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NATIONAL OPEN UNIVERSITY OF NIGERIA

SCHOOL OF EDUCATION

COURSE CODE: SED 323

COURSE TITLE: GENERAL PHYSICS FOR INTEGRATED SCIENCE

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SED 323 GENERAL PHYSICS FOR INTEGRATED SCIENCE

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MODULE 1 MAGNETIC FIELDS

INTRODUCTION: In this module you will be exposed to the meaning of magnetic fields, force or conductor and moving charge fields due to solenoid and long conductor was treated.

The module is divided into five different units as follows: -

Unit 1: Meaning of magnetic fields

Unit 2: Force on a conductor

Unit 3: fields due to solenoid

Unit 4: Fields due to long conductor

Unit 5: Biot-Savert law

UNIT 1 MEANING OF MAGNETIC FIELDS

CONTENT **1.0** INTRODUCTION

2.0 OBJECTIVE

3.0 MAIN CONTENT

4.0 CONCLUSION

5.0 SUMMARY

6.0 ASSIGNMENT

7.0 REFERENCES

1.0 **INTRODUCTION**

Before going in to see fields around conductor there is the need to have clear understanding of the meaning and characteristics of the magnetic field first.

2.0 **OBJECTIVES**

After studying this unit you should be able to: -

- Explain the meaning of magnetic field

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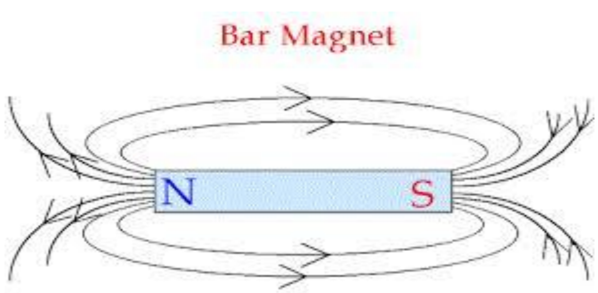
- Describe magnetic fields around magnet and some magnetic materials

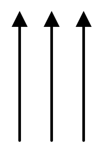
3.0 MAIN CONTENT

3.1 MEANING OF MAGNETIC FIELD

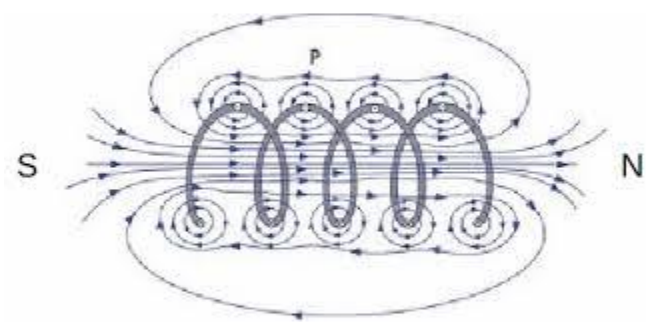
Magnetic field is a region in which a particle with magnetic properties or moving charges experiences force. It can also be seen as a region in the neighborhood of a magnet, electric current, or charging electric field in which magnetic forces are observable. Magnetic fields are usually represented by lines of force that emerge from the north seeking magnetic pole and enter south seeking magnetic pole.



North



Earth's local field



Field row solenoid

Figure 1. Magnetic lines of forces around bar magnet, solenoid and earth local field

Appearance of magnetic field could easily be obtained by ion fillings and accurately plotted with small compass around the magnetic material where the field is showing the magnetic line of forces become dense while at weak field the lines of field is less concentrated.

3.2 DIRECTION OF CURRENT AND FIELDS

The direction of field on a current carrying conductor is determined using cork screw rule. Imagine you are screwing a corkscrew into or out of the paper in the direction of the current, the turning motion is in the direction of the field arrow.

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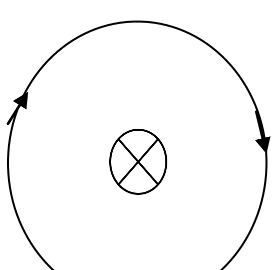

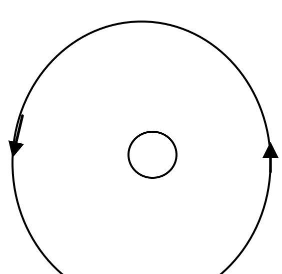

Figure 2. Corkscrew

SELF ASSESSMENT

What is the nature of magnetic field on straight conductor?

4.0 CONCLUSION

In this unit the meaning and shapes of magnetic field around some magnetic materials were highlighted

5.0 SUMMARY

Magnetic fields are region around a magnet current carrying conductor, where magnetic force is experienced. The field is represented by lines starting from north heading to the south. Direction of field is determined using corkscrew rule on straight conductors.

6.0 TUTOR MARKED ASSIGNMENT

Place piece of plane glass on bar magnet. Sprinkle iron filling on the glass, observe the pattern of filling. Draw the spread pattern and comment on that.

7.0 REFERENCES

Nelkon M. and Parker P. (1958) Advanced level Physics, Heineman Publishers Oxford.

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UNIT 2 FORCE ON A CONDUCTOR

1.0 INTRODUCTION

The principle on which moving coil meter, generator and machines are based on interaction of forces on a conductor in a magnetic field. Studying forces on a conductor is therefore a basic step towards understanding further related concepts.

2.0 OBJECTIVES

After successfully studying this unit, you should be able to:

(i) Describe force acting on a conductor in magnetic field

(ii) State the factors on which the force depends on

(iii) Solve some numerical exercises on force acting on a conductor

3.0 FORCE ON A CONDUCTOR

When a current carrying conductor is placed in a magnetic field due to some sources other than itself, the conductor experiences a mechanical force.

