

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. A freely suspended magnet always aligns itself in:
 - (a) East-West direction
 - (b) North-South direction
 - (c) Northeast-Southwest direction
 - (d) Any random direction
2. The SI unit of magnetic field is:
 - (a) Ampere
 - (b) Tesla
 - (c) Newton
 - (d) Weber
3. If a current-carrying coil has 'n' turns, the magnetic field produced is:
 - (a) 'n' times as large as for a single turn
 - (b) Same as for a single turn
 - (c) '1/n' times as large as for a single turn
 - (d) 'n²' times as large as for a single turn
4. Inside a bar magnet, the direction of magnetic field lines is:
 - (a) From north pole to south pole
 - (b) From south pole to north pole
 - (c) Perpendicular to its length
 - (d) There are no field lines inside
5. An electron moving perpendicular to a uniform magnetic field experiences:
 - (a) No force
 - (b) Force parallel to the field

- (c) Force perpendicular to both velocity and field
(d) Force in direction of velocity
6. Which device works on the principle of magnetic effect of current?
(a) Electric heater
(b) Electric bell
(c) Electric bulb
(d) Electric iron
7. In domestic wiring, appliances are connected in:
(a) Series
(b) Parallel
(c) Both series and parallel
(d) Neither series nor parallel
8. The rating of a fuse wire depends on:
(a) Only voltage
(b) Only current
(c) Both voltage and current
(d) Neither voltage nor current
9. A current of 1A is drawn by a filament of an electric bulb. The number of electrons passing through it in one second is approximately:
(a) 6×10^{18}
(b) 6×10^{19}
(c) 6×10^{20}
(d) 6×10^{21}
10. The strength of magnetic field inside a solenoid can be increased by:
(a) Decreasing the number of turns
(b) Decreasing the current
(c) Inserting a soft iron core
(d) Increasing the length of solenoid

SECTION B - Short Answer Questions (2 marks each)

11. A current-carrying conductor is placed perpendicular to the magnetic field. Name and state the rule to find the direction of force acting on it.
12. What is meant by magnetic field lines? Why do they form closed loops?
13. Draw a labeled diagram showing the magnetic field lines around a bar magnet. Mark the regions where magnetic field is (i) strongest and (ii) weakest.
14. Why is the series arrangement of appliances not used in domestic circuits? Give two reasons.

SECTION C - Short Answer Questions (3 marks each)

15. (a) What is the difference between a permanent magnet and an electromagnet?
(b) List two applications where electromagnets are preferred over permanent magnets.
16. A horizontal power line carries a current of 90 A from east to west direction. What is the direction

and magnitude of magnetic field due to the current at a point 1.5 m below the line? (Take permeability of free space $\mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1}$)

17. With the help of a labeled circuit diagram, explain the working of an electric bell. Why does the hammer strike the gong repeatedly when current flows through it?

SECTION D - Long Answer Question (5 marks)

18. (a) Draw a schematic diagram showing the common domestic electric circuit. Label the following in it:

(i) Live wire

(ii) Neutral wire

(iii) Earth wire

(iv) Fuse

(v) Distribution box

(b) Explain why earth wire is necessary in electrical appliances with metallic body.

(c) What are the two separate circuits commonly used in domestic wiring? Why?

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

19. Case Study 1: Electromagnetic Crane

In a scrap yard, a large crane fitted with an electromagnet is used to lift and move heavy iron materials. The crane has a powerful electromagnet at its end, which is made by winding many turns of insulated copper wire around a soft iron core. When electric current is passed through the coil, the soft iron core becomes strongly magnetized and can lift several tons of iron scrap. When the current is switched off, the magnetism disappears immediately and the iron materials fall down at the desired location. This makes it very convenient to load and unload materials.

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

(i) Why is soft iron used as the core of an electromagnet and not steel? (1 mark)

(ii) How can the lifting capacity of the electromagnetic crane be increased? (1 mark)

(iii) What would happen if permanent magnets were used instead of electromagnets in such cranes?

