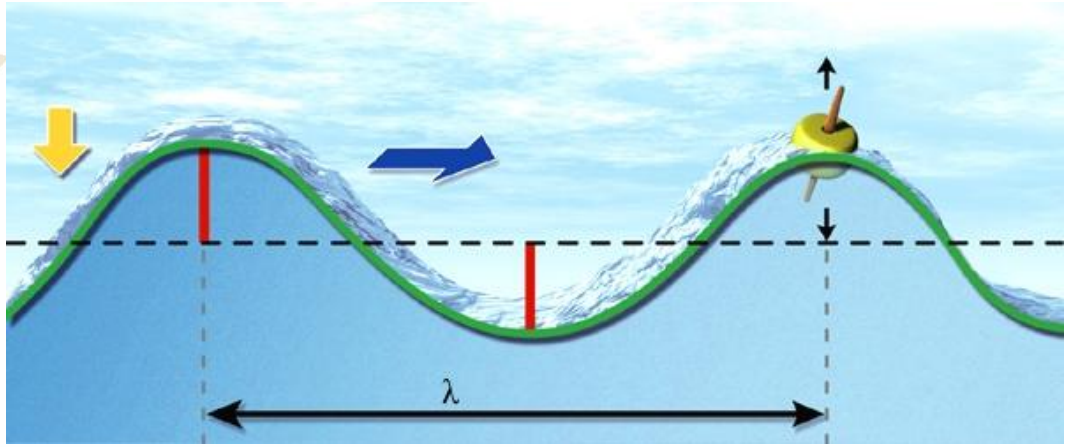
Prepared & presented by : Mr. Mohamad Seif

OBJECTIVES

1. Define of waves
2. Characteristics of a wave

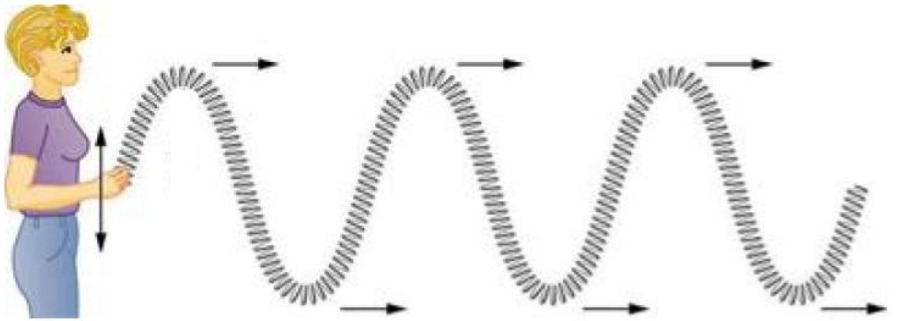
Definition of a wave

A wave is a moving vibration. (It is the propagation of a vibration).



Remark:

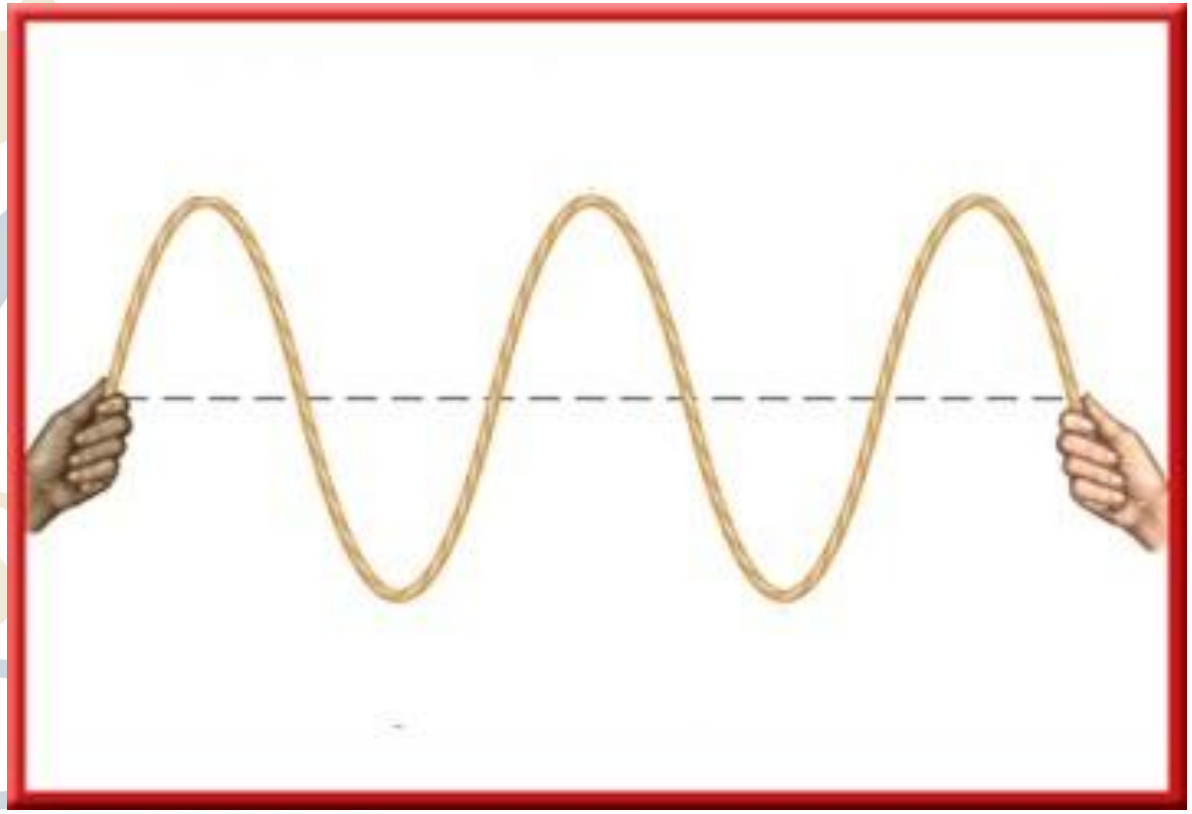
Waves transport energy and does not transport matter