The relative directions of the current, applied field and the motion are determined by the left hand rule. If the middle finger, the fore finger and the thumb of left hand are stretched perpendicular to each other as in diagram bellow:

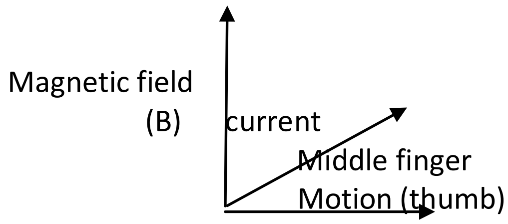

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Figure 3. Left hand rule. Fore finger (field), middle finger current) then thumb will show direction of motion.

SELF ASSESSMENT

If a current carrying conductor is placed in the direction ofrce depend on

Ampere in 1820 showed that if the conductor makes an angle of α with the field, the force on it is proportional to sin α

F α sin α -------------------------- (1)

Further investigation on how magnitude of force F depends on current I flowing in conductor of length L shown that

F α I ----------------------------(2)

F α L ----------------------------(3)

Since the higher the current in the conductor, the higher the force experienced, it was equally observed that the higher the current the higher the magnetic field generated. As such

F α B --------------------------(4)

Combination of the above factors gave the magnitude of the force as

F α BI L sin α

F = BI L sin α -------------(5)

Where K is constant of proportionality

3.3 **Numerical exercises**

A straight horizontal wire carries a current of 50A from west to east in a region where the magnetic field is 45^{o} towards the north east with magnitude 1.2T. Find the magnitude and the direction of the force on a 1m section wire.

F = BILSin α

=1.2X50X1Xsin45^{o}

F = 42.4N

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Force is perpendicular to current and field.

SELF ASSESSMENT

(i) What are the factors on which force on current carrying conductor in a magnetic field experience

4.0 CONCLUSION

A current carrying conductor in a magnetic field experiences a magnetic force and the three variables are mutually perpendicular to each other.

5.0 SUMMARY

The direction of current, magnetic field and mechanical force are mutually perpendicular of which the direction are better determined using left hand rule. The quantity of force on a conductor in a magnetic field is given as F =BILSin α where I s current, L length of conductor, B magnetic field strength, α angle of inclination of conductor and field.

6.0 TUTOR MARKED ASSIGNMENT

(i) Define magnetic flux density B in terms of force, current and length of conductor

(ii) Since B is a vector, what is the component of B in direction at an angle θ to B

(iii) A wire carrying a current of 10A and 2 meters in length is placed in a field of flux density 0.157. What is the force on the wire if is placed at right angle to the field.

REFERENCES

Nelkon M. and Parker P. (1958) Advanced level Physics, Heineman Publishers Oxford.

Sears, F.W., Zemansky, M.W. and Young H.D. (1982) University Physics, Addison-Wesley Publishing Company London

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UNIT 3 FIELD DUE TO SOLENOIDS

CONTENT

1.0 INTRODUCTION

Solenoids are long coils of wire which are widely used in electrical and radio industries. Studying magnetic field around a solenoid is a foundation for further studies on the item and related concepts.

2.0 OBJECTIVES

Students who go through this unit are expected to:

(i) Explain magnetic field due to solenoids

(ii) State some factors magnetic flux in a solenoid depends on.

3.0 MAIN CONTENT

In a solenoid of N turns and length L, carrying current I, the flux density B at all point within it is giving by $B = \mu_o nI$ where μ_o is a constant known as permeability of free space = $4\pi x 10^{-7} Hm^{-1}$, $n = {}^{N}/_{L}$

The flux B varies to maximum at the center of the solenoid and decrease to half B at the edges. The flux density in the middle of solenoid coil is given as:

$B = \mu_o nI = \mu_o \frac{NI}{L}$ --------------------------------------

While the flux at ends of any long solenoid is half that at the center

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$B = \frac{1}{2}\mu_o \frac{NI}{L}$---------------------------------

The direction of B inside solenoid could be determined using corkscrew rule

SELF ASSESSMENT

What are the factors on which the magnetic flux density B in a solenoid depends on?

4.0 CONCLUSION

Solenoids are long coil of wire. When solenoid of length L with number of turn N. with current I flowing in the magnetic field generated will have a flux B given as

$B = \mu_o nI$

5.0 SUMMARY

The magnetic flux density in a solenoid of length L with N number of turn will have a flux density B equal to

$B = \mu_o \frac{NI}{L}$ at the middle of coil

$B = \frac{1}{2}\mu_o \frac{NI}{L}$ at the edges of he coil

6.0 TUTOR-MARKED ASSESSMENT

Explain the direction of B inside the solenoid using the corkscrew rule

REFERENCES:

Nelkon M. and Parker P. (1958) Advanced level Physics, Heineman Publishers Oxford.

Sears, F.W., Zemarsky, M.W. and Young H.D. (1982) University Physics, Addison-Wesley Publishing Company London

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UNIT 4 FIELD DUE TO LONG CONDUCTOR

CONTENT

0.1 INTRODUCTION

Long conductors are important elements in electrical and redio equipments. Studying the behavior of long conductors in a magnetic field is important in understanding its relevance in any system

2.0 OBJECTIVES

After successfully studying the unit you should be able to:

(i) Describe the behavior of a long current carrying conductor in a magnetic field
(ii) State some factors that affect the magnetic flux B of a long current carrying conductor

3.0 MAIN CONTENT

3-1 FIELDS ALONG STRAIGHT CURRENT CARRYING CONDUCTORS

Consider a long straight conductor with the current coming out of the page, magnetic flux will be generated around the conductor in circular shape. The direction of magnetic flux is in direction of arrows on the tangent drawn on the circular field.

