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Class	10th	Chapter	19
Subject	Physics	Board	Federal

CHAPTER 19: ELECTROMAGNETISM

MULTIPLE CHOICE QUESTIONS

1. The presence of a magnetic field can be detected by a A. small mass B. stationary positive charge C. stationary negative charge **D. magnetic compass**

2. A DC motor converts: A. mechanical energy into electrical energy B. mechanical energy into chemical energy **C. electrical energy into mechanical energy** D. electrical energy into chemical energy

3. Which of the following device works on the principle of electromagnetic induction? A. Magnetic compass B. Motor **C. Transformer** D. Oscilloscope

4. Voltage in the secondary coil of transformer does not depend upon A. frequency of source B. primary voltage **C. power losses** D. turns ratio

5. Which of the following quantities remain constant in an ideal step-up transformer? A. current B. voltage **C. power** D. heat

6. Step-up transformer has a transformation ratio of 3:2. What is the voltage in secondary, if voltage in primary is 30 V? A. 15 V **B. 45 V** C. 90 V D. 300 V *(Calculation:* $\frac{V_s}{V_p} =$ Ratio $\Longrightarrow \frac{V_s}{30} = \frac{3}{2} \Longrightarrow V_s = 45$ V*)*

7. Toward which magnetic pole of Earth is the north pole of a compass needle attracted? A. The north pole of a compass needle is attracted to the north magnetic pole of Earth, which is located near the geographic North Pole of Earth. **B. The north pole of a compass needle is attracted to the south magnetic pole of Earth, which is located near the geographic North Pole of Earth.** C. The north pole of a compass needle is attracted to the north magnetic pole of Earth, which is located near the geographic South Pole of Earth. D. The north pole of a compass needle is attracted to the south magnetic pole of Earth, which is located near the geographic South Pole of Earth.

8. The step-up transformer: A. increases the input current **B. increases the output voltage** C. has more turns in the primary D. has less turns in the secondary coil

9. A step up transformer is used before electricity is transmitted by overhead cables. Select the statement that explains why this is done. A. It increases the voltage to increase the speed at which the electricity travels. **B. It increases the voltage to reduce energy loss in the cables.** C. It increases the current to increase the speed at which the electricity travels. D. It increases the current to reduce energy loss in the cables.

10. Which of the following does not change in an ordinary transformer? A. power **B. Frequency** C. Current D. Voltage

CONSTRUCTED RESPONSE QUESTIONS

1. In which direction the current must be flowing through the conductor to create the magnetic field shown in the diagram? Up or Down?

- **Answer: Up**

(Using the Right-Hand Grip Rule: programmatically wrap your right hand around the conductor with fingers curling in the counter-clockwise direction of the magnetic field lines shown, your thumb points upwards.)

2. In the following diagram, will there be a North pole or a South pole at the left side of the solenoid? Also draw its magnetic field having arrows to show its direction.

- **Answer: North pole**

(Using the Right-Hand Grip Rule for solenoids: curling fingers in the direction of conventional current flowing up/over the coils causes the thumb to point towards the left, indicating that the left end acts as the North magnetic pole, while the magnetic field lines emerge from the left end and loop around into the right end.)

3. A current carrying conductor is placed in the magnetic field, as shown.

- **a) In which direction will the conductor move? Up, down, left or right?**
  - **Answer: Up**

(Applying Fleming's Left-Hand Rule: magnetic field directed from North to South [right to left], current flowing into the page/forward, resulting in an upward magnetic force.)

- **b) If the magnetic field was reversed then in which direction will the conductor move?**
  - **Answer: Down**

(Reversing the magnetic field direction reverses the resulting magnetic force direction.)

- **c) If both the magnetic field and the current are reversed, then in which direction will the conductor move?**
  - **Answer: Up**

(Reversing both parameters cancels out the net change, maintaining the original upward force direction.)

