مركز أم الامارات

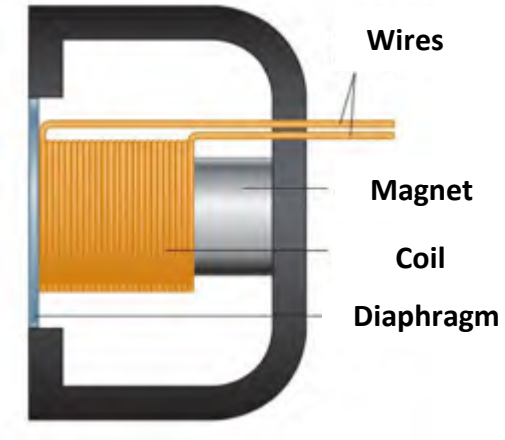
Grade 12 General / physics
Trimester 2 / Academic Year 2019-2020

I Physics

Electro magnetic induction 2

Section 1: Inducing current

7- Induced EMF in microphone:



- **Define microphone.**

Microphone is constructed like earbud, but it works in reverse; it converts sound to electrical energy by electromagnetic induction.

- **How does microphone work?**

Watch this video to understand that well (watch it from 2:40 to 3:40 min)

https://www.youtube.com/watch?v=9HTbgvtAD6E

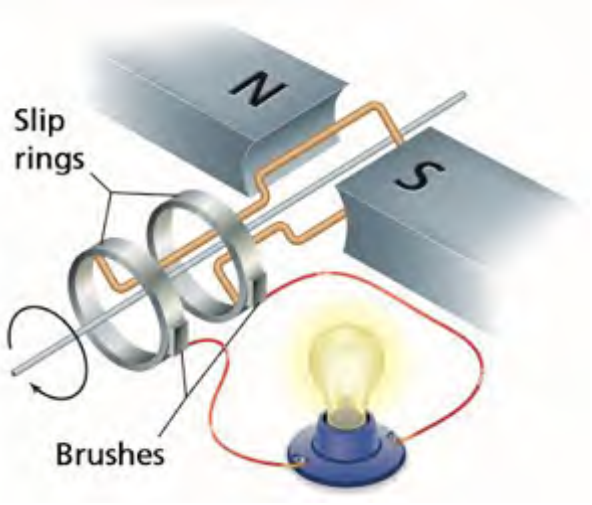
Electric generator

1- Define electric generator

It is a device that converts mechanical energy to electrical energy.

2- What are the components of the AC electric generator?

- Number of wire loops wound around an iron core (armature or rotor)
- Strong magnetic field.
- Two slip rings.
- Two brushes.
- Rotation axle.



3- How does AC electric generator work?

Watch this video to understand that well.

https://www.youtube.com/watch?v=gQyamjPrw-U

4- According to what you see in the Youtube video answer the following questions.

- **Explain how the electric generator works.**

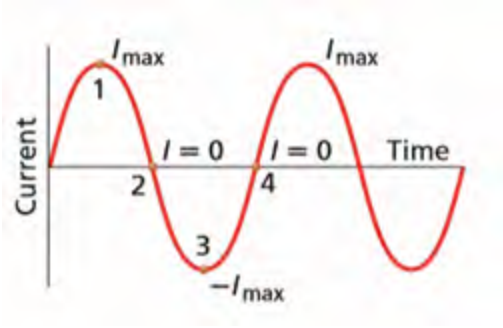
A. The rotor rotates inside a strong magnetic field.
B. The wire loops cross the magnetic field lines.
C. An induces EMF generates and an induced current flow.

- **Note 1:** The maximum induced current produced when the armature becomes in a horizontal position (in parallel to the magnetic field lines) as shown in the figure.

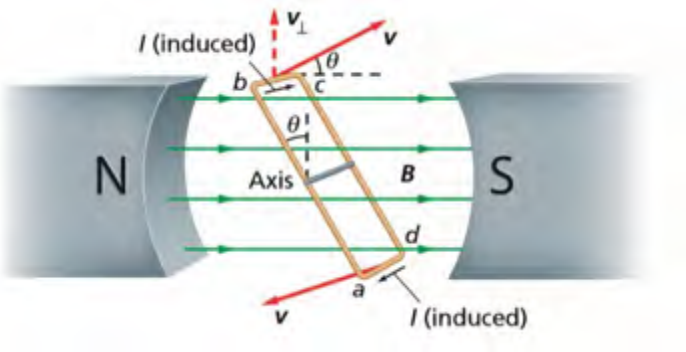
- **Note 2:** No induced current produced when the armature becomes in a vertical position (perpendicular on the magnetic field lines) as shown in the figure.

- **Note 3:** The direction of the induced current reverses every half rotation in the AC generator (starting from horizontal position and rotates 180◦)

5- Draw the induced current-time graph, that represent the changing in induced current magnitude and direction during the rotation of the armature (suppose that the rotation starting from the vertical position of the rotor).



6- Does the entire loop contribute to the induced EMF? No



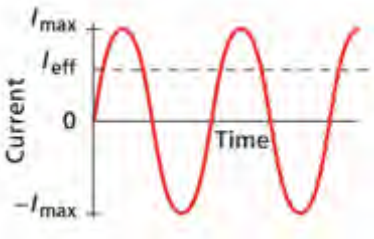
7- In which segments of the previous loop an induced current is produced?

