UNIQUE STUDY POINT

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Class: X	**Subject:** Science	**Session:** 2025-26
Chapter: 12 - Magnetic Effects of Electric Current	**Time:** 1½ Hours	**Max. Marks:** 40

General Instructions:

1. All questions are compulsory.
2. This question paper contains 20 questions divided into five sections A, B, C, D and E.
3. Section A contains 10 MCQs of 1 mark each.
4. Section B contains 4 questions of 2 marks each.
5. Section C contains 3 questions of 3 marks each.
6. Section D contains 1 question of 5 marks.
7. Section E contains 2 Case Study Based questions of 4 marks each.

SECTION A - Multiple Choice Questions (1 mark each)

1. Two magnetic field lines can never intersect each other because:
(a) Magnetic field is strongest at the point of intersection
(b) Magnetic field at a point can have only one direction
(c) Field lines repel each other
(d) Magnetic monopoles do not exist

2. The pattern of magnetic field lines near a long straight current-carrying wire is:
(a) Straight lines parallel to the wire
(b) Concentric circles centered on the wire
(c) Radial lines originating from the wire
(d) Elliptical in shape

3. Which of the following correctly represents Maxwell's right-hand thumb rule?
(a) Thumb shows field direction, fingers show current direction
(b) Thumb shows current direction, fingers show field direction
(c) Thumb shows force direction, fingers show current direction
(d) Thumb shows force direction, fingers show field direction

4. The magnetic field at the center of a circular coil carrying current becomes:
(a) Weaker with increase in radius
(b) Stronger with increase in radius
(c) Independent of radius
(d) Zero at all times

5. A soft iron core is used inside a solenoid to:
(a) Increase the resistance
(b) Increase the magnetic field strength

(c) Decrease the current flow

(d) Make it a permanent magnet

6. Fleming's left-hand rule is used to find:

(a) Direction of magnetic field around a conductor

(b) Direction of induced current

(c) Direction of force on current-carrying conductor in magnetic field

(d) Direction of electric field

7. The potential difference between live wire and neutral wire in India is:

(a) 110 V

(b) 220 V

(c) 330 V

(d) 440 V

8. Which wire in domestic wiring is connected to the metal body of electrical appliances?

(a) Live wire (Red)

(b) Neutral wire (Black)

(c) Earth wire (Green)

(d) Any of the above

9. The main cause of overheating and fire in electrical circuits is:

(a) Use of thick wires

(b) Overloading or short-circuiting

(c) Use of fuse

(d) Connecting appliances in parallel

10. When the direction of current in a wire is reversed, the direction of magnetic field:

(a) Remains the same

(b) Gets reversed

(c) Becomes zero

(d) Becomes perpendicular

SECTION B - Short Answer Questions (2 marks each)

11. How does the strength of magnetic field at a point near a straight current-carrying conductor depend on the current and distance from the conductor?

12. Distinguish between the neutral wire and the earth wire in a domestic electric circuit.

13. A current-carrying straight wire is placed perpendicular to a magnetic field. How will the magnitude of force on the wire change if:

(a) The current flowing through it is doubled?

(b) The length of the wire inside the magnetic field is tripled?

14. What is the role of a fuse in electrical circuits? Why is an alloy of lead and tin used for making fuse wires?

SECTION C - Short Answer Questions (3 marks each)

15. Draw the magnetic field lines pattern due to a circular loop carrying current. How can we use right-hand thumb rule to find the direction of magnetic field at the center of this loop?

16. A proton beam is moving along the direction of a magnetic field. What will be the force acting on the proton? Now if the proton beam moves perpendicular to the magnetic field, what happens to the force? Explain.

17. Define solenoid. How is the magnetic field pattern inside a solenoid different from the magnetic field pattern around a straight current-carrying conductor? Draw neat diagrams to support your answer.

SECTION D - Long Answer Question (5 marks)

18. (a) Explain why a current-carrying conductor experiences a force when placed in a magnetic field. State the rule used to find the direction of this force.
(b) On what factors does the magnitude of this force depend?
(c) In which position of the conductor will the force be: (i) maximum, (ii) minimum? Explain with proper reasoning.

SECTION E - Case Study Based Questions (4 marks each)

19. Case Study 1: Magnetic Resonance Imaging (MRI)

When we touch something, our nerves carry an electric impulse to the muscles. This impulse produces a temporary magnetic field. Though very weak (about one-billionth of Earth's magnetic field), these fields in the heart and brain are significant. Medical professionals use a technique called Magnetic Resonance Imaging (MRI) that uses strong magnetic fields to create detailed images of organs and tissues inside the body. The technique is based on the magnetic properties of atoms in our body. Analysis of these images helps doctors diagnose diseases without surgery.