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SHORT RESPONSE QUESTIONS

1. How does a generator differ from a motor, and what is their relationship to each other?

- A generator converts mechanical energy into electrical energy using electromagnetic induction, whereas an electric motor converts electrical energy into mechanical energy using the magnetic force on a current-carrying conductor.
- Both devices share a fundamentally identical internal construction consisting of coils rotating within a magnetic field.
- Because of this structural reversibility, a motor can act as a generator when its armature is mechanically turned, demonstrating an inverse conversion of energy.

2. Why is a transformer ineffective with DC voltage?

- A transformer relies entirely on electromagnetic induction, which requires a constantly changing magnetic flux to induce an electromotive force (EMF) in the secondary coil.
- Direct current (DC) produces a constant, steady magnetic field that does not change over time, resulting in zero rate of change of flux ($\Delta\Phi/\Delta t = 0$).
- Consequently, no secondary voltage is induced, and the continuous steady DC can overheat or damage the primary winding.

3. Explain the relationship between the direction of a current-carrying conductor and the magnetic field it produces.

- The direction of the circular magnetic field lines produced around a straight current-carrying conductor is directly dictated by the conventional direction of the electric current.
- According to the Right-Hand Grip Rule, if you point your right thumb in the direction of the current, your curled fingers show the direction of the magnetic field.
- Reversing the direction of the electric current immediately causes the magnetic field lines to reverse their circular orientation.

4. Describe the interaction between a current-carrying conductor and a magnetic field, and how to determine the direction of the force exerted.

- When a current-carrying conductor is placed within an external magnetic field, the magnetic field of the current interacts with the external field to create a net deflecting force.
- The magnitude of this force depends on the current, magnetic field strength, length of wire, and the angle of orientation between them.
- Its direction is determined using Fleming's Left-Hand Rule, where the thumb, forefinger, and middle finger represent Force, Magnetic field, and Current.

5. Why is high voltage used for long-distance transmission of electrical power?

- Power loss in transmission cables occurs primarily as heat due to Joule heating ($P = I^2R$).
- By stepping up the transmission voltage to very high levels, the current flowing through the grid lines is drastically reduced for the same transferred power.

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- Because power loss is proportional to the square of the current, lowering the current minimizes resistive energy losses over long distances.

6. Design an experiment to generate an electric current using a coil of wire and a bar magnet.

- Connect a sensitive galvanometer or ammeter across the two ends of a closed, hollow coil of insulated copper wire to detect induced currents.
- Rapidly push the North pole of a permanent bar magnet into the center of the coil and observe the galvanometer needle deflect to one side.
- Pull the magnet out in the opposite direction, noting that the needle deflects the other way, confirming that relative motion induces current.

7. What factors influence the strength of an induced electromotive force (EMF)?

- According to Faraday's Law, the induced EMF is directly proportional to the rate of change of magnetic flux linking the coil.
- Therefore, increasing the total number of turns in the wire coil multiplies the induced voltage proportionally.
- Additionally, increasing the strength of the magnetic field or the speed of relative motion between the magnet and coil raises the induced EMF.

8. Compare and contrast the two primary types of transformers.

- Step-up transformers increase voltage and feature more secondary turns than primary turns ($N_s > N_p$), whereas step-down transformers decrease voltage and have fewer secondary turns ($N_s < N_p$).
- Both share the same fundamental operating principle based on mutual electromagnetic induction across a shared laminated iron core.
- In both ideal types, input electrical power equals output electrical power ($V_p I_p = V_s I_s$), meaning an increase in voltage is accompanied by a decrease in current.

9. Identify three devices that operate on the principle of electromagnetic induction.

- **Transformers:** Alter alternating voltages efficiently using mutual induction between primary and secondary coils.
- **AC Generators (Alternators):** Rotate coils within magnetic fields to mechanically induce alternating electric current.
- **Induction Cooktops:** Utilize rapidly changing magnetic fields to induce eddy currents that directly heat ferromagnetic cookware.

