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COURSE GUIDE

SED 223
GENERAL PHYSICS FOR INTEGRATED SCIENCE II

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MODULE 1 MECHANICS

UNIT 1 PHYSICAL QUANTITIES

CONTENTS

1.0 INTRODUCTION

By now you have read the course guide which is part of your instructional package for this course. If you have not, please ensure that you read the course guide before reading your course material as it provides a comprehensive outline of materials you will cover on a study unit basis. The unit will guide you through fundamental and derived physical quantities, dimensional representations of physical quantities, units of physical quantities, Basic measuring instruments for fundamental physical quantities.

2.0 OBJECTIVES

At the end of the unit, you should be able to:

- Differentiate between fundamental and derived physical quantities.
- Give the fundamental quantities and the derived quantities with their units.
- Give the dimensional representations of physical quantities units of physical quantities

- Name basic measuring instruments for fundamental physical quantities.

3.0 MAIN CONTENT

3.1 Fundamental Quantities

The study of Physics is based on exact measurements, every such measurement demands two things: first a number or quantity, and secondly a unit, for instance, 50 seconds as the time of a race.

There are three Fundamental Physical Quantities in Nature. These are mass, length and time. In an attempt to have meaningful interpretation of physical quantities, they are usually expressed in acceptable physical units. The internationally accepted physical units upon which the three quantities are based are kilogram (Kg), metre (m), and second (s) respectively and are known as fundamental units, otherwise referred to as S.I units (i.e International Standard Units).

3.2 Derived Physical Quantities

Derived quantities are derived of two or all three combinations of the fundamental physical quantities, ditto the units. For instance, the speed of a moving body which is given by distance over time (i.e Speed $= \frac{distance}{time} = \frac{metre}{second}$) is a derived of the combination of length and time. Hence, speed is referred to as a derived physical quantity. Some other examples of Derived physical quantities include:

a) Acceleration $= \frac{Change\ in\ velocity}{time}$

$$\frac{metre}{second} = \frac{m}{s^2}$$

b) Force = Mass × Acceleration $= kg\ .\ \frac{m}{s^2}$ = Newton

c) Work = Force × distance = mass × acceleration × distance

$$= Kg\ .\ \frac{m}{s^2}\ .\ m = \text{Joule}$$

d) Energy = Force × distance = mass ×acceleration × distance

$$= Kg\ .\ \frac{m}{s^2}\ .\ m = \text{Joule}$$

e) Power $= \frac{Work}{time} = \frac{Force\ \times\ distance}{time}$

$$= \frac{Newton \times metre}{second}$$

$$= \text{Watt}$$

SELF-ASSESSMENT EXERCISE

1) Distinguish between fundamental and derived quantities. Give three examples of each with their units.
2) Derive the S.I units for the following physical quantities:-
   i. Energy
   ii. Pressure
   iii. Momentum
   iv. Power

3.3 Dimensional Representations of Physical Quantities

Dimensional representations of the fundamental physical quantities are: M for mass: L for length and T for time. This implies that MLT are dimensional representations of the three fundamental quantities.
The dimensional representations of some of the selected derived physical quantities are given as follows:-

a. Velocity $= \frac{distance}{time} = \frac{Lenght}{time} = \frac{L}{T} =$ LT^{-1}

b. Acceleration $= \frac{Change\ in\ velocity}{time} = \frac{Lenght}{time \times time} = \frac{L}{T^2}$ $= LT^{-2}$

c. Force = Mass × Acceleration = mass $\times \frac{Lenght}{time \times time}$ $= M\,LT^{-2}$

d. Work = Force × distance = mass $\times \frac{Lenght}{time \times time} \times Lenght$

$= M\,L^2T^{-2}$

SELF ASSESSMENT EXERCISE

Obtain the dimensional representations for the following physical quantities:
1) Acceleration
2) Weight
3) Work
4) Momentum.

3.3 Basic measuring instruments for fundamental physical quantities

Mass may be measured using: Lever balance, Chemical balance, 'Butchers' balance e.t.c.

Length is normally measured using metre rules. However, for small lengths such as the diameter of a piece of wire, vernier sliding calipers or micro-metre screw guage may be accurately used.

Time may be measured using stop-clocks, watches or other devices which rely on some kind of constant repeating oscillations.

4.0 CONCLUSION

In this unit, you have learnt about fundamental and derived physical quantities, dimensional representations of physical quantities, units of physical quantities, Basic measuring instruments for fundamental physical quantities. From these discussions you are well equipped with the content of the physical quantities aspect of integrated science, and would be able to teach it better.

5.0 SUMMARY

A summary of the major points in this Unit is that:

- There are three Fundamental Physical Quantities in Nature.
- The internationally accepted physical units upon which the three quantities are based is called fundamental units.
- Derived quantities are derived of two or all three combinations of the fundamental physical quantities, ditto the units.
- Discussion was provided on Dimensional Representations of Physical Quantities
- The basic measuring instruments for fundamental physical quantities were also discussed.

6.0 TUTOR-MARKED ASSIGNMENT

What are the best instruments for measuring?

i. Length of a simple pendulum
ii. Diameter of a metal rod
iii. Thickness of the central portion of a thin converging lens
iv. Internal diameter of a test-tube
v. Diameter of a spherical metal bob

7.0 REFERENCES/FURTHER READING

Anyakoha, M. W. (2008). New school physics for senior secondary schools. Revised edition: AFP Africana First Publishers Limited.

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UNIT 2 POSITION, DISTANCE AND DISPLACEMENT

CONTENTS

1.0 INTRODUCTION

The position of a point in space is determined by its distance and direction from other points. The statement of position is accomplished by means of a frame of reference or a point of reference, which is called the origin.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

i. Explain Frame of reference
ii. Locate the Position of an object
iii. Explain Displacement
iv. Explain Distance
v. Distinguish between Displacement and Distance.

3.0 MAIN CONTENT

3.1 Frame of Reference

Is that point or **land mark** which enables us to know that the position of an object has changed. Thus every measurement must be made with respect to such points known as frames of reference.

3.2 Position

Position is determined by its distance and direction from other points. The statement of position is accomplished by means of a frame of reference.

3.3 Distance

Distance **i**s how far the object has moved, without showing us the direction. It is a scalar quantity that only shows the magnitude, and not the direction. Therefore, knowing the distance alone is not enough to tell us where or in what direction the object has moved.

3.4 Displacement

Is the distance travelled in a specified direction. It is a vector quantity, thus has magnitude and direction. Knowing the distance alone is sufficient to tell us where or in what direction the object has moved.

