NATIONAL OPEN UNIVERSITY OF NIGERIA

SCHOOL OF EDUCATION

COURSE CODE: SED 123

COURSE TITLE: GENERAL PHYSICS FOR INTEGGRATED SCIENCE

COURSE GUIDE

SED 123
GENERAL PHYSICS FOR INTEGRATED SCIENCE 1

Course Team Dr. Apata F. S. (Course Writer/Developer) - NOUN
Dr. Owolabi (course Editor) LASU
Dr. Apata F. S. (Course CO-Ordinator) – NOUN
Dr. Apata F. S. (Programme Leader) – NOUN

NATIONAL OPEN UNIVERSITY OF NIGERIA

National Open University of Nigeria
Headquarters
14/16 Ahmadu Bello Way
Victoria Island
Lagos

Abuja Office
5 Dar es Salaam Street
Off Aminu Kano Crescent
Wuse II, Abuja

e-mail: centralinfo@nou.edu.ng
URL: www.nou.edu.ng

Published by:
National Open University of Nigeria

MAIN CONTENT

CONTENTS **PAGE**

MODULE 1

UNIT 1 PHYSICAL QUANTITIES

CONTENTS

1.0 INTRODUCTION

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 and Derived Physical 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 <u>derived</u> physical quantity. Some other examples of <u>Derived</u> physical quantities include:

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

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

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

c) Work $=$ Force $\times$ distance $=$ mass $\times$ acceleration $\times$ distance

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

d) Energy $=$ Force $\times$ distance $=$ mass $\times$ acceleration $\times$ distance

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

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

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

$$= \text{Watt}$$

SELF-ASSESSMENT EXERCISE

a) Distinguish between fundamental and derived quantities. Give three examples of each with their units.

b) 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:-

Type equation here.

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 $\times \frac{Lenght}{time \times time}$ $= MLT^{-2}$

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

$= ML^2T^{-2}$

SELF-ASSESSMENT EXERCISE

Obtain the dimensional representations for the following physical quantities:-

i. Energy
ii. Pressure
iii. Power
iv. Momentum.

3.4 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:

a. There are three Fundamental Physical Quantities in Nature.
b. The internationally accepted physical units upon which the three quantities are based is called fundamental units.
c. Derived quantities are derived of two or all three combinations of the fundamental physical quantities, ditto the units.
d. Discussion was provided on Dimensional Representations of Physical Quantities
e. 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.

Daramola, S. O. (2004) Philosophical foundation of science teaching in I. O Abimbola and A. O. Abolade (eds.) Fundamental Principles and Practice of Instruction. 79-81.

Adam, Steve & Haliday, Jonathan (2000). Advanced Physics. UK: Oxford University Press.

Ndupu, B. L. N., Okeke, P. N., & Ladipo, O.A. (1989). Senior Secondary Physics, text book 2.Academy press Ltd, Lagos.

UNIT 2 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 problems on Motions.

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.

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

3.2 First equation

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

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

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

Or $\quad v = u + at$……………………………………………*(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.

3.3 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) $\quad v = u + at$

$\therefore \quad$ 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 = $\frac{distance}{time} = \frac{s}{t}$

$\frac{s}{t} = u + ½at$

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

3.4 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.

3.5 Motion in a vertical plane

An object thrown upward experiences retardation due to the gravitational attraction of the earth which tend 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, $a = g$. 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 was 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
- Equation 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

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

Daramola, S. O. (2004) Philosophical foundation of science teaching in I. O Abimbola and A. O. Abolade (eds.) Fundamental Principles and Practice of Instruction. 79-81.

Adam, Steve & Haliday, Jonathan (2000). Advanced Physics. UK: Oxford University Press.

UNIT 3 LAWS OF MOTION

CONTENTS

1.0 INTRODUCTION

In this unit you will learn about the laws governing the motion of an object.

2.0 OBJECTIVES

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

- State and explain the three laws of motion as propounded by Newton.
- Apply the derived formula to solve problems.

3.0 MAIN CONTENT

3.1 The three laws of motion

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

3.2 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.

3.3 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}).

3.4 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.

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 was also dealt with. We derived equations of motion and also state the laws of motion.

5.0 Summary

In this Unit you have learnt the three equations of motion and application of their formula in solving problems.

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 and further reading

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

Daramola, S. O. (2004) Philosophical foundation of science teaching in I. O Abimbola and A. O. Abolade (eds.) Fundamental Principles and Practice of Instruction. 79-81.

Adam, Steve & Haliday, Jonathan (2000). Advanced Physics. UK: Oxford University Press.

UNIT 4 EQUILIBRIUM OF FORCES

CONTENTS

1.0 INTRODUCTION

This unit gives a brief summary of some of the most useful concepts in equilibrium and in energy. The concepts that is germane to effective teaching of integrated science in schools.

2.0 OBJECTIVES

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

i. Differentiate between dynamic and static equilibrium
ii. Differentiate between resultant and equilibrant forces
iii. Define and explain moment of a force
iv. Explain the Centre of gravity.

3.0 MAIN CONTENT

3.1 The concepts of Equilibrium

An object is in equilibrium when there is no net force acting on a body in any direction.

3.2 Static Equilibrium

This means that the forces acting on the body along any direction is zero. The body does not move or rotate, and have the resultant force of zero.

3.3 Kinetic or Dynamic Equilibrium

This is when the body is moving with constant velocity in a straight line or it is rotating with a constant angular velocity about a fixed axis through its centre of mass.

3.4 The Resultant

The resultant force is that single force which acting alone will have the same effect in magnitude and direction as two or more forces acting together.
The resultant force is found by the parallelogram law of vectors.

3.5 The Equilibrant

The equilibriant of two or more forces is that single forces which will balance all the other forces taken together. It is equal in magnitude but opposite in direction to the resultant force.

SELF-ASSESSMENT EXERCISE

When can a body said to be in equilibrium?

3.6 Moment of a Force

The moment of a force about a point is the turning effect of the force about that point. It is equal to the product of the force and the perpendicular distance of its line of action from the point.

The **principle of moments** states that if a body is in equilibrium, then the sum of the clockwise moments about any point on the body is equal to the sum of the anticlockwise moments about the same point.

3.7 Centre of Gravity

Centre of gravity (C.G) of a body is defined as the point through which the line of action of the weight of the body always passed irrespective of the position of the body. It is also the point at which the entire weight of the body appears to be concentrated.

4.0 CONCLUSION

We have learnt that when a body is acted upon by several forces and it does not move or rotate during the time forces acting on it do not change, that body is said to be in equilibrium.