Based on the above case study, answer the following questions:

(i) What causes the production of magnetic field in our body? (1 mark)

(ii) Which two organs produce significant magnetic fields in the human body? (1 mark)

(iii) How does MRI technology help in medical diagnosis? Explain the role of magnetism in this process. (2 marks)

20. Case Study 2: Electric Motor Application

Ravi bought a table fan for his room. The fan has an electric motor inside that converts electrical energy into mechanical energy. The motor works on the principle that a current-carrying conductor experiences a force when placed in a magnetic field. Inside the motor, there is a rectangular coil placed between the poles of a magnet. When current flows through the coil, it experiences force due to the magnetic field. The direction of force changes every half rotation due to a device called commutator, making the coil rotate continuously. The fan blades attached to the motor shaft also rotate, creating air flow.

Based on the above case study, answer the following questions:

(i) State the principle on which an electric motor works. (1 mark)

(ii) What is the function of commutator in an electric motor? (1 mark)

(iii) Why does the coil in an electric motor rotate continuously? Explain with reference to the force experienced by current-carrying conductor. (2 marks)

DETAILED ANSWER KEY - PAPER 02

SECTION A - Answers to MCQs

1. (b) Magnetic field at a point can have only one direction

If two field lines intersected, it would mean that at the point of intersection, the compass needle would point in two different directions simultaneously, which is impossible. The magnetic field has a unique direction at any given point.

2. (b) Concentric circles centered on the wire

The magnetic field lines around a straight current-carrying wire form concentric circles in planes perpendicular to the wire. The wire is at the center of these circular field lines.

3. (b) Thumb shows current direction, fingers show field direction

According to Maxwell's right-hand thumb rule (or right-hand thumb rule): If you hold the conductor in your right hand with thumb pointing in the direction of current, the curled fingers show the direction of magnetic field lines.

4. (a) Weaker with increase in radius

The magnetic field at the center of a circular coil is inversely proportional to its radius. As radius increases, the field becomes weaker because the current is farther from the center.

5. (b) Increase the magnetic field strength

Soft iron is a magnetic material that gets easily magnetized when placed inside a current-carrying solenoid. This greatly increases the magnetic field strength of the solenoid, making it a strong electromagnet.

6. (c) Direction of force on current-carrying conductor in magnetic field

Fleming's left-hand rule is used to find the direction of force experienced by a current-carrying conductor placed in a magnetic field. The thumb shows force, forefinger shows field, and middle finger shows current direction.

7. (b) 220 V

In India, the standard domestic power supply has a potential difference of 220 V between the live wire and neutral wire, with a frequency of 50 Hz.

8. (c) Earth wire (Green)

The earth wire with green insulation is connected to the metal body of electrical appliances as a safety measure. It provides a low-resistance path for leakage current to flow to earth, preventing electric shocks.

9. (b) Overloading or short-circuiting

Overloading (when too much current flows) or short-circuiting (when live and neutral wires touch) causes excessive current flow. This leads to overheating due to Joule heating ($H = I^2Rt$), which can cause fires.

10. (b) Gets reversed

The direction of magnetic field around a conductor depends on the direction of current as given by the right-hand thumb rule. When current direction is reversed, the magnetic field direction also reverses.

SECTION B - Answers to Short Answer Questions

11.

The strength of magnetic field at a point near a straight current-carrying conductor depends on two factors:

(a) Current flowing through the conductor: The magnetic field strength is directly proportional to the current. If the current increases, the magnetic field also increases proportionally at all points around the conductor.

(b) Distance from the conductor: The magnetic field strength decreases as we move away from the conductor. It is inversely proportional to the distance from the conductor. This is evident from the fact that the concentric circular field lines become larger and more spaced out at greater distances.

12.

Differences between Neutral wire and Earth wire:

Neutral Wire	Earth Wire
Has black insulation	Has green insulation
Completes the circuit and provides return path for current	Used as safety measure, does not carry current normally
Connected to all appliances to complete electrical circuit	Connected to metal body of appliances to prevent shock
Essential for operation of appliances	Safety device; provides path for leakage current

13.

The force on a current-carrying conductor in a magnetic field is given by: $F = B \times I \times L \times \sin\theta$
Where B = magnetic field, I = current, L = length of conductor in field, θ = angle between current and field

(a) When current is doubled:
Since $F \propto I$, if current is doubled, the force will also become double (2 times) of the original force.