SELF ASSESSMENT EXERCISE

Give five examples each for *distance* and *displacement.*

3.5 Distinction between Distance and Displacement

Imagine a person walking 700m to the east, and then turning around and walking back (west) a distance of 500m, the total ***distance*** travelled is 1200m but the ***displacement*** is only 200m since he is now only 200m from the starting position.

4.0 CONCLUSION

It will however be impossible to determine the change of position without a ***frame of reference*** which we shall have assumed to be at rest.

5.0 SUMMARY

In this unit you have learnt the following:

- Frame of reference
- The Position of an object
- Displacement
- Distance
- The differences between Displacement and Distance.

6.0 TUTOR-MARKED ASSIGNMENT

A car travels 15km due east on a straight road and then 20km due north before finally comes to rest. Find the resultant displacement of the car.

7.0 REFERENCES/FURTHER READING

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UNIT 3 DISPLACEMENT, SPEED AND VELOCITY

CONTENTS

1.0 INTRODUCTION

Motion involves a change of position of a body with time. Therefore in describing the motion of a body, we consider the displacement, velocity and acceleration of the body.

2.0 OBJECTIVE

At the end of this unit, you should be able to explain the concept of speed, velocity, displacement, and acceleration.

3.0 MAIN CONTENT

3.1 Displacement

This is the distance between two points as a result of change in position in a certain direction. It is a vector quantity and the unit is metre.

3.2 Speed

Speed is the distance travelled in unit time. It is a scalar quantity.
If a car travels 600km from Mary land to Victoria Island in 5 hours, its average speed is $600\,{km}/{5\,hr} = 120\,{km}/{hr}.$

The speedometer would certainly not read 120 ${km}/{hr}.$

for the whole journey but might vary considerably from this value. This is why we state the average speed. If a car could travel at constant speed of 120 $^{km}/_{hr}$ for 5hours, the distance covered would still be 600 km. It is always true that

$$\text{AVERAGE SPEED} = \frac{DISTANCE\ MOVED}{TIME\ TAKEN}$$

The SI unit of distance is metre, that of time is second. Thus the SI unit of speed is metre per second (ms^{-2}). Other multiples of that unit are centimeters per second and kilometers per hour.

3.3 Velocity

Speed has been defined as "the distance travelled in unit time", velocity is the distance travelled in unit time in a stared direction. Thus, velocity is a vector quantity.

If two cars travelled due north at 60 $^{km}/_{hr}$, they have the same speed of 60 $^{km}/_{hr}$ and the same velocity of 60 $^{km}/_{hr}$ due north.

If one travels north and the other south, their speeds are the same, but their velocities differ since their directions of motion are different. Speed is a scalar and velocity is a vector quantity.

$$\text{VELOCITY} = \frac{DISPLACEMENT}{TIME\ TAKEN}$$

The unit of speed and velocity are the same e.g. $^{km}/_{hr}$, $^{metre}/_{second}$

$$60\ ^{km}/_{h} = \frac{60000\ m}{3600\ s} = 17\ ^{m}/_{s}$$

3.4 Acceleration

When the velocity of a body changes we say it accelerates. If a car starting from rest and moving due north has velocity 2 $^{m}/_{s}$
After 1 second, its velocity has increased by 2 $^{m}/_{s}$ due north. We write this as 2 $^{m}/_{s^{-2}}$. Acceleration is the change of velocity in unit time.

$$\text{Acceleration} = \frac{Change\ in\ velocity}{The\ time\ taken\ for\ change}$$

$$= \frac{metre}{second} = \frac{m}{s^2}$$

For a steady increase of velocity from 40 $^{km}/_{h}$ to 70 $^{km}/_{h}$ in 5s

$$\text{Acceleration} = \frac{(70 - 40)^{km}/_{h}}{5s} = 6\ ^{km}/_{h}\ \text{per second}$$

Acceleration is also a vector and its magnitude and direction should be stated.

SELF-ASSESSMENT EXERCISE

Calculate the distance covered for the last 1 second of a motion, if the car starts from rest and moves with a uniform acceleration of 20 ms^{-2} for 10 seconds.

4.0 CONCLUSION

The concept of speed and velocity are often used interchangeably. Therefore it is important to know that in speed, no direction is specified, but in velocity, it is necessary to specify direction.

5.0 SUMMARY

In this unit you have learnt about the following:

- The concept and definition of speed, velocity, displacement, and acceleration
- The application of the formula of each of the concept in solving problems.

6.0 TUTOR-MARKED ASSIGNMENT

A car travels for 3 hours to a distant city 200 km due East. What was its (1) speed (2) Velocity?

7.0 REFERENCES/FURTHER READING

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UNIT 4 VECTORS AND SCALAR QUANTITIES

CONTENTS

1.0 INTRODUCTION

Quantities in Physics can either be classified as *scalars* or *vectors*. These classes of physical quantities are usually handled differently when used in numerical calculations.

2.0 OBJECTIVES

At the end of this unit, you will be able to:

- Explain the concept of scalars and vector
- Distinguish between scalar and vector quantities.
- Explain the meaning of the resultant of two vectors
- Solve simple problems involving resolution and addition of vectors using analytical and graphical methods.

3.0 MAIN CONTENT

3.1 Concept of Scalar

Physical quantities that only have numerical value attached to them are known as scalars or scalar quantities. Such quantities are only described when only their magnitude or sizes are known. Examples of such quantities are *distance, mass, speed, time, and temperature.*
Scalar quantities are the quantities that have only magnitude but no direction.

3.2 Concept of Vectors

Physical quantities that have both magnitude or numerical value and also specified direction are known as *vector quantities.* Therefore, a vector quantity can only be completely described when magnitude and direction are mentioned. Examples are force, weight, momentum, electric field, displacement.
A *vector quantity* has both magnitude and direction.

3.3 Addition of Vectors

Consider two vectors of magnitude say ***P = 40N*** and ***Q = 30N*** acting on a body *O.*

1. If two vectors are acting in the same direction, the resultant force will be:
   R = P + Q = 40 + 30 = 70N

2. If the two vectors are acting directly in opposite direction, the resultant force will be :
   R = P – Q = 40 – 30 = 10N
3. If two equal forces ***P*** and ***P*** act in directly opposite directions, the resultant forces will be :
   R = P – P = 0

SELF ASSESSMENT EXERCISE

A vector of magnitude 20 units in the west direction is combined with another vector to give a zero resultant. What is the other vector?

3.4 The resultant vector

A situation where the two vectors are inclined to each other, the resultant cannot be an arithmetic sum, but a vector sum. Solution to this can be done through the use of ***parallelogram law of forces*** and ***trigonometry*** or ***scale-drawing*** to obtain the resultant.