5.0 SUMMARY

In this unit, we have discussed

- Dynamic and Static equilibrium
- Resultant and Equilibrant forces
- moment of a force
- Centre of gravity

6.0 TUTOR-MARKED ASSIGNMENT

i. Distinguish between resultant force and equilibrant.
ii. State the principle of moment

7.0 REFERENCES/FURTHER READINGS

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

Daramola, S. O. (2004) Philosophical foundation of science teaching in I. O Abimbola and A. O. Abolade (eds.) Fundamental Principles and Practice of Instruction. 79-81.

Adam, Steve & Haliday, Jonathan (2000). Advanced Physics. UK: Oxford University Press.

UNIT 5 ENERGY

1.0 INTRODUCTION

Anything that is capable of doing work has energy.

2.0 OBJECTIVES

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

- explain Kinetic energy
- explain Potential energy
- explain Chemical energy
- explain Radiant energy
- explain Thermal energy
- explain Units of energy
- explain And solve some problems with the formula of kinetic energy and potential energy.

3.0 MAIN CONTENT

3.1 The Concept of Energy

Energy is the ability or capacity to do work. Therefore, energy enables work to be done and men and machine need a supply of it. Energy also exists in many different forms.

Forms of energy
The two main forms of energy are **Potential energy** and **Kinetic energy.**

3.2 Kinetic energy

Kinetic energy is the energy associated with an object by virtue of its motion. The speed and mass of a car or molecule determine its kinetic energy.

Kinetic energy (K.E) = ½ mass × (velocity)^2 = ½mv^2
The unit of mass is kilograms, and the velocity is metres per second (ms^{-2}) giving **KE** unit of kgm^{2}s^{-2} is called the joule.
1 joule = 1 kgm^{2}s^{-2}.

3.3 Potential Energy

Potential energy is the energy an object has because of its position in a gravitational field, or similar environment that affects the object.
Potential energy (P.E) = ***mgh***
Where ***m*** is the mass in kilogram (kg), ***g*** is the acceleration due to gravity measured in metre per second square (ms^{-2}), and ***h*** is the height measured in metre (m). ***g*** is a constant and its value is approximately 10ms^{-2}.

SELF-ASSESSMENT EXERCISE

i. An object of mass 200kg is placed at 50m above the earth surface. If g = 10ms^{-1}, Calculate the energy acquired by the object.
ii. An object of a mass 100kg is moving at a speed of 200m/s. Calculate the energy acquired by the object.

Other forms of energy are:

3.4 Chemical energy

Chemical energy: Food and fuels like coal oil and gas are stores of chemical energy. The energy of food is released by chemical reactions in our bodies. Fuels released their energy when they are burnt (a chemical reaction) in an engine or other device. A car engine uses chemical energy.

3.5 Radiant energy

Radiant energy**:** This is the energy from the sun (solar energy) and is earth's primary energy source. Solar energy heats the atmosphere and earth's surface: stimulates the growth of regulation through the process of photosynthesis, and influence global climate patterns.

3.6 Thermal energy

Thermal energy: This is the energy associated with the random motion of atoms and molecules in a sample of matter; the hotter the sample the greater is its thermal energy. Generally, thermal energy can be calculated from temperature measurements.

3.7 Units of energy

The S.I. unit for measuring energy (i.e Joule) was named after the British physicist, who first showed that the different forms of energy are basically the same. Thus, Potential energy and all other forms of energy can be measured in the same unit. Engineers sometimes use BTUs (British Thermal Units) to define energy. A BTU is equal to 1055.8J. Kilowatt-hour is another energy unit. The power holding company (formally NEPA) uses this unit to charge you for the electrical energy you use. The rate at which energy is produced or used is called power and the S.I. unit of power is the Watt.
1 Watt = 1 joule per second (Js^{-1})
Kilowatt-hour = 1000 watt-hour of energy use This is equal to 3.6 $\times 10^6$ J.

4.0 CONCLUSION

It can be concluded that in the absence of energy, no work can be done. Thus, a person is said to possess energy which he exercises by performing a task over a distance. Also, work and energy are measured in the same unit, the Joule.

5.0 SUMMARY

In this unit, you have leant that anything that is capable of doing work has energy and can also explain the following forms energy:

- Kinetic energy
- Potential energy
- Chemical energy
- Radiant energy
- Thermal energy

- Units of energy.

6.0 TUTOR MARKED ASSIGNMENT

i. Define the terms potential energy and the kinetic energy. Give two examples of each.
ii. At what height above the ground must a body of mass 10kg be situated in order to have potential energy equal in value to the kinetic energy possessed by another body of mass 10kg moving with a velocity of $10ms^{-1}$?

7.0 REFERENCES/FURTHER READING

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

Daramola, S. O. (2004) Philosophical foundation of science teaching in I. O Abimbola and A. O. Abolade (eds.) Fundamental Principles and Practice of Instruction. 79-81.

Adam, Steve & Haliday, Jonathan (2000). Advanced Physics. UK: Oxford University Press.

Ndupu, B. L. N., Okeke, P. N., & Ladipo, O.A. (1989). Senior Secondary Physics, text book 2.Academy press Ltd, Lagos.

MODULE 2

UNIT 1 ELASTICITY

CONTENTS

1.0 INTRODUCTION

If the external force applied to a solid is so strong enough to change or distort the shape of a solid, the solid tends to regain this shape as soon as the applied force is removed.

2.0 OBJECTIVES

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

- Explain elastic properties of substance
- State Hooke's law.
- Apply mathematical expression of Hooke's law to solve problems.

3.0 MAIN CONTENT

3.1 Elasticity

Elasticity: It can be defined as the ability of a substance to regain its original shape and size after being distorted by an external force.

3.2 Elastic Material

Elastic material: Is the one that regains its original shape and size after the distorting force has been removed.

3.3 Elastic limit

Elastic limit is the maximum stretching force beyond which the stretched material would not return to its original length when the force is removed.

3.4 Yield point

Yield point is the point at which the elastic material loses its elasticity permanently and become plastic.

3.5 Hooke's law

Hooke's law: Is a law that governs the relationship between the stretching force and the extension produced in the elastic material. The law states that' provided the elastic limit of an elastic material is not exceeded, the extension, *e,* of the material is directly proportional to the load or applied force, F.

SELF-ASSESSMENT EXERCISE

A force of 0.6N stretches an elastic spring by 4cm. Find the elastic constant of the spring.

According to ***Hooke's law***, the force *F* required to stretch or compress an elastic material is directly proportional to the extension, or compression *e.*

Thus,

$$F \propto e$$

Or

$$F = ke$$

Where *k* is a constant of proportionality called an elastic constant or force constant or stiffness of the material. If *F* is in Newton's and *e* is in metres the elastic constant is given by

$$K = \frac{F}{e} \ (Nm^{-1})$$

4.0 CONCLUSION

You have learnt how Hooke's law governs the relationship between the stretching force and the extension produced in the material.

5.0 SUMMARY

In this unit, you have learnt:

- Elastic properties of substance
- Hooke's law.
- How to apply mathematical expression of Hooke's law to solve problems.

