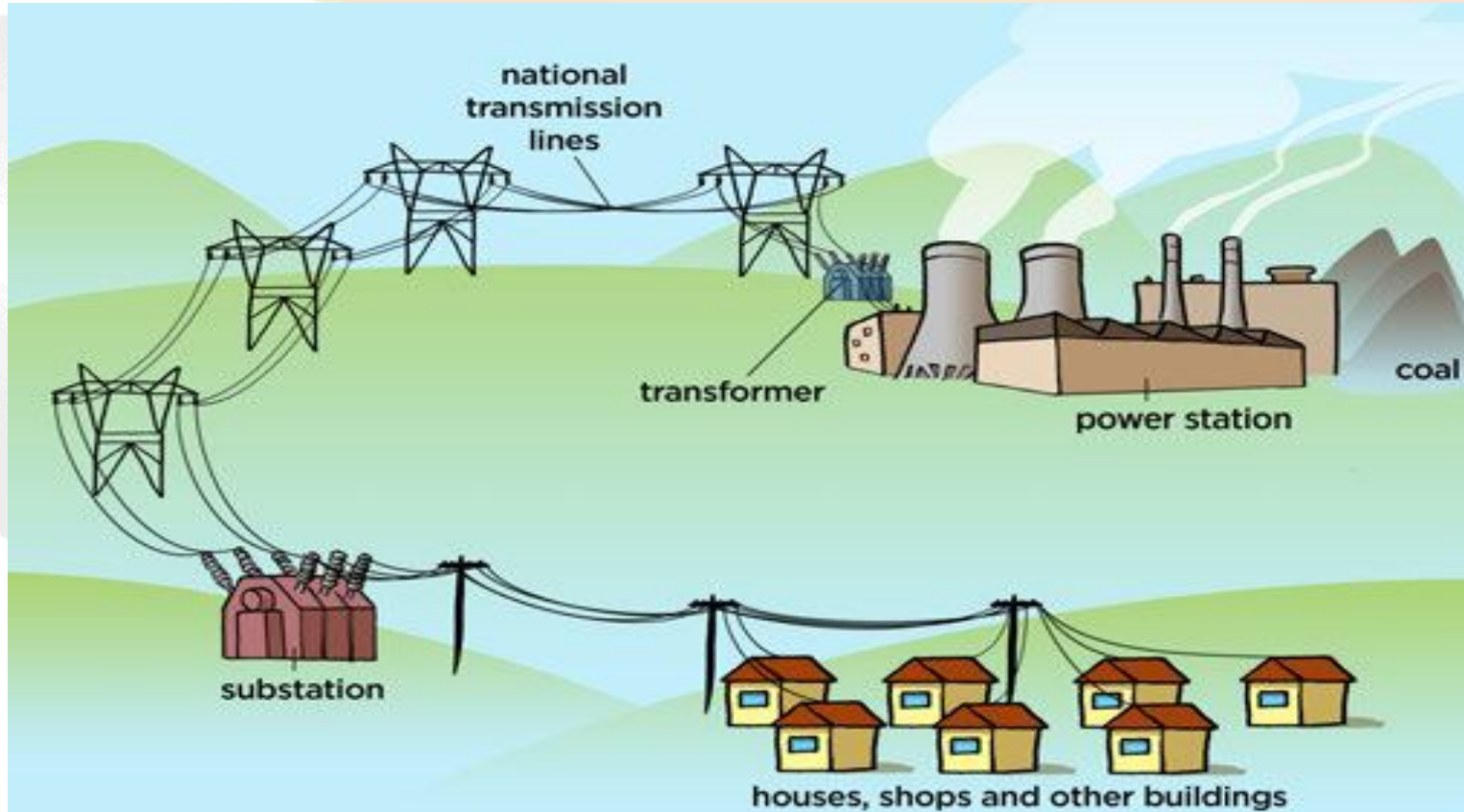


ELECTRODYNAMICS



Lesson prepared by
D.T BALOYI

Electrodynamics

Electrodynamics refers to the study of the relationship amongst electricity, magnetism and mechanical phenomenon.

The topic will focus on two (2) aspects, namely

- 1) Electric machines (Generator and Motor)
- 2) Alternating current (AC)

The following concepts will be used to explain the above-mention aspects:

- ☐ Electromagnetic induction
- ☐ Faraday ` Law
- ☐ Motor effect
- ☐ Fleming `s Left and Right – hand Rules
- ☐ Sine and Cosine graphs (waves)
- ☐ Ohms ` Law

Electric Machines

1. Generator

A generator is an electric machine that convert mechanical (kinetic) to electrical energy.

It uses motion to produce electricity. For instance, ESKOM uses steam (vapour) generated by burning coal to move turbines (blades) of their coal-driven generator to produce the electricity we are using in South Africa.

Principle at which the generator operates is known as Electromagnetic induction.