The resultant vector is that single vector which would have the same effect in magnitude and direction as the original vectors acting together.
The **parallelogram law** *of forces states that if two forces acting at a point are represented in magnitude and direction by the sides of the parallelogram drawn from that point, their resultant is represented in magnitude and direction by the diagonal of the parallelogram drawn from the point.*

4.0 CONCLUSION

From our discussion in this unit it is evident that mathematical operation on both the vector and scalar quantities are done differently.

5.0 SUMMARY

In this unit you have been exposed to the following:

- Concept of Scalar
- Concept of Vectors
- Addition of Vectors
- The resultant vector
- Resolution of Vectors

6.0 TUTOR-MARKED ASSIGNMENT

A man walks 1 km due west and then 1 km due north. Determine his displacement?

7.0 REFERENCES/FURTHER READING

Anyakoha, M. W. (2008). New school physics for senior secondary schools. Revised edition: AFP Africana First Publishers Limited.

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UNIT 5 MOTION

CONTENTS

1.0 INTRODUCTION

Motion is a change in position of a body with time, which involves how things move and what makes them to move. Description of how objects move without regard to force causing the motion is known as Kinematics. While, description of why objects move as they do is refer to as Dynamics.

2.0 OBJECTIVES

At the end of the unit, you should be able to:

- distinguish between the types of motion
- solve some problems in velocity and acceleration in uniform rectilinear motion.
- solve problems in Motions in vertical plane
- state and explain the Newton's laws of motion

3.0 MAIN CONTENT

3.1 Types of motion

3.1.1 Random motion

This is a motion that does not follow any definite pattern, e. g motion of gas molecules in a container.

3.1.2 Rotational motion

This is the motion of a body in a circular path about a fixed point, e.g rotating wheel.

3.1.3 Oscillatory Motion

This is to and fro motion of a body about a given point, e.g. a swing.

3.1.4 Translational Motion

This is the movement of a body in such a way that all points are moved in parallel directions through equal distances, e.g. a car moving in a straight road.

SELF ASSESMENT EXERCISE

List four types of motion and give three examples each.

3.2 Equations of motion

Equations for uniform acceleration
Problems on bodies moving with uniform acceleration can often be solved quickly using the equations of motion.

First equation: If a body is moving with uniform acceleration ***a*** and its velocity increases from ***u*** to ***v*** in time ***t***, then

$$\boldsymbol{a} = \frac{Change\ in\ velocity}{The\ time\ taken\ for\ change} = \frac{v - u}{t}$$

$$\therefore\ \boldsymbol{at} = \boldsymbol{v} - \boldsymbol{u}$$

Or v $= u + at$……………………………………………………(1)

Note that the initial velocity *u* and the final velocity refer to the start and the finish of the timing and do not necessarily mean the start and finish of the motion.

Second equation: The velocity of a body moving with uniform acceleration increases steadily. Its average velocity therefore equals half the sum of its initial and final velocities, that is

Average velocity = $\frac{u + v}{2}$

From (1) $v = u + at$

$\therefore$ Average velocity = $\frac{u+u\,at}{2} = \frac{2u+at}{2} = u + ½at$

If s is the distance moved in time t,

then since average velocity = $distance/_{time} = \frac{s}{t}$

$\frac{s}{t} = u + ½at$

$\therefore s = ut + ½at$ ………………………………………………(2)

Third equation: This is obtained by eliminating t from equations (1) and (2). We have

$v = u + at$

$v^2 = u^2 + 2uat + a^2t^2$

$= u^2 + 2a\ (ut + ½at^2)$

But $s = ut + ½at^2$

$\therefore v^2 = u^2 + 2as$……………………………………………………(3)

If we know any three of *u*, *v*, *a*, *s*, and *t*, the others can be found from the equation.

SELF-ASSESSMENT EXERCISE

A cyclist starts from rest and accelerates at $1m/s^2$ for 20 seconds. He then travels at a constant speed for 1 minute and finally decelerates at $2m/s^2$ until he stops. Find his maximum speed in km/h and the total distance covered in metres.

3.3 The three laws of motion

The three Laws of motion, called Newton's laws of motion were stated by Sir Isaac Newton.

Newton's First Law of Motion

The first law states that every object continues in its state of rest or of uniform motion in a straight line unless acted upon by an external force. This law shows that inertia is inherent in a body at rest or the one moving with a constant velocity. Inertia is a property of matter. Mass is a measure of inertia, the more massive an object is, the more inertia it has.

Newton's Second Law of Motion

The second law of motion states that the rate of change of momentum is proportional to the impressed force and takes place in the direction of that force.

Mathematically, it can be defined as:

$F \propto \frac{change\ in\ momentum}{time\ taken\ for\ the\ change}$

$F \propto \frac{mv - mu}{t}$

Where *m*, *u*, *t* are the mass, initial velocity, final velocity and the time respectively of motion of the body acted upon by a force F; and the product of *m* and *v* is called the momentum.

$F \propto m(\frac{v-u}{t})$

$F \propto ma$

Where $(\frac{v-u}{t})$ = acceleration, ***a***

Thus

$F = kma$

Where *k* is constant and is 1.

Hence,

F = ma

In the SI system, F is in Newton, M is in kilogram and acceleration, ***a***, is in metre per square second (ms^{-2}).

Newton's Third Law of Motion

The third law of motion states that Action and Reaction are equal and opposite. Or to every action there is an equal and opposite reaction

3.4 Motion in a vertical plane

An object thrown upward experiences retardation due to the gravitational attraction of the earth which act to pull the object downward. The ball will thus gradually lose speed as it moves upwards until it comes to rest briefly at the highest point and begins to fall downwards. As it falls its speed gradually increases because of the acceleration due to gravity ($g = 9.8ms^{-2}$)

As the object is moving upwards its acceleration is −g, because its motion is in opposite direction to the gravitational attraction on the body. When the object moves downwards, the acceleration is taken as +g because motion is in the same direction as the direction of the gravitational attraction of the earth on the body.

The equations of motion for a body moving vertically upward or downward (i.e under gravity) are obtained by replacing ***s*** and ***a*** of equation (1) to (3) by ***h*** and ***g*** where ***h*** is the height of the object above the ground and ***g*** is the acceleration due to gravity. When the body moves upwards $a = -g$, when it moves downward, $\boldsymbol{a = g}$. Thus the equations of motion under gravity are:

Downward motion

$V = u + gt$

$h = ut + ½gt$

$v^2 = u^2 + 2gh$

Upward motion

$V = u - gt$

$h = ut - ½gt$

$v^2 = u^2 - 2gh$

Where u = initial velocity; v = final velocity; a = acceleration; t = time taken;

g = acceleration due to gravity; h = height; s = distance or displacement.