6.0 TUTOR-MARKED ASSIGNMENT

An elastic wire extends by 1.0cm when a load of 20g hangs from it. What additional load will be required to cause a further extension of 2.0cm?

7.0 REFERENCES/FURTHER READING

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

Daramola, S. O. (2004) Philosophical foundation of science teaching in I. O Abimbola and A. O. Abolade (eds.) Fundamental Principles and Practice of Instruction. 79-81.

Adam, Steve & Haliday, Jonathan (2000). Advanced Physics. UK: Oxford University Press.

Ndupu, B. L. N., Okeke, P. N., & Ladipo, O.A. (1989). Senior Secondary Physics, text book 2.Academy press Ltd, Lagos.

UNIT 2 FLUID AND FLUID MOTION

CONTENTS

1.0 INTRODUCTION

The force of attraction between molecules of the same kind is called ***Cohesion,*** While the force of attraction between molecules of different kinds is refer to as ***Adhesion.***

2.0 OBJECTIVES

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

- explain *Fluid, viscosity, capillarity;*
- explain Distinguish between *cohesion* and *adhesion.*

3.0 MAIN CONTENT

3.1 Fluid

Molecules Liquids and gases are freer to move than those of solids; as such both are able to flow. Consequently, they are grouped together as **fluids.** They have no rigid shape and their response to forces differ from that of solids.

3.2 Fluid motion

In an experiment performed, it was observed that when three tubes with fine bores but with different diameters were dip into clean water; the water raises in the tubes but with the narrower the bore the higher the height to which the water rises.

When the same experiment was performed with mercury, the mercury falls in the tubes. In this case, it was observed that the narrower the tube, the lower the mercury level. Part of the observation was that the surface of water or its meniscus is curved upwards. But in mercury the meniscus is curved downwards away from the glass tube. The terms *cohesion* and *adhesion* will be needed to explain this capillary action. The action of liquids to rise or fall in capillary tubes is known as capillarity.

3.3 Capillarity

Capillarity or capillary action is the tendency of a liquid to rise or fall in a narrow tube.

3.4 Cohesion

Cohesion is the forces of attraction between molecules of same kind, e.g the molecules of water.

3.5 Adhesion

Adhesion is the force of attraction between molecules of different kind, e.g the molecules of water and glass.

3.6 Viscosity

It is much easier to pour water or kerosene from a container than to pour honey or engine oil. The property of viscosity in these liquids is responsible for the differences.
Thus **viscosity** can be defined as the internal friction between layers of a liquid or gas in motion**.**

SELF-ASSESSMENT EXERCISE
Why do we have capillarity rise and depression?

4.0 CONCLUSION

The molecules of liquids and gases are free to move than those of solids. Therefore the molecules of liquid and gases are grouped together as fluids.

5.0 SUMMARY

In this unit you have learnt the concept of the following:

- Fluid
- Cohesion

- Adhesion
- Capillarity and
- Viscosity.

6.0 TUTOR MARKED ASSIGNMENT

Classify fluids according to their viscous properties.

7.0 REFERENCES/FURTHER READING

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

Daramola, S. O. (2004) Philosophical foundation of science teaching in I. O Abimbola and A. O. Abolade (eds.) Fundamental Principles and Practice of Instruction. 79-81.

Adam, Steve & Haliday, Jonathan (2000). Advanced Physics. UK: Oxford University Press.

Ndupu, B. L. N., Okeke, P. N., & Ladipo, O.A. (1989). Senior Secondary Physics, text book 2.Academy press Ltd, Lagos.

UNIT 3 SIMPLE MACHINES

CONTENTS

1.0 Introduction

This unit focuses on the concept of Simple machine, the device which enables us do work more easily and conveniently than could be done without it.

2.0 Objectives

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

- Define machine
- Define mechanical advantage
- Velocity Ratio
- Efficiency of a machine,
- Apply the formula of the terms to solve questions.

3.0 MAIN CONTENT

3.1 Machine

A machine is a device or tool which allows a force (or effort) applied at one point to overcome a resisting force (or load) at another point.
A machine enables us to overcome a large resistance or load by applying a small effort. Examples of machines are the screw jack, wheel and axle, the wedge, the inclined plane, wheel barrows, nut crackers, pulleys, pliers and so on.

3.2 Terms that applies to the working of a machine

Effort (E): This is the force applied to the machine.

Load (L): Is the force or resistance overcome by the machine.

Mechanical Advantage (MA): Is the ability of a machine to overcome a large load through a small effort.

Mechanical Advantage (MA) $= \frac{Load}{Effort}$

The mechanical advantage of a machine is influenced by friction in the parts of the machine.

Velocity Ratio (VR): This is the ratio of the distances moved by the effort and load, in the same time interval.

$$V.R = \frac{distance\ moved\ by\ effort}{distance\ moved\ by\ the\ load}$$

The velocity ratio depends on the geometry of the machine.

3.3 Efficiency of a machine

For an ideal or perfect machine,
Mechanical Advantage = Velocity Ratio

Efficiency (E_f): The efficiency (E_f) of a machine is defined as:

$$E_f = \frac{Useful\ work\ done\ by\ the\ machine}{Work\ put\ into\ the\ machine}$$

Efficiency is usually expressed as a percentage.

$$E_f = \frac{Useful\ work\ done\ by\ the\ machine}{Work\ put\ into\ the\ machine} \times 100\%$$

Since **Work (W)** is given by
W = Force x distance

$$E_f = \frac{Load}{Effort} \times \frac{distance\ moved\ by\ load\ (l)}{distance\ moved\ by\ effort\ (e)}\ 100\%$$

$$= \frac{L}{E} \times \frac{l}{e} = \frac{L}{E} \times \frac{e}{l}$$

$$= \frac{Mechanical\ advantage}{Velocity\ ratio} \times 100\%$$

$$E_f = \frac{MA}{VR} \times 100\%$$

A perfect or ideal machine has a100% efficiency. Which implies that, all the work done by the effort is wholly used to overcome the load, this is not so in reality because of the friction in the moving parts of the machine. Thus in practical machine, part of the effort applied is used to overcome frictional forces.

SELF-ASSESSMENT EXERCISE

Under what condition will the velocity ratio of a machine be equal to the mechanical advantage?

4.0 Conclusion

You have learnt in this unit the basic concept of mechanics. The knowledge will equip you for good teaching of integrated science.

5.0 Summary

In this unit, you have learnt that:

- **Machine** enables us to do work more easily and conveniently.
- You have been exposed to the formula and application of terms in machine.

6.0 TUTOR-MARKED ASSIGNMENT

A machine with a V. R of 5 requires 1,000J of work to raise a load of 500N through a vertical distance of 1.5m. Determine the efficiency and M.A of the machine.

