RATU NAVULA COLLEGE

Y12 PHYSICS HOME LEARNING KIT 8

LESSON 100 LO: study charge moving in a magnetic field.

MOTION OF A CHARGED PARTICLE IN A MAGNETIC FIELD

- When a charged particle moves through a magnetic field it experiences a force
- For a particle that is moving at right angles to the magnetic field the force is given by

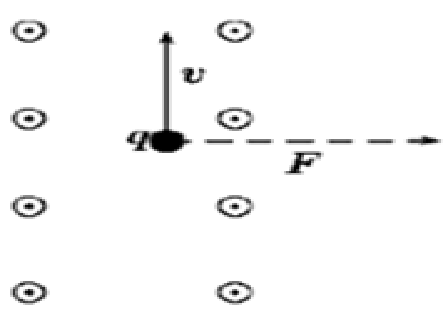
$$F = Bvq$$

where F is the force

q is the charge on the particle,

v is the velocity of the particle and

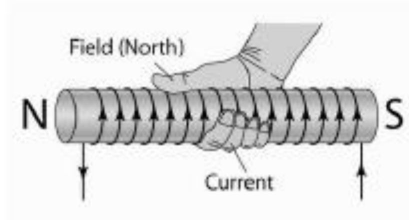
B is the magnetic field through which the particle is moving



HOW TO DETERMINE THE DIRECTION OF FORCE?

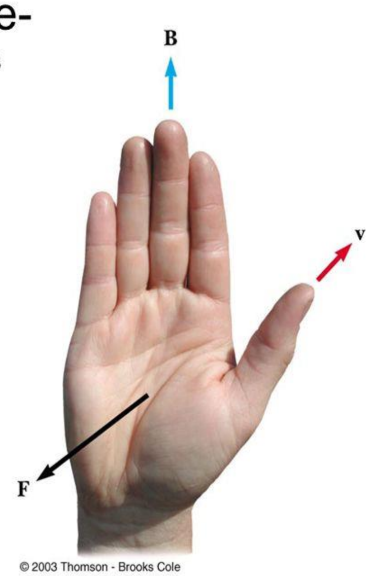
a. RIGHT HAND GRIP rule or
b. RIGHT HAND SLAP RULE

- The direction of the force exerted on a charged particle moving through a magnetic field is given by using the Right Hand Rule.



Right Hand Rule-
for individual charges

- Hold your right hand open
- Place your fingers in the direction of B
- Place your thumb in the direction of v
- The direction of the force on a positive charge is directed out of your palm
  - If the charge is negative, the force is opposite that determined by the right hand rule



EXAMPLE

An electron travels at 150m/s at right angles to a magnetic field of 80 000 T. What force is exerted on the electron?

We are given

q = 1,6 × 10−19C (The charge on an electron)

v = 150m/s

B = 80 000T

using

F = qvB

= (1,6 × 10−19C)(150m.s−1)(80 000T)

= 1,92 × 10−12N

The direction of the force exerted on a charged particle moving through a magnetic field is determined by using the Right Hand Rule.

Point your fingers in the direction of the velocity of the charge and turn them towards the direction of the magnetic field. Your thumb will point in the direction of the force. If the charge is negative, the direction of the force will be opposite to the direction of your thumb.

2019 (EXAMPLE)

A narrow beam of protons (charge 1.6×10^{-19} C) moving with a speed of 2×10^{6} ms^{-1} enters a uniform magnetic field strength of 0.3 T. Calculate the magnetic force on the protons. **(2 marks)**

A wire of length 2 m is moved perpendicular to a magnetic field of strength 4 T with a velocity of 5 ms^{-1}.