4.0 CONCLUSION

We have discussed types of motion that exist, and also derived some useful relations between velocity, displacement and time. Effect of 'acceleration due to gravity' on objects in vertical motion were also dealt with. We derived equations of motion and also state the laws of motion.

5.0 SUMMARY

In this Unit you have learnt:

- Types of motion
- Rectilinear motion Displacement, velocity, acceleration
- Motion in vertical plane
- Laws of motion

6.0 TUTOR-MARKED ASSIGNMENT

i. Calculate the acceleration, if an unbalance force of 40N acts on a 4.0kg mass.

ii. A ball of mass 0.6kg, moving at a velocity of $20ms^{-2}$ is suddenly hit by a force of 5n for a time of 0.03 sec. Find its new velocity of motion.

7.0 REFERENCES/FURTHER READING

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MODULE 2 HEAT

UNIT 1 HEAT AND ITS MEASUREMENT

CONTENTS

1.0 INTRODUCTION

It is important for you not to confuse the temperature of a body with the heat energy that can be obtained from it. Know that temperature decides the direction in which heat flows.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- define and explain the concept of heat
- explain the temperature scale of thermometer
- explain what a thermometer is
- list the differences between various forms of thermometer

3.0 MAIN CONTENT

3.1 Heat

Heat is a form of energy that is transferred from one part of a system to another or to another system by virtue of a difference in temperature.

Heat can also be defined as a measure of the total internal energy of a body. It is a form of energy due to a temperature difference. The unit of heat is the Joule.

3.2 Temperature scales

A scale and unit of temperature are obtained by choosing two temperatures, called the *fixed points*, and dividing the range between them into a number of equal divisions or *degrees*.

On the Celsius scale (named after the Swedish scientist who suggested it), *the lower fixed point is the temperature of pure melting ice* and is taken as 0°C.

The upper fixed point is the temperature of the steam above water boiling at normal atmospheric pressure of 760mmHg and is taken as 100°C.

The difference in temperature between the two temperature points is called the *Fundamental Interval* of a thermometer. The calibration of this interval depends on the temperature scale chosen. There are three types of scales in current use

- The *Celsius scale*
- *The Fahrenheit scale* and
- *The Absolute (or thermodynamic or Kelvin) scale.*

The lower and upper fixed points are 0^{o}C and 100^{o}C for the Celsius scale; 32^{o}F and 212^{o}F for Fahrenheit. The fundamental interval in the Celsius scale is divided into 100 equal parts, each part of which defines 1^{o}C in this scale. For Fahrenheit scale, the fundamental interval is divided into 180 units or degree (^{o}F).

The S.I. unit of temperature is the Kelvin (K) and its scale is called the Absolute or Thermodynamic temperature scale. The Fundamental interval for the Kelvin scale goes from a lower fixed point of 273K to an upper fixed point of 373K. Temperatures on this scale are not measured in degrees but in units called Kelvin (K). The lower fixed point or the zero on the Kelvin scale is equal to -273^{o}C. It is called the absolute zero.

3.3 Triple Point of Water

It is the temperature at which solid ice, liquid and water vapour coexist in thermal equilibrium at the same temperature and pressure. By international convention, the triple point of water is 273.16K and this value is a standard fixed-point temperature ***(T_3)*** for the calibration of thermometers.

$$T_3 = 273.16K$$

Other fixed-point temperatures besides T_3 are boiling point of water, and absolute zero temperature. The boiling point of water is 100^0C while the absolute zero temperature (0 K) is the all gas has zero volume.

Conversion between Temperature scales

There is possibility of changing from one temperature scale to another. The conversion formulas are listed below

3.4 Kelvin scale to Celsius Temperature Scales

The relation between Kelvin scale and Celsius scale is

$$T_c = (T - 273.15)\ ^0C$$

Where T_c is the temperature in degree centigrade, and T is the temperature in Kelvin.

3.5 Kelvin Temperature scale

The relation between Celsius scale and Kelvin scale is

$$T = (T_c + 273.15)K$$

Where T_c is the temperature in degree centigrade, and T is the temperature in Kelvin.

Fahrenheit Temperature scale

The relation between Celsius scale and Fahrenheit scale is

$$T_F = \frac{9}{5}T_c - 32,$$

Where T_c is the temperature in degree centigrade, and T_F is the temperature in Fahrenheit.

SELF-ASSESSMENT EXERCISE

1) Explain what is meant by triple point of water.
2) Differentiate between heat and temperature.

4.0 CONCLUSION

The property of an object determines the way heat energy will flow when it is placed in contact with another object.

5.0 SUMMARY

In this unit we have learnt about:

- Basic concept of heat
- Measurement of heat
- Temperature scales

6.0 TUTOR-MARKED ASSIGNMENT

i. Discuss the process of calibrating a thermometer.

ii. The lower and upper fixed points of a certain thermometer are 30cm apart. At a certain day, the length of mercury thread in the thermometer is 9cm above the ice point (0^0C). What is the temperature recorded by the thermometer in (a) Celsius scale (b) Kelvin scale.

7.0 REFERENCES/FURTHER READING

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UNIT 2 THERMOMETER

CONTENTS

1.0 INTRODUCTION

2.0 OBJECTIVES

3.0 MAIN CONTENT

3.1 Thermometer

Is the instrument used to gauge accurately the exact degree of hotness (i.e Temperature) in a body. There are different kinds of thermometers, each type being more suitable than another for a certain job.

3.2 Types of Thermometer

S/N	Types of Thermometer	Thermometric substance	Physical properties
1	Liquid –in –glass Thermometer	Mercury or Alcohol	Change in volume of liquid with temperature
2	Gas thermometer	Gas	Change of gas pressure at constant volume with temperature
3	Resistance thermometer	Resistance wire	Change in the electrical resistance of wire with temperature.
4	Thermocouple	Two dissimilar metals (e.g. copper and constatan)	Change in electric potential difference (or current) between

			two metal junctions at different temperatures.
5	Bimetallic thermometer	Two dissimilar metals (e.g. iron and copper)	The differential expansion of the two metals of the bimetallic strip.

3.3 Clinical Thermometer

This is a form of mercury-in glass thermometer used in the hospitals for measuring the temperature of human body. The temperature of a normal healthy person is about 37^oC but it may rise to about 41^oC in case of high fever. The temperature range of the clinical thermometer is between 35^oC to 43^oC.

4.0 CONCLUSION

The basis for working of thermometer is the variations in physical properties of materials with temperature. Those properties being used for the construction of thermometers are called thermometric properties and thermometers are named after these properties.