7.0 REFERENCES/FURTHER READING

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

Daramola, S. O. (2004) Philosophical foundation of science teaching in I. O Abimbola and A. O. Abolade (eds.) Fundamental Principles and Practice of Instruction. 79-81.

Adam, Steve & Haliday, Jonathan (2000). Advanced Physics. UK: Oxford University Press.

Ndupu, B. L. N. (1989). Senior Secondary Physics, text book 2.Academy press Ltd, Lagos.

UNIT 4 WAVES

1.0 INTRODUCTION

A wave is generated when a heavy stone is dropped into a pond of water. While 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 ripples. Rather, the wave function to transfers the energy obtained from the stone from one point to another.

2.0 OBJECTIVES

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

- Give the definition of a wave.
- Explain and give examples of Mechanical wave.
- Explain and give examples of Electromagnetic wave.
- Classify waves into Transverse and Longitudinal waves.

3.0 MAIN CONTENT

3.1 Definition of a wave

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

3.2 Mechanical wave

Mechanical waves are those waves that require a material medium for their propagation. Examples are sound waves, water waves and waves on a rope or string.

3.3 Electromagnetic wave

Electromagnetic waves are waves that do not require a material medium for propagation. Examples are light waves, radio waves, X-rays and gamma-rays.

3.4 Progressive waves

Progressive wave is a wave that transfers energy in travelling or moving away from the source of the disturbance. There are two types of progressive waves – The *Transverse waves* and the *Longitudinal waves.*

3.5 Stationary waves

A standing or *stationary* wave is a wave obtained when two progressive waves, of equal amplitude and frequency, are travelling in opposite directions and combine together. Most of the stationary waves are obtained as a result of reflection of the incident waves.

SELF ASSESSMENT EXERCISE

Distinguish between progressive and stationary waves.

4.0 CONCLUSION

This unit has taught you that not all waves require a material medium for propagation.

5.0 SUMMARY

This unit has exposed you to the following:

- The concept of a wave.
- Explanation and examples of Mechanical wave.
- Explanation and examples of Electromagnetic wave.
- Classification of waves into Transverse and Longitudinal waves.

6.0 TUTOR-MARKED ASSIGNMENT

Distinguish mechanical waves from electromagnetic waves with examples.

7.0 REFERENCES/FURTHER READING

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

Adam, Steve & Haliday, Jonathan (2000). Advanced Physics. UK: Oxford University Press.

Ndupu, B. L. N. (1989). Senior Secondary Physics, text book 2.Academy press Ltd, Lagos.

Mark, W. Zemansky & Richard, H. Dittmann (i981). Heat and Thermodynamics (Sixth Edition). New York: McGraw-Hill Book Company.

Online Microsoft Encarta available at: http://encarta.msn.com/ encyclopedia 761575286/Heat (physics).html

Halliday, David, Resnick, Robert & Walker, Jeanrl (2001). Fundamentals of Physics-Extended (Sixth edition). New York: John Wiley and Sons, Inc.

Ndupu, B. L. N., Okeke, P. N., & Ladipo, O.A. (1989). Senior Secondary Physics, text book 2.Academy press Ltd, Lagos.

UNIT 5 WAVES AND SOUND

CONTENTS

1.0 INTRODUCTION

Sound is a longitudinal wave and a form of energy produced by vibrating body. It is also a sensation which a vibrating object transmits to the ear through an elastic medium.

2.0 OBJECTIVES

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

- Explain Sound waves
- Calculating the time to hear the echo
- Production and transmission of sound
- Reflection of sound.
- Determination of speed of sound in air
- Refraction of sound
- Diffraction of sound
- Interference of sound

3.0 MAIN CONTENT

3.1 Sound waves

Sound is a longitudinal wave produce by a vibrating bodies. It is a form of energy and also a sensation which a vibrating object transmits to the ear through an elastic medium.

Sound waves can be reflected like other waves when they strike a plane surface. Reflection of sound gives rise to echoes.

3.2 Production and Transmission of Sound

Sound is produced by vibrating bodies. The vibrations cause the surrounding air to vibrate also producing a disturbance of air. This disturbance travels out from the source of vibration in the form of longitudinal waves.

Almost any object can vibrate and hence be a source of sound wave. When the source is set into vibration like in musical instruments, these vibrations produce the sound from these instruments.

3.3 Reflection of sound

Like the other waves, sound waves can be reflected when they strike a plane surface. Reflection of sound obeys the laws of reflection in the same way as light waves.

Reflection of sound gives rise to ***echoes.***
An ***echo*** is a sound heard after the reflection of sound from a plane surface.

3.4 Determination of speed of sound in air

Suppose the reflecting wall producing the echo is *d* metres away, the time taken to hear the echo can be given as:

$$\text{Time} = \frac{total\ distance\ travelled\ by\ sound}{velocity\ of\ sound}$$

Since the sound travels from the person to the wall and returns as an echo to the person, the total distance travelled is *2d* metres. Hence,

$$T = \frac{2d}{330}\ sec.$$

3.5 Refraction of sound

Like light waves, sound waves are refracted when they pass from one medium to another of slightly different density (e.g. from air to carbon dioxide).

This explains why it is easier to hear sound coming from a distance at night than at day-time. In the day-time, the upper layers of air are colder than the layers near the earth. Since sound travels faster at higher temperatures, the sound waves are refracted in a direction away from the earth. The intensity of the sound waves thus diminishes. At night the reverse process takes place. The layer of the air near the earth is colder than those higher up. Sound waves are therefore refracted towards the earth with a consequent increase in intensity.

3.6 Diffraction of sound

Sound waves also show the diffraction phenomenon. When a person speaks loudly in a room, the sound he produces can be heard round a corner without the speaker being seen.

3.7 Interference of sound

When two sources of sound waves interfere constructively, a loud sound is produced because sound from both sources reinforces each other. When they interfere destructively, silence or no sound is observed.

SELF-ASSESSMENT EXERCISE

What are those features that characterized sound as wave?

4.0 CONCLUSION

It is obvious from this unit that sound is a wave, because of the properties reflection, refraction, diffraction and interference it possess like other waves.

5.0 SUMMARY

In this unit you have learnt about the following:

- Sound waves
- Calculation of the time to hear the echo
- Production and transmission of sound
- Reflection of sound.
- Refraction of sound
- Diffraction of sound
- Interference of sound

6.0 TUTOR-MARKED ASSIGNMENT

A sound wave emitted from the bottom of a ship travels vertically downwards at 1,400m/s through the water to the ocean bed 1200m deep and is reflected upwards. What is the time interval between the instant the sound is emitted and the instant the echo is received?

7.0 REFERENCES/FURTHER READING

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

Daramola, S. O. (2004) Philosophical foundation of science teaching in I. O Abimbola and A. O. Abolade (eds.) Fundamental Principles and Practice of Instruction. 79-81.

