Education and Sports Development

Department of Education and Sports Development
Department van Onderwys en Sport Ontwikkeling
Lefapha la Thuto le Tlhabololo ya Metshameko
NORTH WEST PROVINCE

CAPACITOR

DEFINE a **CAPACITOR** as: a **device** for **storing electrical charge**.

CAPACITORS CAN BE:

☑ **POLARIZED** or **ELECTROLYTIC** Capacitors

(They have specific polarity when connecting to a circuit)

&

☑ Non **POLARIZED** Capacitors

(They can be connected in a way in the circuit irrespective of polarity)

CAPACITORS CAN HAVE:

VARIABLE VALUES:

WHOSE CAPACITANCE can be INCREASED or DECREASED by **turning** a special **Shaft** connected to the **Variable Capacitor** (**Tuning Circuit.** i.e. **Radio**)

FIXED VALUES:
WHOSE CAPACITANCE cannot be INCREASED or DECREASED

MOST COMMON APPLICATIONS OF CAPACITORS

Smoothing capacitor *in* ***power supply circuits:***

To change *the pulsating* ***DC voltage*** *to a smooth* ***DC voltage.***

FILTER CIRCUIT:

Filter out unwanted signals depending on the frequency range of the filter

COUPLING CAPACITOR:

Allows AC signals to pass from ONE part of a circuit to another and to block an DC voltage

POWER SYSTEMS:

In single phase AC motors, to create enough torque to get the motor running when it is switched on.

CAPACITANCE

The **AMOUNT** of **ELECTRIC CHARGE** a **CAPACITOR** can **STORE** (on Its TWO PLATES) **Per Volts**.

MEASURED IN FARADS (F)

The Following Prefixes (Multipliers Are Used To Show Smaller Values)

μ (Micro) Means 10^{-6} Millionth 1 OOO OOO **μ**F =1F	n (Nano) Means 10^{-9} Thousand-Millionth 1 OOO nF =1**μ**F	p (Pico) Means 10^{-12} Million-Millionth 1 OOO pF =1nF

SUFFIX	SYMBOL	POWER OF 10
Micro Farad	μF	$x\ 10^{-6}$
Nano Farad	nF	$x\ 10^{-9}$
Pico Farad	pF	$x\ 10^{-12}$

THE RELATIONSHIP BETWEEN:

CAPACITANCE (**C**), **CHARGE** ON THE **PLATES** (**Q**) & VOLTAGE (**V**):

$$C = \frac{Q}{V}$$

☑ **CAPACITANCE** (**C**), is **DIRECTLY PROPORTIONAL** to **CHARGE** on the **PLATES** (**Q**) & **INVERSELY PROPORTIONAL** to the **APPLIED VOLTAGE** (**V**)

AIR AS **THE DIELECTRIC**, THE **CAPACITANCE** OF **CAPACITOR** CAN BE **CALCULATED** BY: $C = \frac{A\varepsilon_0}{d}$

WHERE:

C = **CAPACITANCE** (**F**)

A = **AREA** of the PLATES in **Square Metres** (**m^2**).

N.B:

(THE **GREATER** The **AREA** of the plates the **MORE CHARGE** can be **STORED**) d = THE **DISTANCE** between the **TWO** plates in **Meters** (**m**).

N.B:

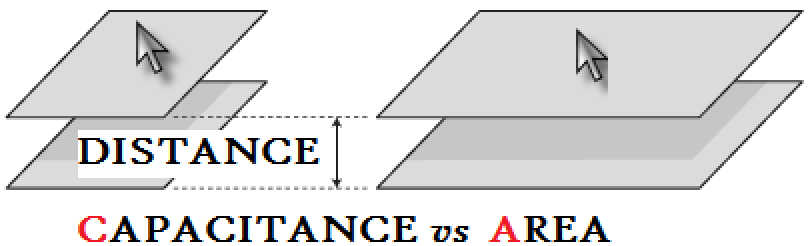
THE SMALLER the **DISTANCE** between plates, the **GREATER** the **ABILITY** of **THE PLATES** to **STORE CHARGE**.

ε_0 = **THE VALUES** of the **PERMITTIVITY** of **DIELECTRIC CONSTANT** for **AIR**, **WHICH**: 8.85×10^{-12} F.m^{-1}

FACTORS AFFECTING CAPACITANCE

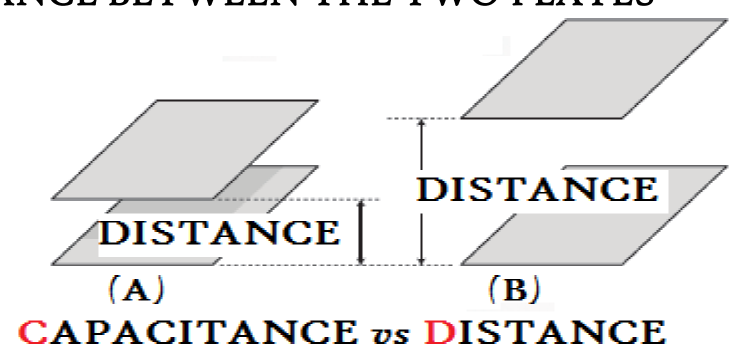
The Capacitance of a **Capacitor Depends Mainly** in **Three Things:**

