1.1 UNDERSTANDING WAVES

What is meant by wave motion

What is meant by a wavefront

State the direction of propagation of waves in relation to wavefronts

What is transverse wave?  A transverse wave is a wave in which particles of the medium...

Example of this type of waves are .................. and 

What is longitudinal wave?  A longitudinal wave is a wave which the particles of the medium...

Example of this wave is ...................................................

Fill in the blank with the correct answer given below

<table>
<thead>
<tr>
<th>frequency</th>
<th>period</th>
<th>sound waves</th>
</tr>
</thead>
<tbody>
<tr>
<td>transverse wave</td>
<td>hertz (Hz)</td>
<td>amplitude</td>
</tr>
<tr>
<td>electromagnetic waves</td>
<td>longitudinal waves</td>
<td>water waves</td>
</tr>
</tbody>
</table>

1. The __________________________ of an oscillation is the maximum displacement for one complete oscillation .

2. The __________________________ of the oscillation is the time taken to complete one oscillation.

3. The __________________________ of the oscillation is the number of complete oscillation made in one second. The SI unit is __________________

Label the graph below and fill in the blank with correct answer.

4. In the displacement – time graph as shown above, amplitude is represented by the symbol of _____ and period is represented by the symbol of ______________
5. In the displacement–distance graph as shown above, amplitude is represented by the symbol of ________ and wave is represented by the symbol of ____________.

6. **Damping** is occur when in an oscillating system when the system _____________ (gain/loses) energy to surrounding in the form of ___________ (heat/chemical) energy.

7. The force responsible for damping is called _________________ (equilibrium/dissipative) forces.

8. In a simple pendulum, its natural frequency depending on its ___________ (length/mass).

9. When an oscillating systems driven at its natural frequency, the system is said to be at ______ _________________ (damping/reasonance).

10. A wave travels with a speed of $3.0 \times 10^8$ ms$^{-1}$
    (a) What is the frequency of the wave if its wave length is 1.0 m?
    (b) Another wave is travelling with the same speed but has a frequency of $1.5 \times 10^{12}$ Hz. What is the wavelength of the wave?

    **Solution.**

    Wave speed, $v = f \lambda$

    
    (a) 
    (b)

    **Answer** (a) $3.0 \times 10^8$ Hz  
    (b) $2.0 \times 10^{-4}$ m
11. The displacement – time graphs and displacement – distance graph describe the motion of a particular wave. Determine the speed of the wave.

**a) Displacement – time graph**

<table>
<thead>
<tr>
<th>S/cm</th>
<th>t/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>-5</td>
<td>2</td>
</tr>
<tr>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

**b) Displacement – distance graph**

<table>
<thead>
<tr>
<th>S/cm</th>
<th>l/cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>-5</td>
<td>2</td>
</tr>
<tr>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

**Solution:**

12.

Based on the displacement-distance graph of a wave, find

(a) the amplitude

(b) the wavelength of the wave

13. Calculate the frequency of the given wave below

**Displacement/s**

<table>
<thead>
<tr>
<th>-5</th>
<th>0</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>

**Time/s**

8
1. Base on the diagram 1.11 above, which distance represents the amplitude?

2. Which of the following is true?

<table>
<thead>
<tr>
<th>Amplitude/ m</th>
<th>Period / s</th>
<th>Frequency / Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 0.1</td>
<td>0.50</td>
<td>2</td>
</tr>
<tr>
<td>B 0.2</td>
<td>0.50</td>
<td>1</td>
</tr>
<tr>
<td>C 0.1</td>
<td>0.25</td>
<td>4</td>
</tr>
<tr>
<td>D 0.2</td>
<td>0.50</td>
<td>2</td>
</tr>
</tbody>
</table>

3. The period of oscillations of a simple pendulum increases when the _________ increases.

   A length of the pendulum
   B mass of the bob of the pendulum
   C acceleration due to gravity

5. Diagram 1.14 shows a wavefront pattern. What is the speed of the waves? What is the speed of the waves?

<table>
<thead>
<tr>
<th>Speed/ cm/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 12</td>
</tr>
<tr>
<td>B 18</td>
</tr>
<tr>
<td>C 24</td>
</tr>
<tr>
<td>D 36</td>
</tr>
</tbody>
</table>

9. Which of the following statements is true about the water waves?

   A. T and U have the same phase
   B. Wave energy is transferred from position S to U.
   C. The wave length is the distance between S and U.
   D. The particles at U oscillates in a direction parallel to the direction of the wave propagation.
10. The graphs show the cross-sections of water waves. Which wave has the greatest energy?