Characteristics of wave

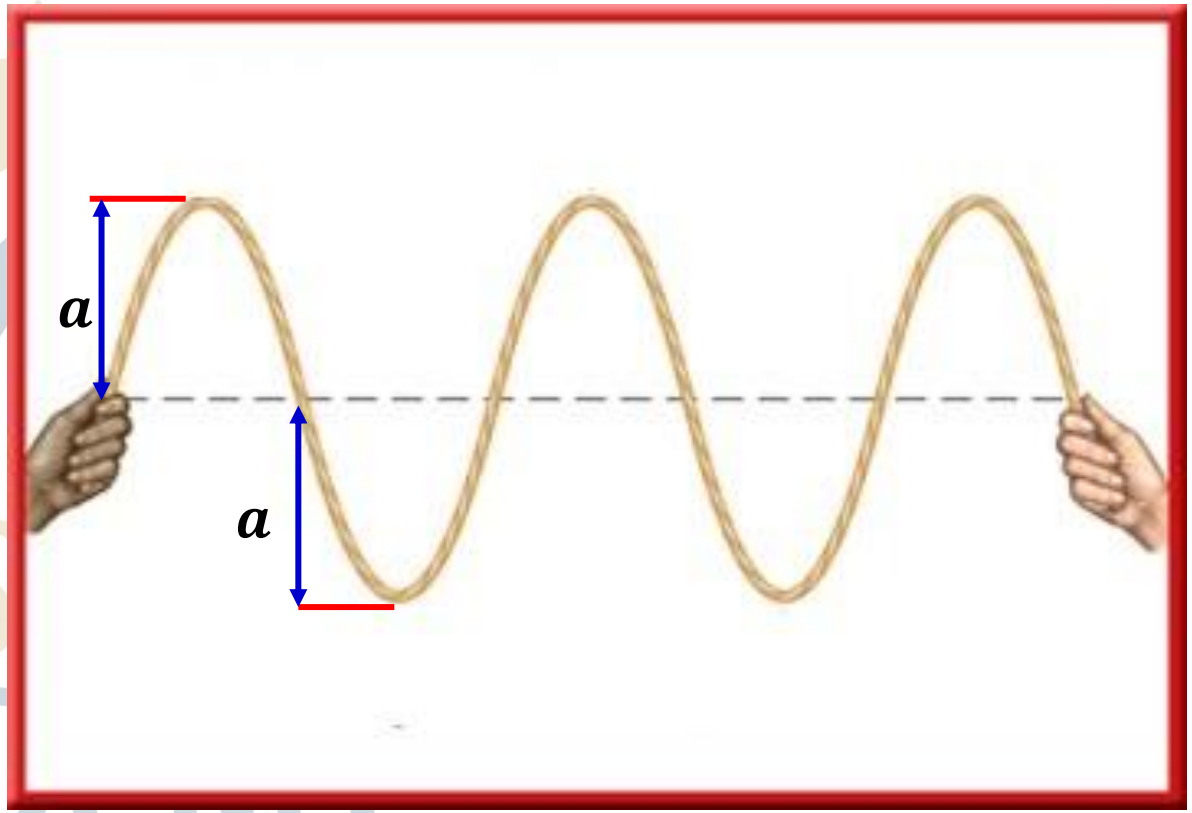
A wave is a moving vibration, so it has the same characteristics of a vibration:

- Amplitude:
- Period:
- Frequency:
- Wavelength: A wave move, this means it covers a certain distance called wavelength (λ).
- Speed of wave.



Characteristics of wave

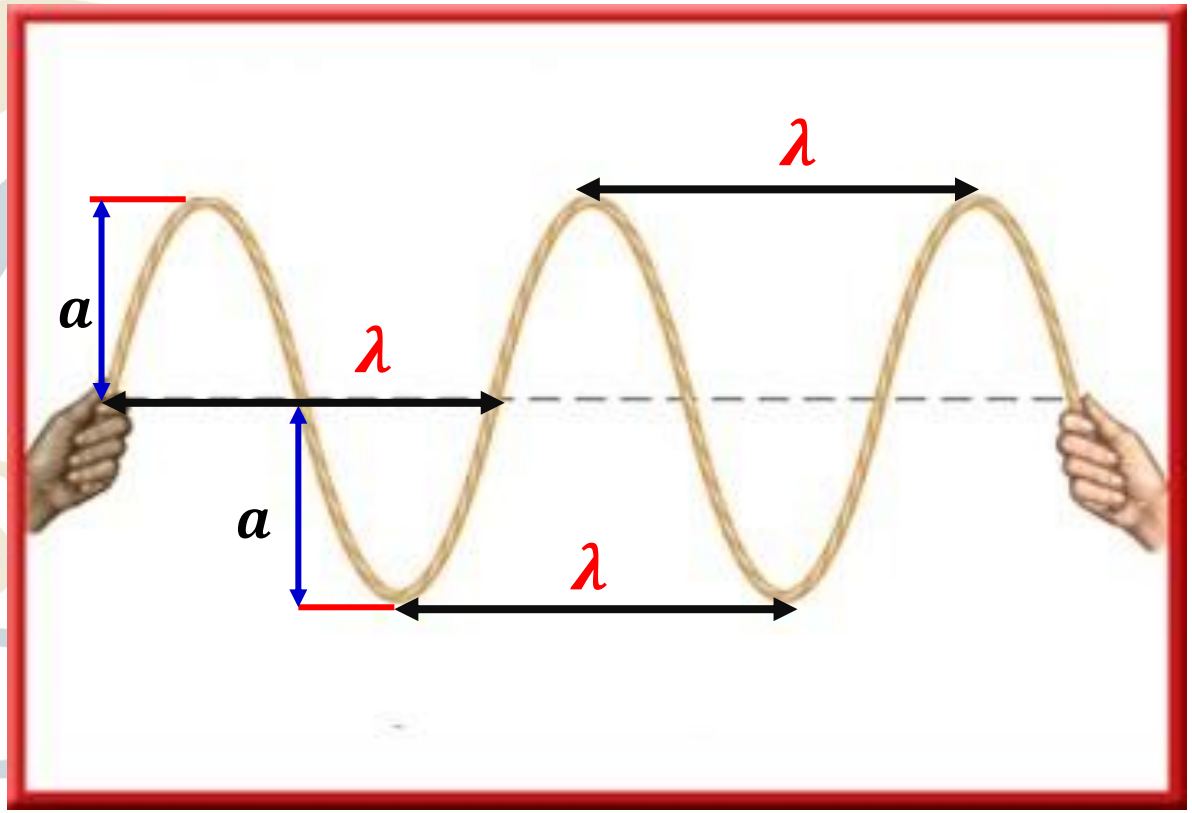
1. **Amplitude (a):** is the distance between axis and maximum (crest) or minimum point (trough).
2. **Period:** is the time for one wave, in seconds.
3. **Frequency:** is the number of waves per time. For one wave.