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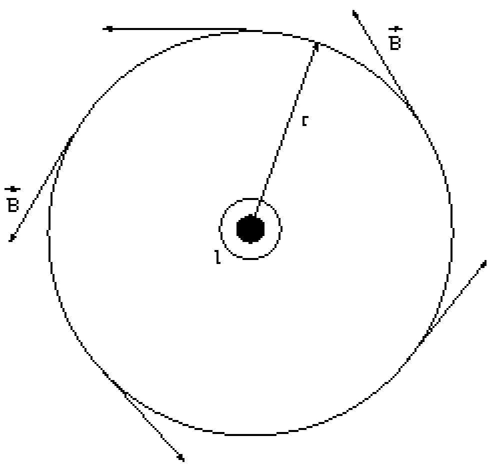

Figure 4. The magnetic of a long straight wire

At a distance *r* from the wire, as shown, the magnitude of the magnetic field is given by

$$B = \frac{\mu_0 I}{2\pi r}, \qquad (6)$$

where the constant μ_0 is called the **permeability of free space**, and is given by

$\mu_0 = 4\pi \times 10^{-7}\ T \cdot m / A$.

Figure 5. Variation of flux density B with radius r and current I

SELF ASSESSMENT

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What is the relationship between magnetic flux B around a straight conductor and the distance of flux from the conductor?

3.12 BIOT AND SAVART LAW

The magnitude of B for shape of a conductor at a point due to small element $\propto L$ of current carrying conductor is given by

$$\Delta B = \frac{\mu_o}{4\pi} \frac{IdLsin\theta}{r^2}$$

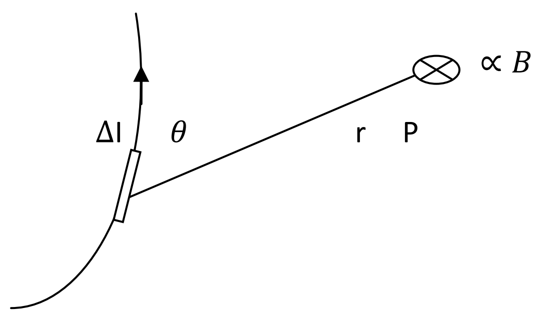

Fig6. Magnitude of B due small ΔL on a conductor

In vector form

$$\Delta B = \frac{\mu_o}{4\pi} \frac{Idlx\dot{\vec{r}}}{r^2}$$

SELF ASSESSMENT

At what angle of inclination between flux and current will the flux be equal to zero

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4.0 CONCLUSION

Magnetic field flux in a long current carrying conductor is circular around the conductor. Biot and Savert developed a law for calculation of B for any shape of a conductor.

5.0 SUMMARY

The magnetic flux (B) on a long straight current carrying conductor is given by

$$B = \frac{\mu_o}{2\pi}$$

Biot and Savert law states the flux B for any shape of conductor at a point due to small element $\Delta l \; is \; given \; by$ $\Delta B \propto \frac{I\alpha l \sin\theta}{r^2}$

θ is angle between $\Delta l$and line joininbg element and point of ΔB.

6.0 ASSIGNMENT

A vertical solenoid has 200 turns in a length of 0.40m and carries a current of 3A. What is the flux density in the middle of the solenoid?

7.0 REFERENCES

Nelkon M. and Parker P. (1958) Advanced level Physics, Heinemann Publishers Oxford.

Sears, F.W., Zemansky, M.W. and Young H.D. (1982) University Physics, Addison-Wesley Publishing Company London

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UNIT 5 FORCES BETWEEN CURRENTS

CONTENT

1.0 INTRODUCTION

In Electrical and radio devices several current carrying conductors are in use. We learnt that magnetic flux is generated around conductors. When two or more current carrying conductors are close to each other how will the magnetic flux interact between the conductors?

2.0 OBJECTIVES

By the end of the unit, students should be able to;

(i) Describe forces between current carrying conductors
(ii) State the magnitude of the force existing between parallel conductors
(iii) Define Ampere in term of force existing between conductors.

3.0 MAIN CONTENT

Consider two long straight parallel wires separated by a distance d carrying currents I_1 and I_2 in the same direction

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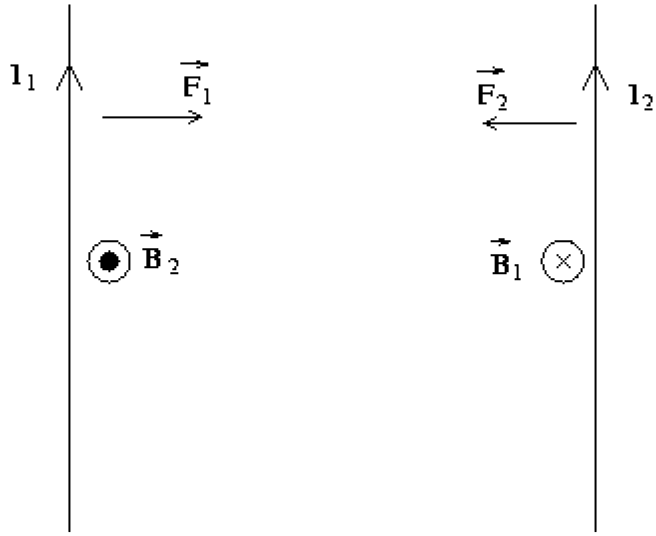

Figure 7. Force between two long straight parallel wires

Wire 2 will experience a magnetic field due to wire No1 given by

$$B_1 = \frac{\mu_{oI}}{2\pi r}$$

and hence will experience a force per unit length given by

$$\frac{F_2}{l} = \frac{\mu_o I_, I_2}{2\pi d}$$

In a similar manner, o wire 1 will experience a force due to the magnetic field B_2 of wire No2, and that this force F will have a magnitude equal to that of F_2 but opposite in direction.