11. Which graph represents a wave with amplitude of 4.0 cm and period of 0.05 s

12. Diagram 1.16 shows the displacement distance graph. The frequency of the wave is 5.0 Hz.

What is the velocity of the wave?
A. 50 cm\(^{-1}\) B. 75 cm\(^{-1}\) C. 100 cm\(^{-1}\) D. 150 cm\(^{-1}\)

13. Diagram 1.16 shows a silky spring being moved left and right continuously.

(a) Complete the sentence below by ticking (✓) the correct box.
The wave produced by the slinky spring is a
Transverse wave

(b). On diagram 1.16, mark ‘X’ on any of the crest of the wave.

(c) Complete the following sentence by underlining the correct phase in the bracket.

(d) What is transferred by the wave?

..........................................................................................................................
1.2 ANALYSING REFLECTION OF WAVES.

1. Complete the diagram 1.21 below to show the reflected waves.

Diagram 1.21

2. Fill in the box with the correct answer.

$$i = \underline{\hspace{2cm}}$$

$$r = \underline{\hspace{2cm}}$$

3. Draw the correct pattern of reflected water waves.

(a) wavefronts

(b) wavefronts

$45^\circ$
(c) Compare the following quantities before and after reflection.

(i) velocity: ________________________________

(ii) frequency: ________________________________

(iii) wavelength: ________________________________

(iv) direction: ________________________________

d) In reflection, the angle of reflection is always equal to ________________________________
Praktis 1.2

1. Which of the following characteristic of waves changes when the wave are reflected?
   A. Direction of propagation
   B. Wavelength
   C. Frequency
   D. Speed

2. What happens to the wave length and the magnitude of the velocity of water waves when it is reflected?

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Magnitude of velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Unchanged</td>
<td>Unchanged</td>
</tr>
<tr>
<td>B. Increases</td>
<td>Decreases</td>
</tr>
<tr>
<td>C. Decreases</td>
<td>Increases</td>
</tr>
<tr>
<td>D. Increases</td>
<td>unchanged</td>
</tr>
</tbody>
</table>

3. Diagram 1.22 shows a sound wave reflected from a concrete wall.

   Diagram 1.22

   Which statement is correct about the reflected and incident waves?
   A. The speed of the reflected waves is the same as the speed of the incident waves.
   B. The wavelength of the reflected waves is shorter than that of the incident waves.
   C. The frequency of the reflected waves is lower than that of the incident waves.
   D. The directions of the reflected waves are always at right angles to the incident waves.

4. Echo is a phenomenon caused by
   A. the refraction of sound waves
   B. the reflection of sound waves
   C. the diffraction of sound waves
   D. the polarization of sound waves

5. Diagram 1.23 shows the wavefront of a plane wave wave incident on a plane reflector.
   Which comparison is correct about the reflected sound wave and the incident sound wave?

   Diagram 1.23

   A. The wavelength of the incident wave is shorter than the reflected wave.
   B. The speed of the incident wave and the reflected wave is the same.
   C. The frequency of the incident wave is less than the reflected wave.
   D. The angle of incident wave is greater than the angle of reflection of the reflected wave.
6. Diagram 1.24 shows the apparatus is used to investigate the reflection of sound waves. At what position of the cardboard tube is adjusted until a loud ticking sound of the stop watch is heard?

![Diagram 1.24](image)

Diagram 1.24

7. Diagram 1.25 and Diagram 1.26 show the water and sound waves propagating towards a reflector.

![Diagram 1.25](image)

Diagram 1.25

Diagram 1.26

ii) With reference to Diagram 1.25 and Diagram 1.26, compare the incident and reflected angle, wavelength, frequency, speed and direction of propagation of the reflected

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................................................................................................................................................
1. Waves can be refracted as they move from one ___________ (volume / medium) to another.