Segment	Induce a current?	Explain your answer
ab		
bc		
cd		
da		

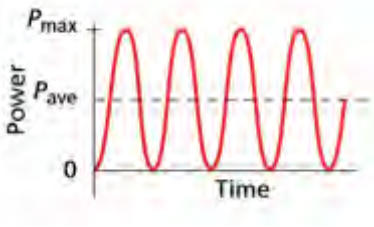
8- Compare between DC and AC generators.

DC generator	AC generator
Charges move in a single direction. Current is in one direction because the wires of the armature connect to a circuit by means of a commutator.	Charges move in two direction. Current is in tow directions because the wires of the armature connect to a circuit by means of a slip ring device

- **Note 1:** The current in the AC electric generator alternates at a fixed rate and varies sinusoidally as shown in the figure.



- **Note 2:** The power produced by the AC generator is always positive because I and V are either both positive or both negative.



9- How to calculate the average induced power by AC generator?

$$P_{AC} = \frac{1}{2} P_{AC\,max}$$

10- How to calculate the effective current produced by AC generator?

$$I_{eff} = \frac{\sqrt{2}}{2} I_{max} = 0.707\, I_{max}$$

11- How to calculate the effective potential difference produced by AC generator?

$$V_{eff} = \frac{\sqrt{2}}{2} V_{max} = 0.707\, V_{max}$$

Effective voltage is commonly referred to as RMS (root mean square) voltage

➢ **Note:** The voltage generally available at wall outlets is the magnitude of the effective voltage, not the maximum voltage.

Applications

1- A generator develops a maximum voltage of 170 V.

A. What is the effective voltage?
B. A 60-W lightbulb is placed across the generator with an Imax of 0.70 A. What is the effective current through the bulb?
C. What is the resistance of the lightbulb when it is working?

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2- The RMS voltage of an AC household outlet is 117 V.

A. What is the maximum voltage across a lamp connected to the outlet?
B. If the RMS current through the lamp is 5.5 A, what is the maximum current in the lamp?

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3- An AC generator delivers a peak voltage of 425 V.

A. What is the V_{eff} in a circuit placed across the generator?
B. The resistance is 5.0×10^2 Ω. What is the effective current?

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4- If the average power used over time by an electric light is 75 W, what is the peak power?

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5- What changes to the generator are required to increase the frequency?

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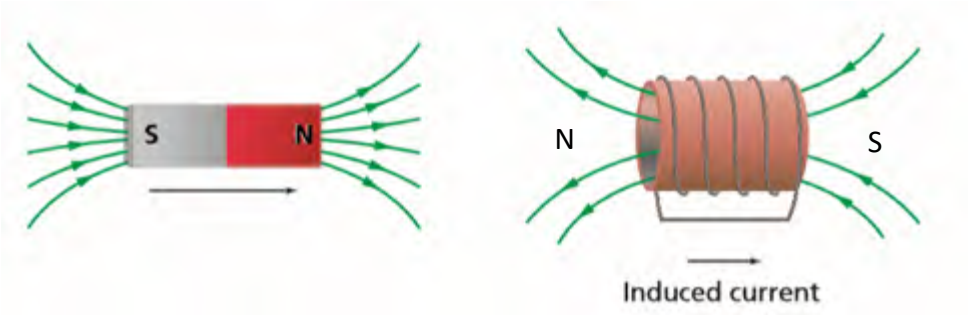
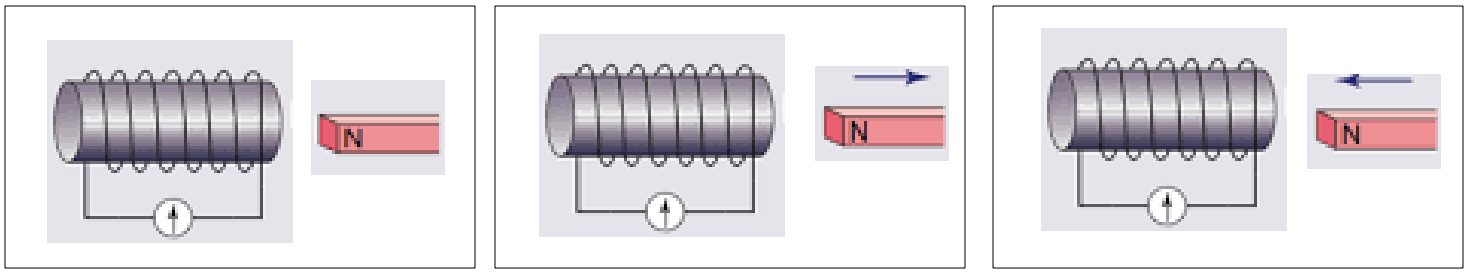
Section 2: Applications of induced current

1- Lenz's Law.

Lenz's law says that the magnetic field produced by the induced current is in the direction that is opposite the original field.



2- According to Lenz's law, determine the direction of the induced current and the induced magnetic field in the following cases shown in the figure.