Definition of Ampere

If two long parallel wires 1m apart each carry a current of 1A, then the force per unit length on each wire is 2 X 10^{-7}N/m.

Numerical Exercise

A long straight conductor X carrying a current of 2A is placed parallel to a short conductor Y of length 0.05cm carrying a current of 3A. The two conductors are 0.1 apart. Calculate the flux density due to X and Y.

Solution

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$$B = \frac{\mu_{oI}}{2\pi r} = \frac{4\pi\ X\ 10^{-7} X2}{2\pi\ X\ 0.10} = 4\ X\ 10^{-6} T$$

SELF ASSESSMENT

(i) Define Ampere.

4.0 CONCLUSION

Equal but opposite forces exist between two paralleled current carrying conductors/

5.0 SUMMARY

The magnitude of force existing between parallel conductors with current I separated by a distance r is given by $F = \frac{\mu_o Il}{2\pi r}$

6.0 ASSIGNMENT

State the law of force acting on a conductor carrying and electric current in a magnetic field. Indicate the direction of the force.

7.0 REFERENCES

Nelkon M. and Parker P. (1958) Advanced level Physics, Heineman Publishers Oxford.

Sears, F.W., Zemansky, M.W. and Young H.D. (1982) University Physics, Addison-Wesley Publishing Company London

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MODULE 2 ELECTROMAGNETIC INDUCTION

1.0 INTRODUCTION:

In this module you will be exposed to the meaning of electromagnetic induction, Faraday's and Lenz's laws, the dynamo and transformer and electric motors.

The module is divided into five different units as follows: -

Unit 1 Electromagnetic Induction

Unit 2 Faraday's and Lenz laws

Unit 3 the dynamo

Unit 4 Transformer

Unit 5 Electric Motors

UNIT 1 ELECTROMAGNETIC INDUCTION

CONTENT

1.0 INTRODUCTION

2.0 OBJECTIVE

3.0 Main CONTENT

4.0 CONCLUSION

5.0 SUMMARY

6.0 ASSIGNMENT

7.0 REFERENCES

1.0 **INTRODUCTION**

Ampere and colleague found out that electric current has some magnetic effect. The possible effect of magnetic flux on electric current was studied by faradays and others.

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2.0 OBJECTIVES

After studying this unit you should be able to:

- Explain the meaning and condition for electromagnetic induction

3.0 MAIN CONTENT

3.1 MEANING OF ELECTROMAGNETIC INDUCTION

Michael Faraday discovered that when a magnet is moved towards or away from a coil connected to a galvanometer, there was a kick in the galvanometer. The kick indicated that some e.m.f has been created which generate flow of electrical charges. The generation of e.m.f and electrical current flow due to magnetic flux charge is called electromagnetic induction.

Results from Faraday's experiment indicated that the induced e.m.f was only generated when the magnet flux was charging i.e by moving the coil to and fro the electrical coil. It was also discovered that speed of movement of flux charge increases the induced current.

SELF ASSESSMENT

Explain the meaning of e.m.f

4.0 CONCLUSION

Movement of magnet to and fro a coil produces charges in e.m.f which causes a galvanometer to kick

5.0 SUMMARY

When ever there is charge in magnetic flux towards or away from a coil e.m.f charge is induced which induces electrical current flow. The speed of the flux charges increases the induced current.

6.0 ASSIGNMENT

What will be the impact of resistance of the coil in the e.m.f and electrical current induced?

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7.0 REFERENCES

Nelkon M. and Parker P. (1958) Advanced level Physics, Heineman Publishers Oxford.

Sears, F.W., Zemansky, M.W. and Young H.D. (1982) University Physics, Addison-Wesley Publishing Company London

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UNIT 2 FARADAY'S AND LENZ'S LAWS OF ELECTROMAGNETIC INDUCTION

CONTENT

1.0 INTRODUCTION

The quantity and direction of flow of induced e.m.f and current were studied by Faraday and Lenz.

2.0 OBJECTIVES

After studying this unit, you should be able to: -

- State and explain Faraday's and Lenz's law of electromagnetic induction

3.0 MAIN CONTENT

3.1 FARADAY'S LAW

Faraday in his study of the magnitude of induced e.m.f found out that the induced e.m.f increases with the following:

(i) The speed turning induction coil
(ii) The area of the coil
(iii) The strength of the magnetic field
(iv) The number of turn in the coil

Based on observation (i) to (iv) Faraday concluded that the e.m.f induced in a c oil increases with the rate of charge of the magnetic flux through it.

Faraday's law states that the induced e.m.f is directly proportional to the rate of change of magnetic flux linking the coil.

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SELF ASSESSMENT

What will be the outcome of e.m.f by keeping magnet and induction coil stationary?