☑ **THE TOTAL SURFACE AREA OF THE PLATES**



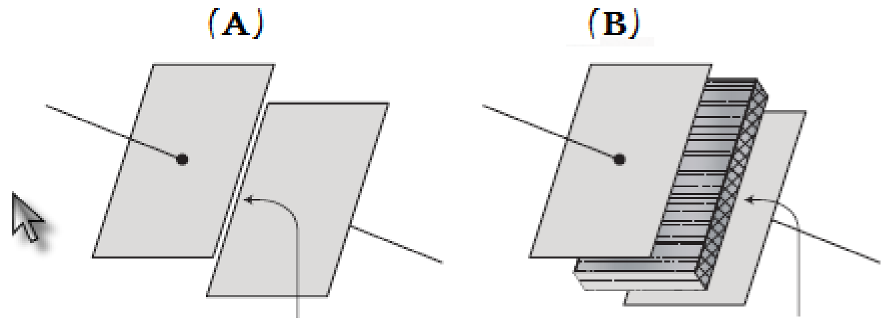
- The **SMALLER** the **SURFACE AREA** of the plates**: THE SMALLER** the **CAPACITANCE.**
- The **BIGGER** the **SURFACE AREA** of the plates: **THE GREATER** the **CAPACITANCE.**

☑ **THE DISTANCE BETWEEN THE TWO PLATES**



- **THE SMALLER** the **DISTANCE** between the **TWO PLATES THE BIGGER** the **CAPACITANCE** of the **CAPACITOR**

☑ THE TYPES OF DIELECTRIC MATERIAL



❖ **TYPE OF DIELECTRIC: AIR: PLASTIC: GLASS: MICA**

☑ The **GREATER** the **DIELECTRIC CONSTANT** of the **DIELECTRIC** used, the **GREATER** the **CAPACITANCE** of the **CAPACITOR.**

EXAMPLE NO: 1

If CHARGES of 1, 25 μC are placed on TWO separated metal plates, the POTENTIAL DIFFERENCE between them is 11, 3 V.

1 CALCUALATE THE CAPACITANCE of the metal plates

EXAMPLE NO: 2

A CAPACITOR has a CAPACITANCE of 7, 28 μF.
What AMOUNT of access CHARGE must be placed on each of its plates to make a Potential Difference between the plates equal to 25 V?

EXAMPLE NO: 3

CALCUALATE THE CHARGE STORED on either plates of a 4 μF parallel-plate CAPACITOR when connected to a 12 V BATTERY.

EXAMPLE NO: 4

CALCUALATE THE CHARGE on a 10 μF CAPACITOR when it is connected across a 200V DC supply.

EXAMPLE NO: 5

A steady CURRENT of 10 Amps Flows into a Previously DISCHARGED CAPACITOR for 20 Seconds, when the POTENTIAL DIFFERENCE between the plates is 600 Volts.

1 What is the CAPACITANCE of the CAPACITOR?

Hint: CALCULATE the CHARGE 1st: $Q = I.\Delta t$

LEARNER ACTIVITY NO: 1

A PARALLEL - PLATE CAPACITOR as an AREA of 0, 0002 m^2 and the plates are SEPARATED 0, 001 m.

1 Calculate the CAPACITANCE of a CAPACITOR.

LEARNER ACTIVITY NO: 2

Calculate the POTENTIAL DIFFERENCE of a BATTERY connected to a parallel - plate CAPACITOR with a plate AREA of 0, 002 m^2 and plate SEPARATION of 2 mm if the CHARGE STORED on the plates is 4 pC.

LEARNER ACTIVITY NO: 3

A parallel-plate CAPACITOR as an AREA of 0, 0002 m^2 and the plates are SEPARATED 0, 001 m

1 Calculate the CAPACITANCE of a CAPACITOR.
2 How MUCH CHARGE is on the POSITIVE PLATE if the CAPACITOR is connected to a 3 V battery?

LEARNER ACTIVITY NO: 4

A parallel-plate CAPACITOR has a plate AREA of 2×10^{-4} m^2 and a plate separation DISTANCE of 1 mm.

1 Calculate its CAPACITANCE.

LEARNER ACTIVITY NO: 5

Two plates of a parallel-plate CAPACITOR are 5 mm apart and have a 2 m^2 AREA. A POTENTIAL DIFFERENCE of 100 V is applied across the CAPACITOR.

1 Calculate the CAPACITANCE of the CAPACITOR.

2 Calculate the CHARGE on each plate.

LEARNER ACTIVITY NO: 6

The TWO plates of a parallel-plate CAPACITOR are 3, 28 mm apart and each has an AREA of 12, 2 cm^2. Each plate carries a CHARGE of 0, 435 nC. The plates are in a vacuum (AIR).

1 CALCULATE THE:

- 1.**1** What is the CAPACITANCE of this CAPACITOR?
- **1.2** What is THE POTENTIAL DIFFERENCE between the plates?