(i) Calculate the induced voltage across the ends of the wire. **(1 mark)**

$V = Bvl$

$= (4) \times (5) \times (2)$

$= 40$ V

(ii) The ends of the wire are connected to a circuit with a negligible resistance it is found that a 4 A current flows around it. Calculate the force that must be applied to keep the wire moving and generating this current. **(1 mark)**

$F = BIl$

$F = (4) \times (4) \times (2)$

$=$ **32 N**

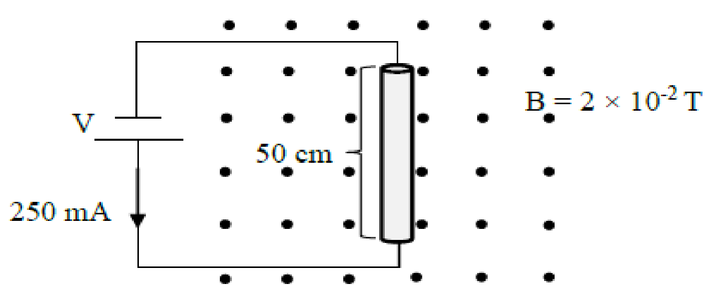
(iii) State **two** ways of increasing the current which is generated by the moving wire. **(2 marks)**

1. By increasing the speed of the wire
2. By decreasing the resistance of the wire
3. Using a stronger field

ACTIVITY

2018

A conductor of length 50 cm is placed in a magnetic field of strength 2×10^{-2} T. The current in the wire is 250 mA as shown in the diagram below.



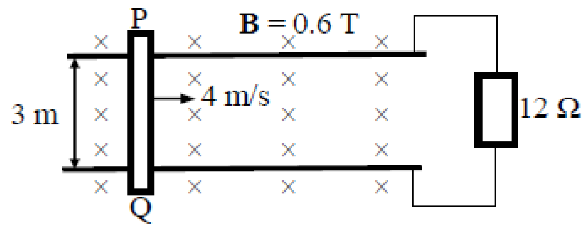
(i) State the direction of the magnetic force experienced by the wire. **(1 mark)**

(ii) Calculate the magnitude of the magnetic force experienced by the conductor. **(1 mark)**

(iii) Determine the magnitude of the magnetic force if the length of the conductor is doubled and the current flow through the wire is decreased to one quarter of the original. **(2 marks)**

2015

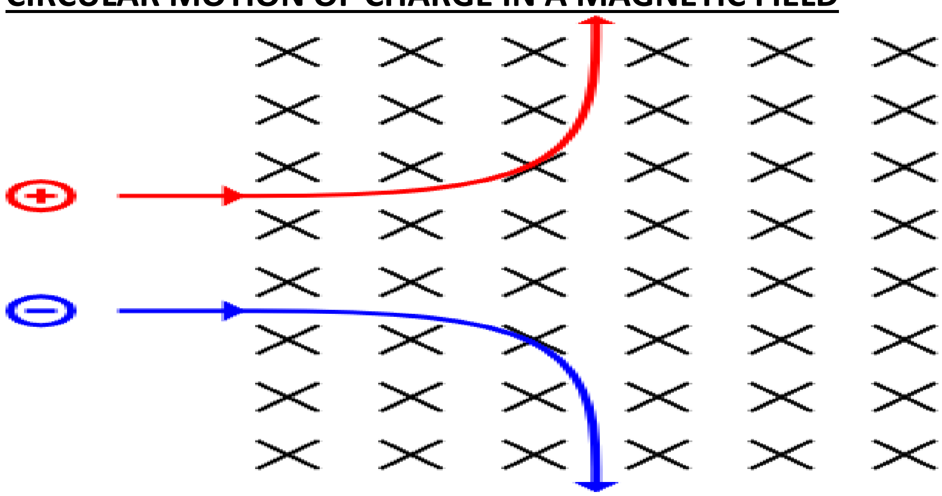
A copper rod, PQ moves horizontally to the right at a uniform speed of 4 m/s along two conducting rails 3 m apart that are connected to a 12 Ω resistor. The set-up is in a magnetic field, **B**, of 0.6 T directed into the page.



Calculate the induced voltage across the rod PQ. **(2 marks)**

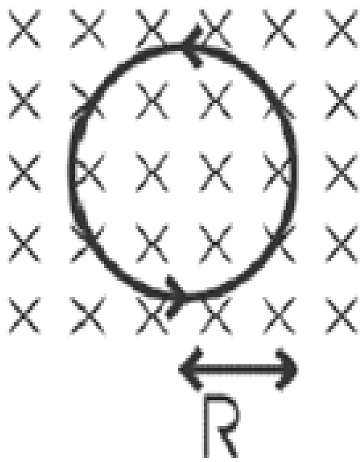
LESSON 101 LO: describe effects of a magnetic field on a moving charge
: calculate radius of curvature of the path of a charged particles in a magnetic field.