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

Characteristics of wave

4. **Wavelength:** for one wave the wave length is the distance traveled.
5. **A speed:** It is the distance covered by the wave per unit of time. It is in m/s



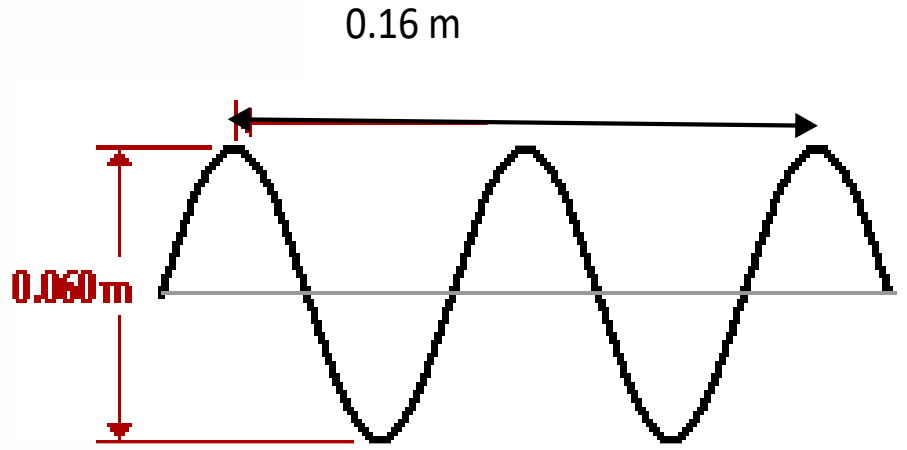
$$V = \frac{d}{t} \Rightarrow V = \frac{\lambda}{T}$$

$$V = \lambda . f$$

Characteristics of wave

Application 2:

The adjacent figure represent a wave.



1)Using the figure determine:

a.The amplitude of the wave on the rope.

b.The wavelength of the wave.

2)Knowing that the speed of the wave is 0.2m/s, calculate its frequency.

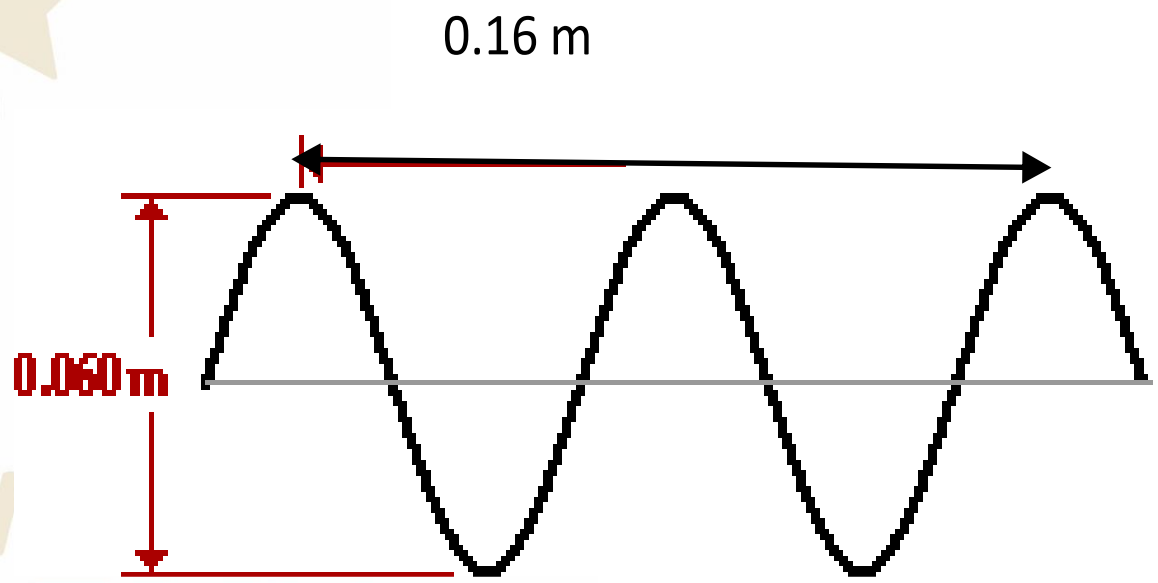
3)A piece of fabric is placed initially at the first crest. Determine the position of the piece of fabric after 2 s. Justify

Characteristics of wave

1)Using the figure determine:

a.The amplitude of the wave on the rope

$$\text{Amplitude} = a = \frac{sigment}{2}$$



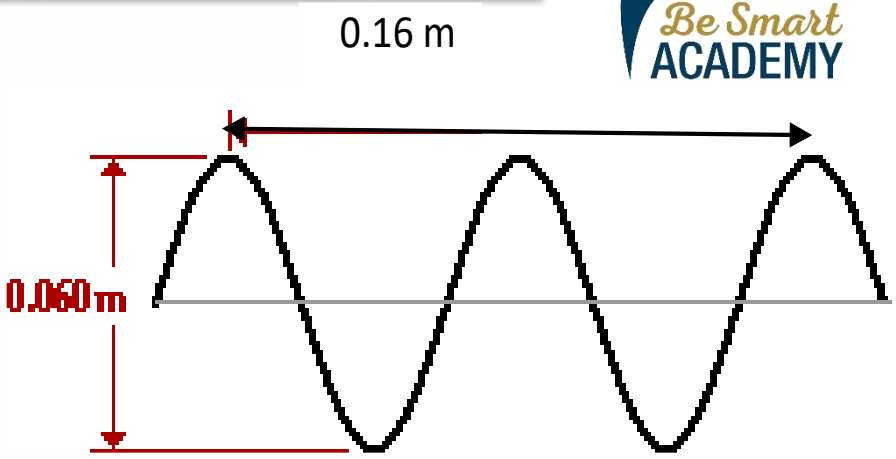
$$a = \frac{0.06}{2} \Rightarrow a = 0.03\ m$$

b.The wavelength of the wave

$$2\lambda = 0.16 \Rightarrow \lambda = 0.08\ m$$

Characteristics of wave

2)Knowing that the speed of the wave is 0.2m/s, calculate its frequency



$$f = \frac{v}{\lambda} \Rightarrow f = \frac{0.2}{0.08} \Rightarrow f = 2.5\ Hz$$

3)A piece of fabric is placed initially at the first crest. Determine the position of the piece of fabric after 2 s. Justify