LEARNER ACTIVITY NO: 7

A PARALLEL - PLATE CAPACITOR has a CAPACITANCE of 5 pF and a CHARGE 0, 200 μC on each plate. The plates are 0, 6 mm apart.

1 CALCULATE THE:

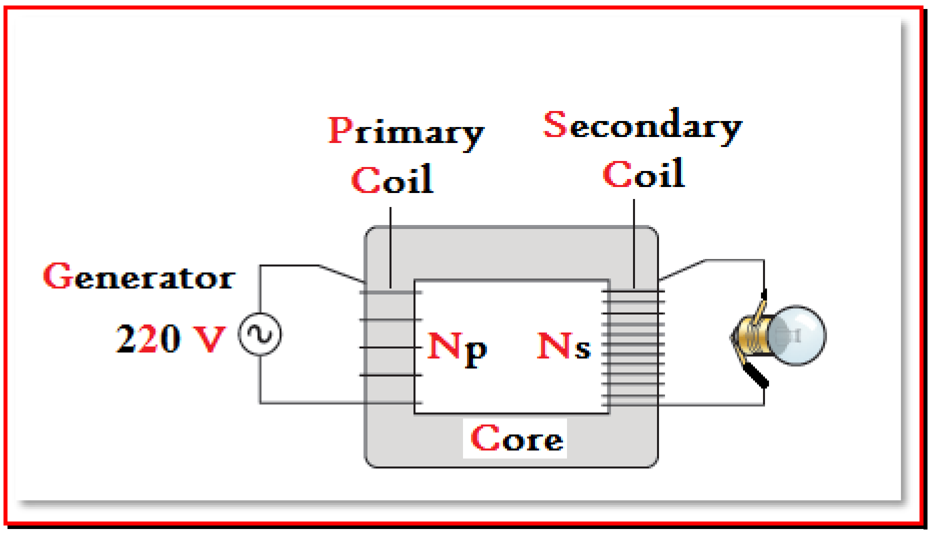
- **1.1** POTENTIAL DIFFERENCE BETWEEN the plates?
- **1.2** AREA of each plate?

Formula Sheet	
$C = \frac{A\varepsilon_0}{d}$	$\varepsilon_0 = 8.85 \times 10^{-12}\ F.m^{-1}$
$Q = I.\Delta t$	$C = \frac{Q}{V}$
$A = \Pi r^2$ OR $A = \Pi \frac{D^2}{4}$	

TRANSFORMER

PRINCIPLE AND OPERATION OF A TRANSFORMER
ELECTRICAL GENERATORS (AC & DC GENERATOR)
ELECTRIC MOTORS

- ☑ A TRANSFORMER IS A DEVICE USED TO STEP UP OR DOWN THE VOLTAGE.
- ☑ THE PURPOSE OF A TRANSFORMER IS TO INCREASE OR DECREASE VOLTAGE.



A TRANSFORMER CONSIST OF TWO COILS THAT ARE

- ❖ **PRIMARY COIL (*Np*) Number of Turnings/Windings**
- ❖ **SECONDARY COIL (*Ns*) Number of Turnings/Windings**

PRINCIPLE & OPERATION OF A TRANSFORMER:

TRANSFORMER

☑ THE OPERATION of **TRANSFORMERS** DEPENDS ON THE **PRINCIPLE** of **MUTUAL INDUCTION.**

$$\frac{E_S}{E_P} = \frac{V_S}{V_P} = \frac{N_S}{N_P} = \frac{I_P}{I_S}$$

This is **KNOWN** as the **TRANSFORMER EQUATION:**

Where:

Vp = Primary Voltage (V)	*Vs = Secondary Voltage (V)*
Ip = Primary Current (A)	*Is = Secondary Current (A)*
Np = No. of Turns on the primary Coil	*Ns= No. of Turns on the Secondary Coil*
Ep = Emf induced on the primary Coil	*Ep = Emf induced on the Secondary Coil*

TWO TYPEs OF TRANSFORMERS

STEP UP

☑ Has more **Turns** or **Windings** on the **Secondary Coil** than the **Primary Coil**.

☑ **Resulting** in the **Induced Secondary Voltage** being **More** than the **Primary Voltage**

STEP DOWN

☑ **Has** more **Turns** or **Windings** on the **Primary Coil** than the **Secondary Coil**.

☑ **Resulting** in the **Induced Primary Voltage** being **More** than the **Secondary Voltage**

Example NO: 1

A **Step -Up Transformer** in the **X-Ray Machines** of a **Hospital** is used to **Convert** a **Potential Difference** of 120 V to 100 kV. If there are **50 Turnings** in the **Primary Coil.**

1 HOW many **TURNINGS** are there in the **SECONDARY COIL**?

Example NO: 2

The ADAPTER of a CELLPHONE BATTERY has a TRANSFORMER that REDUCES the MAIN SUPPLY from 240 V to 6 V. If the PRIMARY COIL has 1000 turns/ windings**.**

Assume that the TRANSFORMER is 100% EFFICIENT and that the CURRENT IN the SECONDARY COIL is 10 A.