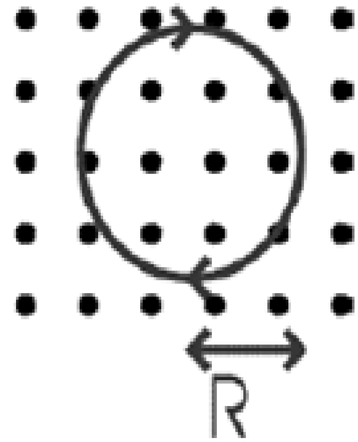
<u>CIRCULAR MOTION OF CHARGE IN A MAGNETIC FIELD</u>



-Motion of charged particle entering magntic field is circular. Why?
Because FORCE is perpendicular to motion

- Charged particles in a magnetic field feel a force perpendicular to their velocity.
- Since their movement is always perpendicular to the force, magnetic forces do no work and the particles velocity stay constant. Since, the force F = qvB in a constant magnetic field a charged particle feels a force of constant magnitude always directed perpendicular to its motion. The result is a circular path.
- Motion of positive particle in magnetic field is :
  a)anticlockwise when B is into page b) clockwise when B is out of page





-velocity (magnitude) of charged particle is constant, but direction of velocity keeps changing hence particle is accelerating.

-the acceleration of the particle on a circular path is

$$a = \frac{v^2}{R}$$

Using ***F* = *ma***, one obtains:

$$F = qvB = m\frac{v^2}{R} \quad \Rightarrow \quad R = \frac{mv}{qB}$$

$F_c = F_m$

R: radius of circular orbit

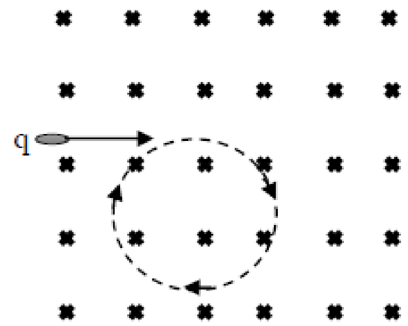
$R \propto mv$

$R \propto p$

$R \propto 1/Bq$

2018

A charged particle, q, is moving through a uniform magnetic field in circular motion as shown below.

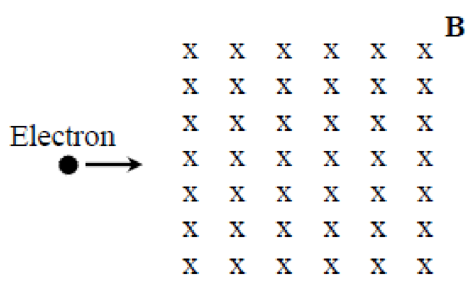


If the charged particle moves with a faster velocity, the radius of the circular motion will

A. increase.
B. decrease.
C. become zero.
D. remain the same.

2017

An electron enters a uniform magnetic field, **B**, of intensity 2.8 T at right angles with a speed of 2.1×10^3 ms^{-1} as shown below.



(i) State the direction of the magnetic force experienced by the electron. **(1 mark)**

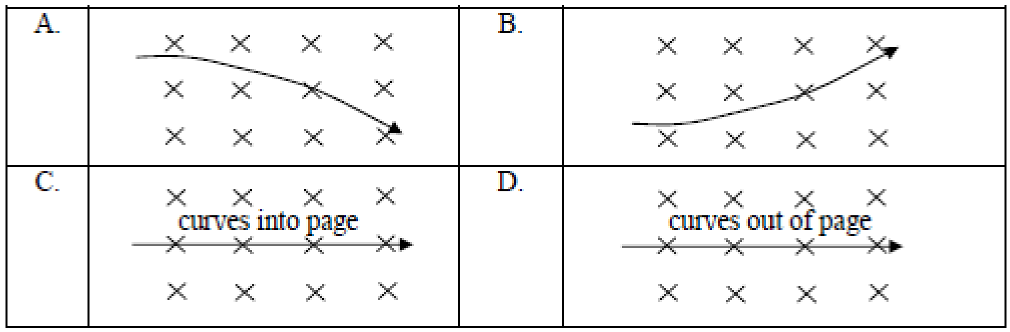
(ii) Calculate the magnitude of the magnetic force experienced by the electron. **(1 mark)**

(iii) State why the electron will follow a circular path. **(1 mark)**

(iv) Calculate the radius of the circular path followed by the electron in the magnetic field. **(1 mark)**

2012

A moving positive charge particle enters a uniform electric field that is into the page. Which of the following diagrams best represents the path of the moving charge?