Explain why electromagnets are preferred. (2 marks)

20. Case Study 2: Solar Panel System with Battery Backup

Rajesh installed a solar panel system in his house with battery backup. The solar panels generate DC (Direct Current), but his home appliances work on AC (Alternating Current) at 220V. An inverter converts the DC to AC. The system has a main switch, circuit breakers (similar to fuses), and proper earthing. The electrician explained that for high-power appliances like air conditioner and water heater, he installed a separate 15A circuit, while for lights and fans, a 5A circuit was used. All circuits have proper grounding with green earth wire connected to appliances with metal body.

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

(i) Why are separate circuits used for high-power and low-power appliances? (1 mark)

(ii) What is the role of circuit breakers in this installation? (1 mark)

(iii) Why is earthing especially important for appliances with metallic bodies? Explain how earthing protects users from electric shock. (2 marks)

SECTION A - Answers to MCQs

1. (b) North-South direction

A freely suspended magnet always aligns itself in the North-South direction due to Earth's magnetic field. The north pole of the magnet points towards the Earth's magnetic north, and the south pole points towards the Earth's magnetic south.

2. (b) Tesla

The SI unit of magnetic field (B) is Tesla (T), named after scientist Nikola Tesla. One tesla is equal to one weber per square meter ($1 \text{ T} = 1 \text{ Wb/m}^2$). Another commonly used unit is gauss, where $1 \text{ T} = 10,000 \text{ gauss}$. The unit oersted is used for magnetic field strength.

3. (a) 'n' times as large as for a single turn

If a circular coil has 'n' turns, the magnetic field produced is 'n' times as large as that produced by a single turn. This is because the current in each circular turn has the same direction, and the field due to each turn adds up. Therefore, $B \propto n$.

4. (b) From south pole to north pole

Inside a bar magnet, the magnetic field lines travel from the south pole to the north pole. Outside the magnet, they go from north to south. This makes the field lines form closed continuous loops.

5. (c) Force perpendicular to both velocity and field

When a charged particle (like an electron) moves perpendicular to a magnetic field, it experiences a force that is perpendicular to both its velocity and the magnetic field. This is given by the Lorentz force: $F = q(v \times B)$. This perpendicular force causes the particle to move in a circular path.

6. (b) Electric bell

An electric bell works on the principle of magnetic effect of electric current. It uses an electromagnet that attracts an armature when current flows, causing a hammer to strike the gong. Electric heater, bulb, and iron work on the heating effect of current.

7. (b) Parallel

In domestic wiring, all appliances are connected in parallel so that each gets full voltage (220V), can operate independently, and failure of one doesn't affect others. Also, each appliance can be controlled by its own switch.

8. (b) Only current

The rating of a fuse wire depends only on the maximum current it can safely carry. Common ratings are 5A, 15A, etc. When current exceeds this rating, the fuse wire melts due to Joule heating and breaks the circuit. Voltage doesn't directly affect fuse rating.

9. (a) 6×10^{18}

Current $I = \text{Charge}/\text{Time} = Q/t$

$Q = I \times t = 1\text{A} \times 1\text{s} = 1 \text{ Coulomb}$

Charge of one electron = $1.6 \times 10^{-19} \text{ C}$

Number of electrons = $Q/e = 1/(1.6 \times 10^{-19}) = 0.625 \times 10^{19} \approx 6 \times 10^{18}$ electrons

10. (c) Inserting a soft iron core

The strength of magnetic field inside a solenoid can be greatly increased by inserting a soft iron core inside it. Soft iron is a magnetic material that gets easily magnetized and enhances the magnetic field. Other ways to increase field: increase current or increase number of turns.

SECTION B - Answers to Short Answer Questions

11.

Name: Fleming's Left-Hand Rule

Statement: Stretch the thumb, forefinger (or first finger), and middle finger (or second finger) of your left hand such that they are mutually perpendicular to each other.

If the forefinger points in the direction of the magnetic field and the middle finger points in the direction of current, then the thumb points in the direction of force or motion experienced by the conductor.