This principle can be also used to explain how the emf is induced in a coil through the relative motion between the coil and the magnet, better known as Faraday`s Law (Grade 11).

$$\varepsilon = \frac{-N\Delta\phi}{\Delta t}$$

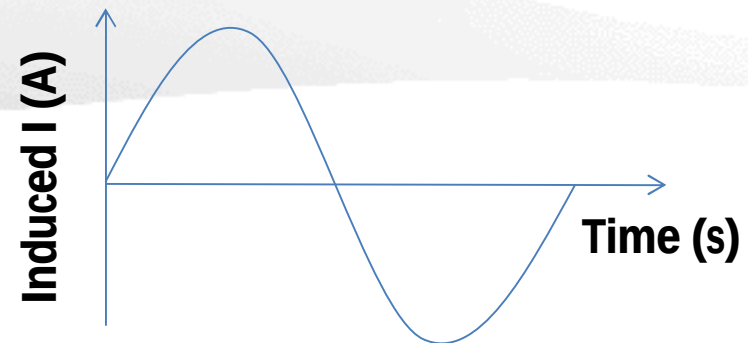
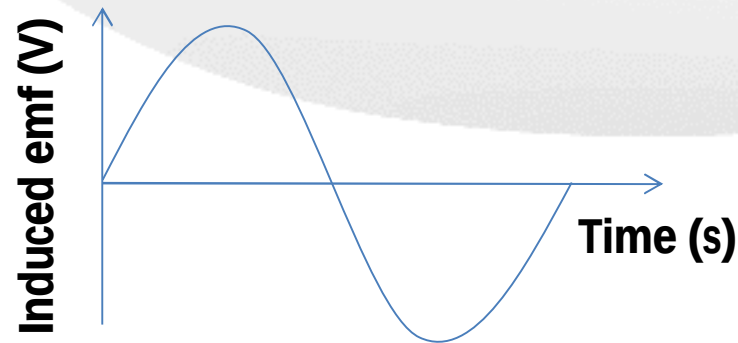
Types of Generators

There are two types of generators, namely **AC** and **DC generators**

(I) AC generator

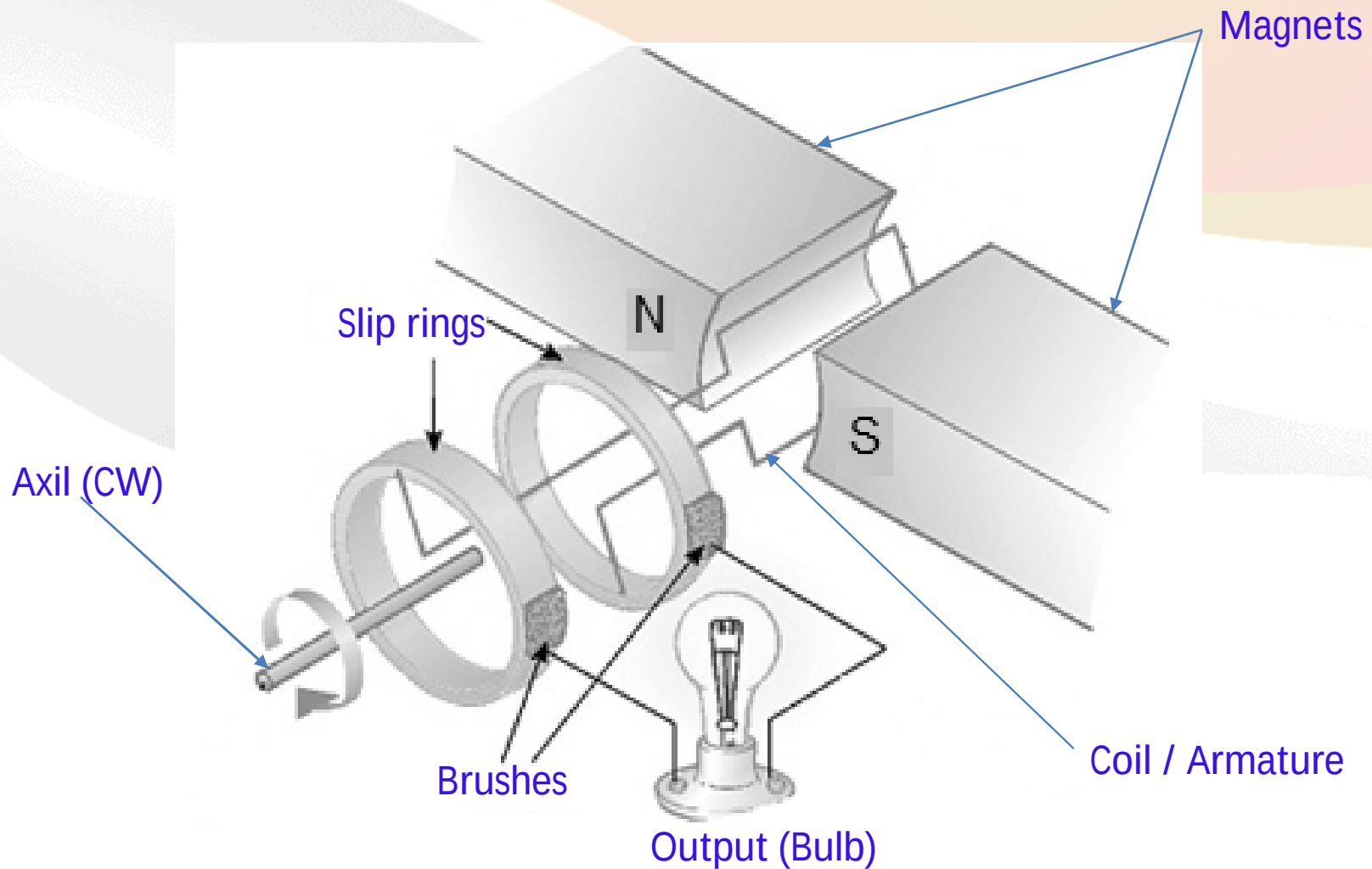
AC generator is a generator which produces (induces) **alternating current (AC)** / **voltage**.