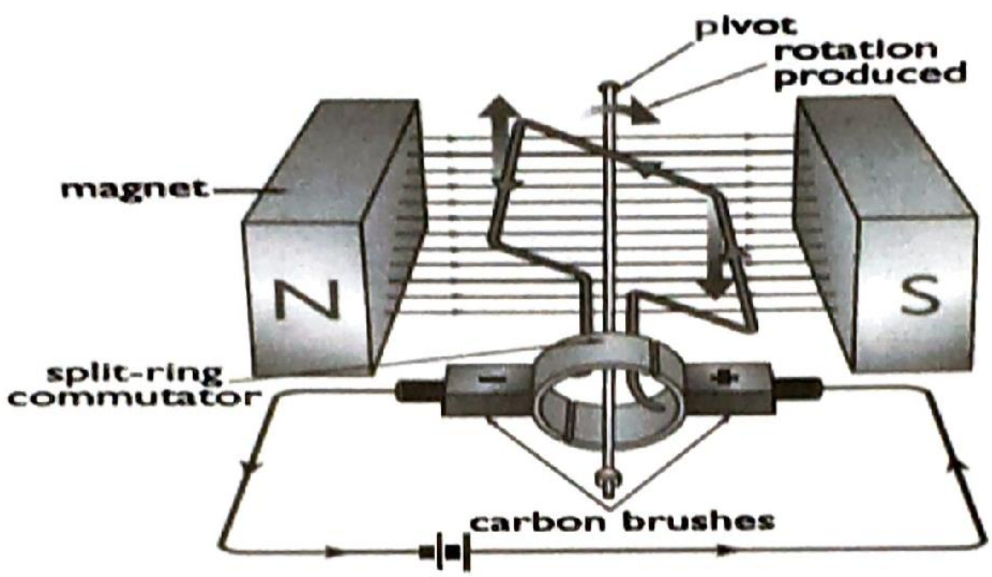
LESSON 102 LO: Study the electric motor

THE ELECTRIC MOTOR

-DC motor consists of a single turn coil of wire that is free to rotate in a magnetic field about an axle.

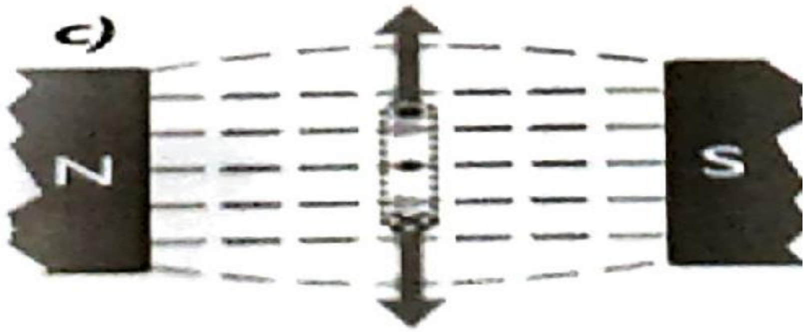
-carbon brushes makes contact with the ends of the coil that are connected to a split ring commutator so that a current can be passed through the coil.

-use FLEMINGS LEFT HAND (FBI) RULE.