2. When water waves travel from one area to another area of different depth, their speed______________ (remain / changes) and the frequency ______________ (remain / changes).

3. The wavelength of waves in deep area is ______________ (shorter / longer) than that in the shallow area.

4. When waves travel from a denser medium to less dense medium, they refracted ____________ (away / towards) to normal.

5. Diagram 1.30 shows the incident ray is refracted ____________________________ (away / towards) to normal.

Draw a diagram to show refraction of wave

Complete the diagrams below.
Why is the wave bend according to the shape of the shoreline when they are approaching the beach?

Diagram 1.31: the shape of shoreline when they are approaching the beach

<table>
<thead>
<tr>
<th>uniform speed</th>
<th>depth of the sea</th>
<th>parallel</th>
<th>shallower</th>
</tr>
</thead>
<tbody>
<tr>
<td>reduce</td>
<td>refraction</td>
<td>refracted</td>
<td>wavefront</td>
</tr>
</tbody>
</table>

In the centre of the ocean, the water wave travel at ________________ speed as the ________________ water is uniform. Hence the wavefront are straight and ____________ to each other.

When the waves reach the coast, the water is ________________. Wave speed is ____________ and ________________. The wavefront are ____________ and become closer to each other.

________ causes the ________________ to be bent ____________ the normal and this results the wavefront following the shape of the coastline.

Sound wave travel faster in ________ (warm air / cool air) than in ________________ (warm air / cool air). On hot day, the hot surface of the earth causes ________________ layer of air/layer of density) near the surface to be ________________ (colder/warmer). This causes ________________ (light waves/sound waves) to be refracted ________________ (away/closer) from the earth. During night time, the sound waves travel ________________

As a result, the wave are ________________ (refracted/reflected) towards the earth. This explain why sound can be heard over a longer distance on a cold night compared with a hot day.
Praktis 1.3

1. Diagram 1.34 shows water waves propagating through a Perspex block in a ripple tank.

![Diagram 1.4](image)

Diagram 1.4
Which wave pattern is observed when the waves pass through the Perspex block.

A
B
C
D

2. Diagram 1.35 shows water waves propagating in an area of different depths.

![Diagram 1.35](image)

Diagram 1.35
Which of the following diagrams shows the propagation of the waves correctly?

A
B
C
D

3. When water waves pass from deep water into shallow water, how do the speed, wavelength and frequency change?

<table>
<thead>
<tr>
<th>Speed</th>
<th>Wavelength</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increases</td>
<td>Decreases</td>
<td>No change</td>
</tr>
<tr>
<td>Decreases</td>
<td>Increases</td>
<td>Decreases</td>
</tr>
<tr>
<td>Increases</td>
<td>Increases</td>
<td>No change</td>
</tr>
<tr>
<td>Decreases</td>
<td>Decreases</td>
<td>No change</td>
</tr>
</tbody>
</table>

4. An observer cannot see the coin in an empty glass as shown in figure (a). However, he can see the coin when the glass is filled with water as shown in figure (b).

Figure (a)  Figure (b)

The observer can see the coin in Figure (b) due to

A the total internal reflection of light
B the refraction of light
C the reflection of light
D the diffraction of light

4. A tilted basin contains water. Water is dripped at a constant rate into the basin as shown in the diagram below.

![Diagram](image)

Which pattern of the wavefronts will be observed in the basin?

A
B
C
D
5. A ray of light passes from water to air. Which labeled arrow shows the direction of the ray in air?

![Ray of light diagram]

6. Diagram 1.36 shows the side view of two ripple tanks. When the motors are switched on, water waves with the same frequency are produced.

Diagram 1.36

Diagram 1.37 shows the waves formed on the screens.

Diagram 1.37

a) What is the meaning of frequency?

b) Observe diagram 1.36 and diagram 1.37.

(i) compare the depths of the water in region X and region Y.

(ii) Compare the wavelength of the waves in region X and region Y.

(iii) Relate the depth of water to the wave length of the waves.

(iv) Name the wave phenomenon involved.

c) Explain why the wave front of the sea will follow the shape of the shore when it approaches the shore.

7. Diagram 1.38 (a) shows the wave formed without a flat piece of plastic and diagram 1.38 (b) shows the wave with a flat piece of plastic.