Alternating current (AC) is a current which flows in opposite directions. i.e the current **oscillate** or **fluctuate**.

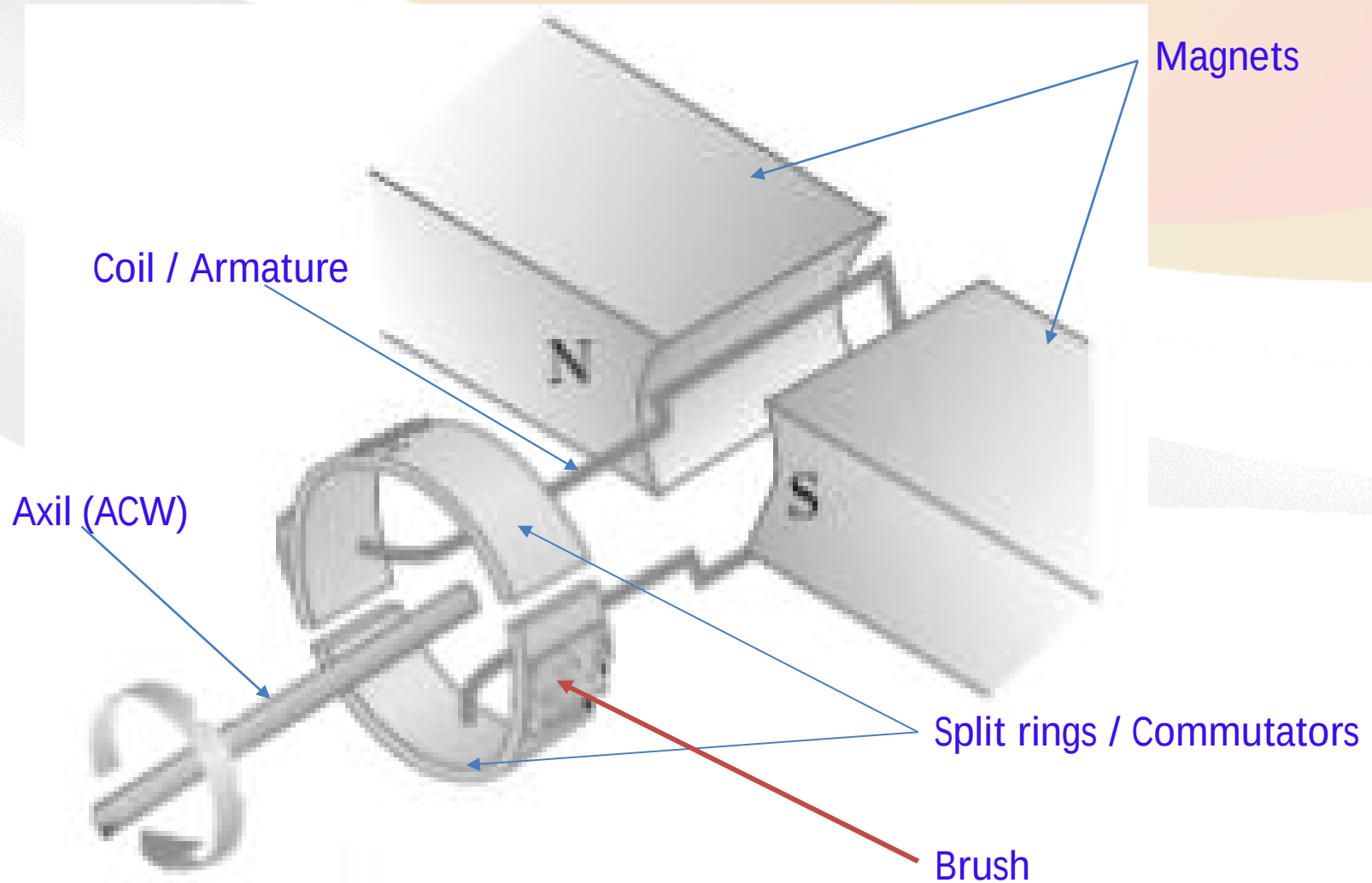


Examples of AC generators : Generators used by ESKOM in their various power stations, such as Coal-driven, Hydropower, Wind-driven (Windmill).