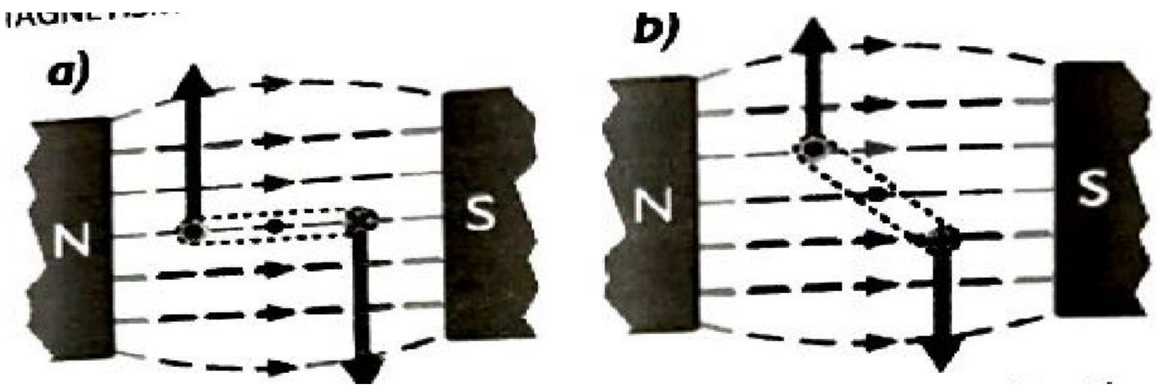


Simple electric Motor

-when coil is parallel to the permanent magnets, turning effect is 0.(coil stops in this position, but it will inevitably overshoot, then commutator will reverse the direction of current in the coil which means coil will keep rotating.



a)if the current is reversed, the motion will be in the opposite direction.
b) if the field is reversed, the motion will change direction again.



EXAMPLE
State 3 ways you can change the design of a DC motor to make it spin faster for a given load.

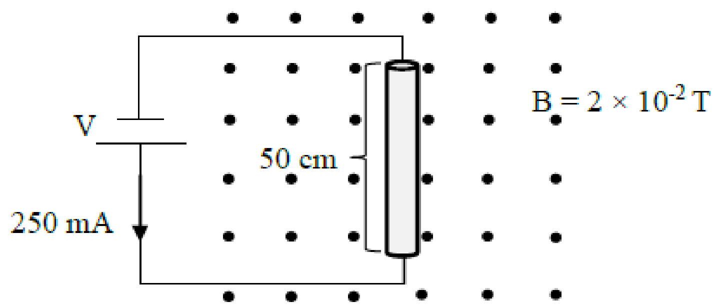
F = BIL : F α B, F α I, F α L

-increase the strength of magnetic field
-put more turns on the coil
-put a larger current through the coil

(But note that if the maximum design current for a motor is exceeded then the motor is likely to burn out.)

2018

A conductor of length 50 cm is placed in a magnetic field of strength 2×10^{-2} T. The current in the wire is 250 mA as shown in the diagram below.



(i) State the direction of the magnetic force experienced by the wire. **(1 mark)**

(ii) Calculate the magnitude of the magnetic force experienced by the conductor. **(1 mark)**

(iii) Determine the magnitude of the magnetic force if the length of the conductor is doubled and the current flow through the wire is decreased to one quarter of the original. **(2 marks)**

2014

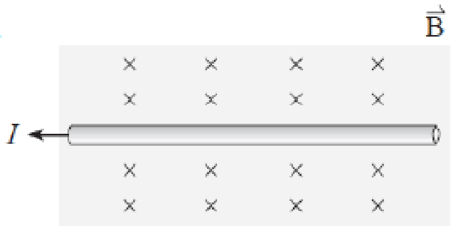
A magnetic field is best described as a region in space where a magnetic pole experiences a

A. force.
B. current.
C. velocity.
D. resistance.

2010

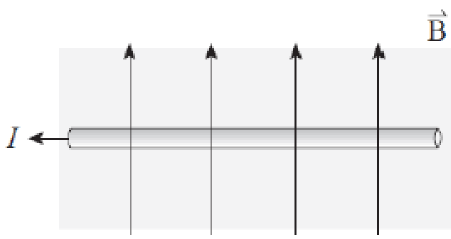
In which diagram would the current-carrying conductor experience a magnetic force out of the page?

A.

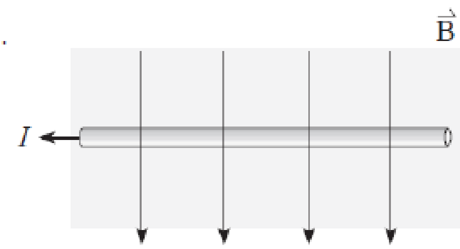


B.

C.

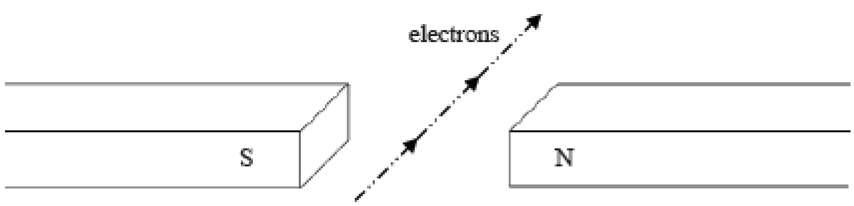


D.