Diagram 1.38(a)  

Diagram 1.38(b)

a) Observe the diagram and state the difference between diagram (a) and diagram (b).

b) Using your answer, state the relationship between depth and wavelength.

c) Name the wave phenomenon involved.
Describe diffraction of waves in terms of wavelength, frequency, speed, direction of propagation and shape of waves

1. Diffraction is the ________________ when they move through a gap or around an obstacle.

2. The ________________ the gap, the more the wave ________________

3. When the width of the gap is approximately the size of the wave length of the waves, the diffracted waves ________________.

4. When the gap is much wider than the wavelength of the wave, the diffraction is ________________.

5. After diffraction, the frequency ________________, the wavelength and the speed ________________.

6. The direction of propagation of the diffracted waves ________________

Draw a diagram to show diffraction of waves

Complete the diagrams below.

![Diagram 1](image1)

![Diagram 2](image2)

![Diagram 3](image3)

![Diagram 4](image4)
Practice 1.4

1. Which of the following figure is true to show the diffraction of a water wave?

![Diagram 1.40](image)

A B

C D

2. Diagram 1.40 shows the bright and dark bands of the wave patterns formed on the screen when plane waves pass through narrow and wide gaps.

![Diagram 1.40](image)

Diagram 1.40

a) Observe Figure 1.40 compare the waves pattern and the wavelength of the waves before and after they pass through the gaps.

........................................................................
........................................................................
........................................................................
........................................................................

b) Relate the size of the gaps, the waves patterns and the wavelengths to deduce a relevant physics concept.

........................................................................
........................................................................
........................................................................
........................................................................

3. Diagram 1.42 shows waves moving towards a harbour.

![Diagram 1.42](image)

a) (i) What is the meaning of diffraction?
........................................................................
........................................................................
........................................................................
........................................................................

(ii) Draw the wave pattern of the waves after passing through the entrance of the harbour.

........................................................................
........................................................................
........................................................................
........................................................................

b) The entrance is made wider to allow more ships to enter harbour. What is the effect on

(i) The wave passing through the entrance?
........................................................................
........................................................................
........................................................................
........................................................................

(ii) The harbour?
........................................................................
........................................................................
........................................................................
........................................................................
## 1.5  ANALYSING INTERFERENCE OF WAVES

| State the principle of superposition. | The principle of superposition state .........................................................................................................................
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>complete the diagram below.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><img src="image1.png" alt="Diagram 1" /></td>
</tr>
<tr>
<td></td>
<td><img src="image2.png" alt="Diagram 2" /></td>
</tr>
</tbody>
</table>

- ................................................................................... occur when a wave peak meets a wave peak.
- ................................................................................... occur when a wave peak meets a wave trough.
Complete the diagram 1.51 below with the information given.

Diagram 1.51

a. Label \( P \) at a point of constructive interference.
b. Label \( Q \) at a point of destructive interference.
c. Draw the antinodal line and label it as \( R \).
d. Draw the nodal line and label it as \( S \).

5. In constructive interference, the resultant wave is at \( \ldots \) amplitude.

6. In destructive interference, the resultant wave is at \( \ldots \) amplitude.

7. An \( \ldots \) line is a line joining all the points where constructive interference takes place.

8. An \( \ldots \) line is a line joining all the points where destructive interference takes place.

Question 9, 10 and 11 based on diagram 1.52 and diagram 1.53.
9. The distance between consecutive antinodal lines; \( x \), in diagram 1.52 is _______________ compare to diagram 1.53.

10. The distance of between two coherent source; \( a \), in diagram 1.52 is _______________ compare to diagram 1.53.

11. When the \( x \) is _______________ (longer / shorter), the \( a \) is _______________ (longer/shorter).

12. The light interference experiment is also known as ________________________________.

13. Diagram 1.54 show the interference pattern of a light wave.

![Diagram 1.54](image)

- Bright fringes in diagram 1.54 correspond to ________________________________
- Dark fringes in diagram 1.54 correspond to ________________________________

14. In the experiment set-up for the interference of sound wave, two loud speaker are connected to the common audio signal generator to produce ________________________________.