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LONG RESPONSE QUESTIONS

1. Design an experiment to qualitatively demonstrate the existence of a magnetic field around a current-carrying conductor.

- **Objective:** To show that an electric current produces a circular magnetic field around a conductor (Oersted's discovery).
- **Apparatus Required:** A straight rigid copper wire, a DC power supply or battery, a switch, connecting wires, a small magnetic compass, and a horizontal cardboard sheet.
- **Experimental Procedure:**
    1. Pass the straight copper wire vertically through a small hole punched in the center of the horizontal cardboard sheet.
    2. Connect the ends of the wire in series with a battery and a switch to establish a controlled electrical circuit.
    3. Place multiple small magnetic compasses in a circular pattern on the cardboard surrounding the wire.
    4. Close the switch to allow current to flow through the conductor and observe the immediate deflection of the compass needles.
    5. Open the switch and note that the compass needles return to their original North-pointing alignment.
    6. Reverse the battery polarity to reverse the current direction and observe that the compass needle orientations flip.
- **Scientific Conclusion:** The deflection of the compass needles proves that an electric current generates a surrounding magnetic field whose direction depends on the direction of current flow.

2. Describe an experimental setup to induce an EMF in a circuit using a changing magnetic field. How can you measure the induced EMF?

- **Apparatus:** A solenoid coil connected to a sensitive center-zero galvanometer, a bar magnet, and connecting leads.
- **Experimental Setup:** Connect the terminals of the solenoid to form a closed electrical loop with the galvanometer. Keep the bar magnet stationary near the coil initially.
- **Inducing EMF:** Move the bar magnet toward or away from the coil. The motion changes the magnetic flux (Φ) passing through the loops of the wire over time (Δt). According to Faraday's Law ($\text{EMF} = -N\frac{\Delta\Phi}{\Delta t}$), this changing magnetic flux induces an electromotive force, driving a current that deflects the galvanometer.
- **Measuring Induced EMF:** The magnitude of the induced EMF can be measured directly using a calibrated voltmeter connected across the coil terminals, or indirectly by measuring the induced current with the galvanometer and applying Ohm's law ($V = IR$) if the internal resistance of the coil is known.

3. Explain Lenz's law in your own words, and provide a real-world application to illustrate its application.

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- **Definition:** Lenz's Law states that the direction of an induced current is always such that its own magnetic field opposes the original change in magnetic flux that produced it. It is a direct consequence of the conservation of energy, ensuring you cannot get something for nothing.
- **Real-World Application (Electromagnetic Braking / Eddy Current Brakes):**
    - Heavy trains and roller coasters use eddy current braking systems where an electromagnet induces opposing currents in metal tracks or wheels.
    - When the magnet approaches a metal plate, it induces swirling eddy currents inside the metal.
    - By Lenz's law, these eddy currents generate a magnetic field that pushes back against the moving magnet, creating a smooth, frictionless deceleration force without physical wear and tear.

4. Define an alternating current (AC) generator. Draw a labeled diagram and explain its components and operation. How does it convert mechanical energy into electrical energy?

- **Definition:** An AC generator is an electromechanical device that converts mechanical energy into electrical energy in the form of an alternating current using electromagnetic induction.
- **Components:**
    - **Magnetic Field Poles (N and S):** Permanent magnets or electromagnets providing a stable external magnetic field.
    - **Armature Coil:** A rectangular coil of insulated copper wire wound on an iron core that rotates within the magnetic field.
    - **Slip Rings:** Two continuous metal rings connected to the ends of the rotating armature coil that rotate alongside it.
    - **Carbon Brushes:** Stationary graphite blocks that maintain continuous sliding electrical contact with the rotating slip rings to draw current to the external circuit.
- **Operation & Energy Conversion:** When mechanical torque rotates the armature coil, its wires cut through the external magnetic field lines. This continuous change in magnetic flux induces an alternating EMF and current within the coil every half-rotation. The slip rings and brushes transfer this alternating electricity to the external load, successfully converting input mechanical rotation into output electrical energy.