1 CALCULATE the RATIO of the turnings of this TRANSFORMER.
2 What is CURRENT in the PRIMARY COIL?

Example NO: 3

An IDEAL TRANSFORMER has a 500 Primary Turns and 3 000 SECONDARY TURNS. If the PRIMARY VOLTAGE is 240 V.

1 CALCULATE the SECONDARY VOLTAGE

Example NO: 4

An IDEAL TRANSFORMER with a RATIO OF 2:7 is FED FROM a 240 V SUPPLY.

1 CALCULATE THE OUTPUT VOLTAGE

Learner Activity NO: 1

CALCULATE the OUTPUT VOLTAGE for a Transformer if the SUPPLY VOLTAGE BETWEEN the VOLTAGES is 230 V.

THE Number of Turns on the Primary Coil is 2500 and on the SECONDARY COIL is 150

Learner Activity NO: 2

A SINGLE PHASE TRANSFORMER HAS 6000 TURNS on its PRIMARY WINDING, WHICH IS CONNECTED to a 230 V AC SUPPLY. The VOLTAGE on the SECONDARY SIDE is 113, 5 V.

1 CALCULATE the NUMBER of TURNS on the SECONDARY SIDE.

Learner Activity NO: 3

A CD PLAYER IS DESIGNED TO WORK ON A 6 V POTENTIAL DIFFERENCE.
The ELECTRICAL POTENTIAL DIFFERENCE SUPPLY IS 240 V.
Kabza Da Small DECIDES TO USE A TRANSFORMER THAT HAS 480 WINDINGS IN ITS PRIMARY COIL FOR HIS CD - PLAYER.

1 CALCULATE the NUMBER of WINDINGS in the SECONDARY COIL of the TRANSFORMER

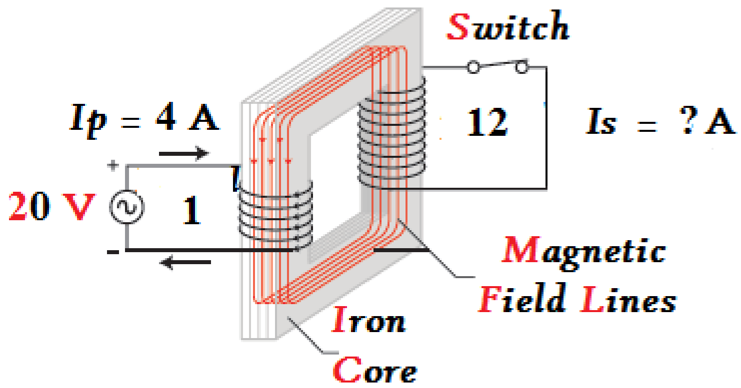
Learner Activity NO: 4

An IDEAL TRANSFORMER has TURNS RATIO 8:1 and the PRIMARY CURRENT is 3 A WHEN it is SUPPLIED AT 240 V.

1 CALCULATE the SECONDARY VOLTAGE and CURRENT.

Learner Activity NO: 5

An IDEAL TRANSFORMER has TURNS RATIO of 1:12 and is SUPPLIED at 20 V when the PRIMARY CURRENT is 4 A.



CALCULATE the SECONDARY VOLTAGE assuming that this is an IDEAL TRANSFORMER.

1 CALCULATE the SECONDARY CURRENT.

Learner Activity NO: 6

A TRANSFORMER with an INPUT VOLTAGE of 250 V AC, has a TURN RATIO of 5:1

1 CALCULATE THE:

1.1 SECONDARY VOLTAGE:

1.2 CURRENT if the PRIMARY CURRENT is 30 mA COIL?

ELECTRICAL GENERATORS

(AC & DC GENERATOR)

THERE ARE TWO TYPES OF GENERATORS:

AC GENERATOR & DC GENERATOR.

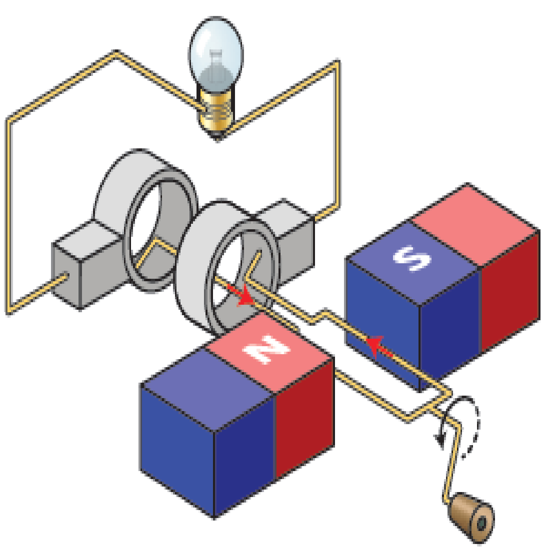
AC/DC GENERATOR CONVERTS:

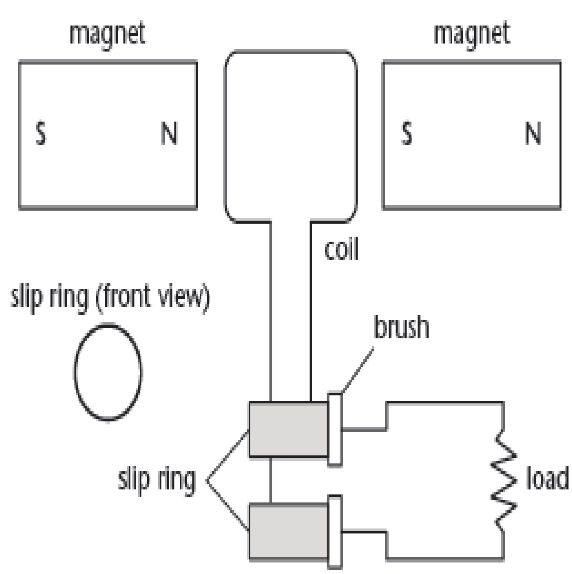
MECHANICAL ENERGY INTO ELECTRICAL ENERGY.

☑ **BASED** on same **FUNDAMENTAL PRINCIPLE** which is **FARADAY'S LAW** of **ELECTROMAGNETIC INDUCTION.**

THE PRINCIPLE OF FUNCTIONING OF A GENERATOR IS THE LAW OF ELECTROMAGNETIC INDUCTION**:**

The layout of a **SIMPLE AC GENERATOR** is shown in **FIGURE BELOW.**





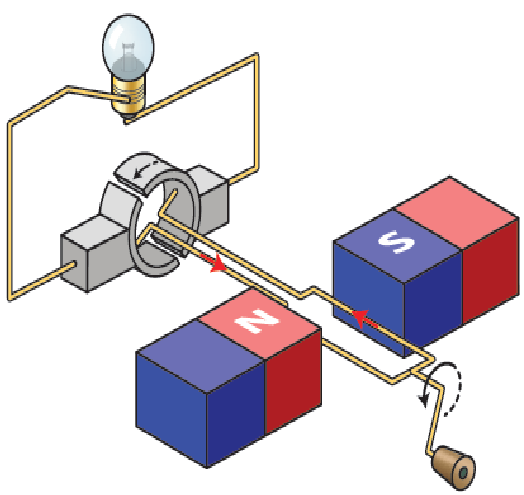
☑ The **CONDUCTOR** in the **SHAPE** of a coil is **CONNECTED TO** a **SLIP RING.**

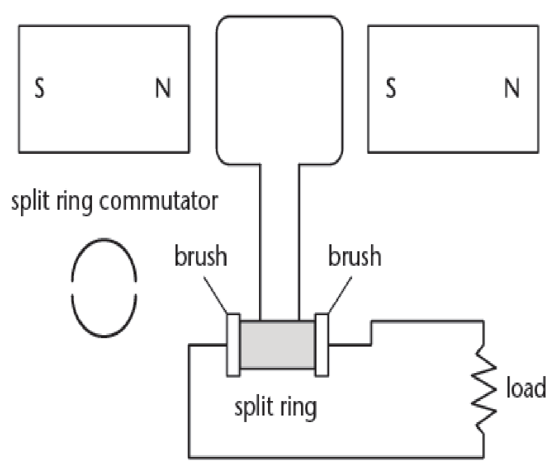
- ☑ The CONDUCTOR is then MANUALLY ROTATED in the MAGNETIC FIELD GENERATING an ALTERNATING EMF.
- ☑ The SLIP RINGS are CONNECTED to the LOAD *via* BRUSHES.

DC GENERATOR

- ☑ A simple DC GENERATOR is constructed the same way as an AC GENERATOR
- ☑ EXCEPT that there is ONE SLIP RING which is SPLIT into TWO PIECES,
- ☑ CALLED a COMMUTATOR, so the CURRENT in the EXTERNAL CIRCUIT does not change direction.

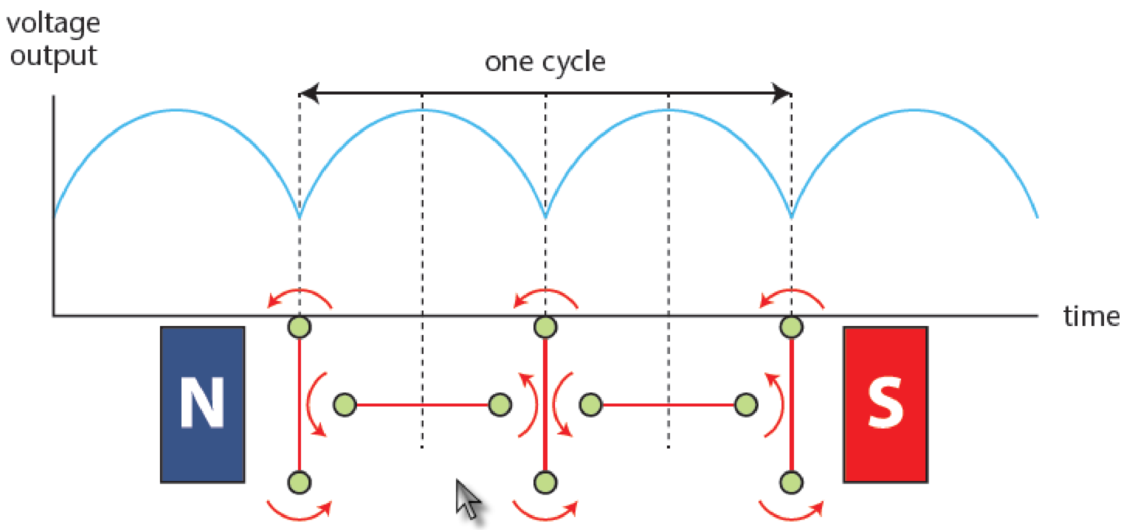
The layout of a DC GENERATOR is SHOWN BELOW.