Adam, Steve & Haliday, Jonathan (2000). Advanced Physics. UK: Oxford University Press.

Mark, W. Zemansky & Richard, H. Dittmann (i981). Heat and Thermodynamics (Sixth Edition). New York: McGraw-Hill Book Company.

Ndupu, B. L. N., Okeke, P. N., & Ladipo, O.A. (1989). Senior Secondary Physics, text book 2.Academy press Ltd, Lagos.

Online Microsoft Encarta available at: http://encarta.msn.com/ encyclopedia 761575286/Heat (physics).html

MODULE 3

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:

- Explain the concept of heat
- Define 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^{o}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^{o}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

1. The *Celsius scale*
2. *The Fahrenheit scale* and
3. *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.

3.4 Conversion between Temperature scales

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

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.

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.
3) 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.

3.5 Thermometer

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.

3.6 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.

4.0 CONCLUSION

Thermometers are the instruments used to measure the temperature of a body or a system. 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:

- Basic concept of heat
- Measurement of heat

- Temperature scales
- Thermometers
- Types of thermometers

6.0 TUTOR-MARKED ASSIGNMENT

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

ii. Discuss the process of calibrating a thermometer.

7.0 REFERENCES/FURTHER READING

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

Daramola, S. O. (2004) Philosophical foundation of science teaching in I. O Abimbola and A. O. Abolade (eds.) Fundamental Principles and Practice of Instruction. 79-81.

Adam, Steve & Haliday, Jonathan (2000). Advanced Physics. UK: Oxford University Press.

Mark, W. Zemansky & Richard, H. Dittmann (i981). Heat and Thermodynamics (Sixth Edition). New York: McGraw-Hill Book Company.

Ndupu, B. L. N., Okeke, P. N., & Ladipo, O.A. (1989). Senior Secondary Physics, text book 2.Academy press Ltd, Lagos.

Online Microsoft Encarta available at: http://encarta.msn.com/encyclopedia 761575286/Heat (physics).html

UNIT 2 INTERNAL ENERGY/THERMODYNAMICS

CONTENTS

1.0 INTRODUCTION

This unit focuses on thermodynamics and Internal energy, one of the four thermodynamic potentials, which is useful in explaining many of the physical processes in thermodynamics.

2.0 OBJECTIVES

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

- Explain internal energy.
- Definition of thermodynamics.
- Explain Ideal system and its surrounding
- List the Thermodynamic Properties/Coordinates
- Explain each of Thermodynamic System
- Relate internal energy to thermodynamics.

3.0 Main content

3.1 Internal energy U

The internal energy **U** of a system is a state function i.e. it depends on the state of a system. This is because it can change only if:

- there is flow of heat into the system or out of the system
- work is done on the system or by the system.

The work done on a system may comprise of an irreversible component dW_I (such as stirring with a paddle, or forcing an electric current through a resistor) and some reversible components $dW_{R.}$ The irreversible component of work is dissipated as heat and is identical to adding heat to the system. So we can write

$dS = \frac{dQ+dWI}{T}$ and this gives $dQ = TdS - dW_{I.}$ The reversible component of work may consist of work done in compressing the system (PdV), but there may also be other kinds of work.

For example, if a particular system is held at a constant volume, then no PdV work of expansion or compression is done. And if no other sort of work is done (either non- PdV reversible work or irreversible work dW_I),then the increase in internal energy of this system is just equal to the heat added to the system.

Thus, internal energy **U** can be used to describe a system in which heat is transferred (either in or out) and / or work is done on or by the system.

3.3 Definition of Thermodynamics

Thermodynamics is the study of the effects of work, heat, and energy on a system. Thermodynamics deals only with the large-scale response of a system, which can be observed and measured in an experiment, of heat and work. Small-scale gas interactions are described by kinetic theory of gases.

3.4 Ideal of a system and its Surrounding

System is a restricted region of space or a finite portion of matter one has chosen to study. Or the part of the universe, with well defined boundaries, one has chosen to study.

Surrounding is the rest of the universe outside the region of interest (i.e. the rest of space outside the system).

Boundary or Wall is the surface that divides the system from the surroundings.
This wall or boundary may or may not allow interaction between the system and the surroundings.

3.5 Thermodynamics Properties/Coordinates

These are macroscopic coordinates or properties used to describe or characterize a system. Because they are macroscopic properties or coordinates, they can be observed and measured. Some examples are Temperature (**T**), Pressure (**P**), Volume (**V**), density (ρ), mass (**m**), specific heat capacity at constant pressure (**Cp**), **thermal** conductivity (***k***), thermal diffusivity (***α*)**, and chemical potential (***μ***).

3.6 Thermodynamics System

This is a system that could be described in terms of thermodynamic coordinates or properties. Thermodynamic Systems can be categorized into the followings depending on the type of boundary:

Open System: This is a system that its boundary allows transfer of *mass and energy* into or out of the system. In other words, the boundary allows exchange of mass and energy between the system and the surrounding.

Closed system: This is a system that its boundary allows exchange of *energy alone* (inform of heat) between the system and its surrounding (i.e the boundary allows exchange of energy alone).
Isolated System: This is a system that its boundary allows *neither mass nor energy* between it and the surrounding. In other words, the boundary does not allow exchange of mass nor energy.

3.7 Thermodynamics.

Zeroth Law of Thermodynamics:
The law states that if bodies ***A*** and ***C*** are each in thermal equilibrium with a third body ***B*,** then they are in thermal equilibrium with each other.

First Law of Thermodynamics:
The law states that the internal energy of a system tends to increase if energy is added as heat **Q** and tends to decrease if energy is lost as work **W** done by the system
The change in internal **ΔU** of a system is

$$\Delta U = U_f - U_i = Q - W \quad (1)$$

Where **Q** is the heat and ***W*** is work. Equation **(1)** is the first law of thermodynamic.
The differential form of first law of thermodynamics is

$$dU = dQ - PdV \quad (2).$$

SELF-ASSESSMENT EXERCISE

What are the properties used to describe or characterize a system

4.0 CONCLUSION

The ***internal energy*** depends on the state of a system. Thermodynamics is the study of the effects of work, heat, and energy on a system.

5.0 SUMMARY

In this unit, you have learnt about the following:

- Heat and work are the only way by which the internal energy of a system can change.
- Definition of thermodynamics.
- Ideal system and its surrounding
- Thermodynamic Properties/Coordinates
- Thermodynamic System
- The differential for the first law of thermodynamics is
- $dU = dQ - PdV$

a. The rate at which solids, liquids and gases increases in size

6.0 TUTOR-MARKED ASSIGNMENT

Distinguished between Open, Close and Isolated system in thermodynamics.

7.0 REFERENCES/FURTHER READING

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

Adam, Steve & Haliday, Jonathan (2000). Advanced Physics. UK: Oxford University Press.