5. What is an AC motor? Draw a labeled diagram and explain its components and operation. How does it convert electrical energy into mechanical energy?

- **Definition:** An AC motor is an electrical machine that converts alternating electrical energy into continuous mechanical rotational energy using magnetic forces.
- **Components:**
    - **Stator:** The stationary outer casing containing electromagnets or windings supplied with alternating current to produce a rotating magnetic field.
    - **Rotor (Armature):** The rotating inner assembly consisting of conducting bars or coils mounted on a shaft.

- **Slip Rings / Commutator:** Contacts that deliver or distribute electrical currents to the rotor windings.

- **Operation & Energy Conversion:** When alternating current is supplied to the stator and rotor, the interaction between the magnetic fields generates a net Lorentz force on the current-carrying conductors. This magnetic force produces a turning torque that forces the rotor to spin continuously. Thus, electrical energy supplied to the motor terminals is transformed into useful mechanical work.

6. Define a transformer. Explain its principle of operation, components, and applications. How does it change the AC voltage?

- **Definition:** A transformer is a static electromagnetic device used to step up or step down alternating voltages and currents without changing frequency.
- **Principle of Operation:** It operates entirely on **mutual induction**. An alternating current in the primary coil creates a continuously changing magnetic flux, which is guided by an iron core to induce an alternating EMF in the secondary coil.
- **Components:**
  - **Primary Coil:** Input winding connected to the AC source.
  - **Secondary Coil:** Output winding connected to the load.
  - **Laminated Iron Core:** A high-permeability magnetic core made of stacked insulated sheets to minimize eddy current energy losses and contain magnetic flux.
- **How it Changes AC Voltage:** The voltage transformation is governed by the turns ratio equation:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

If the secondary coil has more turns than the primary ($N_s > N_p$), the voltage is stepped up; if it has fewer turns ($N_s < N_p$), the voltage is stepped down.

- **Applications:** Power transmission grids (stepping up voltage for long-distance lines), household appliance adapters (stepping down mains voltage for electronics), and electrical isolation circuits.

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NUMERICAL RESPONSE QUESTIONS

1. A step-up transformer has a turn ratio of 1:100. An alternating supply of 20 V is connected across the primary coil. What is the secondary voltage?

- **Given Data:**
  - Turn ratio ($N_p : N_s$ or $\frac{N_p}{N_s}$) = $1:100 \Longrightarrow \frac{N_s}{N_p} = \frac{100}{1} = 100$
  - Primary voltage (V_p) = 20 V
- **To Find:**
  - Secondary voltage (V_s) = ?
- **Formula:**

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

- **Calculation:**

$$V_s = V_p \times \left(\frac{N_s}{N_p}\right)$$

$$V_s = 20\ \text{V} \times 100 = 2000\ \text{V}$$

- **Answer:** 2000 volts

2. A step-down transformer has a turns ratio of 100:1. An ac voltage of amplitude 170 V is applied to the primary. What is the voltage across the secondary?

- **Given Data:**
  - Turns ratio ($N_p : N_s$) = $100:1 \Longrightarrow \frac{N_s}{N_p} = \frac{1}{100} = 0.01$
  - Primary voltage (V_p) = 170 V
- **To Find:**
  - Secondary voltage (V_s) = ?
- **Formula:**

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

- **Calculation:**

$$V_s = V_p \times \left(\frac{N_s}{N_p}\right)$$

$$V_s = 170\ \text{V} \times \frac{1}{100} = 1.7\ \text{V}$$

- **Answer:** 1.7 volts

3. Calculate the input voltage if it draws 0.5 A. Also calculate turn ratio of primary to secondary coil if a transformer is rated for an output of 100 W and 8.3 A. Also identify the type of transformer.