15. Diagram 1.55 show two loud speakers placed apart from each other. A person hears alternating loud and soft sounds as he walks along XY.

![Diagram 1.55](image)

- The alternating loud and soft sounds is caused by ________________________________ of the sound waves, where the loud sound corresponds to the ________________________________ and the soft sound corresponds to the ________________________________.
\[ \lambda = \frac{ax}{D} \]

\( \lambda \) = wavelength,  
\( a \) = distance between two coherent source  
\( x \) = distance between two consecutive nodes (or antinodes)  
\( D \) = perpendicular distance from the source and the position where \( x \) is measured.

**Worked example.**

In a Young’s double-slit experiment, a light of wavelength 633 nm passes through two slits which are 0.5 mm apart. Vertical fringes are observed on a screen placed 4 m from the slits.

a) Calculate the distance between two adjacent bright fringes.

Solution:
Answer: 5.1 mm

Two loudspeakers placed 2 m apart are connected to an audio signal generator that is adjusted to produce sound wave of frequency 550 Hz. The figure shows the detection of loud and soft sound as a person moves along a line, 4.0 m from the loudspeakers.

Calculate the:

(a) Wavelength (ans: 0.6 m)  
(b) Speed (ans: 330 m s\(^{-1}\))

of the sound wave.

Solution
1. Diagram 1.56 shows the interference pattern for water waves from two coherent source, $S_1$ and $S_2$.

![Diagram 1.56]

Which of the following shows the superposition of the waves at point Y?

2. In which diagram will destructive interference occur when the wave meet?

![Diagram 1.57]

Which diagram is correct when both waves meet?

3. Diagram 1.57 shows two coherent wave propagate towards each other.

![Diagram 1.57]

4. Diagram 1.54 shows two loudspeakers connected to an audio generator. Students are standing at position where loud sounds can be heard.

![Diagram 1.54]

(a) What type of wave is the sound waves?

(b) Why are loud sounds heard by the students at that positions?

(c) The distance between the two loudspeakers is 1.5 m. At 10.0 m from the loudspeakers, the distance between two adjacent rows of student is 4.0 m. Calculate the wavelength of this sound wave.
5. Diagram 1.42 shows another modification to the harbour to overcome the heavy sea traffic problem. The wave pattern produced at the entrances is shown in diagram 1.42

![Diagram 1.42](image)

(i) The wave pattern formed is caused by the superposition of waves from two coherent sources. What is the meaning of coherent sources?

.............................................................................................................

.............................................................................................................

(ii) Describe a movement of two similar ship that are located at A and B. Explain your answer.

.............................................................................................................

.............................................................................................................

4. Diagram 1.43 shows the arrangement of apparatus for Young’s double slit experiment. A white light source is passed through a coloured filter to produce a monochromatic light. Diagram 1.44 shows the pattern of the fringe formed on the screen when a red filter is used

The experiment is repeated by using a blue filter and the fringes formed are shown in diagram 1.45

![Diagram 1.43](image)

![Diagram 1.44](image)

![Diagram 1.45](image)

What is meant by monochromatic light?

.............................................................................................................

b) Using the pattern of the fringes in figure 1.44 and 1.45, state two observation about the distance between consecutive fringes for the red light and the blue light.

.............................................................................................................

.............................................................................................................

.............................................................................................................

c) Compare the wavelength of red light to blue light.

.............................................................................................................

.............................................................................................................

d) Compare the wavelength of red light and blue light with the distance between two consecutive fringes in (b)

.............................................................................................................

.............................................................................................................
Describe sound waves

Sound waves are produced by ..................................................

Sound waves are ................................................................. (transverse waves/longitudinal waves).

Sound cannot be transmitted through a .................................................................

Loudness of a sound is dependent on its .................................................................

The louder the sound, the .................................................................

The pitch of a sound heard depends on the ............................................................

The higher the pitch of the sound, the .................................................................