3.2 LENZ'S LAW

Lenz investigated on the direction of induced e.m.f. He took a coil whose direction of winding where known and connected to a galvanometer. In turn the pole of each magnet was pushed into and out of the coil. The generalized outcome indicated that the induced current flows always inn such a direction as to oppose the charge causing it. This is Lenz's law.

Lenz's law is in consonance with the law of conservation of energy.

SELF ASSESSMENT

State Lenz's law in your own words.

4.0 CONCLUSION

An induced e.m.f and electric current is obtained when there is charge amount of magnetic flux.

5.0 SUMMARY

* Lenz's law states that the induced current opposes the motion or charge producing it.

* Faraday found out that the induced e.m.f is directly proportional to the rate of magnetic flux linking the circuit or coil.

6.0 ASSIGNMENT

Explain why Lenz's law is a consequence of law of conservation of energy.

7.0 REFERENCES

Nelkon M. and Parker P. (1958) Advanced level Physics, Heineman Publishers Oxford.

Sears, F.W., Zemarsky, M.W. and Yoong H.D. (1982) University Physics, Addison-Wesley Publishing Company London

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UNIT 3 THE DYNAMO GENERATOR

CONTENT

1.0 INTRODUCTION

The electromagnetic induction discovered by Faraday laid the foundation for the development of electric current generation machines

2.0 OBJECTIVES

After the going through the unit, students should be able to;

- State and explain the working principle of an electrical dynamo (generator)

3.0 MAIN CONTENT

3.1 THE DYNAMO GENERATOR

The general principle on which electric generators are designed is on the fact that when a conductor carrying a current in a magnetic field due to some sources other than itself. The conductor experiences a mechanical force. In a generator a conductor in a magnetic field is put unto motion using mechanical force to generate electrical current in the conductor.

The generator consists of coil which rotates on a shaft between the poles of a horseshoe magnet. The ends of the coil are connected to slip-rings. Contact with rings is made by small block of carbon

As the coils rotate the magnetic flux linkage changes and current is induced according to Faraday's law. The magnitude and direction of current is determined by considering

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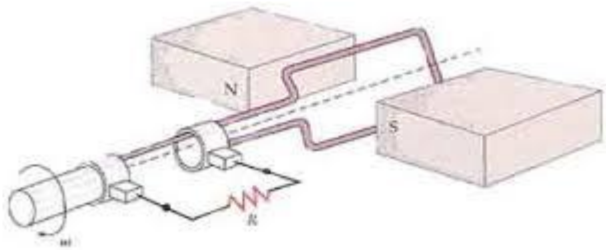
the mutual perpendicular of flux, current and mechanical force using Fleming right hand rule.

Figure 8 Action of simple Dynamo



When the dynamo coil is horizontal, the e.m.f is a maximum. When the coil is vertical the e.m.f is zero.

SELF ASSESSMENT

What is the working principle of electric generator?

4.0 CONCLUSION

An electric dynamo produces electric current by turning a long conductor placed in a magnetic field.

5.0 SUMMARY

The electric dynamo generator works on the principles of Electromagnetic Induction discovered by Faraday.

The theory of generation of electrical current is that when a long conductor is mechanically rotated in a magnetic field in another foundation principle of a generator. The direction of the current is determined by the position of the coil and the direction of the magnetic flux.

6.0 ASSIGNMENT

What is the difference between a d.c and a.c generator?

7.0 REFERENCES

Nelkon M. and Parker P. (1958) Advanced level Physics, Heineman Publishers Oxford.

Sears, F.W., Zeemansky, M.W. and Yoong H.D. (1982) University Physics, Addison-Wesley Publishing Company London

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UNIT 4 TRANSFORMER

CONTENT **1.0 INTRODUCTION**

2.0 OBJECTIVE

3.0 Main CONTENT

4.0 CONCLUSION

5.0 SUMMARY

6.0 ASSIGNMENT

7.0 REFERENCES

1.0 INTRODUCTION

Studying of the devices used is regulating current flow in electrical system is fundamental in having good control in electrical devices.

2.0 OBJECTIVES

After going through this unit, students are expected to be able to:

- Define a transformer
- State working principles of the device

3.0 MAIN CONTENT

3.1 TRANSFORMER

It is a device for stepping up or down an alternating voltage. Transformer has primary and secondary coils or winding with an iron core insulting bound at the center

The iron core is usually made up of thin insulated E-shaped slices tightly bound so that the magnetic flux does not pass through air at all.

When alternating e.m.f E_P is connected to the primary coil, it sends alternating current through it. The alternating set up and alternating magnetic flux in the core. The magnitude of the flux is BA where A is the cross-sectional are of the core and B is the flux density. The magnetic flux induces an alternating e.m.f in the secondary E_S. if the

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primary and secondary coils have N_P and N_S number of turns respectively. Flux linkages for the coils are

$$\emptyset_p = N_p AB \qquad \emptyset_s = N_s AB$$

Magnitude of induces e.m.f in the secondary is $E_s = \frac{d\phi_s}{dt} = N_s A \frac{\delta B}{\delta t}$

The charging flux induces a back e.m.f in the primary

$$E_p = \frac{\delta\phi_p}{\delta t} = N_p A \frac{\delta B}{\delta t}$$

Voltage applied in primary is used in overcoming back e.m.f E_p this let to the fact that

$$\frac{secondaryvoltage}{primaaryvoltae} = \frac{numberof\,secondaryturns}{numberof\ primaryturns}$$

Transformer efficiency $\frac{power\ in\,seconary}{power\,in\ primary} X100\% = \frac{power\ input}{power\ output} X100\%$

SELF ASSESSMENT

What is the differences between step up and step down transformer?