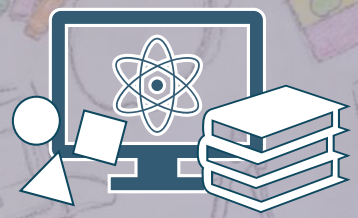
The piece of fabric be on a crest, equilibrium or trough after 2 sec ?

$$T = \frac{1}{f} = \frac{1}{2.5} = 0.4\ s$$

$$n = \frac{t}{T} = \frac{2}{0.4} = 5$$

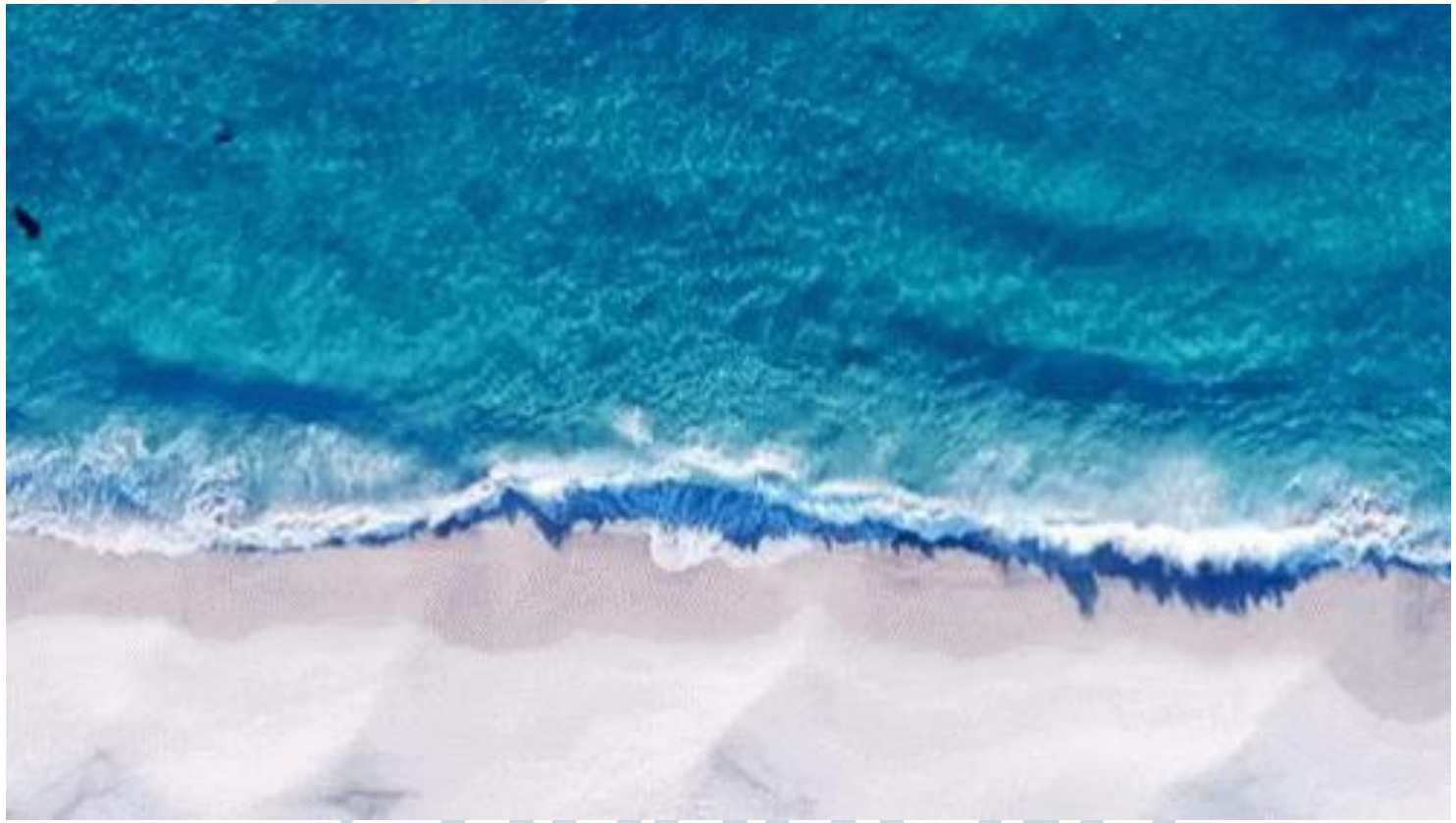
After 2 sec, the piece of fabric is on the crest .