(b) When length is tripled:
Since $F \propto L$, if the length of wire inside the magnetic field is tripled, the force will also become three times (3 times) the original force.

14.

Role of fuse:
A fuse is a safety device that protects electrical circuits and appliances from damage due to excessive current flow caused by overloading or short-circuiting. When current exceeds the safe limit, the fuse wire melts due to Joule heating and breaks the circuit.

Why lead-tin alloy is used:

An alloy of lead and tin is used for making fuse wires because:
(i) It has a low melting point, so it melts quickly when excess current flows
(ii) It has high resistance, which helps in heating up and melting when current increases
(iii) This alloy is economical and readily available

SECTION C - Answers to Short Answer Questions

15.

Magnetic field pattern due to circular loop:
When current flows through a circular loop:
- At points near the wire, the field lines are nearly circular
- As we move towards the center, these circular arcs become larger
- At the center, the field lines appear as straight lines perpendicular to the plane of the coil
- The field lines are more concentrated at the center
- On one side of the coil, field lines emerge (north pole), on the other side they enter (south pole)

Using right-hand thumb rule:
To find the direction of magnetic field at the center:
1. Curl the fingers of your right hand in the direction of current in the loop
2. The thumb, when stretched perpendicular to the curled fingers, points in the direction of magnetic field at the center of the loop
3. If current is clockwise when viewed from one side, field is into the plane; if anticlockwise, field is out of the plane

This can also be remembered as: the face of the coil from which field lines emerge behaves as north pole, and where they enter behaves as south pole.

16.

Case 1: When proton moves along the magnetic field direction:
When a charged particle (proton) moves parallel to the magnetic field ($\theta = 0°$), the force experienced is zero.
This is because: $F = q \times v \times B \times \sin\theta$
When $\theta = 0°$, $\sin 0° = 0$, therefore $F = 0$

Case 2: When proton moves perpendicular to magnetic field:
When the proton beam moves perpendicular to the magnetic field ($\theta = 90°$), it experiences maximum force.
This is because: $\sin 90° = 1$, so $F = q \times v \times B$ (maximum)

Explanation:
The force on a moving charged particle in a magnetic field is given by the Lorentz force: $F = q(v \times B)$
- The force is always perpendicular to both the velocity and magnetic field
- When the particle moves along the field, there is no component of velocity perpendicular to field, hence no force
- When the particle moves perpendicular to field, the entire velocity contributes to the force
- This perpendicular force causes the proton to move in a circular path without changing its speed

17.

Solenoid: A solenoid is a coil of many circular turns of insulated copper wire wrapped closely in the shape of a cylinder. When current flows through it, it behaves like a bar magnet.

Difference in magnetic field patterns:

Straight current-carrying conductor:
- Field lines are concentric circles centered on the wire
- Field lines lie in planes perpendicular to the conductor
- Field strength decreases rapidly with distance
- No distinct poles are formed
- Field is non-uniform in space

Solenoid:
- Field lines inside are parallel straight lines
- Field lines outside are similar to a bar magnet
- One end behaves as north pole, other as south pole
- Field inside is uniform (same at all points)
- Field strength inside is much higher
- The pattern shows that magnetic field lines emerge from one end (north pole) and merge at the other end (south pole)

Why this difference?
In a solenoid, each turn of wire contributes to the field in the same direction inside the coil. The fields from all turns add up to produce a strong, uniform field inside. The field lines complete their loops by spreading out around the outside of the solenoid, creating a pattern similar to a bar magnet.

SECTION D - Answer to Long Answer Question

18.

(a) Why a current-carrying conductor experiences force in magnetic field:
When a conductor carrying current is placed in a magnetic field, it experiences a force because:
- The current-carrying conductor has its own magnetic field around it
- This magnetic field interacts with the external magnetic field
- The interaction of these two fields produces a force on the conductor
- This phenomenon was suggested by French scientist Andre Marie Ampere

Rule to find direction - Fleming's Left-Hand Rule:
Stretch the thumb, forefinger, and middle finger of your left hand mutually perpendicular to each other. If:
- Forefinger points in the direction of magnetic Field
- Middle finger points in the direction of Current
- Then Thumb points in the direction of Force (or Motion)