- **Given Data:**

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- Input current (I_p) = 0.5 A
- Output power (P_{out}) = 100 W
- Output current (I_s) = 8.3 A
- Assumption (Ideal Transformer): Input power (P_{in}) = Output power (P_{out}) = 100 W

- **To Find:**
  - Input voltage (V_p) = ?
  - Turn ratio of primary to secondary ($N_p : N_s$) = ?
  - Type of transformer = ?
- **Calculations:**

1. **Input Voltage (V_p):**

$$P_{in} = V_p \times I_p$$
$$100 \text{ W} = V_p \times 0.5 \text{ A}$$
$$V_p = \frac{100}{0.5} = 200 \text{ V}$$

2. **Secondary Voltage (V_s):**

$$P_{out} = V_s \times I_s$$
$$100 \text{ W} = V_s \times 8.3 \text{ A}$$
$$V_s = \frac{100}{8.3} \approx 12.05 \text{ V}$$

3. **Turn Ratio ($N_p : N_s$):**

$$\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{200}{12.05} \approx 16.6$$

Ratio = 1: 16.6 (or 16.6: 1 for primary-to-secondary ratio evaluation: $V_p/V_s \approx 200/12.05 \approx 16.6 : 1$).

4. **Transformer Type:** Since primary voltage (200 V) is greater than secondary voltage (12.05 V), it is a **step-down transformer**.

- **Answer:**200 volt**, 1: 16.6, step down**

4. Calculate the output power and output current of the following step-down transformer. The value of input current is 0.050 A (Assuming that the transformer is 100% efficient).*(Referenced from diagram: Primary Voltage $V_p = 230$ V, Primary Turns $N_p =$* not needed directly since efficiency is 100%, *Secondary Voltage $V_s = 6$ V, Input Current $I_p =$* 0.050 A*)*

- **Given Data:**
  - Input voltage (V_p) = 230 V
  - Input current (I_p) = 0.050 A
  - Secondary voltage (V_s) = 6 V
  - Efficiency (η) = 100% ($\Longrightarrow P_{out} = P_{in}$)

- **To Find:**
  - Output power (P_{out}) = ?
  - Output current (I_s) = ?
- **Calculations:**
  1. **Input Power (P_{in}):**

$$P_{in} = V_p \times I_p = 230\ \text{V} \times 0.050\ \text{A} = 11.5\ \text{W}$$

  2. **Output Power (P_{out}):** Since the transformer is 100% efficient:

$$P_{out} = P_{in} = 11.5\ \text{W}$$

  3. **Output Current (I_s):**

$$P_{out} = V_s \times I_s$$
$$11.5\ \text{W} = 6\ \text{V} \times I_s$$
$$I_s = \frac{11.5}{6} \approx 1.916\ \text{A} \approx 1.9\ \text{A}$$

- **Answer:** 11.5 W, 1.9 A

5. A transformer in an adapter steps up a 115 V to the 230 V needed for a hair dryer. A current of 5 A flows through the hairdryer. Assuming that the transformer is 100% efficient, calculate the current drawn from the mains supply.

- **Given Data:**
  - Primary voltage (V_p) = 115 V
  - Secondary voltage (V_s) = 230 V
  - Secondary current (I_s) = 5 A
  - Efficiency (η) = 100% ($P_{in} = P_{out}$)
- **To Find:**
  - Current drawn from mains supply / Input current (I_p) = ?
- **Formula:** For a 100% efficient transformer:

$$P_{in} = P_{out}$$
$$V_p \times I_p = V_s \times I_s$$

- **Calculation:**

$$115\ \text{V} \times I_p = 230\ \text{V} \times 5\ \text{A}$$
$$115 \times I_p = 1150$$
$$I_p = \frac{1150}{115} = 10\ \text{A}$$

- **Answer:** 10 A

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