1. Sound with frequency lower than 20 Hz is called ...........................................

2. Sound with frequency higher than 20000 Hz is called ........................................

3. Depth of the sea can be determined by using ................................. wave. The is wave is sent by

........................................................ from the boat to the seabed. ............................... are detected by hydrophone

next to the transmitter. The ............................... is measured and the depth will be calculated.

\[
\text{Depth of sea, } d = v \times \frac{t}{2}
\]

Worked example

In an expedition to determine the depth of a freshwater lake using an ultrasonic ruler, a pulse of

ultrasonic sound is generated and travels to the bottom of the lake and reflected by it. The time taken

by the pulse to travel to the bottom of the lake and return to the ruler is 0.35 s. If the speed of sound

in the freshwater is 1482 ms\(^{-1}\), calculate the depth of the lake. (ans: 259.35 m)
1. A thin guitar string is strummed hard. It will produce a loud and high pitch sound. The most suitable graph to represent the above situation is

2. Diagram 1.63 shows a submarine transmitting ultrasonic waves directed at a big rock on the sea bed. After 10 seconds, the submarine detects the reflected wave. Calculate the distance of the submarine from the big rock. [velocity of ultrasonic wave = 1 560 ms⁻¹]

   A. 3.9 km       D. 31.2 km
   B. 7.8 km       E. 156.6 km
   C. 15.6 km

3. Diagram 1.64 shows a stretched steel wire which produces a loud sound when the wire is plucked.

A loud sound means
A. a high speed       C. a high frequency
B. a large amplitude   D. a large wavelength

4. Which of the following corresponds to the highest pitch of sound?

5. Two notes are played on a guitar. The second is louder and has a higher pitch. The second note is

A. higher in amplitude and lower in frequency
B. higher in both amplitude and frequency
C. lower in amplitude and higher in frequency
D. lower in both amplitude and frequency
6. Diagram 1.65 shows an ultrasonic waves transmitted from a boat to the seabed to determine the depth, D, of the sea. The speed of the ultrasonic waves in water is 1 500 ms$^{-1}$. The echo of the waves is received 2.0 s after the transmission.

![Diagram 1.65](image)

What is the value of D?

A. 375 m  
B. 750 m  
C. 1 500 m  
D. 3 000 m  
E. 6 000 m

7. Diagram 1.65 shows an audio frequency generator connected to a speaker and placed near the corner of a wall. Three students, A, B and C are standing around the next corner. The generator and speaker can produce sound with the same speed but different pitch.

![Diagram 1.65](image)

a) State the physical quantity that affects the pitch of the sound.

............................................................

(b) The depth of a sea is 90 m. A ship transmits an ultrasonic wave of frequency 50 kHz to the seabed and receives an echo 0.12 s later. Calculate:

i) The speed of the ultrasonic wave in the water.

(ii) The wavelength of the ultrasonic wave in the water.

8. Diagram 1.66 shows an airport radar transmitting microwave signals. Microwave are transmitted to determine the position of aeroplane.

![Diagram 1.66](image)

a) Microwave are a type of ............... waves.

b) The radar transmits a signal at a velocity of $3.0 \times 10^8$ ms$^{-1}$ towards the aeroplane P and detects the reflected signal $4.0 \times 10^3$ s later.
Calculate the distance of P from the radar transmitter at that time.

(c) The radar detects the same signal after reflection by another aeroplane Q. The signal from Q arrives later than the signal from P.
(i) Compare the distance of P and Q from the radar.
........................................................................................
........................................................................................

(ii) State how the difference of the distance of P and Q from the radar is determined any time.
........................................................................................
........................................................................................

9. The diagram below shows a fishing boat is detecting a shoal of fish by using a sonar system which has a high frequency sound wave.

(a) State the sound wave phenomenon for detecting the shoal of fish.
........................................................................................

(b) Explain why sonar used a high frequency sound wave. [2 m]
........................................................................................

(d) Explain why does the speed of sound in water is greater than the speed of sound in air? [2 m]
........................................................................................
........................................................................................

(e) Name one application of sonar.
........................................................................................
## Analyzing Electromagnetic Waves

Describe the electromagnetic spectrum.

<table>
<thead>
<tr>
<th>Long waves</th>
<th>Short waves</th>
<th>Micro waves</th>
<th>Infra Red</th>
<th>Ultra Violet</th>
<th>X-rays</th>
<th>Gamma Rays</th>
</tr>
</thead>
</table>

Describe the properties of electromagnetic waves.

1. ________________________ consist of a group of waves with similar natures.