2008

A stream of electrons is passed through a magnetic field as shown below.



The direction of the force experienced by the electrons due to the magnetic field would be

A. upwards.
B. downwards.
C. into the page.
D. out of the page.

S/S 6.2 GENERATOR

LESSON 103 LO: study generator effect

: solve problems involving a conductor moving perpendicular through a uniform magnetic field.

<u>THE GENERATOR EFFECT</u>

- <u>When a conductor moves through a magnetic field, there will be voltage generated.</u>

Electromagnetic induction is a process of generating current by the movement of a wire in a magnetic field. In motor, the coil is connected to a battery or power source but in electromagnetic induction process, current is induced. Actually voltage is induced and voltage pushes electron and hence current is generated or produced.

$$\boxed{V = B\,l\,v\sin\theta}$$

The above formula is used when the circuit is closed with a resister but without a battery.

*

The induced voltage depends on the velocity and the magnetic field strength.

- The voltage generated in a length of wire in a uniform field is given by

$$V = Bvl\sin\theta$$

V- voltage
B - Magnetic Field Strength
l- length of conductor (in meters)
v - velocity of conductor moving through the field

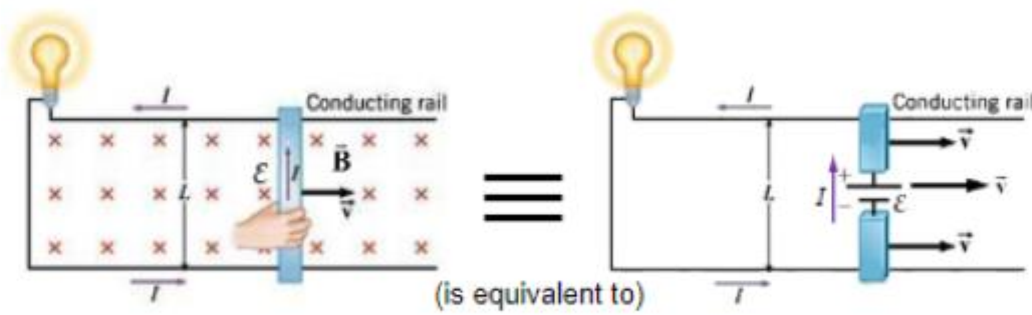
- To increase the voltage or current produced:
  1. Spin the coil faster
  2. Put more loops or coil of wire
  3. Use a stronger magnet or strengthen the magnetic field
  4. Use a coil with a larger area

- A generator converts **mechanical energy to electrical energy**

Motional emf (electromotive force)/voltage

[Emf/Voltage = energy or workdone per unit charge]

The moving bar is in fact exactly **equivalent to a battery,** that one can construct a circuit with it to power a light bulb. The diagrams below show such a circuit made using conducting rails over which the bar slides while making full electrical contact to form a closed circuit.