The End



Physics - Grade 11 S

Unit One: Waves



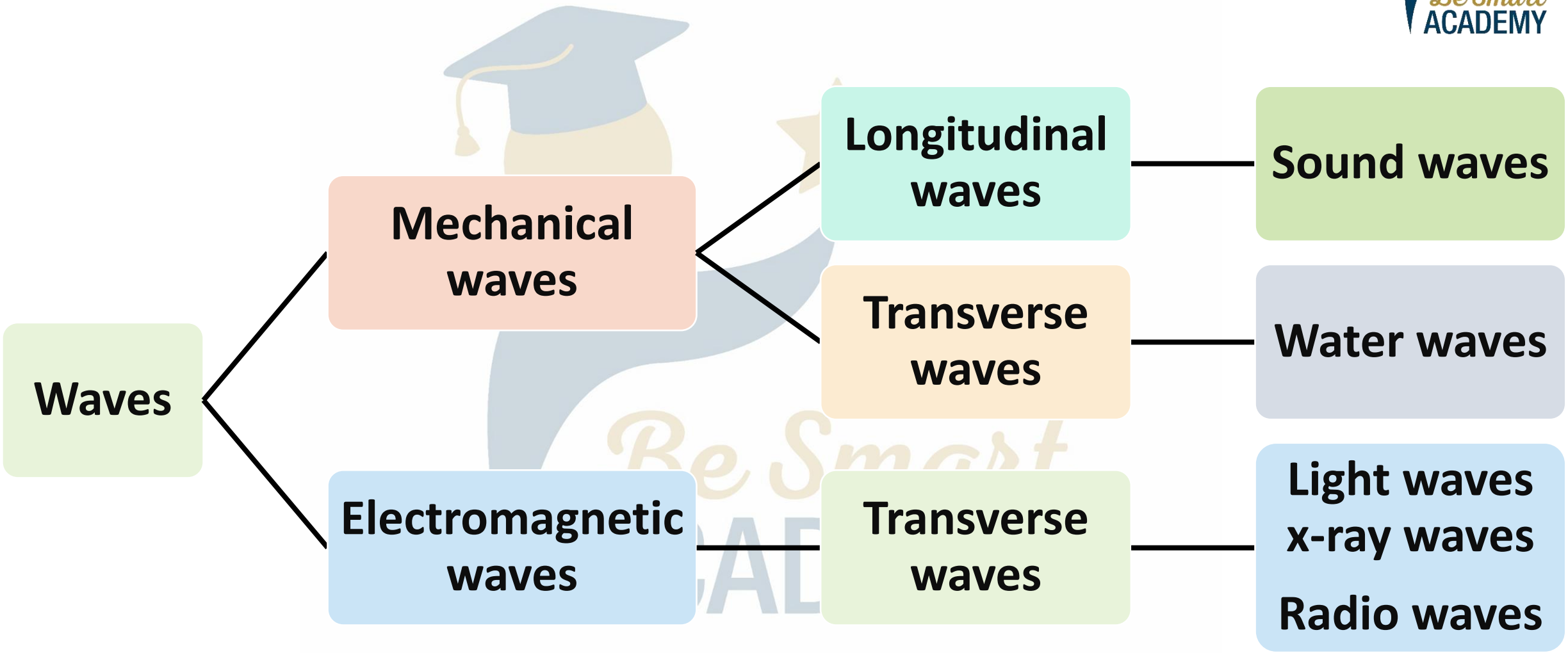
Chapter 1: Waves

Prepared & presented by : Mr. Mohamad Seif

OBJECTIVES

1. Nature and types of waves
2. Vibratory state of two points belonging to a wave

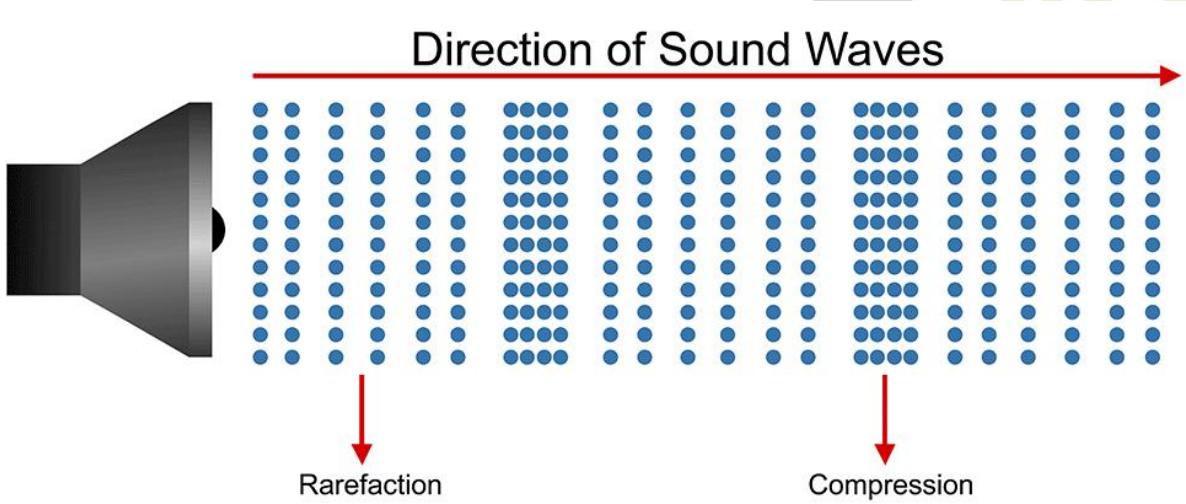
Nature and types of wave



Nature and types of wave

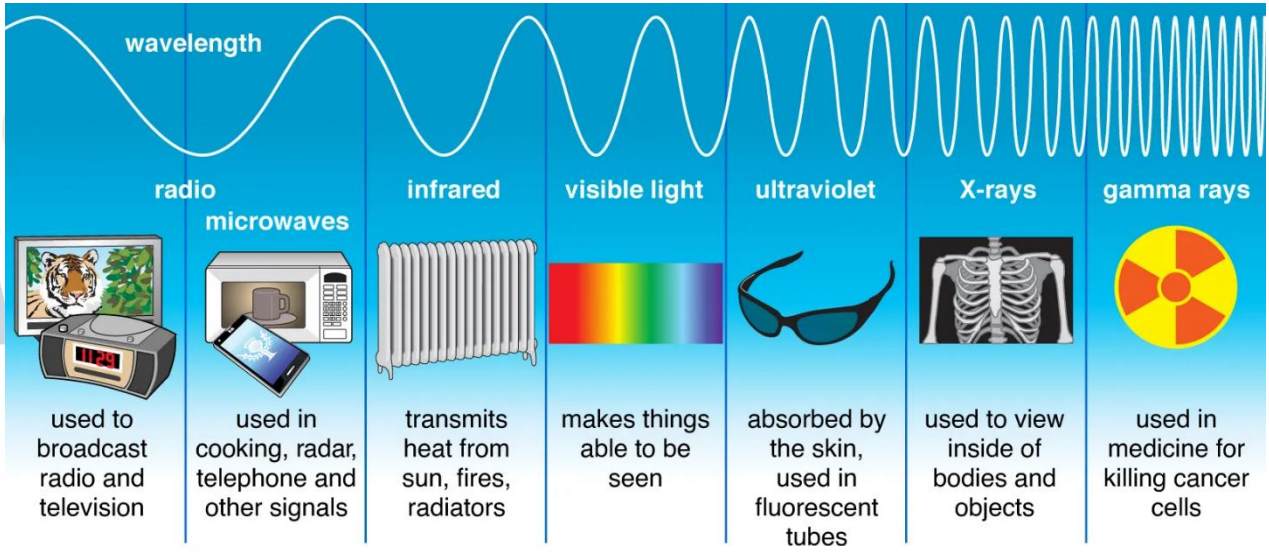
Mechanical waves:

It is a wave that needs a medium to propagate, so it can’t propagate in vacuum, such as sound wave, water wave, and sound wave.