Simplified set up of AC generator



Simplified set up of DC generator



Functions of components of a generator

- **Magnets** produce magnetic fields which result in magnetic flux linkage.
- **Coil / Armature** becomes magnetized and produce electric field which induce current.
- **Brushes** make electrical contacts with the rings / take in current to the load.
- Slip rings ensure the direction of current changes every half cycle (rotation)
- **Split rings / Commutators** ensure that the direction of current does not change.
- **Axle** used to rotate/spin the generator.

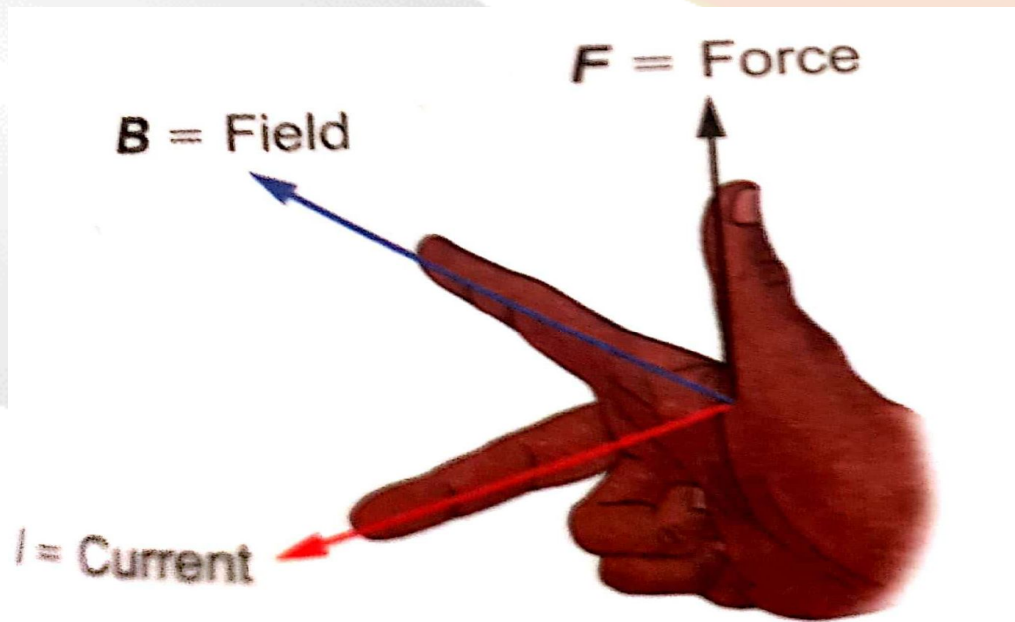
3 Ways at which the efficiency (Output) of a generator can be improved

1. Increase the speed of rotation / Rotate the coil faster.
2. Increase the number of turn in the coil.
3. Increase the magnetic field strength / Use a bigger magnets.

$$\varepsilon = \frac{-N\Delta\phi}{\Delta t}$$

Flemming's Right-hand (Dynamo) Rule

The direction of the magnetic force is **perpendicular** to both the **direction of the flow of current** and **the direction of the magnetic field** and can be found using the **Flemming's Right Hand (Dynamo) Rule** as shown in the picture below.

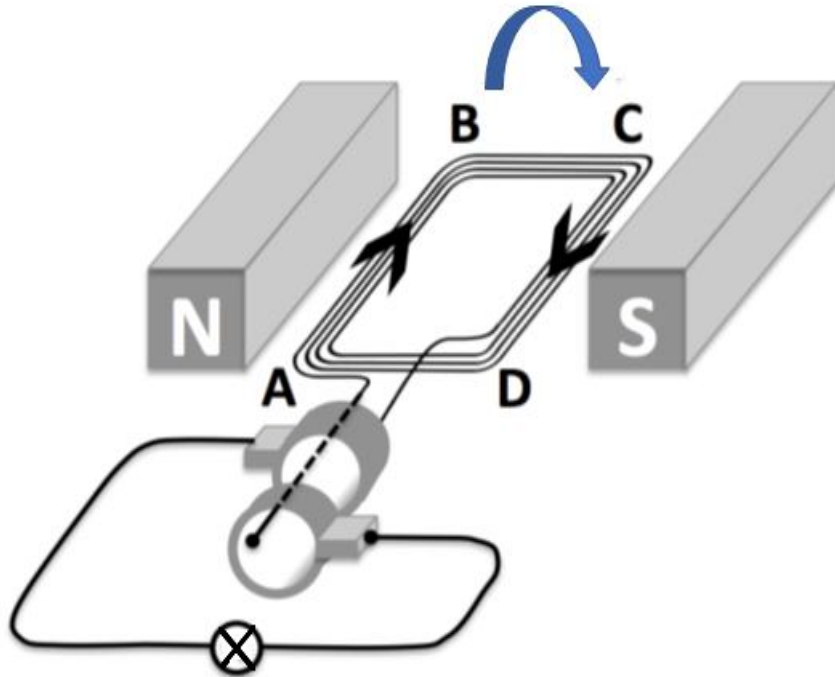


Use your right hand as follows;