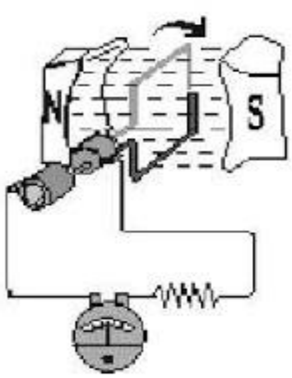


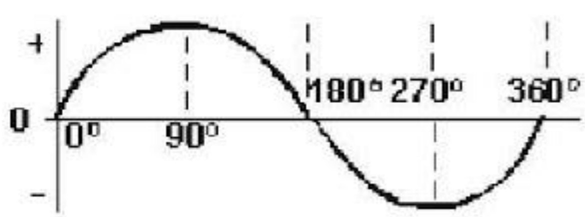
$$\mathcal{E} = vBL$$

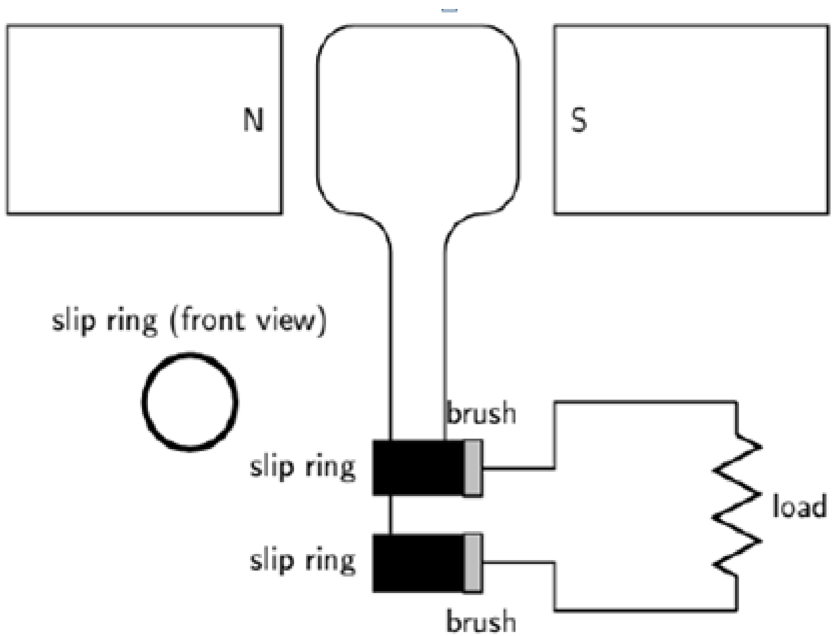
LESSON 104 LO: compare AC vs DC Generator.

AC GENERATORS

- Also known as alternators.
- Found in motor cars to charge the car battery
- Has slip rings to allow current to change directions and become AC current.
- Graph of Current output:

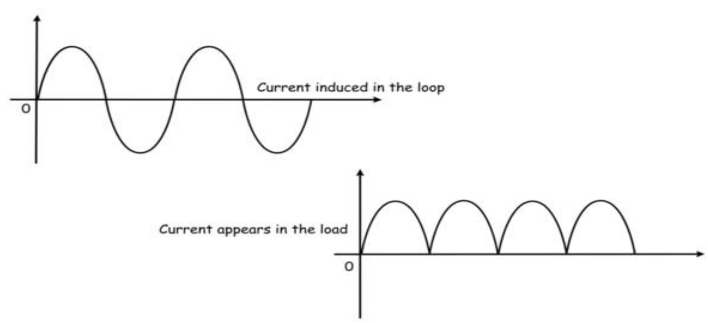


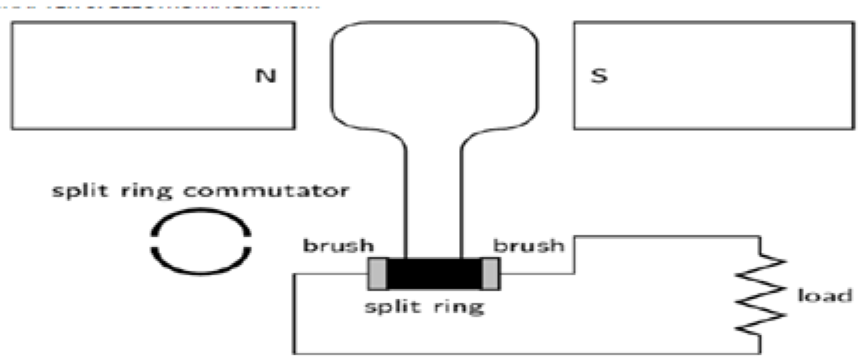


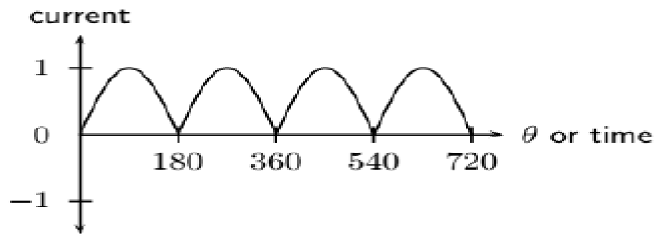


DC GENERATORS

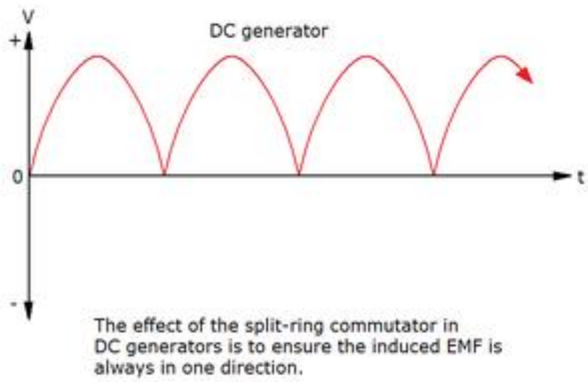
- **has split rings so that the roles are reversed every half cycle and the polarity remains the same.**
- **Graph of Current output:**

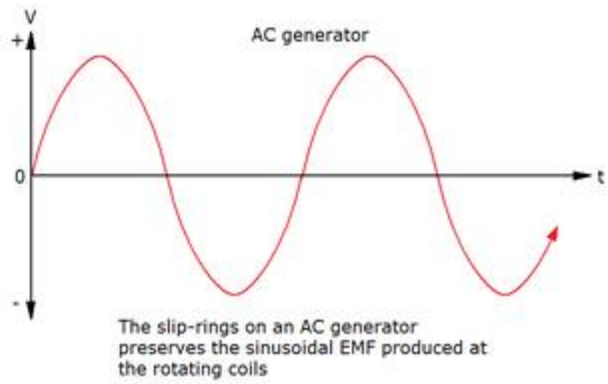






AC	DC
current reverses direction with time.	current goes only in one direction.
The coil through which current flows is fixed while magnet moves.	The coil through which current flows rotates in a fixed yield.
Rotating parts has low current so its safe even in high speed.	Rotating parts are heavy and with high current, limiting its maximum speed.
Home appliances uses it to power small motors and common electrical appliances (vacuum cleaners, food mixers..)	Used to power very large electrical motors.(provides reliable and sufficient energy supply that can charge banks of batteries and off-grid uses)
Does not have problems of sparking and heat	Requires brush and commutators hence sparking and heating is a problem





*In both generators, the amount of voltage produced is α rotation speed of the coil.

* Both convert mechanical energy to electrical energy.

*both have coils that are rotated through magnetic fields when the big wheel is turned.

2019

1.

A wire of length 2 m is moved perpendicular to a magnetic field of strength 4 T with a velocity of 5 ms^{-1}.

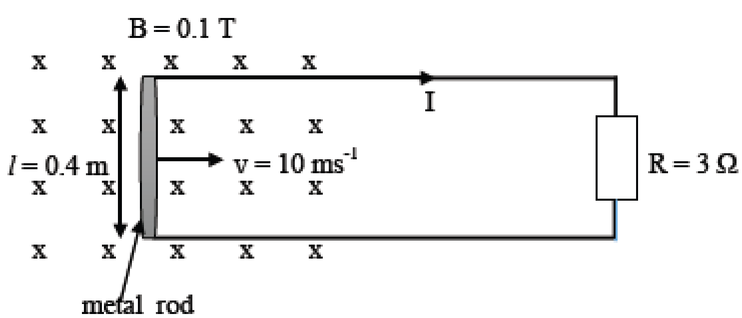
(i) Calculate the induced voltage across the ends of the wire. **(1 mark)**

(ii) The ends of the wire are connected to a circuit with a negligible resistance it is found that a 4 A current flows around it. Calculate the force that must be applied to keep the wire moving and generating this current. **(1 mark)**

(iii) State **two** ways of increasing the current which is generated by the moving wire. **(2 marks)**

2.

A metal rod is pushed in a uniform magnetic field along contacts which are connected to a 3 Ω resistor. The length, *l* of rod in the magnetic field is 0.4 m. The rod moves at 10 ms^{-1}. The strength of the magnetic field, B is 0.1 T.



Calculate the

(i) induced voltage across the rod. **(1 mark)**

(ii) current, I. **(1 mark)**

2013

The **emf** or **electromotive force** of a cell is a measure of the cell's

A. current.
B. internal resistance.
C. work done per unit charge.
D. force acting per unit charge.

Which of the following is an example of a **moving coil meter**?

A. a generator
B. a DC ammeter
C. an AC voltmeter
D. a digital multi-meter