Electromagnetic waves:

It is a wave that doesn't require medium to propagate. This wave can propagate in medium or in vacuum, such as light waves

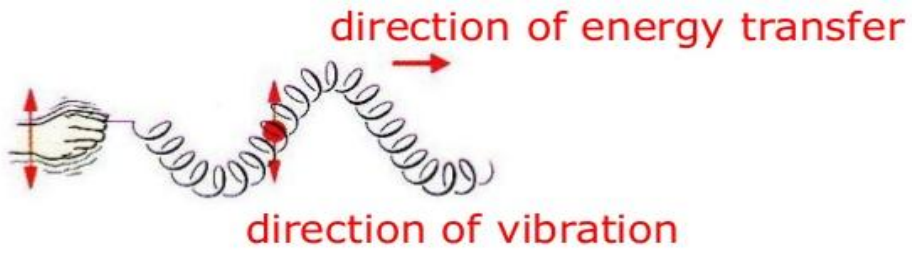


Nature and types of wave

Transverse wave :

Causes the particles of the medium vibrate ⊥ to the direction of the wave motion

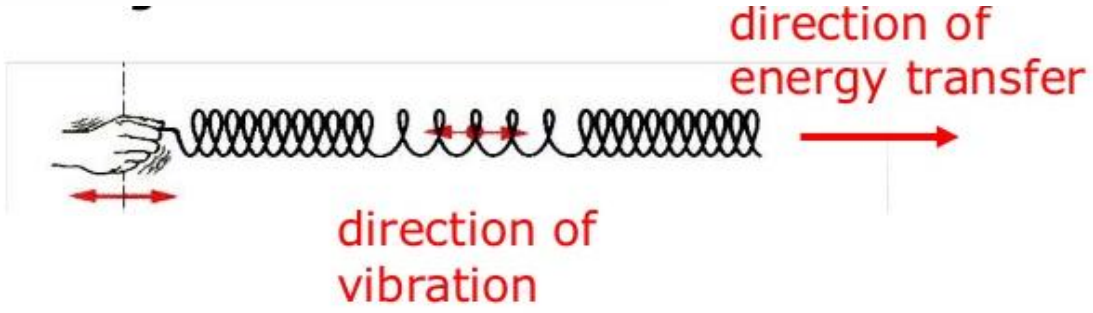
water waves, light waves...

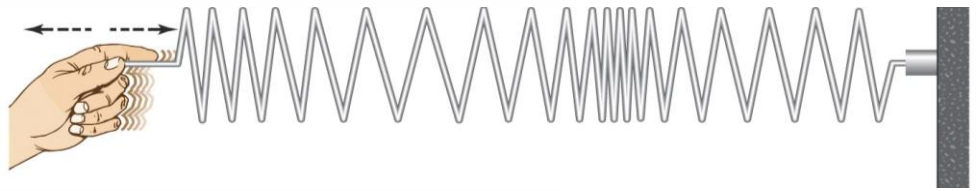


Longitudinal wave:

Causes the particles of the medium vibrate parallel to the direction of the wave motion.

Sound waves, spring…

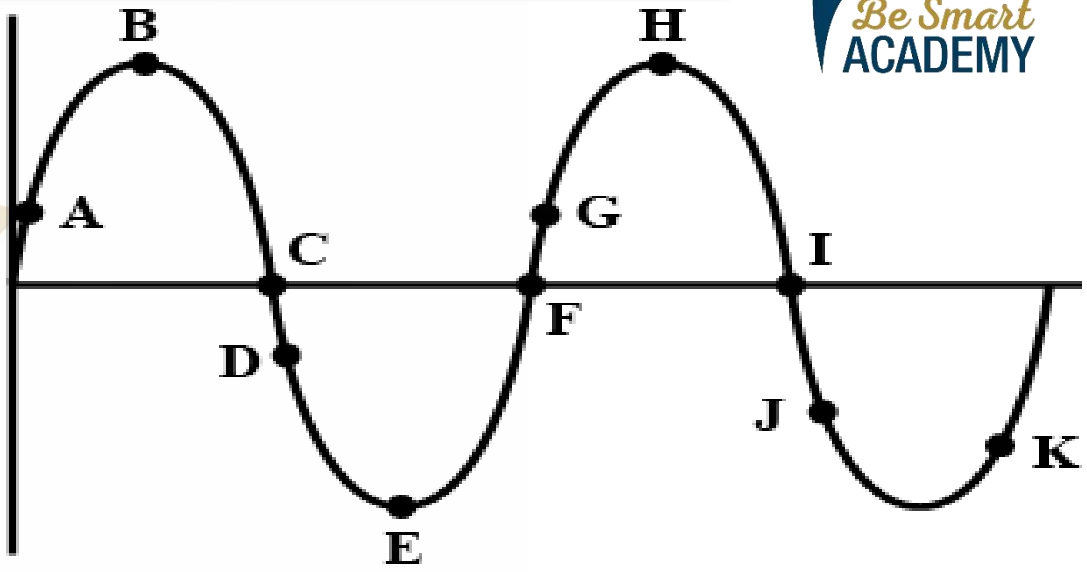




Vibratory state of two points belonging to a wave

Points in phase:

Two points vibrate in phase if they reach their highest and lowest positions.



Points vibrating in phase :

- A and G vibrate in phase.
- B and H vibrate in phase
- C and F vibrate in phase

Two points vibrate **in phase** if the distance separating them is whole multiple of wave length:

$$d = k\lambda$$

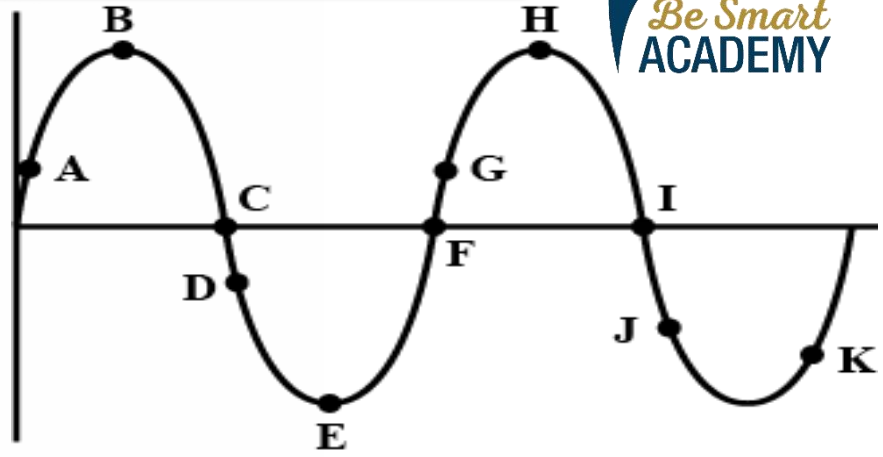
Vibratory state of two points belonging to a wave

Points vibrate in anti-phase:

Two points vibrate in anti-phase if one reaches highest position while the other reaches lowest position at same time:

Points vibrating in antiphase:

- B & E are vibrating in antiphase.
- G & J are vibrating in antiphase.
- E & H are vibrating in antiphase.



