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WORKSHEET 18

SCHOOL : BA SANGAM COLLEGE **YEAR 12**

SUBJECT: PHYSICS **NAME OF STUDENT: ____________**

STRAND	*ELECTRICITY*
SUB-STRAND	*ELECTROSTATICS*
Content Learning Outcome	Explore electric forces by using Coulomb's law **and** effects on charged objects

GENERATOR

When a conductor moves through a magnetic field, there will be a generated voltage. The voltage generated in a length of wire, presuming that the entire length moves through a uniform field, is given below.

$$\boxed{V = BLv\sin\theta}$$

V- Voltage

B - Magnetic Field Strength

L - Length of conductor (in meters)

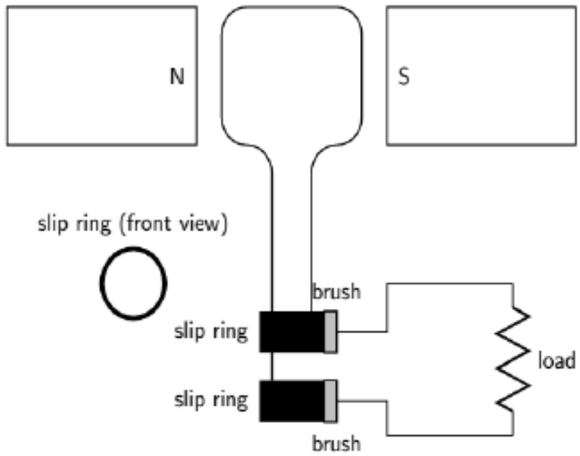
v - Velocity of conductor moving through the field

θ- is the angle (in degrees)

A generator converts mechanical energy into electrical energy.

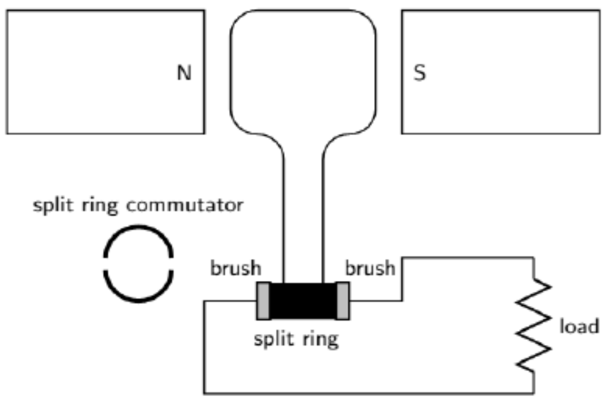
AC GENERATOR The principle of rotating a conductor in a magnetic field is used in electricity generators.

The layout of an AC generator is shown below. The conductor in the shape of a coil is connected to a 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 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 in below. The split-ring commutator accommodates for the change in direction of the current in the loop, thus creating DC current going through the brushes and out to the circuit.



Lenz's Law

In 1834, German physicist Heinrich Friedrich Lenz (1804-1865) deduced a rule, known as *Lenz's law* which gives the polarity of the induced emf in a clear and concise fashion. The statement of the law is:

The polarity of induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produced it.

ELECTROMOTIVE FORCE (EMF) INDUCED BETWEEN THE ENDS OF THE CONDUCTOR

When a conductor moves through a magnetic field, an EMF is induced across it. If the conductor was connected to an external circuit, a current would flow just like a battery. The Emf generated depends upon the following

-The magnetic field strength = B [Tesla]

-length of the conductor in the field = L [meters]

-The speed of the conductor = v [metres per second]

Consider a conductor in a magnetic field where the magnetic field flows from North to South Pole. If the conductor is moved through the field in the direction shown below, the emf will have the polarity shown. When the conductor is placed 90^o to the magnetic field it induces maximum $emf\,(\sin 90 \quad 1)$.

$$V = BLv$$

Example

A 200 turn coil has a radius of 0.12 m and length of 0.23m. It is placed in a magnetic field strength of 0.06T and rotated at 3000rpm. When the coil is in its vertical position at right angles to the field, calculate the EMF.

$$v = 2\pi r N/60$$
$$= (2)(\pi)(0.12)(3000/60)$$
$$= 37.70\ m/s$$

$$V = BLv$$
$$= (0.06)(0.23)(37.70)$$
$$= 0.52V$$

THE TRANSFORMER

Definition:

A transformer is an electrical device that uses the principle of induction between the primary coil and the secondary coil to either step-up or step-down voltage. A **step-up transformer** results in an increased voltage. A **step-down transformer** results in a decreased voltage.