- ☑ The SPLIT-RING (COMMUTATOR) accommodates for the CHANGE in DIRECTION of the CURRENT in the LOOP,

☑ THUS CREATING DIRECT CURRENT (DC) CURRENT GOING through the BRUSHES and OUT to the CIRCUIT.



Induced emf for a DC Generator Output of a d.c generator

IN CONCLUSION:

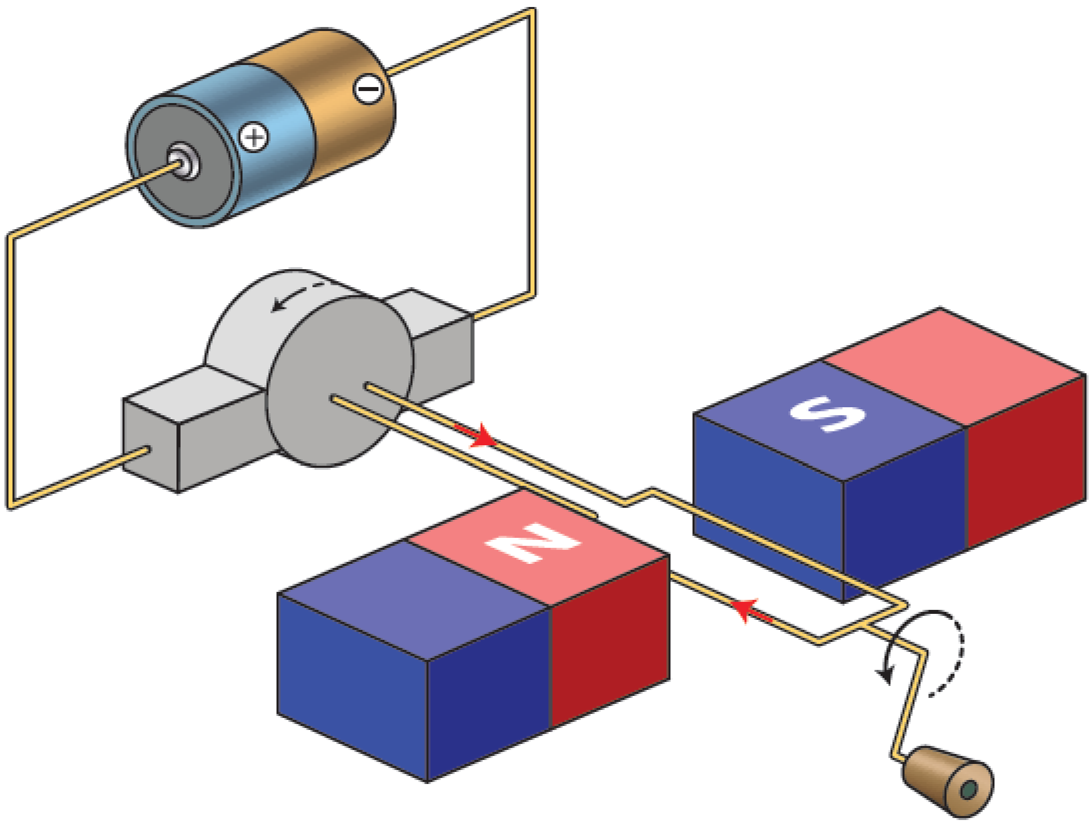
1. AC GENERATOR uses SLIP - RINGS on output while DC GENERATOR use SPLIT - RINGS COMMUTATOR.

COMMUTATOR

❖ MAINTAINS ELECTRICAL CONTACT BETWEEN THE LOAD AND THE ROTATING COIL IN A DC GENERATOR OR MOTOR

ELECTRIC MOTORS

☑ An ELECTRIC MOTOR works by using a source of EMF to make a CURRENT FLOW in a CONDUCTOR LOOP.