4.0 CONCLUSION

Transformer works on the principle of electromagnetic induction. Voltage connected to the primary coil induces e.m.f and electric current in the secondary coil.

5.0 SUMMARY

Transformer is a device for stepping up or down an alternating voltage. Connected voltage at the primary coil induces magnetic flux on the secondary coil. The flux charge depends on the cross-sectional A are of coil, magnitude of flux B. and the number of turns of coil.

$$\frac{secondaryvoltage}{primaaryvoltae} = \frac{numberof\,secondaryturns}{numberof\ primaryturns}$$

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6.0 **ASSIGNMENT**

Suppose a 240V main transfer has an efficiency of 90% and light is used to light normally a 12V 36W lamp. Determine the turn-ratio and the current un the primary coil.

7.0 **REFERENCES**

Nelkon M. and Parker P. (1958) Advanced level Physics, Heineman Publishers Oxford.

Sears, F.W., Zemansky, M.W. and Young H.D. (1982) University Physics, Addison-Wesley Publishing Company London

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UNIT 5 ELECTRIC MOTOR

CONTENT

1.0 INTRODUCTION

Electric motor is another device developed based on electromagnetic induction.

2.0 OBJECTIVES

By the end of the unit, students should be able to:

- Describe an electric motor
- State and explain working principle of electric motor

3.0 MAIN CONTENT

3.1 ELECTRIC MOTOR

An electric motor is an electric machine that converts electrical energy into mechanical energy. It is used for driving many machines at homes and in the industry.

Simple electric motor consists of;

(i) A coil of wire (armature) which can rotate about a fixed axis
(ii) A powerful magnetic which the coil turns
(iii) A commutator which in its simplest form, is a split copper ring whose two halves A and B are insulated from each other

Current flaws round the armature coil, and the magnetic field exerts a couple on this, as in a moving coil meter. The commutative reverses the current just as the slides of the coil are changing from upward to downward movement and vice versa.

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SELF ASSESSMENT

Where do we get back e.m.f motors?

4.0 CONCLUSION

Electric motor generates mechanical force by rotating a current carrying conductor in a heavy magnetic field.

5.0 SUMMARY

Electric motor generates mechanical force by rotating conductor carrying current. The coil has two commutator which is made of two halves, and reverses the current in the coil after half revolution so that the coil keeps turning around.

6.0 ASSIGNMENT

What are the working principle of an electric mototr

7.0 References Nelkon M. and Parker P. (1958) Advanced level Physics, Heineman Publishers Oxford.

Sears, F.W., Zemansky, M.W. and Young H.D. (1982) University Physics, Addison-Wesley Publishing Company London

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MODULE 3 MODERN PHYSICS

INTRODUCTION

In this module, you will be exposed to the meaning of radioactivity, nuclear reaction and relativity.

The module is divided into five different units as follows: -

Unit 1 Nuclear Atom

Unit 2 Radioactivity

Unit 3 Nuclear Reaction

Unit 4 Fission and Fusion Reaction

Unit 5 Relativity

UNIT 1 THE NUCLEAR ATOM

CONTENT 1.0 INTRODUCTION

2.0 OBJECTIVE

3.0 Main CONTENT

4.0 CONCLUSION

5.0 SUMMARY

6.0 ASSIGNMENT

7.0 REFERENCES

1.0 **INTRODUCTION**

Most studies in modern or atomic physics centers around what happens in the nucleus of the atom. Proper grasp of the structure and content of the nucleus would be a sound beginning.

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2.0 OBJECTIVES

After successfully studying content of this unit you should be able to: -

- Describe the structure and content of the atomic nucleus
- State some general properties of the nucleus

3.0 MAIN CONTENT

3.1 THE NUCLEAR ATOM

Atom contains a massive, positively charged nucleus, much smaller than the overall dimension of the atom but containing most of the total mass of the atom. The nucleus contains positively charged proton and neutral neutrons. The particles inside the nucleus are call nucleons.

The nucleus was discovered by Geiger and Marsden in 1909 after the scattering of α -particle by thin film of metal of high atomic mass. In the experiment some α -particles were scattered through very large angles. The scattering was due to the positively charged nucleus.

PROPERTIES OF NUCLEUS

The radius of the nucleus is found to depend on the number of nucleons in the nucleus. The radii off most nuclei are represented by the equation

$r = r_o A^{1/3}$

where r is radius of nuclei, A is the mass number r_o is a constant equal to 1.2 X 10^{-15}m. In the nucleus the total number of nucleons (proton and neutron) is called the mass number denoted by A. The total number of protons equal in neutral atom to the number of electrons is called the atomic number Z. The number of neutrons called the neutron number N. For any nucleus it is represented as $^{A}_{Z}X_{N}$ *and* $A = Z + N$

SELF ASSESSMENT

Determine the radius of the nucleus of $^{12}_{6}O$ taken r_o = 1.2 X 10^{-15}m.

4.0 CONCLUSION

The nucleus is the central part of an atom with two major nucleons i.e. proton and neutrons.

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5.0 SUMMARY

Neutral atom is expected to have equal number of protons and electrons. The radius of the nucleus depends on the number of nucleus as expressed in the relation $r = r_o A^{1/3}$. Nucleus of an atom is symbolically represented as ${}_{Z}^{A}X_{N}$ where A is mass number, Z atomic number and N neutron number.

6.0 ASSIGNMENT

* The radius of uranium -238 nucleus is about 7.4 X 10^{-15}m, what is the number of nucleus of the atom?