Mark, W. Zemansky & Richard, H. Dittmann (i981). Heat and Thermodynamics (Sixth Edition). New York: McGraw-Hill Book Company.

Ndupu, B. L. N., Okeke, P. N., & Ladipo, O.A. (1989). Senior Secondary Physics, text book 2.Academy press Ltd, Lagos.

Online Microsoft Encarta available at: http://encarta.msn.com/ encyclopedia 761575286/Heat (physics).html

Halliday, David, Resnick, Robert & Walker, Jeanrl (2001). Fundamentals of Physics-Extended (Sixth edition). New York: John Wiley and Sons, Inc.

UNIT 3 EXPANSION OF SOLIDS

CONTENTS

1.0 INTRODUCTION

When heated an object, it expands and also contracts when cooled. Expansion means an increase in the size of an object.

2.0 **OBJECTIVES**

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

- Solid
- Liquid
- Gas

3.0 MAIN CONTENT

3.1 The concept of expansion

This is the change in size of an object when there is change in temperature.

Expansion can be in length alone- ***Linear expansion.*** It can be in length and breadth-***Area*** or ***Superficial expansion.*** It can be in length, breadth and height-***Volume or Cubic expansion.***
The rate at which an object increases in size is calle***d expansivity.***

3.2 Linear expansivity α:

Linear expansivity α: Is the fraction of the original length of an object that expanded per Kelvin rise in temperature.
Mathematically, this can be expressed as:

$$\alpha = \frac{increase\ in\ lenght}{original\ lenght \times temperature\ rise}$$

The unit of α is ***per*** ^{o}C or ***per K (*****K^{-1}**).
In symbols, this is equivalent to:

$$\alpha = \frac{L_2 - L_1}{L_1 (\theta_2 - \theta_1)} = \frac{e}{L_1 \Theta}$$

where α = linear expansivity
L_1 = length of metal at temperature θ_1
L_2 = length of metal at temperature θ_2
Θ = $\theta_2 - \theta_1$ = the temperature rise
e = $L_2 - L_1$ = expansion or increase in length.

SELF-ASSESSMENT EXERCISE

A copper rod whose length at 30°C is 10.0m is heated to 50°C. Find its new length. Take α for copper as 0.000017K^{-1}.

3.3 Expansion in liquids

Before a liquid is heated, it requires a container. Both the container and the liquid will expand. The expansion due to both of them is called ***Real Expansion.*** The expansion taking place in the liquid alone is called ***Apparent expansion.***

Real Expansion = Apparent Expansion + Expansion due to the container.
Also,
Real Expansivity = Apparent Expansivity + Expansivity due to the container.
$\gamma_R = \gamma_A + \gamma_C$
$\gamma_C = 3\alpha_C = 3 \times$ linear expansivity of the material of the container.

Therefore,

$$\gamma_R = \gamma_A + 3\alpha_C$$

3.4 Expansion in gases

Charles' law states that the volume of a fixed mass of gas increases by 1/273 of its volume at 0^{0}C for each ^{0}C (or Kelvin) rise in temperature, provided its pressure remains constant. Hence the volume is proportional to absolute temperature

$V \propto T$ ***or*** VT^{-1} = ***constant or***

$$V_1 = V_0[1 + \frac{1}{273}t].$$

The way the volume of a material increases with temperature at constant pressure is described by coefficient of volume expansion or expansivity (β).

$$\beta = \frac{1}{V} [\frac{\partial v}{\partial T}] p$$

The unit of expansivity is K^{-1}.

4.0 CONCLUSION

The first law of thermodynamics gives an insight to the internal energy of a system. Effect of heat on solid, liquid and gases has been found to result in expansion. The rate at which each of them expands is called expansivity.

5.0 SUMMARY

In this unit, you have learnt about the:

i. The rate at which solids, liquids and gases increases in size
ii. Formula for Calculating rate of expansion in solids, liquids and gases.

6.0 TUTOR-MARKED ASSIGNMENT

i. An iron rod of length 100cm at a temperature 50℃ is heated to a temperature of 90℃ such that its length is increased by 0.01cm. Calculate the linear expansivity of the rod.
ii. The temperature of a glass vessel containing $100cm^3$ of mercury is raised from 10℃ to 100℃. Calculate the apparent cubic expansion of mercury. (Real cubic expansivity of mercury = $1.82 \times 10^{-4} K^{-1}$; Cubic expansivity of glass = $2.4 \times 10^{-5} K^{-1}$).

7.0 REFERENCES/FURTHER READING

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

Adam, Steve & Haliday, Jonathan (2000). Advanced Physics. UK: Oxford University Press.

Mark, W. Zemansky & Richard, H. Dittmann (i981). Heat and Thermodynamics (Sixth Edition). New York: McGraw-Hill Book Company.

Ndupu, B. L. N., Okeke, P. N., & Ladipo, O.A. (1989). Senior Secondary Physics, text book 2.Academy press Ltd, Lagos. Online Microsoft Encarta available at:http://encarta.msn.com/ encyclopedia 761575286/Heat (physics).html

Halliday, David, Resnick, Robert & Walker, Jeanrl (2001). Fundamentals of Physics-Extended (Sixth edition). New York: John Wiley and Sons, Inc.

UNIT 4 ELECTRICITY–ELECTRIC/COULOMB'S LAW

CONTENTS

1.0 INTRODUCTION

Electric field is created by charged bodies and these bodies are in turn affected by the electric field.

2.0 OBJECTIVES

After studying this unit, you should be able to:

- explain electric line of force.
- define and calculate for electric current
- State Ohm's law, and use its formula for solving problems.
- differentiate between A closed circuit and an Open circuit.
- differentiate between Potential Difference and e.m.f.
- Electric field
- State Coulomb's Law and calculate with its formular.

3.0 MAIN CONTENT

3.1 Electric Line of Force

This can be defined as an imaginary line drawn in an electric field in such a way that the direction at any point (or the direction of the tangent) gives the direction of the electric field at such a point. OR, The path which an isolated small positive charge would follow if placed in the field.

3.2 Electric current

Is the rate at which charges are transferred from one point to another per unit time along a conductor.

Electric current $= \frac{Amout\ of\ charge\ (Q) flowing\ through\ a\ wire}{time\ (t) require\ for\ the\ flow.}$

By symbol **current** can be defined as;

$$\mathbf{I} = \frac{Q}{t}$$

Where **I** is **Current; Q** is the **Charge; t** is the **time taken.**

The unit is Ampere (A). The commonly used submultiples of the ampere are the milliampere (mA) and the microampere (μA)**. Ammeter** is used for measuring large amount of current. For low amount of current, **Milliammeter/Galvanometer** are used for measurement.