5.0 SUMMARY

In this unit we have learnt about:

- Thermometers
- Types of thermometers
- Clinical thermometer

6.0 TUTOR-MARKED ASSIGNMENT

Explain the differences between ***Liquid –in-glass thermometer*** and ***bimetallic thermometer.***

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UNIT 3 HEAT AND WORK

CONTENTS

1.0 INTRODUCTION

In the previous unit, heat has been described as energy, and energy has the ability to do work. The demonstration of what you shall learn in this unit.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain heat engine
- explain The basic operation of heat engine
- explain Thermodynamic Efficiency ***e*** of Real Engine.

3.0 MAIN CONTENT

3.1 Heat engine

A heat engine is a device used to convert thermal energy (i.e heat) into mechanical work and then exhausts the heat which cannot be used to do work.

3.2 Basic Operation of Heat Engine.

The working body absorbed heat from the hot reservoir at relatively high temperature. Part of the absorbed heat is used by the working body to do mechanical work. The unused energy is then ejected as heat at lower temperature. The process converts thermal energy to mechanical work by heat engine.

Heat engine comprises of two heat reservoir, one hot at $\mathbf{T_H}$ and the other cold at $\mathbf{T_C}$. The interaction between these two reservoirs and the working body leads to the conversion of *heat energy* to *mechanical energy*. Also, the working body absorbs heat $\mathbf{Q_H}$ at temperature $\mathbf{T_H}$, uses part of it to do mechanical work, and then ejected the unused heat energy ($\mathbf{Q_C}$) at temperature $\mathbf{T_C}$ through the cold reservoir.

SELF-ASSESSMENT EXERCISE

Explain the working principle of a heat engine

3.3 Thermodynamic Efficiency *e* of Real Engine.

The efficiency of a heat engine is

$$\mathbf{E} = \frac{W}{Q_H} = \frac{\text{work output}}{\text{heat in}} \qquad \textbf{(1)}$$

The efficiency **E** measures the fraction of heat pumped into the working body that is converted to mechanical work by the working body. The efficiency of real heat engines is always less than unity.
The changes in energy of the working body are related to the changes in the thermodynamic properties. Using the combined first and second laws of thermodynamics,

$$dU = TdS - PdV = dQ - dW \qquad (2)$$

where ***dQ*** is the heat into the working body and ***dW*** is the mechanical work(work output). But the working body operates in a cycle (i.e cyclic process), returning the system back to its initial state.

4.0 CONCLUSION

Heat engines are devices used to convert heat energy to mechanical work.

5.0 SUMMARY

In this unit, you have learnt that heat energy can be use to do some work as demonstrated by heat engine.

6.0 TUTOR-MARKED ASSIGNMENT

Explain the "Thermodynamic Efficiency *e* of Real Engine"

7.0 REFERENCES/FURTHER READING

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UNIT 4 HEAT CAPACITIES

CONTENTS

1.0 INTRODUCTION

In the previous units, you have learnt that heat is a form of energy that is transferred from a hot object to a cooler one as a result of their temperature difference. Such energy always flows from the hot object to the cold object. Heat energy can be referred to as thermal energy, and like the other forms of energy, it is measured in *Joules.*

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain Specific Heat Capacity of a body
- define Heat capacity of a body
- explain Latent heat
- define Specific latent heat of fusion
- explain Latent heat of vaporization
- definition of Specific latent heat of vaporization
- apply the formula to solve some related problems.
- calculate unknown quantities using the relation $\boldsymbol{H = mc\Delta T}$ when no change of state is involved

3.0 MAIN CONTENT

3.1 Specific Heat Capacity of a body

Specific Heat Capacity of a body (c) of a substance is the quantity of heat required to raise the temperature of unit mass of the substance by 1^{o}C.

In symbols,

$$c = \frac{H}{m\theta} \qquad (1)$$

where H is in joules, m in kg and θ in ^{o}C or k then the unit of specific heat capacity is Joules per kilogram per Kelvin (J/kg.K).

If we consider the quantity of heat required to raise the entire mass of the body by 1K instead of just 1kg of the mass, the heat involved is known as heat capacity or thermal capacity.

3.2 Thermal Capacity or Heat Capacity

Thermal capacity or Heat capacity (*Cp)* of a body is the quantity of heat required to raise the temperature of the body by 1 K.
The unit of thermal or heat capacity is joules per Kelvin (J/K).
Heat capacity = specific heat capacity × mass.

Thus from equation (1),

$$H = mc\Theta = Cp\Theta \qquad (2)$$

SELF-ASSESSMENT EXERCISE

Calculate the heat required to raise the temperature of 20kg of aluminum by 10K, assuming that the specific heat capacity of aluminum is 900J/kg K.

3.3 Latent Heat

When a solid is heated, it may melt and change its state from solid to liquid. If ice is heated it becomes water. The opposite process of freezing occurs when a liquid solidifies.

A pure substance melts at a definite temperature, called the *melting point*: It solidifies at the same temperature-*the freezing point.*

During solidification a substance loses heat to its surroundings but its temperature does not fall. Conversely, when a solid is melting, the heat supplied does not cause a temperature rise. For example, the temperature of a well-stirred ice-water mixture remains at 0^{o}C until all ice is melted.

Heat which is *absorbed* by a solid during melting or *given out* by a liquid during solidification is called ***latent heat of fusion.***

3.4 Definition of Specific Latent Heat of Fusion

The specific latent heat of fusion of a substance is the quantity of heat needed to change unit mass from solid to liquid without temperature change.

It is measure in J/kg or J/g.
The heat involved (H), the mass (m), and the specific latent heat of fusion (l) are related by the formular:
$H = ml$

3.5 Latent heat of vaporization

Latent heat is also needed to change a liquid into a vapour. The reading of a thermometer in boiling water remains constant at 100^{o}C even though heat called *latent heat of vaporization* is still being absorbed by the water from whatever is heating it.
When steam condenses to form water, latent heat is given out. This is why a scald from steam may be more serious than one from boiling water.

3.6 Definition of Specific Latent Heat

The specific latent heat of vaporization of a substance is the quantity of heat needed to change unit mass from liquid to vapour without change of temperature.

The quantity of heat, H, required for vaporization of mass m is given by:
$H = ml$

SELF-ASSESSMENT EXERCISE

How much heat is required to change 3 kg of ice at 0^{o}C to water at the same temperature. Specific latent heat of fusion of ice = 336000J/kg

4.0 CONCLUSION

A substance can exist in any of the three states of matter, the state in which a substance exist depends on its temperature.