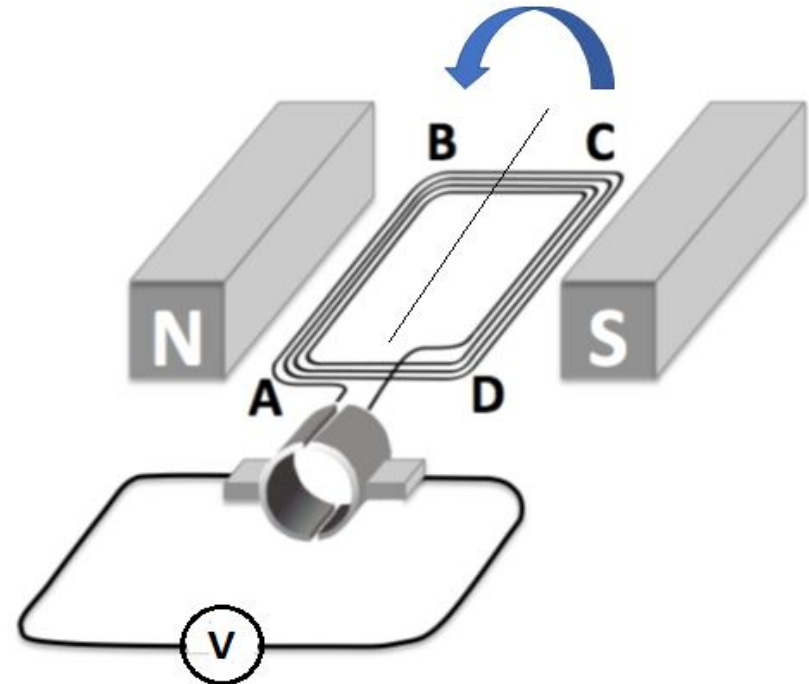
- ❖ your **First finger** points in the direction of the **magnetic Field**,
- ❖ your **Second** finger in the direction of the **Current** and
- ❖ your **Thumb** will then point in the direction of the **Thrust(Force)**.

Fleming's Right-hand (Dynamo) Rule

X – AC generator



Y – DC generator



Refer to figure X (AC generator)

- ❖ The direction of the current is from **A** to **B** shown by the seCond finger.
- ❖ The direction of the magnetic field is from **North** to **South** pole shown by the **first** finger
- ❖ The direction of the force (motion)/Thrust is clockwise (AB up the plane) shown by the **thumb**

Electric Machines

2. Motor

A **motor** is an electric machine that convert electrical to mechanical (kinetic) energy.

It uses electricity to produce motion.