Memory tip: First finger = Field, second finger = Current, thumb = Motion or Force

12.

Magnetic field lines: Magnetic field lines are imaginary lines that represent the magnetic field visually. They are the paths along which a hypothetical free north pole would tend to move if placed in the magnetic field. The direction of the field at any point is given by the tangent to the field line at that point.

Why they form closed loops:

Magnetic field lines always form closed continuous loops because:

- (i) They emerge from the north pole and merge at the south pole outside a magnet
- (ii) Inside the magnet, they continue from south pole to north pole
- (iii) Unlike electric field lines which originate from positive charges and terminate at negative charges, magnetic field lines have no starting or ending point as magnetic monopoles (isolated north or south poles) do not exist
- (iv) This represents the continuous nature of magnetic field

13.

Labeled diagram of magnetic field lines around a bar magnet:

[The diagram would show:]

- A rectangular bar magnet with N (North) pole marked on left end and S (South) pole on right end
- Curved field lines emerging from N pole, spreading outward, and converging into S pole
- Arrows on field lines showing direction from N to S
- Field lines are denser (more crowded) near the poles
- Field lines spread out and are more spaced in the middle region

Regions marked:

(i) Strongest magnetic field: At the poles (marked with close field lines)

The magnetic field is strongest near the poles where field lines are most crowded and close together.

(ii) Weakest magnetic field: At the middle of the magnet and far away from the magnet (marked with widely spaced field lines)

The magnetic field is weakest where field lines are far apart.

14.

Series arrangement is not used in domestic circuits because:

(i) Same current flows through all appliances:

In series connection, the same current flows through all appliances. Different appliances require different currents to operate properly. For example, a bulb needs small current while a heater needs large current. In series, they cannot get their required current, so they won't function properly.

(ii) Total voltage gets divided:

In series connection, the total voltage (220V) gets divided among all appliances. So each appliance receives less than 220V and cannot operate at its rated capacity. For example, if two 220V bulbs are connected in series, each gets only 110V and will glow dimly.

(iii) No independent operation:

In series, if one appliance is switched off or fails, the circuit breaks and all other appliances stop working. This is highly inconvenient in domestic use where we want to control each appliance independently.

(iv) Cannot use separate switches:

Each appliance cannot have its own independent switch in series connection, making it impractical for household use.

SECTION C - Answers to Short Answer Questions

15.

(a) Differences between permanent magnet and electromagnet:

Permanent Magnet	Electromagnet
Retains magnetism permanently	Magnetic only when current flows
Made of hard magnetic materials like steel	Made of soft iron core with wire coil
Fixed magnetic strength	Strength can be varied by changing current
Poles cannot be reversed	Poles can be reversed by reversing current
Generally weak magnetic field	Can produce very strong magnetic field

(b) Two applications where electromagnets are preferred:

(i) Electric cranes in scrapyards:

Electromagnets are used in cranes to lift heavy iron materials. The advantage is that when current is switched on, it lifts the material, and when switched off, it releases the material at the desired location. This would not be possible with permanent magnets as they cannot be switched on and off.

(ii) Electric bells and buzzers:

Electromagnets are used in electric bells because they need to be magnetized only when we press the button (current flows). When button is released, magnetism should disappear. Permanent magnets would keep attracting the armature continuously, making the bell unusable.

16.

Given:

Current, $I = 90 \text{ A}$

Distance from wire, $r = 1.5 \text{ m}$

Direction of current: East to West

Permeability of free space, $\mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1}$

Magnetic field due to straight current-carrying conductor:

$$B = (\mu_0 \times I)/(2\pi \times r)$$

Calculation:

$$B = (4\pi \times 10^{-7} \times 90)/(2\pi \times 1.5)$$

$$B = (4\pi \times 10^{-7} \times 90)/(3\pi)$$

$$B = (4 \times 90 \times 10^{-7})/3$$

$$B = (360 \times 10^{-7})/3$$

$$B = 120 \times 10^{-7}$$

$$B = 1.2 \times 10^{-5} \text{ T}$$

$$B = 12 \text{ } \mu\text{T (microtesla)}$$

Direction of magnetic field:

Using right-hand thumb rule:

- Point thumb in direction of current (East to West)
- Curl fingers around the wire
- At a point 1.5 m below the wire, the curled fingers point towards North

Therefore, the magnetic field at the point 1.5 m below the line is **$1.2 \times 10^{-5} \text{ T}$** directed towards **North**.