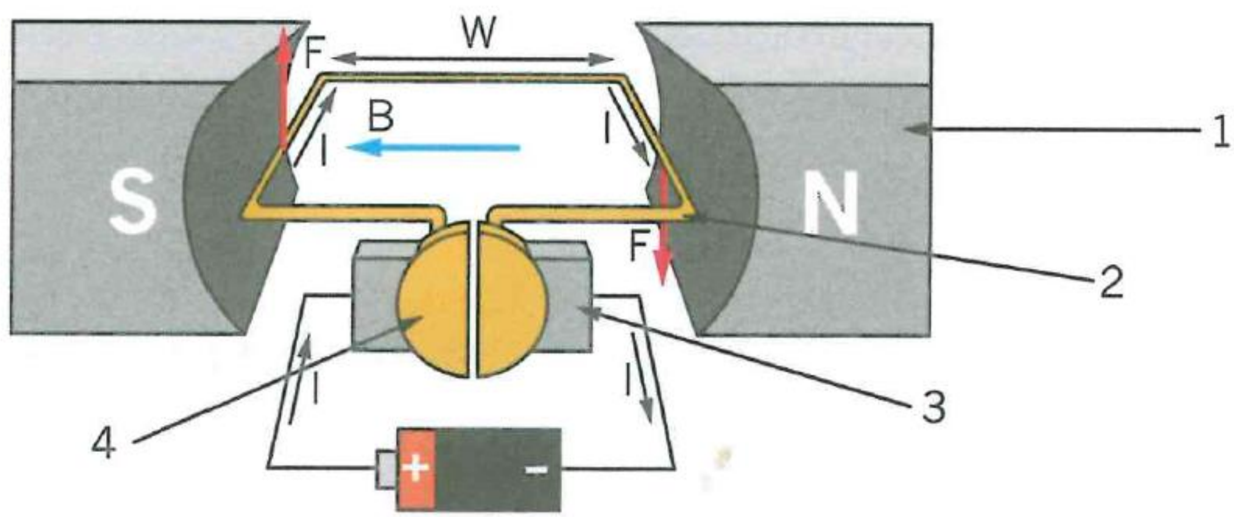
Electric Motor

MOTORS CONVERT ELECTRICAL ENERGY INTO MECHANICAL ENERGY

APPLICATIONS OF GENERATORS AND MOTOR	
GENERATORS	MOTORS
☑ Car Alternator	☑ In Electric Drills

☑ Bicycle Dynamo ☑ Hybrid Electric Vehicle (HEV) Drive Systems ☑ Aircraft Auxiliary Power Generation ☑ Wind Generators ☑ High Speed Gas Turbine Generators	☑ In Washing Machines ☑ In Mixers ☑ In Dentist Drills ☑ In Fans ☑ The Starter Of A Car

Learner Activity NO: 1



1 Identify the following parts labelled **1 – 4**

2 What type of motor is this?

3 What energy conversion that take place in this motor

4 Name the function of part **4**

ELECTRIC POWER

DEFINE POWER As:

☑ The RATE at which ELECTRICAL ENERGY is CONVERTED in an ELECTRIC CIRCUIT.

WRITTEN MATHEMATICALLY AS:

$$(P = \frac{W}{\Delta t})\ (P = VI)\ (P = I^2R)\ (P = \frac{V^2}{R})$$

SI UNIT For POWER (P) is Watts (W).

PRACTICAL UNITS of POWER is KILOWATT HOUR (kWh)

N:B 1 kWh = 3.6×10^6 J

THE HEATING EFFECT OF ELECTRIC CURRENT

MATHEMATICALLY:

$$W = P\,\Delta t:\ W = I^2R\Delta t:\ W = \frac{V^2}{R}\Delta t:\ W = VI\Delta t:$$

N.B: W = ENERGY (E)

SI UNIT OF ENERGY IS JOULES (J).

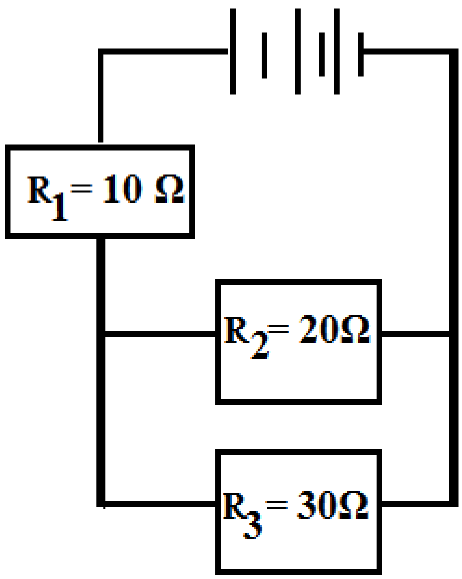
COST OF ELECTRICITY

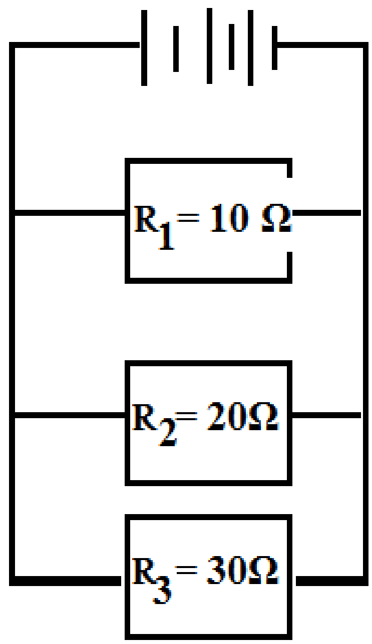
COST OF ELECTRICITY = (kWh) *x* Tarrifs.