5.0 SUMMARY

In this unit you have leant about the following:

- Specific Heat Capacity of a body
- Definition of Heat capacity of a body
- Explanation on Latent heat
- Definition of Specific latent heat of fusion
- Explanation on Latent heat of vaporization
- Definition of Specific latent heat of vaporization
- Calculate unknown quantities using the relation $\boldsymbol{H = mc\Delta T}$ when no change of state is involved

6.0 TUTOR-MARKED ASSIGNMENT

If 1.13×10^6 J of heat energy is required to convert 0.5 kg of steam to water, calculate the specific latent heat of steam.

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UNIT 5 HEAT TRANSFER

CONTENTS

1.0 INTRODUCTION

It was stated that heat flows from a body at a higher temperature to another at a lower temperature. This transfer of heat can happen in three ways: *conduction, convection, and radiation.*

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- mention and discuss the three (3) methods / process of heat transfer.
- write the useful equations for the heat transfer.

3.0 MAIN CONTENT

3.1 Methods of heat transfer

The transfer of heat from one part of a system to another or to another system by virtue of a temperature difference can only be by one or more of the three processes namely; *conduction, convection, and radiation.* Each of these mechanisms or processes is discussed in the preceding sections.

3.2 Conduction

Conduction is the process of heat transfer whereby heat is transferred directly through a material *without any bulk movement* of the material.

3.3 Conductors and insulators

Materials can be divided into groups based on their ability to conduct thermal energy namely; thermal conductor and thermal insulator.

Thermal Conductors are the materials that conduct heat well. Examples are metals (most metals are conductors) like gold, silver, iron, and aluminum.

Thermal Insulators are the materials that conduct heat poorly. Examples are glass, wood, and most plastics. These materials poorly conduct heat energy because their molecules are not free to move and the materials do not contain free electrons.

SELF-ASSESSMENT EXERCISE

Give five examples each for *Thermal conductors and Thermal insulators.*

3.4 Convection

This is the process in which heat energy is transferred from place to place by the bulk movement of a fluid. Movement current in liquid is a good of this example.

3.5 Radiation

This is a process in which energy is transferred by means of electromagnetic waves. A good example of this is the solar radiation from the sun travelling in all directions in space. Part of this radiation is reaching the earth on daily basis and in actual sense; the bulk of energy on earth is from the sun. All bodies, hot or cold, continuously radiate energy in form of electromagnetic waves. But the amount of this radiation is proportional to the body and the nature of its surface.

4.0 CONCLUSION

The three mechanism of heat transfer are conduction, convection, and radiation. Heat can be transferred in or out of a system by one or more of these three mechanisms.

5.0 SUMMARY

In this unit you have learnt that:

- Heat is a form of energy that can be transferred from one body to another.
- Heat can be transferred by three main mechanisms.

6.0 TUTOR-MARKED ASSIGNMENT

Name and explain the main methods of heat transfer.

7.0 REFERENCES/FURTHER READING

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MODULE 3

UNIT 1 PROPERTIES OF MATTER

1.0 INTRODUCTION

Attempt to develop the concept of matter involves making propositions and developing hypothesis, from such hypotheses, theory of matter emerges. The first step is to know the properties of matter.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- define of matter
- state the characteristics of solid
- state the characteristic of liquid
- state the characteristic of Gas
- explain the elastic property of solid
- explain the elastic property of liquid

3.0 MAIN CONTENT

3.1 Concept of matter

Matter exists as living and non-living entity. The three states of matter are *solid*, *liquid* and *gas.* Matter takes its own shape when in solid form. It takes the shape of the container as liquid (and flow when poured) and occupies all available space as gas.

Definition of matter
Matter is anything that has mass, occupies space and exists in some time period.

3.2 Characteristics of Solid

- It is made up of so many smaller particles called molecules.
- The molecules are bonded with a stronger force of attraction
- The molecules always vibrate because of the **(*2*)** above
- The molecules move at a slower rate.
- They have weight and occupy space.
- They have their own volume.
- They have their own shape.

3.3 Characteristic of Liquid

- It is made up of smallest particles called molecules.
- The molecules are bonded together with a weak force of attraction.
- They are always moving randomly i.e Brownian motion.
- They move faster than the molecules of the solid.
- They have weight and occupy space and they take the shape of the container in which they are kept.
- They have volume.

3.4 Characteristic of Gas

- It is made up of smaller particles called molecules.
- The molecules are bonded with a weak force of attraction called the ***Vander Waal's*** force of attraction.
- They are always moving randomly.
- The molecules of gas moves faster than that of the liquids.
- They have weight, occupy the whole space provided and they have no shape.
- They have volume.

3.5 Elastic Property of Solid

This is the property of an object to increase its size when a force is applied on it. It takes place in solid and liquids.

Hooke's law states that the force acting on an elastic material is proportional to the extension of the material provided the elastic limit is not exceeded.
In symbol,

$F \propto e$

$F = ke \quad [k = \text{force constant}]$

$k = \frac{f}{e}$

S.I unit of k is Nm^{-1}

Where k is the force constant, F (Newton) is the applied load, and ***e (***metre) is the extention.

SELF-ASSESSMENT EXERCISE

A spring of natural length 3m is extended 0.01m by a force of 4N. What will be its length when the applied force is 12N.

3.6 Elastic property of liquid

It is possible for a duck and water skater to float on the surface of water. This is possible because the surface of the water is behaving as elastic membrane. This elastic property of the surface of the water is as a result of so many forces acting on the surface molecules of the water. These forces are called the ***surface tension***.

Therefore, ***Surface tension can be defined as the force per unit length acting tangentially (perpendicularly) to a line drawn at the surface of the liquid.***

4.0 CONCLUSION

Matter is anything that has weight and occupies space. It exists as living and non-living entity.

5.0 SUMMARY

Below is a summary of all that you have learnt in this unit.

- Concept of matter
- Characteristics of solid
- Characteristic of liquid
- Characteristic of Gas

- The elastic property of solid
- The elastic property of liquid

6.0 TUTOR-MARKED ASSIGNMENT

i. What is surface tension?
ii. State three examples to illustrate the effect of surface tension.

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UNIT 2 CONCEPTS AND PROPERTIES OF WAVES

1.0 INTRODUCTION

Waves can move over large distances but the medium itself has only a limited movement.

2.0 OBJECTIVES

After going through this unit you should be able to:

- Explain the concept of a wave
- State the definition of a wave
- Define each of the terms used in describing waves
- Give the mathematical relationships between Frequency (f), Wave length (λ) and Velocity (v)

3.0 MAIN CONTENT

3.1 Concept of a Wave

A wave can be generated by dropping a heavy stone into a pond from a height. The ripples spread out on the surface of the water from the point where the stone has dropped, the water itself does not move in the direction of the ripples. Rather, the wave transfers the energy obtained from the stone from one point to another.