17.

Working of Electric Bell:

Circuit Diagram components:

- Battery or power source
- Push button or switch
- Electromagnet (coil wound on soft iron core)
- Soft iron armature
- Contact screw
- Hammer attached to armature
- Gong (bell)
- Spring

Working mechanism:

Step 1: When the push button is pressed, the circuit is completed and current flows through the coil of the electromagnet.

Step 2: The electromagnet gets magnetized and attracts the soft iron armature towards it.

Step 3: As the armature moves towards the electromagnet, the hammer attached to it strikes the gong, producing sound.

Step 4: When the armature moves, it breaks contact with the contact screw, thus breaking the circuit.

Step 5: As soon as the circuit breaks, no current flows through the coil, and the electromagnet loses its magnetism.

Step 6: The spring pulls the armature back to its original position, making contact with the screw again.

Step 7: The circuit is complete again, and the whole process repeats.

Why hammer strikes repeatedly:

The hammer strikes the gong repeatedly because:

- When current flows → electromagnet attracts armature → hammer strikes gong
- This movement breaks the contact → current stops → electromagnet loses magnetism
- Spring brings armature back → contact is made again → current flows again
- This creates a make-and-break mechanism that continues as long as the push button is pressed
- The rapid making and breaking of contact causes the hammer to strike repeatedly, producing a continuous ringing sound

SECTION D - Answer to Long Answer Question

18.

(a) Schematic diagram of common domestic electric circuit:

[The diagram would show:]

- Main supply from overhead poles or underground cable
- (i) Live wire (Red) - carrying current to appliances
- (ii) Neutral wire (Black) - providing return path
- (iii) Earth wire (Green) - connected to metal plate in earth and to metallic bodies of appliances
- Electricity meter - measuring power consumption
- Main switch - to control entire house supply
- (iv) Fuse or MCB (Miniature Circuit Breaker) - connected to live wire after meter
- (v) Distribution box - containing main switch and fuses for different circuits
- Two separate circuits branching from distribution box:
 - * 15A circuit for high-power appliances (geyser, AC, etc.)
 - * 5A circuit for low-power appliances (bulbs, fans, etc.)
- Multiple appliances connected in parallel with their own switches
- All appliances connected between live and neutral wires
- Earth wire connected to metallic bodies

(b) Why earth wire is necessary for appliances with metallic body:

The earth wire is necessary for electrical appliances with metallic body because:

Safety purpose:

- If the insulation of live wire inside an appliance gets damaged, the live wire may touch the metal body
- Without earthing, the metal body would become live (at 220V)
- Anyone touching the appliance would get a severe electric shock as current would flow through their body to the earth

How earthing protects:

- The earth wire is connected to the metal body of the appliance
- The other end is connected to a metal plate buried deep in the earth
- Earth wire provides a very low-resistance path for current to flow to the earth
- If live wire touches the metal body, the current flows through the earth wire to the ground instead of through the person

- The metal body remains at earth potential (zero potential), safe to touch
- This high leakage current also blows the fuse, disconnecting the faulty appliance

Examples of appliances needing earthing:

- Electric press (iron)
- Refrigerator
- Washing machine
- Table fan
- Microwave oven
- Water heater/geyser
- Any appliance with exposed metal parts

(c) Two separate circuits commonly used:

The two separate circuits are:

(i) 15 Ampere circuit:

Used for high-power appliances such as:

- Electric geysers
- Air conditioners
- Water heaters
- Electric ovens
- Washing machines

These appliances have high power ratings (typically 1000W to 2000W or more) and draw large currents.