Two points vibrate in **out of phase** if the distance separating them is whole multiple of wave length:

$$d = (2k + 1)\frac{\lambda}{2}$$

Vibratory state of two points belonging to a wave

Application 3: A vibratory point source S hits the surface of water in a ripple tank with a frequency f =50 Hz

The distance measured along a wave ray between the first and the sixth crest is d=3cm.

1) Indicate the nature and the type of the wave produced on water.
2) Calculate the wavelength and deduce the speed of the wave.
3) We choose at the surface of the water the points A, B,C and D such that SA=1.7cm , SB=2.4 cm, SC=3.5 cm and SD=3.8 cm. Determine the vibratory state of

a) A with respect to C.
b) A with respect to D.
c)S with respect to A.

Vibratory state of two points belonging to a wave

f =50 Hz, d=3cm.

1) Indicate the nature and the type of the wave produced on water.

The nature of this wave is mechanical and its type transverse

2)Calculate the wavelength and deduce the speed of the wave.

$$5\lambda = 3 \Rightarrow \lambda = 0.6 \text{ cm}$$

$$v = \lambda . f = 0.6 \times 50 \Rightarrow v = 30\ cm/s$$

Vibratory state of two points belonging to a wave

f =50 Hz, d=3cm.

3) We choose at the surface of the water the points A, B,C and D such that SA=1.7cm , SB=2.4 cm, SC=3.5 cm and SD=3.8 cm. Determine the vibratory state of:

a) A with respect to C.

$$\frac{d}{\lambda} = \frac{SC - SA}{\lambda}$$

$$\frac{d}{\lambda} = \frac{3.5 - 1.7}{0.6}$$

$$3 = integer = K$$

Hence A and C vibrate in phase

Vibratory state of two points belonging to a wave

f =50 Hz, d=3cm.

b)A with respect to D.

$$\frac{d}{\lambda} = \frac{SD-SA}{\lambda} = \frac{3.8-1.7}{0.6} = 3.5 = \frac{2k+1}{2}$$

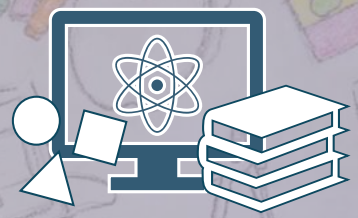
hence A and D vibrate in anti phase

c) S with respect to A.

$$\frac{d}{\lambda} = \frac{SA}{\lambda} = \frac{1.7}{0.6} = 2.83$$

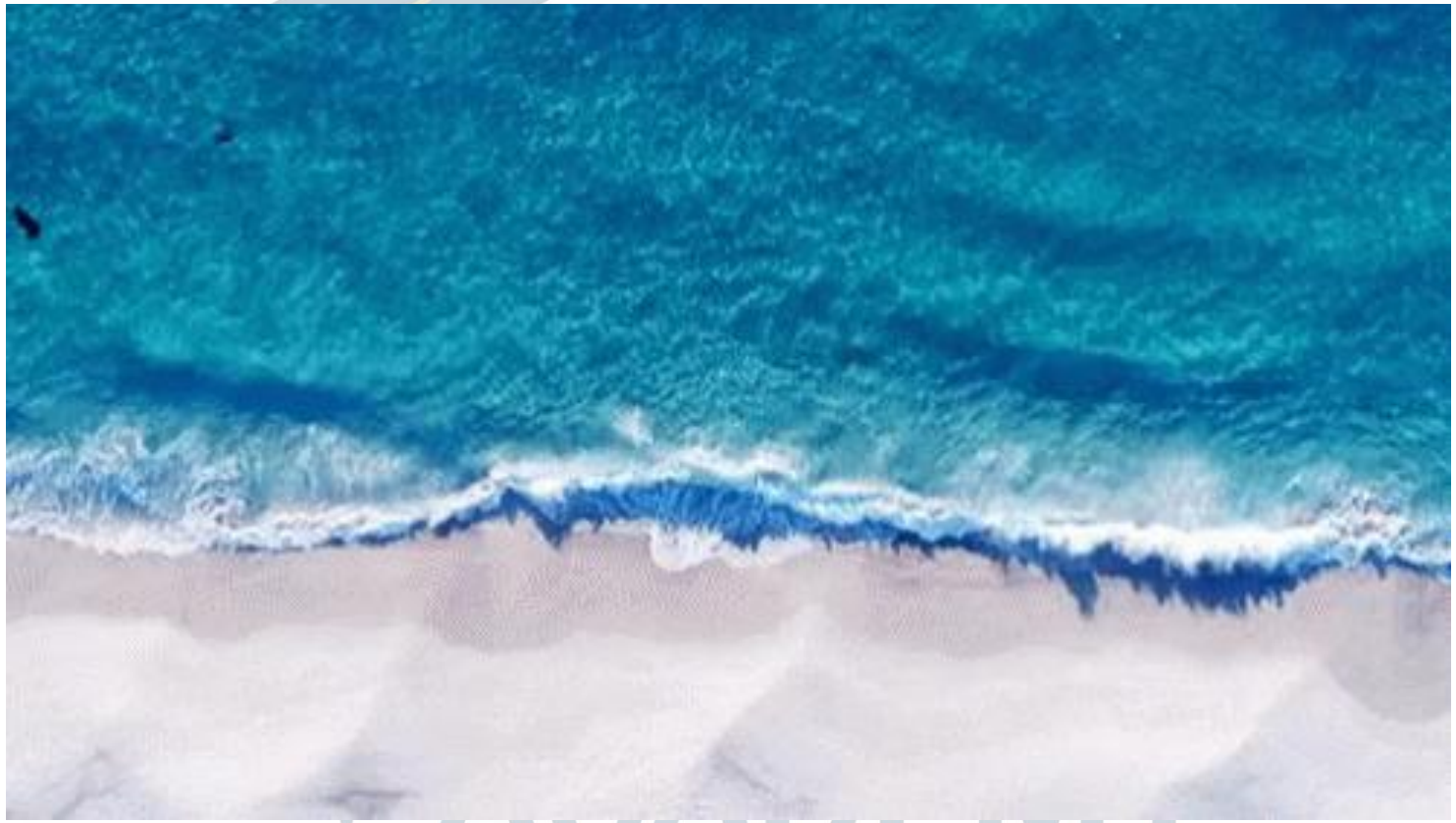
hence A vibrate neither in phase nor in antiphase with respect to S

The End



Physics - Grade 11 S

Unit One: Waves



Chapter 1: Waves

Prepared & presented by : Mr. Mohamad Seif

OBJECTIVES

5 Study the stroboscopy technique

Study the stroboscopy technique

Stroboscopy is a technical method used to study fast motion.