3- Why do generators that generate a large amount of electricity need high mechanical energy to rotate?

When the armature rotates the induced current produce a force in the opposite direction of the external force that rotates the armature. The magnitude of the opposite force increases when the induced current increases.

4- Why do motors start rotating with slow motion when they turn on?

When a motor is first turned on, the current is large. As soon as the motor begins to turn, the motion of the wires across the magnetic field induces an EMF that opposes the current. Therefore, the net current through the motor is reduced

5- Why lights dim when a motor starts?

Because the potential difference across the light bulb decreases as a result of drawing a large amount of current in the motor branch.

6- Define eddy currents.

eddy currents are generated in any piece of metal moving through a magnetic field; the magnetic field they produce opposes the motion that caused the currents

7- Name one application of eddy currents.

The brakes of some trains and roller coasters.

8- How to reduce the effect of eddy currents in the metal parts in motors (iron core)?

The motor cores are constructed from thin metal layers that have insulation added between the layers.

9- Define the self-inductance.

It is the property of a wire either straight or in a coil to create an induced EMF that opposes the change in the potential difference across the wire

Transformers

1- Define transformers.

Transformers are devices that increase or decrease potential difference with relatively little waste of energy

- **Note:** Only alternating current can be sent through a transformer. Direct current cannot pass through a transformer.

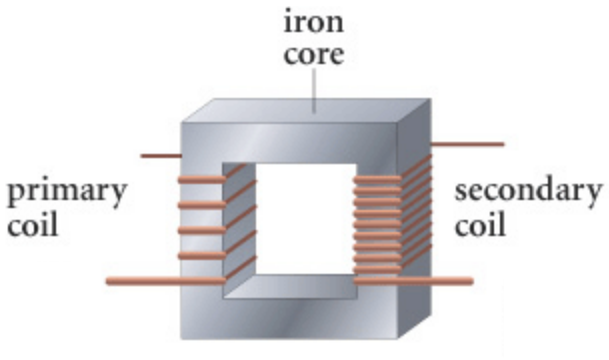
2- What is the principle of transformer work?

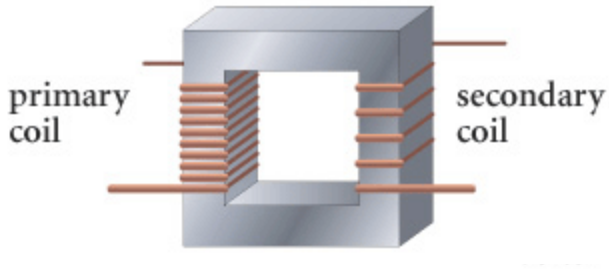
The transformer depends on mutual inductance where an EMF and current in one coil due to changing current in another coil.

3- What are the components of the transformer?

Primary coil	Which is connecting to the alternating current source
Secondary coil	Which is connecting to the devices (resistance)
Iron core	Which is carrying the changes in magnetic field from the primary coil to the secondary coil.

4- What is the type of each of the following transformers?





5- Define the isolation transformer.

It is a transformer with identical primary and secondary coils (the coils have the same number of turns). It is not step-up or step-down transformer and used for safety reasons also can be used to reduce the electrical noise.

6- Define the ideal transformer.

It is a transformer that the electric power delivered to the secondary circuit equals the power supplied to the primary circuit. It is 100% efficient

7- Write the ideal transformer equation.

$$\frac{I_s}{I_P} = \frac{V_P}{V_s} = \frac{N_P}{N_s}$$

N_P, N_s	**The number of turns of the primary and secondary coils**
V_P, V_s	**The potential difference of the primary and secondary coils**
I_P, I_s	**The electric current of the primary and secondary coils**

➢ **Note:** The efficiency of the real transformer is between 95-98% which is the ratio of the output power to the input power.

Remember

Step-Up Transformer	Step-Down Transformer
$V_p < V_s$	$V_p > V_s$
$I_p > I_s$	$I_p < I_s$
$N_p < N_s$	$N_p > N_s$

Applications

1- A step-up transformer has a primary coil consisting of 200 turns and a secondary coil consisting of 3000 turns. The primary coil is supplied with an effective AC voltage of 90.0 V.

A. What is the voltage in the secondary circuit?
B. The current in the secondary circuit is 2.0 A. What is the current in the primary circuit?

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2- A step-up transformer has a primary coil consisting of 200 turns and a secondary coil consisting of 30 turns. The primary coil is supplied with an effective DC voltage of 10.0 V. what is the voltage in the secondary circuit?

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3- A step-down transformer has 7500 turns on its primary coil and 125 turns on its secondary coil. The voltage across the primary circuit is 7.2 kV.

A. What voltage is being applied across the secondary circuit?
B. If the current in the secondary circuit is 36 A, what is the current in the primary circuit?

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4- A step-up transformer has 300 turns on its primary coil and 90,000 turns on its secondary coil. The EMF of the generator to which the primary circuit is attached is 60.0 V.

A. What is the EMF in the secondary circuit?
B. The current in the secondary circuit is 0.50 A. What current is in the primary circuit?

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The end