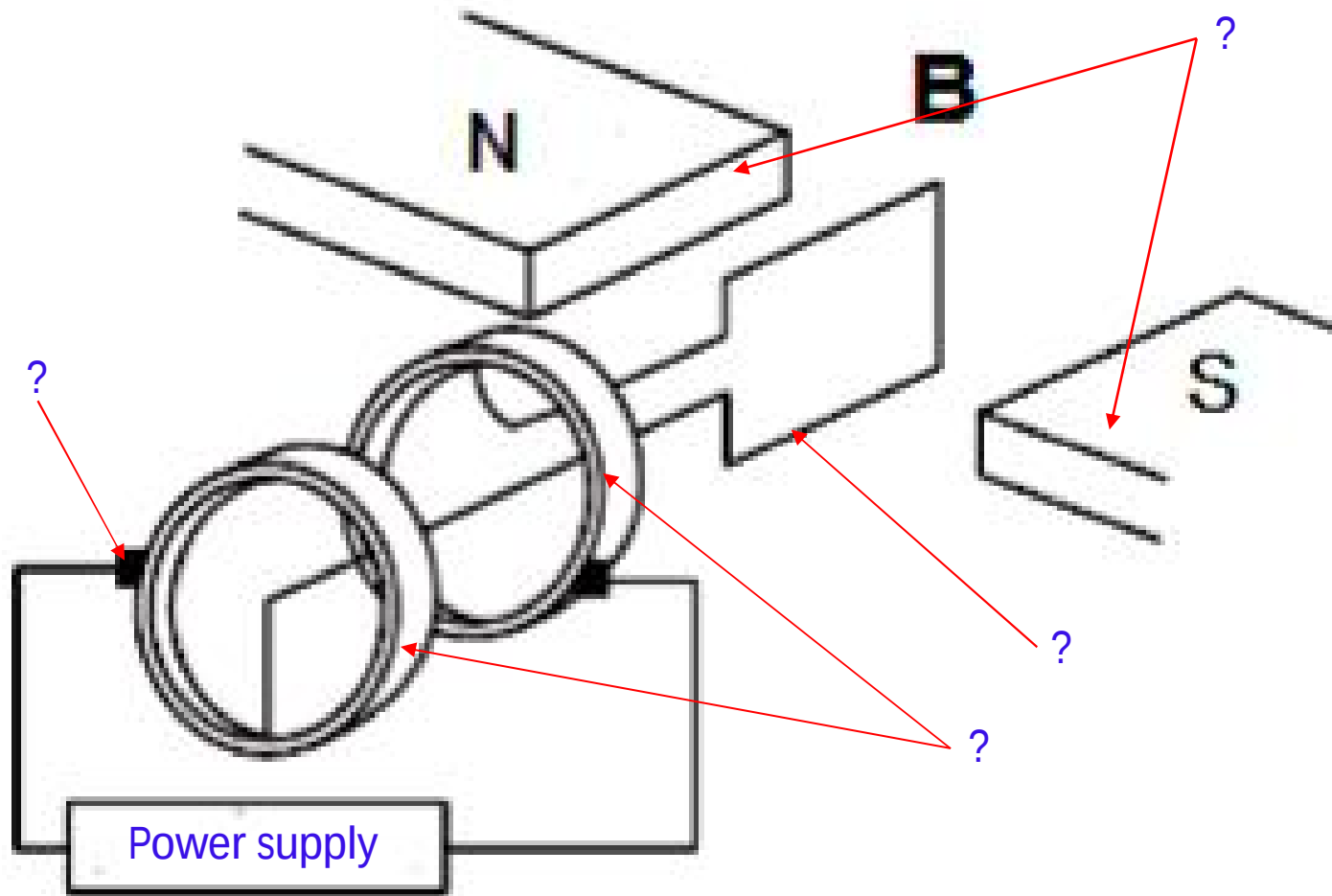
Examples of electric devices that uses motors: Fan, hair dryer, escalator, lift, drill, electric toys, CD/DVD player, e.t.c

Principle at which a motor operates is known as **Motor effect**.

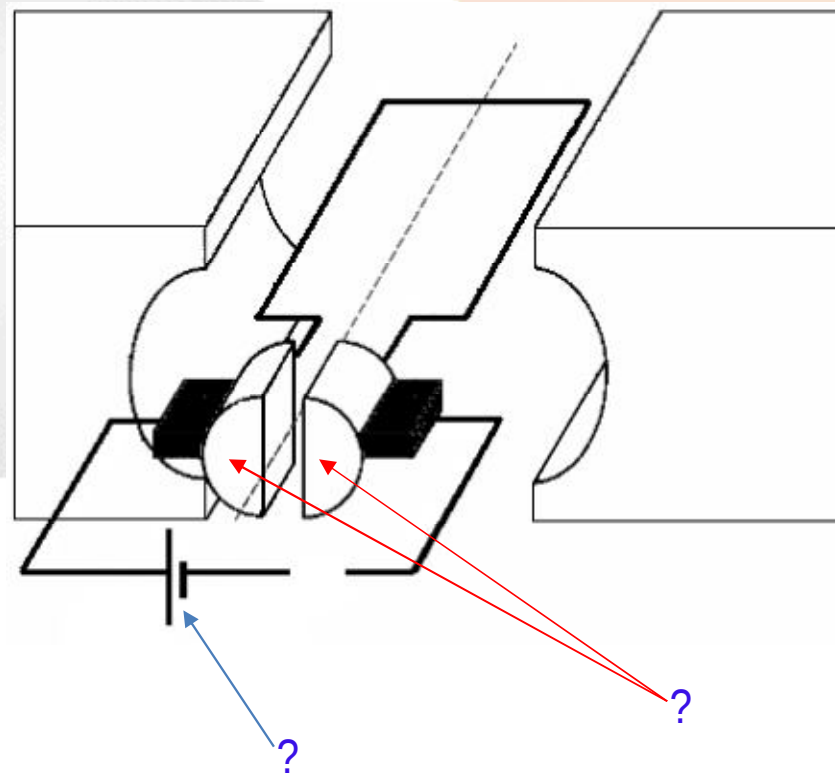
3 Ways in which the efficiency (output) of a motor can be improved

1. Use bigger current.
2. Increase the number of turn in the coil.
3. Increase the magnetic field strength / Use a bigger magnets.