* Explain some general properties of nucleus of an atom.

7.0 REFERENCES

Nelkon M. and Parker P. (1958) Advanced level Physics, Heineman Publishers Oxford.

Sears, F.W., Zemansky, M.W. and Young H.D. (1982) University Physics, Addison-Wesley Publishing Company London

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UNIT 2 RADIOACTIVITY

1.0 INTRODUCTION

In further studies on the properties of the atom, study of radioactivity is very important aspect.

2.0 OBJECTIVES

After studying, the students should be able to: -

- Define and state different types of radioactivity
- State names and general properties of radioactive particles
- Describe radioactive transformation

3.0 MAIN CONTENT

3.1 RADIOACTIVITY

It is the spontaneous disintegration of radioactive materials resulting into generation of some energy and emission of some radioactive particles. There are three major particles emitted in radioactivity; alpha α, Bête particle β and gamma γ radiations. The radiation particles are found to have general properties such as penetration and ionization. The general properties are displayed in the following table:

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Table 1.0 Some general properties of elements in radioactivity

Type	Penetration	Ionization	Charge	Nature	Speed	Mass
α	Least	Most	+ve	Helium atom	Slow	Heavy
β	Moderate	Moderate	-ve	Electron	Moderate	Moderate
γ	Most	Least	Neutral	E.M wave	Fast	Light

The rate at which radioactive material decays is known as activity. The number of radioactive nuclei in any sample of radioactive material decreases continuously as some of the nuclei disintegrates.

The new elements formed after disintegration can be identified by considering the particles emitted from the nucleus of parent atom;

For α particle A – 4

Z – 2 eg. ${}_{92}U^{238} \rightarrow {}_{90}Th^{234} + {}_{2}^{4}He$

For β -particle A – 0

Z + 1 e.g. ${}_{90}Th^{234} \rightarrow {}_{91}Pa^{234} + \ell$

For gamma particle no charge in A, Z or N

4.0 CONCLUSION

There some elements that disintegrates into other elements with emission of some particles naturally or artificially. The radiated particles can penetrate ionize gases.

5.0 SUMMARY

Disintegrated particles in radioactivity are alpha, Beta and gamma radiation. Alpha is a helium atom, beta an electron and gamma an E.M.

6.0 ASSIGNMENT

A uranium nucleus, U -238, atomic number 92, emits two α particles and two β particles (electrons) and forms a thorium (Th) nucleus. What is the symbol of this nucleus?

7.0 REFERENCES

Nelkon M. and Parker P. (1958) Advanced level Physics, Heineman Publishers Oxford.

Sears, F.W., Zemansky, M.W. and Young H.D. (1982) University Physics, Addison-Wesley Publishing Company London

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UNIT 3 NUCLEAR REACTIONS

CONTENT

1.0 INTRODUCTION

In radioactivity, emission of some [articles and energy are involved. There is the need to know how to determine the energy and nature of particles involved.

2.0 OBJECTIVES

By studying this unit, you should be able to; -

- Determine energy involved in simple nuclear reactions

3.0 MAIN CONTENT

3.1 NUCLEAR REACTION

In any nuclear reaction, the law of conservation of mass and charge is applied. It is stated as follows: -

1. Total mass (nucleon) number is constant before and after reaction
2. Total charge (proton) number is constant before and after reaction

Consider the following reaction:

$${}_1H^1 + {}_3Li^7 \rightarrow {}_2^4He + {}_2^4He$$

Masses before reaction

$${}_1^1H = 1.00783u$$
$${}_3^7Li = 7.01601u$$
$$\text{--------}$$
$$8.02384$$

masses after reaction

$${}_2^4He = 4.00260u$$
$${}_2^4H = 4.00260u$$
$$\text{---------}$$
$$8.00520u$$

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The difference between the masses before reaction and after reaction is called mass difference. The energy from mass difference is obtain using relation E = mc^2 gives the reaction energy.

Mass difference = 8.02384 – 8.00520 = 0.01864u

E = mc^2 = 0.01864u X 931meV (1u = 931meV)

E = 17.4Mev

This is the energy release after reaction. If energy obtained is +ve, energy is release, if energy obtained is –ve, energy is absorbed.

SELF ASSESSMENT

How does energy release relate to stability of nucleus?

4.0 CONCLUSION

In any nuclear reaction the law of conservation of energy and charge is maintained.

5.0 SUMMARY

In nuclear reaction, the difference between rest masses gives mass defect. The energy

Equivalent of the mass difference obtained using Eisten relation E = mc^2 gives nuclear reaction energy.

6.0 ASSIGNMENT

Consider the following reaction:

$$^{210}_{84}Po \rightarrow ^{206}_{82}Pb + ^{4}_{2}He + Q$$

Determine whether energy is release or absorbed

$$^{210}Po = 209.982u, \quad ^{208}Pb = 205.969u, \ ^{4}_{2}He = 4.004u$$

7.0 REFERENCES

Nelkon M. and Parker P. (1958) Advanced level Physics, Heineman Publishers Oxford.

Sears, F.W., Zemarsky, M.W. and Yoong H.D. (1982) University Physics, Addison-Wesley Publishing Company London

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UNIT 4 NUCLEAR FISSION AND FUSION

1.0 INTRODUCTION

Nuclear reaction goes beyond release of small particles like $\alpha, \beta \, or \, \gamma$. Release of heavy particles and large amount of energy is possible in nuclear reaction of fission and fusion.