(b) Factors on which magnitude of force depends:
The magnitude of force (F) depends on:
(i) **Current (I):** Force is directly proportional to current. More current means more force.
(ii) **Length of conductor (L):** Force is directly proportional to the length of conductor placed in the magnetic field. Longer conductor experiences more force.
(iii) **Strength of magnetic field (B):** Force is directly proportional to magnetic field strength. Stronger field produces more force.
(iv) **Angle (θ):** Force depends on the angle between current direction and magnetic field direction.
Mathematically: $F = B \times I \times L \times \sin\theta$

(c) Position of conductor for maximum and minimum force:

(i) Maximum force:
Force is maximum when the conductor is placed perpendicular to the magnetic field ($\theta = 90°$)
Reason: When $\theta = 90°$, $\sin 90° = 1$ (maximum value)
Therefore, $F = B \times I \times L \times 1 = B \times I \times L$ (maximum)
This is the position where the conductor cuts maximum number of field lines per unit movement.

(ii) Minimum force:
Force is minimum (zero) when the conductor is placed parallel to the magnetic field ($\theta = 0°$ or $180°$)
Reason: When $\theta = 0°$, $\sin 0° = 0$
Therefore, $F = B \times I \times L \times 0 = 0$ (minimum)
This is the position where the conductor moves along the field lines and doesn't cut any field lines, hence no force.

SECTION E - Answers to Case Study Based Questions

19.

(i) What causes magnetic field production in body: (1 mark)
The magnetic field in our body is produced by the electric currents (ion currents) that flow through nerve cells. When we touch something or when our heart beats, weak electric impulses flow through the nerves and heart muscles. These electric currents produce temporary magnetic fields according to the principle that an electric current always produces a magnetic field.

(ii) Two organs with significant magnetic fields: (1 mark)
The two main organs in the human body where the magnetic field produced is significant are:
(a) The Heart
(b) The Brain
These organs have substantial electrical activity and thus produce detectable magnetic fields.

(iii) How MRI helps in diagnosis - Role of magnetism: (2 marks)
MRI (Magnetic Resonance Imaging) helps in medical diagnosis through the following process:

Working principle:
- MRI uses very strong magnetic fields to align the magnetic properties of atoms (especially hydrogen atoms) in our body tissues
- When radio waves are applied, these atoms absorb energy and get disturbed from their alignment
- When the radio waves are turned off, the atoms return to their original alignment and release energy
- Different tissues release energy at different rates and amounts

Role in diagnosis:
- The released energy signals are detected and processed by computers to create detailed images of internal organs and tissues
- These images can show soft tissues, bones, organs, and even blood vessels with great clarity
- Doctors can detect abnormalities, tumors, injuries, or diseases without performing surgery
- Unlike X-rays, MRI doesn't use harmful radiation
- The technique is completely non-invasive and based entirely on magnetic properties

Thus, magnetism plays a crucial role in modern medical diagnosis by allowing doctors to "see inside" the body without cutting it open.

20.

(i) Principle of electric motor: (1 mark)
An electric motor works on the principle that a current-carrying conductor placed in a magnetic

field experiences a force. The direction of this force is given by Fleming's left-hand rule. When a current-carrying coil is placed in a magnetic field, the two sides of the coil experience forces in opposite directions, which produces a turning effect (torque) causing the coil to rotate.

(ii) Function of commutator: (1 mark)
The commutator is a device that reverses the direction of current flowing through the coil every half rotation. Its function is essential for continuous rotation because:
- It acts as a split ring
- After every half rotation, it changes the polarity of current in the coil
- This ensures that the direction of force on the coil sides remains such that rotation continues in the same direction
- Without commutator, the coil would oscillate back and forth instead of rotating continuously

(iii) Why coil rotates continuously: (2 marks)
The coil in an electric motor rotates continuously due to the following mechanism:

Step-by-step process:
1. Initially, when current flows through the coil placed between magnetic poles, the two vertical sides of the rectangular coil carry currents in opposite directions
2. According to Fleming's left-hand rule, these two sides experience forces in opposite directions (one upward, one downward)
3. These equal and opposite forces acting on the two sides of the coil create a torque (turning effect) that rotates the coil
4. As the coil reaches the vertical position (after half rotation), the commutator reverses the current direction
5. This reversal changes the direction of force on each side, but since the sides have also swapped positions, the torque continues to act in the same rotational direction
6. This process repeats continuously, making the coil rotate

Energy conversion:
The electrical energy supplied to the motor is continuously converted into mechanical energy (rotational motion). The fan blades attached to the motor shaft rotate due to this continuous rotation, creating air flow.

Key point: Without the commutator reversing the current every half turn, the coil would rotate until it became perpendicular to the field and then stop. The commutator ensures that the torque always acts in the same rotational direction, producing continuous rotation.