1 mA $= 10^{-3}$A

1 μA $= 10^{-6}$A

3.3 Ohm's Law

It states that the current **(I)** flowing through a metallic conductor is proportional to the potential difference **(V)** across its ends provided temperature and all other physical quantities are constant.

By symbol,

$I \ \alpha \ V$

$I = V/R$

Or $R = V/I$

Where ***R*** is the proportionality constant called the resistance of the metallic conductor. It has the unit of Ohm (Ω).

3.4 Electric circuit

A circuit is the arrangement and connections of all the electrical parameters, such as the battery, a wire, a load (e.g. an electric bob) and a key or a switch. The switch serves to complete (close) or (open) the circuit. OR is the path provided for the flow of electric current.

A circuit can be of two types;

i. Open circuit

It is the arrangement and the connection of all the electrical parameters without a resistor. In an open circuit, current is not flowing.
Whatever the voltmeter reads is the E.M.F of the cell because there is no resistor. Therefore, E.M.F. is the work done per unit charge in an open circuit.

Closed Circuit
This is the arrangement and connection of all electrical parameters including the resistors. In a closed circuit, current is flowing.

3.5 Potential Difference

The potential difference between any two points in an electric field is defined as the work done in moving a positive charge of 1 coulomb from one point in the electric field to another. Potential difference is measured in volts (V).

Electromotive force (E.M.F)
The E.M.F. is the total work done in driving one coulomb of electricity round a circuit or total energy per coulomb obtained from a cell or battery.

SELF-ASSESSMENT EXERCISE

Differentiate between Potential difference and Electromotive Force.

3.6 Electric field

Electric field is the region where an electric force is experienced by a charged body.

3.7 Electric force between point charges.

There is an electrical force between two point charges. The French Physicist Charles Coulomb (1736-1806) investigated the nature and magnitude of this force. He showed that if the bodies were small compared with the distance between them, then the force between two such bodies was inversely proportional to the square of the distance, **r,** between them.

$$\mathbf{F} \propto \frac{1}{r^2} \quad \textbf{Inverse square law} \qquad \textbf{(1)}$$

Where ***F*** is the force; *r* is the distance between the two bodies.
Coulomb's investigation showed that the force was also proportional to the product of the charges, q_1, q_2 on the two bodies, i.e

$$F \propto q_1, q_2 \quad (2)$$

A combination of expressions (1) and (2) led to ***Coulomb's Law.***

3.8 Coulomb's Law

The law states that the electric force between two point charges, q_1, and q_2 separated by a distance r is directly proportional to the product of the charges and inversely proportional to the square of the distance between the charges.

$$F \propto \frac{q1,q2}{r^2} \quad \textbf{(3)}$$

The magnitude of this force is given by

$$F = \frac{Kq1,q2}{r^2} \quad \textbf{(4)}$$

K is the constant of proportionality. SI units, F is in Newton's, $q1, q2$ are in Coulombs (C), r is in metres. The constant K is usually taken as:

$$K = \frac{1}{4\pi\epsilon_o} \quad \textbf{(5)}$$

Where ϵ_o is a constant known as *permittivity* of free space. Hence we can finally state the value of force F as:

$$F = \frac{1}{4\pi\epsilon_o} \times \frac{q1,q2}{r^2} \quad \textbf{(6)}$$

The unit of ϵ_o is Coulomb^2-Newton^{-1}-metre^{-2}($C^2N^{-1}m^{-2}$),

$K = \frac{1}{4\pi\epsilon_o} = 9.0 \times 10^9 Nm^2C^{-2}$.

4.0 CONCLUSION

The knowledge of the concept of an electric field as a region or space where a charged body experiences an electric force has enable us understand the Coulomb's Law.

5.0 SUMMARY

This unit discussed electricity with particular reference to the following:

- Electric line of force.
- Electric current
- Ohm's Law
- **A closed circuit** and an **Open circuit.**
- Potential Difference and E.M.F.
- Electric field
- Coulomb's Law.

6.0 Tutor-Marked Assignment

Find the force of repulsion between two protons of 1.6×10^{-19} C each if the distance between them is 5.3×10^{-11}m. (Take $\frac{1}{4\pi\epsilon_o} = 9.0 \times 10^{9} Nm^{2}C^{-2}$).

7.0 REFERENCES/FURTHER READING

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

Adam, Steve & Haliday, Jonathan (2000). Advanced Physics. UK: Oxford University Press.

Ndupu, B. L. N., Okeke, P. N., & Ladipo, O.A. (1989). Senior Secondary Physics, text book 2.Academy press Ltd, Lagos.

Mark, W. Zemansky & Richard, H. Dittmann (i981). Heat and Thermodynamics (Sixth Edition). New York: McGraw-Hill Book Company.

Online Microsoft Encarta available at: http://encarta.msn.com/ encyclopedia 761575286/Heat (physics).html

Halliday, David, Resnick, Robert & Walker, Jeanrl (2001). Fundamentals of Physics-Extended (Sixth edition). New York: John Wiley and Sons, Inc.

UNIT 5 LIGHT: REFLECTION/REFECTION

CONTENTS

1.0 INTRODUCTION

We can see things around us because of light. Therefore, this unit will concentrate on Sources of light; Reflection of light; Refraction of light waves only.

2.0 OBJECTIVES

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

- List different sources of light.
- Give the Speed and wavelength of light
- State the laws of reflection of light.
- Differentiate between a virtual image and a real image.
- State the laws of refraction.

3.0 Main Content

3.1 Sources of light

Sources of light: There are various sources of light. For example the sun and the stars are natural sources of light. Artificial sources are candle, electric torch, the electric lamp, incandescent and arc lights and fluorescent light.

Self luminous or ***luminous*** of light are those that generate and emit light by themselves. Examples are sun, stars, fire-flies and some deep-sea fishes, and the artificial light sources.
Non- luminous bodies depend on natural or artificial light sources to illuminate them. They are seen only when they reflect the light from a luminous body. For example, the road sign in the night.

Transmission of light
Rays of light can be transmitted through a vacuum, transparent bodies, translucent bodies and opaque bodies.

3.2 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.

3.3 Ray of light and Beam of light

Narrow stream of light is referred to as a ***ray of light.*** It can be produced by passing light through a small hole in a screen. A ray of light is represented in a diagram by a line with an arrow showing the direction of propagation. A collection of rays is called a ***beam*** of light. When the rays in a beam are parallel to one another, we have a parallel beam. When the rays in a beam of light diverge, we have a divergent beam. When the rays in a beam of light converge, we have a convergent beam.

3.4 Reflection of light

The Laws of Reflection:
There are two laws governing the reflection of light

1. The incident ray, the reflected ray and the normal at the point of incidence all lie in the same plane.
2. The angle of incidence **(i)** is equal to the angle of reflection ***(r)***

3.5 Types of Image formation

A ***virtual image*** is the one that cannot be caught in a screen. It is one through which rays of light do not actually pass but which is nevertheless visible to the eye.