3.2 Definition of Wave

A wave is a disturbance which travels through a medium and transfer energy from one point to another, without causing any permanent displacement of the medium itself.

3.3 Terms Used in Describing Wave

Amplitude
This is the maximum displacement of a particle from its rest position. It is measured in metres.

Wavelength (λ)
This is the distance between two successive crests or successive troughs (or two successive points in phase) of a wave. It is measured in metres.

A cycle
Is a complete to-and-fro movement or oscillation of a vibrating particle.

Frequency (f)
This is the number of complete vibrations or cycles that a particle makes in one second. It is also the number of complete waves passing a given point in one second. The S. I. unit of frequency is the Hertz (Hz) which is defined as one cycle or oscillation per second.

Period (T)
This is the time taken by a wave particle to make one complete oscillation. It is measured in seconds. The period is also the time taken by the wave to travel one wavelength. The period (T) and frequency (f) are related by: $\boldsymbol{f = \frac{1}{T}}$ *or*

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

Wave speed (v)
This is the distance which the wave travels in one second. Its unit is metre-per-second (ms^{-1}).

3.4 Mathematical Relationships between *Frequency (f), Wavelength (λ) and Velocity (v)*

From the definition of frequency, *f,* and period, *T,* it pillows that the two quantities are related by

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

This follows from the fact in T(*s*), that is one period, 1 cycle is performed. Then in 1 (*s*),
$\frac{1}{T}$ cycle will be described. This number is called the frequency, *f.*

Also, the velocity, wavelength and frequency are related by
$\boldsymbol{v = f\lambda}$

This follows from the definition

$$v = \frac{Distance\ of\ waave}{Time}$$

In one period, *(T)s*, the wave covers a distance equal to **λ**,
In other words, v = $\frac{\lambda}{T}$ = f.

SELF-ASSESSMENT EXERCISE

Calculate the period of vibration in second, if a source of sound produces waves in air of wavelength 1.65m. (Take the speed of sound in air as $330ms^{-1}$).

The frequency of a vibrating source is 450Hz and the velocity of the sound it produces in air is 330 ms^{-1}. Find how far the sound travels when the source completes 50 vibrations.

4.0 CONCLUSION

It has been emphasized that in any disturbance that produces a wave, it is only the wave energy that is carried forward but not the medium.

5.0 SUMMARY

In this unit we have learnt the about following:

- Definition of a wave
- Terms used in describing waves
- Mathematical relationships between Frequency (*f*), Wave length (λ) and Velocity (*v*)

6.0 TUTOR-MARKED ASSIGNMENT

The wavelength and velocity of a set of plane waves travelling in a medium are 60cm and 320 cms^{-1} respectively. It meets a plane refracting surface at an angle of incidence of 60°. Its velocity after refraction is 280 cms^{-1}. Calculate the wavelength of the waves in the second medium and also the angle of refraction.

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UNIT 3 CLASSIFICATION OF WAVES

CONTENTS

1.0 INTRODUCTION

Depending on the direction of particle vibration with respect to the direction of the travel of the wave, we can distinguish two types of waves.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- classify waves into longitudinal and transverse waves.
- explain and give examples of the longitudinal waves.
- classify waves into progressive and stationary waves.
- explain and give examples of stationary waves.

3.0 MAIN CONTENT

3.1 Transverse Waves

Transverse Waves are waves which travel perpendicularly to the direction of the vibrations producing the waves.
Examples are water waves, light waves, radio waves and waves produced in a rope or string. In all such waves the vibrations are vertical and the direction of the wave motion is horizontal.

3.2 Longitudinal Waves

Longitudinal Waves are waves which travel in a direction parallel to the vibrations of the medium.

Sound waves are an important example of longitudinal waves. A vibrating tuning fork or drum head, for examples, alternatively compresses and rarefies the air and produces longitudinal waves that travel outward in the air.

SELF-ASSESSMENT EXERCISE

Distinguish between transverse and longitudinal waves. Give three examples each.

3.3 Progressive waves

This is a wave which continues to spread out transferring energy from the source of disturbance.

3.4 A stationary

A stationary wave is set up when two equal progressive waves of equal amplitude and frequency and travelling in opposite directions are superposed or made to overlap or combine together.
Both longitudinal and transverse waves can produce stationary waves. Examples are musical notes produced by wind instruments like flute, trumpet or saxophone.

4.0 CONCLUSION

In this unit, you have learnt how you can use (i) ***the mode of vibration*** and (ii) ***direction of propagation*** to classify waves into longitudinal and transverse waves.

5.0 SUMMARY

In this unit you have acquired knowledge on:

- Classification of waves into longitudinal and transverse waves.
- Longitudinal waves and transverse waves.
- Explain and give examples of stationary waves.

6.0 TUTOR-MARKED ASSIGNMENT

Distinguish between stationary and progressive waves.

7.0 REFERENCES/FURTHER READING

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UNIT 4 PROPERTIES OF WAVES

1.0 INTRODUCTION

2.0 OBJECTIVES

3.0 MAIN CONTENT

Waves have the following characteristics properties:

3.1 Reflection of Waves

The plane waves on meeting the plane surface are reflected in a definite direction as another set of plane waves.

3.2 Refraction of waves

Refraction is the change in the speed and direction of the wave as they cross the boundary between two media of different densities.

Since velocity $\boldsymbol{v} = \boldsymbol{f\lambda}$, where $\boldsymbol{f}$ is frequency which always remains constant, it means that the wavelength of the wave, $\boldsymbol{\lambda}$, changes say from $\boldsymbol{\lambda_1}$ to $\boldsymbol{\lambda}$, therefore, as in the light waves, Snell's law is obeyed, such that:

$$\frac{Sin i}{Sin r} = \boldsymbol{n} \text{ (refractive index)}$$

With reference to the media

$$\text{Refractive index, } {}_1n_2 = \frac{\text{Velocity of wave in medium 1}}{\text{Velocity of wave in medium 2}}$$

$${}_1n_2 = \frac{v_1}{v_2} = \frac{f\lambda_1}{f\lambda_2} = \frac{\lambda_1}{\lambda_2}$$

3.3 Interference

This is the effect produced when two waves of the same frequency, amplitude and wavelength and wavelength travelling in the same direction in a medium are superposed**.**

When the superposition of the two identical waves, result in increased disturbance (i.e. they reinforce each other) it is known as ***Constructive Interference.*** Constructive Interference occurs when the path difference between two identical waves at a point, is
$\Delta_s = n\lambda$, where n = 0, 1, 2………

Destructive Interference occurs when the resultant effect of the combination of two identical waves result in their annihilation or complete cancellation of the effect of each other (i.e zero or minimum disturbance).