EXAMPLE NO: 1

CIRCUIT: (A)	CIRCUIT: (B)

EACH CELL HAS 1.5 V





1 CALCULATE THE TOTAL RESISTANCE IN

1.1 CIRCUIT: (A)

1.2 CIRCUIT: (B)

2 CALCULATE THE TOTAL POWER DISSIPATED IN

2.1 CIRCUIT: (A)

2.2 CIRCUIT: (B)

EXAMPLE NO: 2

CALCULATE the POWER DISSIPATED by a RESISTOR 10 Ω when a CURRENT of 6 A flows through it

EXAMPLE NO: 3

CALCULATE the VALUE of the CURRENT which, when flowing in a 220 Ω RESISTOR, dissipate 1 kW of POWER.

EXAMPLE NO: 4

A DC Motor takes 9 A from 240 V Power Supply.
CALCULATE THE POWER INPUT to the Motor

EXAMPLE NO: 5

A HEATING ELEMENT ABSORBS 2, 1 kW of POWER and the CURRENT is 10, 5 A.

CALCULATE THE VOLTAGE APPLIED to the HEATING ELEMENT.

EXAMPLE NO: 6

A 12 V BATTERY is CONNECTED across a LOAD HAVING a RESISTANCE of 10 Ω.

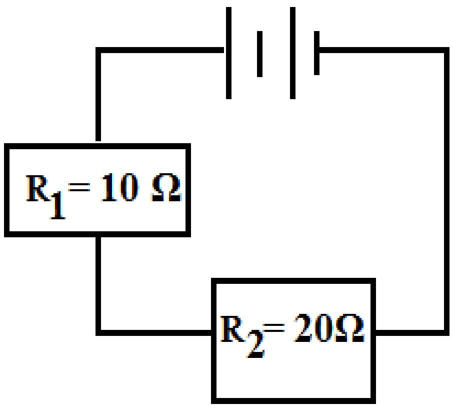
1 CALCULATE THE:

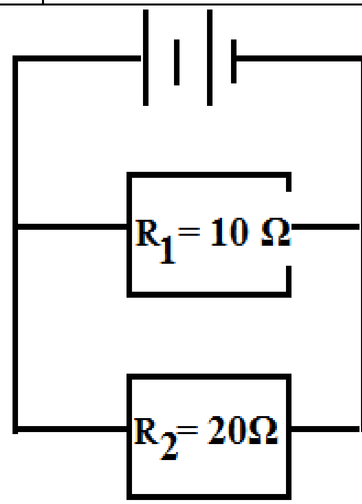
1.1 CURRENT Flowing in the load
1.2 POWER consumed
1.3 HEAT DISSIPATED in 60 min
1.4 COST of ELECTRICITY: Tariff R0. 50 Per kWh

LEARNER ACTIVITY NO: 1

CIRCUIT: (A)	CIRCUIT: (B)

EACH CELL HAS 1.5 V





1 CALCULATE THE TOTAL RESISTANCE IN
- 1.1 CIRCUIT: (A)
- 1.2 CIRCUIT: (B)

2 CALCULATE THE TOTAL POWER DISSIPATED IN
- 2.1 CIRCUIT: (A)
- 2.2 CIRCUIT: (B)

LEARNER ACTIVITY NO: 2

A 20 A CURRENT flows in a cable of RESISTANCE 200 Ω

CALCULATE THE POWER LOST in the cables

LEARNER ACTIVITY NO: 3

A 100 W LAMP PASSES a CURRENT of 0, 42 A.

1 CALCULATE IT'S:
- 1.1 RESISTANCE
- 1.2 VOLTAGE

LEARNER ACTIVITY NO: 4

A CONTRACTOR COIL has RESISTANCE of 20 Ω
CALCULATE THE POWER absorbed by this coil from 240 V DC supply.

LEARNER ACTIVITY NO: 5

An ELECTRIC HEATER of RESISTANCE 8 Ω draws 15 A from the SERVICE MAINS in 2 Hours.

1 CALCULATE THE:

1.1 POWER consumed
1.2 HEAT DISSIPATED in 2 Hours
1.3 COST of ELECTRICITY: Tariff R0. 50 Per kWh

LEARNER ACTIVITY NO: 6

An ELECTRICAL APPLIANCE takes a CURRENT of 12 A FROM a 240 V

1 CALCULATE THE:

1.1 RESISTANCE of the ELECTRIC WIRE.
1.2 POWER RATING of the ELECTRIC WIRE
1.3 ENERGY (HEAT) TRANSFERRED in 20 hours
1.4 COST of ELECTRICITY: Tariff R1. 50 Per kWh

Formula Sheet

$R_S = R_1 + R_2$ $\quad R_p = \frac{R_1 . R_2}{R_1 + R_2}$ $\quad \frac{1}{Rp} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$

$$(P = \frac{W}{\Delta t})\ (P = VI)\ (P = I^2R)\ (P = \frac{V^2}{R})$$

$$W = P\Delta t: \quad W = I^2R\Delta t: \quad W = \frac{V^2}{R}\Delta t: \quad W = VI\Delta t$$

COST OF ELECTRICITY = (kW