3. It is arranged in __________ frequencies and _______________ wavelengths.

4. Radio wave have the ___________ (longest / shortest) wavelength and _______________ (low / high) frequency waves.

5. Gamma rays have the _______________ (longest / shortest) wavelength and ___________ (low / high) frequency waves.

6. Electromagnetic waves consist of combination of __________________ (interaction / oscillating) electric and __________________ (force / magnetic) field perpendicular.

7. Electromagnetic wave is a ________________________ (transverse / longitudinal) wave.
ULTRAVIOLET RAYS  X-RAYS  GAMMA RAY

- Longest wavelength \((10^6 - 10^{-1})\) m
- Used for broadcasting and communication
- Carries along with it audio, video and other encoded information.

- Have shorter wavelength \((10^{-1} - 10^{-3})\) m
- Suitable for satellite-based communication systems, mobile phone networks
- Military uses it for spying and surveillance.

- The range of wavelength is between \(10^{-3} - 10^{-6}\) m.
- Ordinary ovens, grills and toasters use this wave to cook food.
- Can transmit information through the air to operate televisions and video recorders by remote control.
- Also used in night vision devices.

- Easily detected by human and animal eyes.
- Used in photography and can be transmitted through optical fibre

- The range of wavelength is between \(10^{-6} - 10^{-9}\) m.
- Can cause skin to tan and may result in skin cancer.
- Can kill living cells, bacteria and germs.

- The range of wavelength is between \(10^{-8} - 10^{-12}\) m.
- Widely used in the medical field.
- Used to inspect metal castings and welded joints for hidden faults.

- Shortest wavelength in the electromagnetic spectrum.
- Used in radiotherapy to treat cancer
- Used sterilisation process
1. Which of the following statements is true about electromagnetic waves?
   A. They are longitudinal waves.
   B. They are waves that require a medium to travel.
   C. The velocity of the waves is influenced by the wavelength
   D. They consist of both magnetic field and electric field.

2. What is the correct relationship between the wave length of an electromagnetic radiation and the energy it carries.

<table>
<thead>
<tr>
<th>Wave length</th>
<th>Energy carried</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Short</td>
<td>High</td>
</tr>
<tr>
<td>B. Short</td>
<td>Low</td>
</tr>
<tr>
<td>C. Long</td>
<td>High</td>
</tr>
<tr>
<td>D. Long</td>
<td>Low</td>
</tr>
</tbody>
</table>

3. Diagram 1.7 shows an electromagnetic spectrum.

   Diagram 1.7

   The waves at P,Q,R and S are

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>Ultraviolet</td>
<td>X-ray</td>
<td>Microwave</td>
</tr>
<tr>
<td>Q</td>
<td>X-ray</td>
<td>Ultraviolet</td>
<td>Infrared</td>
</tr>
<tr>
<td>R</td>
<td>Microwave</td>
<td>Infrared</td>
<td>Ultraviolet</td>
</tr>
<tr>
<td>S</td>
<td>Infrared</td>
<td>Microwave</td>
<td>X-ray</td>
</tr>
</tbody>
</table>

4. At an airport, a passenger’s bag is placed in the baggage scanner.

5. Which is the correct arrangement of electromagnetic waves in order of increasing frequency?
   A. Infrared rays, Microwaves, Gamma rays, Ultraviolet rays.
   B. Gamma rays, Ultraviolet rays, Infrared rays, Microwaves.
   C. Microwaves, Infrared rays, Ultraviolet rays, Gamma rays.
   D. Ultraviolet rays, Gamma rays, Microwaves, Infrared rays.

6. Figure 1.8 (a) shows the x-rays film of a patient. Figure 1.8 (b) shows the microwave from the satellite used in communication.

   Figure 1.8 (a)                           Figure 1.8 (b)

   a) Observe the figures and state two similarities between the waves.

   ..........................................................
b) Which group does these two waves belong to?

.................................................................................................
.................................................................................................

c) Name one other wave that has the same properties.

.................................................................................................

d) Microwaves travel at a speed of $3.0 \times 10^8 \text{ms}^{-1}$ in a vacuum and have a frequency of $15 \times 10^{10} \text{Hz}$.

i) Calculate the wavelength of these microwaves.