Simplified set up of AC Motor

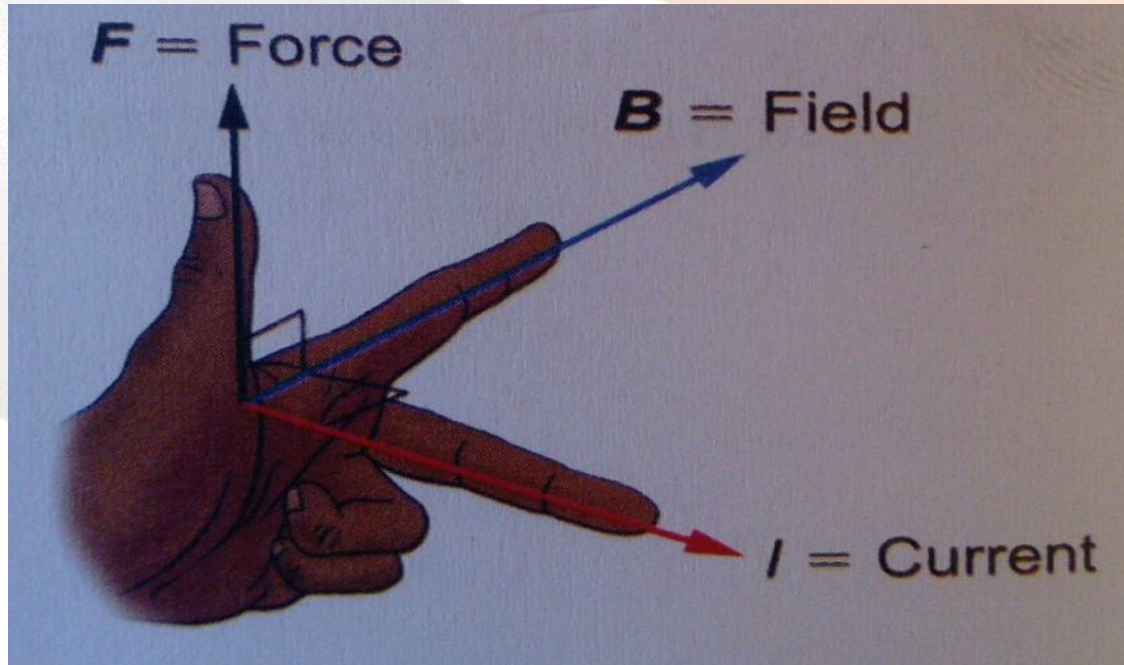


Simplified set up of DC Motor



Flemming's Left-hand (Motor) Rule

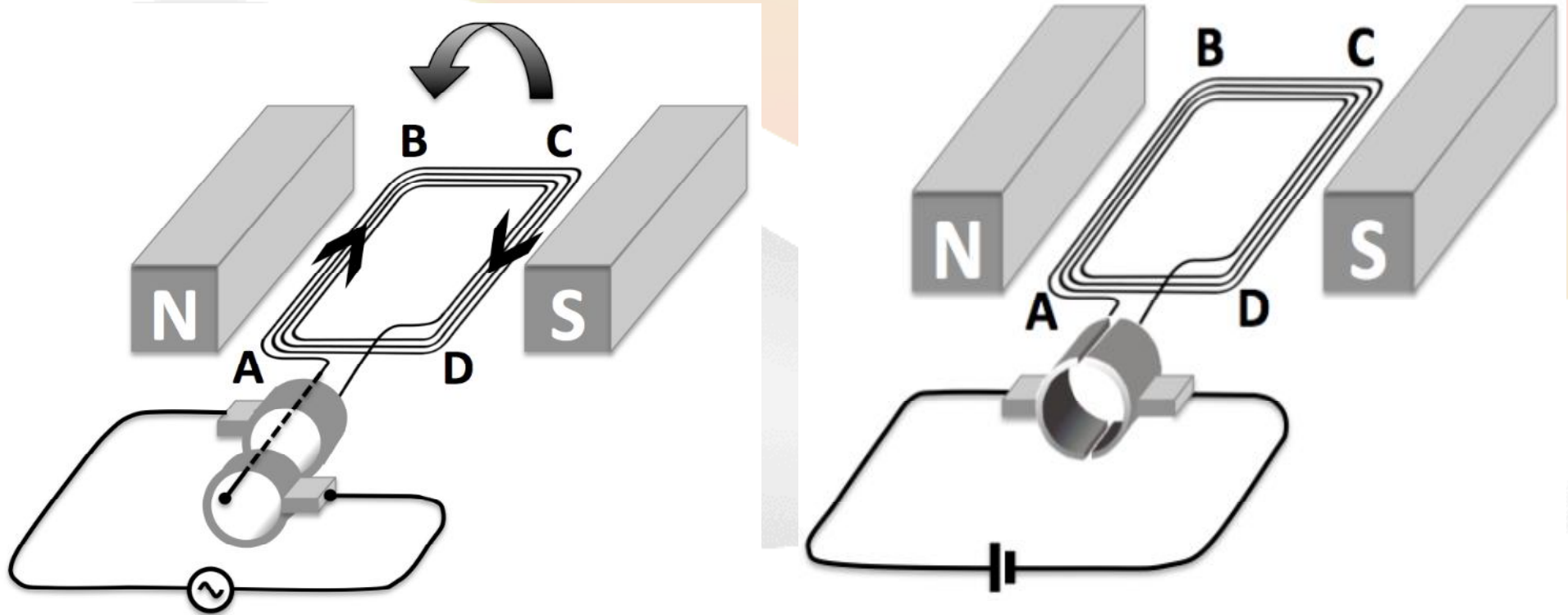
The direction of the magnetic force is **perpendicular** to both the **direction of the flow of current** and **the direction of the magnetic field** and can be found using the **Left Hand (Motor) Rule** as shown in the picture below.