This occurs when the path difference between the two identical waves at a point is:

$$\Delta_s = n\lambda + \frac{1}{2}\lambda \qquad \text{where } n = 0, 1, 2\ldots\ldots\ldots$$

SELF ASSESSMENT EXERCISE

Explain what you understand by *interference of waves.*

3.4 Diffractions of waves

This is the phenomenon where travelling waves pass through narrow openings or move round obstacles, and tend to spread out in different directions. It occurs when the wavelength of the wave is longer than the width of the opening or size of the obstacle.
Diffraction can be defined as the ability of waves to bend around obstacles in their path.

3.5 Polarization of Mechanical waves

Polarization is a phenomenon whereby a wave whose vibrations are only in one plane is produced.

Only transverse waves can be plane-polarised. Polarisation therefore occurs with light waves and other electromagnetic waves, but not with sound waves because sound waves are longitudinal waves.

A wave is said to be plane-polarised if its vibrations occur only in one plane. The plane is known as the plane of polarisation.

4.0 CONCLUSION

In this unit, you have learnt how you can use (i) ***the mode of vibration*** and (ii) ***direction of propagation*** to classify waves into longitudinal and transverse waves.

5.0 SUMMARY

In this unit you have acquired knowledge on how to:

- Classify waves into longitudinal and transverse waves.
- Explain and give examples of the longitudinal waves.
- Explain and give examples of the transverse waves.
- Explain reflection property of waves
- Explain Interference characteristics of a wave.
- Explain Diffraction property of a wave
- Explain Polarization characteristics of a wave mechanical wave.

6.0 TUTOR-MARKED ASSIGNMENT

i. Distinguish between *constructive interference* and *destructive interference*.
ii. Explain the terms: *Diffraction, Refraction* and *Polarisation.*

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UNIT 5 WAVE NATURE OF LIGHT, VELOCITY OF LIGHT

1.0 INTRODUCTION

Light sometimes exhibits behaviors that are characteristic of both ***waves*** and particles. In this unit, the focus will be on the wavelike nature of light.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

List and explain the behaviours that are characteristics of both waves and light.

3.0 MAIN CONTENT

3.1 Reflection of Light

Light reflects in the same manner that any wave would reflect. One of the characteristics of a wave is that the angle at which it approaches a flat reflecting surface is equal to the angle at which it leaves the surface. This is also observed for light waves, which like any wave, follow the law of reflection when bouncing off surfaces. Therefore, the reflective behavior of light provides evidence for the wavelike nature of light.

3.2 Refraction of light

All waves are known to undergo ***refraction*** when they pass from one medium to another medium. When a wavefront crosses the boundary between two media, the direction that the wavefront is moving undergoes a sudden change; the path is "bent." the direction of "bending" is dependent upon the relative speed of the two media. A wave will bend one way when it passes from a medium in which it travels slowly into a medium in which it travels fast; and if moving from a *fast medium* to a *slow medium*, the wavefront will bend in the opposite direction. Second, the amount of bending is dependent upon the relative speeds of the two media on each side of the boundary.

Light, like any wave, is known to refract as it passes from one medium into another medium. And its refractive behavior follows the same conceptual and mathematical rules that govern the refractive behavior of other waves such as water waves and sound waves.

Therefore, the refractive behavior of light provides evidence for the wavelike nature of light.

3.3 Interference

Interference is the effect produced when two waves of the same frequency, amplitude and wavelength travelling in the same direction in a medium are superposed – as they simultaneously pass through a given point.

In an experiment performed with a narrow beam of monochromatic light (i.e., single wavelength light) passed directed at the penny. The result is that an interference pattern consists of alternating rings of light and darkness was created, the same result the other waves will give. Therefore it is enough to say that the interference behavior of light provides evidence for the wavelike nature of light.

3.4 Diffraction of waves

Diffraction is the change in direction of waves as they pass through an opening or around an obstacle in their path. Water waves, Sound waves have the ability to travel around corners, around obstacles and through openings. Sound waves do the same. In the same way, light waves bend around obstacles and through openings, thus, providing more evidence to support the belief that light behaves as a wave.

3.5 Speed and wavelength of light

Light travels at a speed of about $3 \times 10^5\ km/s$. Light travels on waves, so it has wavelength. The average wavelength for the visible spectrum that is white light is 0.0005mm.

4.0 CONCLUSION

Some observable phenomenon in the nature of light, such as reflection, refraction, diffraction, and interference can be interpreted that light behaves like waves.

5.0 SUMMARY

In this unit you have learnt about:
About the nature of light, such as reflection, refraction, diffraction, interference and polarization which can be interpreted that light behaves like waves.

6.0 TUTOR-MARKED ASSIGNMENT

Explain the wave nature of light.

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UNIT 6 CLASSIFICATION OF WAVES

1.0 INTRODUCTION

Depending on the direction of particle vibration with respect to the direction of the travel of the wave, we can distinguish two types of waves.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- classify waves into longitudinal and transverse waves.
- explain and give examples of the longitudinal waves.
- classify waves into progressive and stationary waves.
- explain and give examples of stationary waves.

3.0 MAIN CONTENT

3.1 Transverse Waves

Transverse Waves are waves which travel perpendicularly to the direction of the vibrations producing the waves.

Examples are water waves, light waves, radio waves and waves produced in a rope or string. In all such waves the vibrations are vertical and the direction of the wave motion is horizontal.

3.2 Longitudinal Waves

Longitudinal Waves are waves which travel in a direction parallel to the vibrations of the medium.

Sound waves are an important example of longitudinal waves. A vibrating tuning fork or drum head, for examples, alternatively compresses and rarefies the air and produces longitudinal waves that travel outward in the air.

SELF-ASSESSMENT EXERCISE

Distinguish between transverse and longitudinal waves. Give three examples each.

3.3 Progressive waves

This is a wave which continues to spread out transferring energy from the source of disturbance.

3.4 A stationary

Wave is set up when two equal progressive waves of equal amplitude and frequency and travelling in opposite directions are superposed or made to overlap or combine together.
Both longitudinal and transverse waves can produce stationary waves. Examples are musical notes produced by wind instruments like flute, trumpet or saxophone.

4.0 CONCLUSION

In this unit, you have learnt how you can use (i) ***the mode of vibration*** and (ii) ***direction of propagation*** to classify waves into longitudinal and transverse waves.

5.0 SUMMARY

In this unit you have acquired knowledge on:

- Classification of waves into longitudinal and transverse waves.
- Longitudinal waves and transverse waves.
- Explain and give examples of stationary waves.

6.0 TUTOR-MARKED ASSIGNMENT

Distinguish between stationary and progressive waves.

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