The stroboscope: is an instrument which emits periodic, intensive and brief flashes.

- **The period T_e:** of flashes is the time separating two consecutive flashes.
- **The frequency (f_e):** of flashes is which expressed in flashes/second.

Study the stroboscopy technique

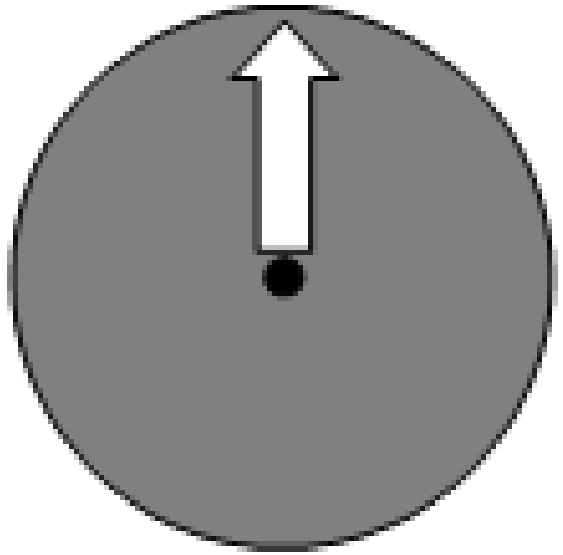
Observation a fast periodic motion using a stroboscope:

Consider a disk is in fast periodic motion of frequency f.
The disk is illuminated in a dark room by a stroboscope which emits flashes of frequency f_e

We will obtain the following cases:

Case 1: $f = f_e$ then $T = T_e$

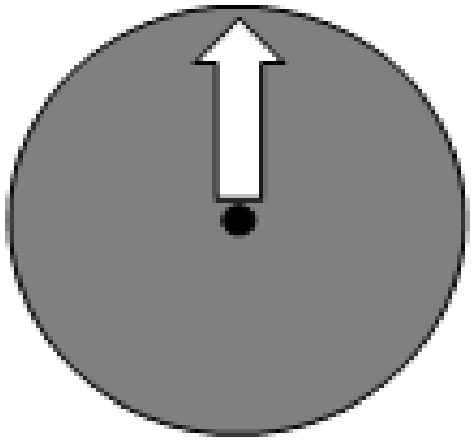
We will observe motionless or one stationary segment.



Study the stroboscopy technique

Case 2: $f = kf_e$

We will observe motionless or one stationary segment.



Case 3: $f_e = kf$ or $f = \frac{f_e}{k}$ then

We will observe k motionless segment.

- If k=1, we observe 1 motionless segment.
- If k=2, we observe 2 motionless segment.

Figure 1

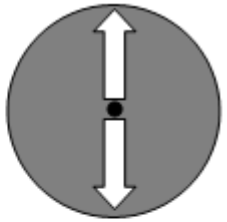


Figure 2

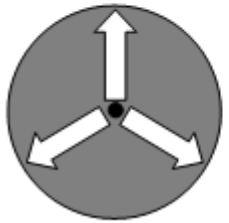


Figure 3

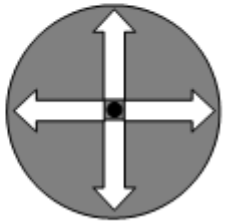


Figure 4

Study the stroboscopy technique

Case 4: $f \gtrsim f_e$

The segment seems in apparent slow motion in the real direction of rotation of the disk.

The apparent frequency of the apparent motion of the disk is given by $f_{app} = |f_e - f|$

Case 5: $f \lesssim f_e$

The segment seems in apparent slow motion in the real opposite direction of rotation of the disk.

The apparent frequency of the apparent motion of the disk is given by $f_{app} = |f_e - f|$

Study the stroboscopy technique

Application 4:

A black disk, with a white radial segment, rotating at f=50r.p.s is illuminated in a dark room by a stroboscope of frequency f_e. Determine the apparent shape and apparent frequency of the disk for the following cases:

1. $f_e = 50$	*2.* $f_e = 25$	*3.* $f_e = 100$
4. $f_e = 47$	*5.* $f_e = 52$	*6.* $f_e = 5$

Take the time of persistence of vision as $T_p = 0.1s$

Study the stroboscopy technique

f=50r.p.s and $T_P = 0.1s$

1) For $f = f_e = 50$

then one motionless segment is observed.

$$f_{app} = |f_e - f| = 50 - 50 = 0$$

2) For $f = 50$ and $f_e = 25$

then $f = 2f_e$:

Then one motionless segment is observed.

$$f_{app} = |f_e - f| = |25 - 50| = |-25| = 25Hz$$

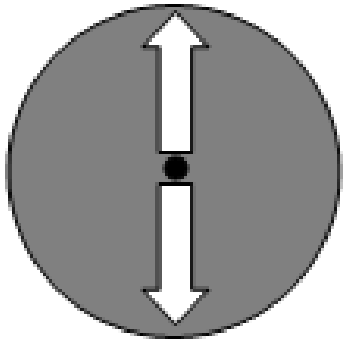
Study the stroboscopy technique

f=50r.p.s and $T_P = 0.1s$

3) For $f = 50$ and $f_e = 100$

then $f_e = 2f$

Then two motionless segment is observed.



4) For $f = 50$ and $f_e = 47$

then $f \gtrsim f_e$:

The disk is observed in slow apparent motion in the real sense of rotation

$f_{app} = |f_e - f| = |47 - 50| = |-3| = 3Hz$

Study the stroboscopy technique

f=50r.p.s and $T_P = 0.1s$

5) For $f = 50$ and $f_e = 52$

then $f_e \gtrsim f$

The disk observed in slow apparent motion in the opposite sense of rotation.

$$f_{app} = |f_e - f| = |52 - 50| = |2| = 2Hz$$

6) For $f = 50$ and $f_e = 5$

then $f = 10f_e$:

We observe one fixed or motionless segment

$$f_{app} = |f_e - f| = |5 - 50| = |-45| = 45Hz$$

The End