A ***real image*** is one that can be caught on a screen. Light rays actually pass through a real image.

3.6 Characteristics of the image formed by a plane mirror

1. It is the same size as the object
2. It is virtual
3. It is laterally inverted
4. It is as far behind the mirror as the object is in front of the mirror
5. It is upright.

3.7 Curved or Spherical mirror

There are two types of curved mirrors **-** ***Convex*** and ***Concave*** mirrors.
They are made by silvering a glass surface which is part of a sphere. If the inside surface of this spherical part is silvered and the outside surface is the reflecting part, the resulting mirror is called a ***convex*** or ***diverging mirror.*** If the outside surface is silvered and the inside surface is the reflecting part, the resulting mirror is known as a ***concave*** or ***converging mirror.***

3.8 Essential Parts of Spherical Mirrors

- The ***Aperture*** is the width of a mirror.
- The ***Pole*** is the centre of the reflecting surface of the curved mirror.
- The ***Centre of curvature*** is the centre of the sphere of which the mirror forms a part.
- The ***Radius of Curvature*** is the radius of the sphere of which the mirror forms a part.
- The ***Principal Axis*** is the line from the pole to the centre of ***urvature.***

3.9 The mirror formula

The object distance, ***u,*** the image distance, ***v,*** and the focal length, ***f,*** of a spherical mirror are related by the equation

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

The formula for calculating Magnification (M) produced by a mirror

$$M = \frac{v}{u} = \frac{height\ of\ image}{height\ of\ object}$$

Where ***v*** is the image distance, and ***u,*** is the object distance.

3.10 Characteristics of the image formed by a concave mirror

1. If $u > 2f$ where **u** is object distance and distance and f is the focal length. The image formed is inverted, diminished, and real.
2. If $u = 2f$, image formed is inverted, same size as object, and real.
3. If $f < u < 2f$ the image formed is inverted, enlarged, and real.
4. If $u = f$ the image formed is at infinity
5. If $u < f$ the image formed is erect, enlarged, and virtual.

Note: If a ***convex mirror*** is used, an erect and virtual image smaller than the object results for any position of the object.

3.11 Characteristics of the image formed by a convex lens

1. If $u > 2f$ where **u** is object distance and distance and f is the focal length. The image formed is inverted and diminished.
2. If $u = 2f$, image formed is inverted, same size as object, and real.
3. If $2f > u > 2f$ the image formed is inverted, magnified, and real.
4. If $u = f$ the image formed is at infinity
5. If $f > u$ the image formed is erect, enlarged, and virtual.

Note: Unlike *Convex lens**, the*** ***Concave lens gives virtual image only*** *no matter the position of the object. Also the images are always erect and diminished.*

3.12 Lens formula

The object distance, ***u,*** the image distance, ***v,*** and the focal length, ***f,*** of a ***lens*** are related by the equation

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

The formula for calculating Magnification (M) produced by a lens

$$M = \frac{v}{u} = \frac{height\ of\ image}{height\ of\ object}$$

Where v is the image distance, and u, is the object distance.

Real is positive sign convention

Distance of a real objects and real images are positive. Focal length of convex lens is positive. Focal length of concave lens is negative.

3.13 Refraction of light

A ray of light travels from one transparent medium to another of different density, its direction is abruptly changed at the surface separating the two media. This is known as the *refraction* of the light ray. Therefore, a ray of light which travels through a medium is said to be refracted when it has its path changed on entering another medium. Refraction is due to the difference in the speed of light in the different media.

3.14 Refraction

Refraction is the bending of a light ray as it crosses the boundary between two media of different densities, thus causing a change in its direction.

Instances of refraction are: (1) a rectangular glass slab placed on a page of a book and gives the impression that the portion of the book covered by the slab is elevated. (2) A rod or spoon appears bent or broken when it is partially immersed in water or any liquid.

3.15 Laws of refraction

There are two laws governing the refraction of light

1. The incident ray, the refracted ray and the normal at the point of incidence all lie on the same plane.
2. The ratio of the Sine of the angle of incidence to the Sine of the angle of refraction is a constant for a given pair of media.

The second law is known as *Snell's law:*

$\frac{\sin i}{\sin r}$ = n, a constant for a given pair of media

The constant **n,** is known as the refractive index of the second medium with respect to the first medium.

For example, if light is travelling from air to glass, the refractive index of glass is given by

$$_{a}n_{g} = \frac{sine\ of\ angle\ of\ incidence\ in\ air}{sine\ of\ angle\ of\ refraction\ in\ glass}$$

If the light travels from glass to air then the refractive index $_{g}n_{a}$ is given by

$$_{g}n_{a} = \frac{sine\ of\ angle\ of\ incidence\ in\ glass}{sine\ of\ angle\ of\ refraction\ in\ air}$$

From the principle of the reversibility of light we have that:

$$_{a}n_{g} = \frac{1}{_{g}n_{a}}$$

Since refraction is due to the change in the speed of light as it travels from one medium to another, the refractive index is also given by

$$_{a}n_{g} = \frac{speed\ of\ light\ in\ air\ (vacuum)}{speed\ of\ light\ in\ glass}$$

4.0 CONCLUSION

It is not possible to see anything in a room during a blackout. If, however different sources of light are made available, then everything in the room becomes visible because they provide light. To illuminate more on the concept of light, discussion were done on the Speed and wavelength of light, laws of reflection of light, differences between a virtual image and a real image and the definition of the laws of refraction.

5.0 SUMMARY

This unit discusses light with particular reference to the following:

- different sources of light.
- Speed and wavelength of light
- Laws of reflection of light.
- virtual image and a real image.
- Laws of refraction.

6.0 TUTOR-MARKED ASSIGNMENT

i. State the laws of reflection and refraction
ii. Distinguish between *real* and *virtual* images.
iii. A transparent rectangular block 5.0cm thick is placed on a black dot. The dot when viewed from above is seen 3.0cm from the top

of the block. Calculate the refractive index of the material of the block.

7.0 REFERENCES/FURTHER READING

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

Adam, Steve & Haliday, Jonathan (2000). Advanced Physics. UK: Oxford University Press.

Ndupu, B. L. N., Okeke, P. N., & Ladipo O. A. (1989). Senior Secondary Physics, text book 2.Academy press Ltd, Lagos.

Mark, W. Zemansky & Richard, H. Dittmann (i981). Heat and Thermodynamics (Sixth Edition). New York: McGraw-Hill Book Company.

Online Microsoft Encarta available at: http://encarta.msn.com/encyclopedia 761575286/Heat (physics).html

Halliday, David, Resnick, Robert & Walker, Jeanrl (2001). Fundamentals of Physics-Extended (Sixth edition). New York: John Wiley and Sons, Inc.