Use your right hand as follows;

- ❖ your first finger points in the direction of the current,
- ❖ your second finger in the direction of the magnetic field and
- ❖ your thumb will then point in the direction of the force.

Fleming's Left-hand (Motor) Rule



- ❖ The direction of the current is from **A** to **B** shown by the seCond finger
- ❖ The direction of the magnetic field is from **North** to **South** pole shown by the **first** finger
- ❖ The direction of the force (motion)/Thrust is clockwise (up the plane) shown by the **thumb**

Alternating Current

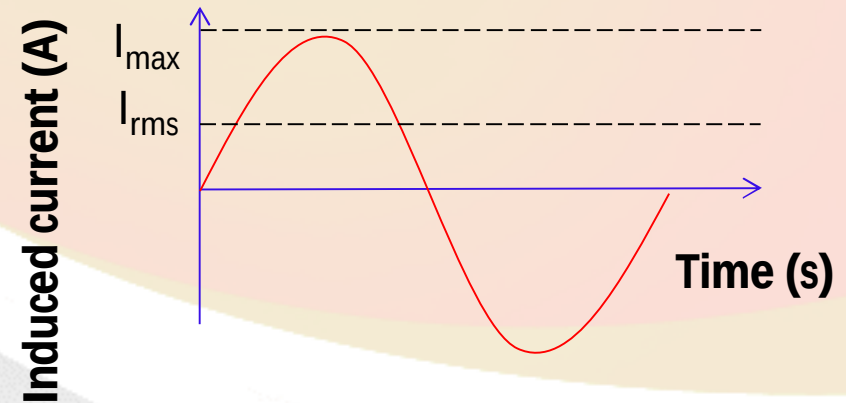
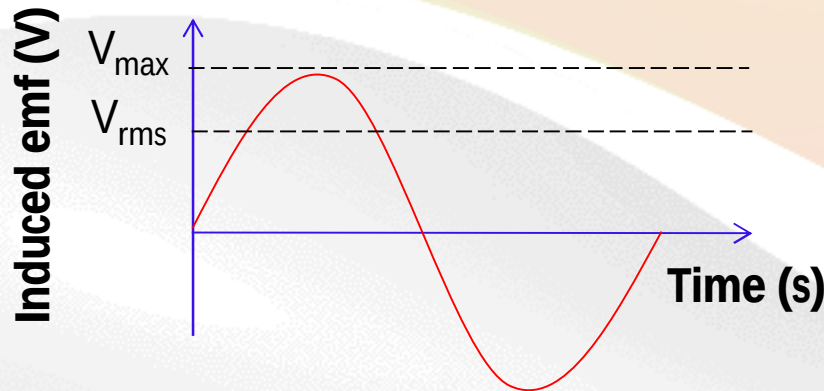
Alternating current (AC) is a current which flows in opposite directions. i.e. the current oscillate or fluctuate.

Current and voltage generated by ESKOM has a frequency of 50 Hz (50 s^{-1}), meaning **it changes direction 50 times per second**.

Advantages of AC over DC

- ☐ It can be transmitted at high voltage and low current over long distances with less energy lost.
- ☐ Easy to be transformed (step up or step down using a transformer).
- ☐ Easier to convert from AC to DC than from DC to AC.
- ☐ Easier to generate.
- ☐ High frequency used in AC makes it suitable for motors.

Graphs for AC circuit



Define the term **root mean square for an alternating voltage/current**.

The **rms value** of AC is the AC **current/voltage**, which dissipates the **same amount of energy** as DC. OR

The **rms value** of AC is the AC **current/voltage**, which have the **same heating effect** as DC.

$$V_{rms} = \frac{V_{max}}{\sqrt{2}}$$

$$I_{rms} = \frac{I_{max}}{\sqrt{2}}$$

Using Ohm's Law: $R = \frac{V_{max}}{I_{max}}$ $R = \frac{V_{rms}}{I_{rms}}$

Average Power:

$$P_{average} = V_{rms} I_{rms} ; P_{average} = I_{rms}^2 R ; P_{average} = \frac{V_{rms}^2}{R} ; P_{average} = \frac{1}{2} V_{max} I_{max}$$

*** THE END ***

THANK YOU