The essential features of a transformer are two coils of wire, called the primary coil and the secondary coil, which are wound around different sections of the same iron core to intensify the magnetic field in the primary.

When an alternating voltage is applied to the primary coil it creates an alternating current in that coil, which induces an alternating magnetic field in the iron core, thus creating a changing magnetic field that thread through the secondary. Thus, there is a changing magnetic flux in the secondary coil, which produces a current in that coil.

Transformers consist of a core made from thin sheets of a magnetically soft material clamped together. Two separate coils of wire, insulated from one another, are tightly wound onto the core. Transformers are designed to perform the job of changing voltage with very little power loss → you may **assume that they are 100%** efficient.

$$\frac{\text{input (primary) voltage}}{\text{output (secondary) voltage}} = \frac{\text{primary turns}}{\text{secondary turns}}$$

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

If np > ns then the transformer steps down the input voltage; if ns > np then the transformer steps up the input voltage.

EXAMPLE

A transformer is designed to step down the mains voltage of 230 V to 11.5 V. If there are 1200 turns on the primary coil how many turns should be wound on the secondary coil?

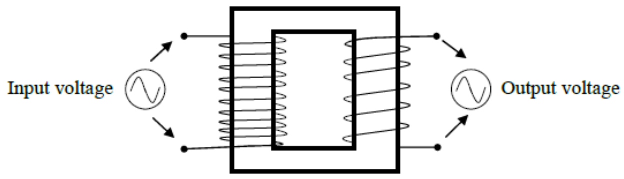
$$Rearrange\ \frac{Vp}{Vs} = \frac{n_p}{n_s}\ to\ give\ n_s = \frac{V_s}{V_p} \times n_p$$

$$So,\ n_s = \frac{11.5\ V}{230V} \times 1200$$

$$Therefore,\ n_s = 60\ turns$$

Activity 1

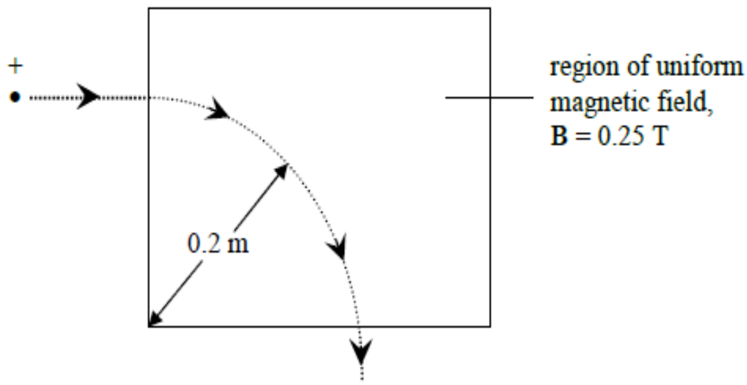
The diagram of a transformer is shown below.



Why does the transformer work on AC supply only?

Activity 2

A positively charged particle of mass 4×10^{-20} kg travelling to the right at a speed of 5×10^{4} m/s enters a region of a uniform magnetic field. The force due to the magnetic field causes the particle to move in a circular path of radius 0.2 m.



(i) State the direction of the magnetic field. Give your answer as **either** into the page **or** out of the page. **(1 mark)**

(ii) What is the magnetic force on the particle? **(1 mark)**

(iii) Calculate the radius of the circular path if magnetic field, B, in the region is doubled. **(2 marks)**