2.0 OBJECTIVES

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

- Describe nuclear fission and fusion reaction
- State some conditions

3.0 MAIN CONTENT

3.1 NUCLEAR FISSION

When the nucleus of heavy radioactive elements is split into two or more particles, the nucleus is said to undergo fission. Fission reaction could be initiated by bombarding nucleus of heavy radioactive element by fast particles like neutron.

Uranium bombarded with fast neutron, gave out barium, krypton and neutron among the products. In Uranium fission released neutron could cause continuous fission in neighbouring nucleus causing chain reaction;

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{148}_{57}La + ^{85}_{35}Br + 3^{1}_{0}n$$

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Fission chain reaction occurs only in nuclear reactor. In the reactor, energy generated could be tapped and used in generating electricity and other isotopes for other uses. Action of atomic bomb occurs in the fission fashion.

SELF ASSESSMENT

What is fission reaction?

3.2 FUSION REACTION

Fusion involves the combination of two light nuclei to form a nucleus that is heavier and more complex. Example:

$$ {}_1^1H + {}_1^1H \rightarrow {}_1^2H + {}_1^0\ell $$
$$ {}_1^2H + {}_1^1H \rightarrow {}_2^3He + \gamma $$

For fusion to occur, the two nuclei must come together within the range of 2 X 10^{-15}m to overcome electrostatic repulsive forces. The nuclei must be at a temperature of 5 X 10^{9}k almost the temperature of the sun. The above fusion reaction occurs in the sun. The energy release in both fission and fusion reaction can be determined by setting the energy equivalent of the total mass of reactant and that of the mass of the product.

SELF ASSESSMENT

Describe fusion reaction

4.0 CONCLUSION

Fission and fusion reaction give out heavy particles and large amount of energy.

5.0 SUMMARY

Nuclear fission is the splitting of heavy atom such as uranium into two lighter parts.

Nuclear fusion is the combination of two light elements to give heavier nuclei. Fusion could only occur when the nucleus of combining particles are extremely close and are at extremely high temperature of the sun.

6.0 ASSIGNMENT

Describe chain reaction.

What is the difference between fission and fusion reaction?

7.0 REFERENCES

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Nelkon M. and Parker P. (1958) Advanced level Physics, Heineman Publishers Oxford.

Sears, F.W., Zemarsky, M.W. and Yoong H.D. (1982) University Physics, Addison-Wesley Publishing Company London

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UNIT 5. RELATIVITY

1.0 INTRODUCTION

Several laws of physics have been developed. Are these laws true everywhere and at any time? This is one of subject of discussion in present unit.

2.0 OBJECTIVE

After studying this unit, you should be able to;

- State the meaning of Relativity
- State the different kinds of Relativity

3.0 MAIN CONTENT

3.1 MEANING OF RELATIVITY

It is the notion or believe that the laws of physics are the same everywhere. We here on Earth obey the same laws of light and gravity as someone in a far off corner of the universe.

The universality of physics means that history is provincial. Different viewers will see the timing and spacing of events differently. What for us is a million years may just be a blink of an eye for someone flying in a high speed rocket or falling into a black hole.

The theory of relativity, or simply relativity in physics, usually encompasses two theories by Albert Einstein: special relativity and general relativity

Special relativity

Special relativity came first and is based on the speed of light being constant for everyone. That may seem simple enough, but it has far-reaching consequences.

Einstein came to this conclusion in 1905 after experimental evidence showed that the speed of light didn't change as the Earth swung around the Sun.

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This result was surprising to physicists because the speed of most other things does depend on what direction the observer is moving. If you drive your car alongside a railroad track, a train coming at you will seem to be moving much faster than if you turned around and followed it in the same direction.

Einstein said that all observers will measure the speed of light to be 186,000 miles per second, no matter how fast and what direction they are moving.

Mass, too, depends on speed. The faster an object moves, the more massive it becomes. In fact, no spaceship can ever reach 100 percent of the speed of light because its mass would grow to infinity.

This relationship between mass and speed is often expressed as a relationship between mass and energy: E=mc^2, where E is energy, m is mass and c is the speed of light.

General relativity

Einstein wasn't done upsetting our understanding of time and space. He went on to generalize his theory by including acceleration and found that this distorted the shape of time and space.

To stick with the above example: imagine the spaceship speeds up by firing its thrusters. Those onboard will stick to the ground just as if they were on Earth. Einstein claimed that the force we call gravity is indistinguishable from being in an accelerating ship.

This by itself was not so revolutionary, but when Einstein worked out the complex math (it took him 10 years), he discovered that space and time are curved near a massive object, and this curvature is what we experience as the force of gravity.

The equations of general relativity predict a number of phenomena, many of which have been confirmed:

- bending of light around massive objects (diffraction)
- weakening of light escaping gravity's pull (gravitational red shift)
- the existence of black holes that trap everything including light

SELF ASSESSMENT What is relativity?

4.0 CONCLUSSION Relativity theory is saying that all Physics are relative same everywhere

5.0 SUMMARRY Einstein's Relativity theory is divided into special and general relativity.

Special relativity came first and is based on the speed of light being constant for

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everyone. Einstein generalised his theory by including acceleration and found that this distorted the shape of time and space.

6.0 ASSIGNMENT

i Identify some of the concepts introduced by Einstein' relativity theory

ii What are some of the predictions of the special relativity theory?

7.0 REFERENCES

1 Einstein A. (1916), *Relativity: The Special and General Theory* (Translation 1920), New York: H. Holt and Company

2 Will, Clifford M (August 1, 2010). "Relativity". *Grolier Multimedia Encyclopedia*. Retrieved 20-01-2015.

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