(ii) 5 Ampere circuit:

Used for low-power appliances such as:

- Electric bulbs and tube lights
- Ceiling and table fans
- Television
- Mobile chargers

These appliances have lower power ratings (typically 5W to 200W) and draw smaller currents.

Why separate circuits are used:

1. Prevention of overloading:

- If all appliances were on a single circuit, running high-power appliances along with others would overload the circuit
- The total current could exceed the safe limit of wiring, causing overheating and fire risk

2. Safety of wiring:

- High-power circuit uses thicker wires that can safely carry 15A current
- Low-power circuit uses thinner wires (which are cheaper) that can safely carry 5A
- Using appropriate wire thickness for each circuit prevents wastage and ensures safety

3. Economic consideration:

- Thicker wires are more expensive
- Using thick wires throughout the house would be wasteful
- Separate circuits allow use of appropriate wire thickness, saving money

4. Proper fuse protection:

- Each circuit can have a fuse appropriate to its current rating
- 15A fuse for high-power circuit, 5A fuse for low-power circuit

- This provides proper protection without unnecessary tripping

SECTION E - Answers to Case Study Based Questions

19.

(i) Why soft iron is used instead of steel: (1 mark)

Soft iron is used as the core of an electromagnet instead of steel because:

- Soft iron is a magnetically soft material that gets easily magnetized when current flows through the coil
- It also loses its magnetism immediately when current is switched off
- Steel is a hard magnetic material that becomes a permanent magnet once magnetized and does not lose magnetism quickly
- For a crane, we need the magnet to work only when needed and release materials when switched off, which soft iron provides

(ii) How to increase lifting capacity: (1 mark)

The lifting capacity of the electromagnetic crane can be increased by:

- Increasing the electric current flowing through the coil (increases magnetic field strength)
- Increasing the number of turns of wire in the coil (magnetic field \propto number of turns)
- Using a larger or thicker soft iron core
- Using multiple electromagnets together

(iii) Problems with using permanent magnets: (2 marks)

If permanent magnets were used instead of electromagnets in cranes, the following problems would occur:

Major problem:

- Permanent magnets cannot be switched on and off
- Once they attract and lift the iron material, they would keep holding it
- There would be no way to make the magnet release the material at the desired location
- Workers would have to manually pull and separate the materials from the magnet, which is extremely difficult and dangerous for heavy loads of several tons

Why electromagnets are preferred:

- Electromagnets can be easily controlled by switching current on and off
- When current flows \rightarrow strong magnetism \rightarrow lifts the material
- When current is switched off \rightarrow magnetism disappears \rightarrow material falls at desired location
- The strength of electromagnet can be varied by changing current, allowing it to handle different weights
- This on-off control makes loading and unloading very convenient and efficient
- Electromagnets can be made much stronger than permanent magnets of the same size
- The magnetic strength of electromagnet remains constant over time, whereas permanent magnets may lose strength

Practical advantage:

In a scrapyards, the crane operator can:

1. Move the crane over the pile of iron scrap
2. Switch on the electromagnet to lift the material
3. Move the crane to the desired location (like a truck or storage area)
4. Switch off the electromagnet to drop the material
5. Repeat the process efficiently

This process would be impossible with permanent magnets, making electromagnets essential for

such applications.

20.

(i) Why separate circuits for high-power and low-power appliances: (1 mark)

Separate circuits are used for high-power and low-power appliances because:

- High-power appliances (AC, water heater) draw large currents (10-15A or more)
- Low-power appliances (lights, fans) draw small currents (0.1-2A)
- If all appliances were on one circuit, running high-power appliances would cause the total current to exceed safe limits
- Separate circuits prevent overloading and allow use of appropriate wire thickness for each circuit, ensuring safety and economy

(ii) Role of circuit breakers: (1 mark)

Circuit breakers serve the same purpose as fuses in the installation:

- They protect the circuit from damage due to overloading or short-circuiting
- When current exceeds the safe limit, the circuit breaker automatically trips (switches off)
- Unlike fuses that need replacement after melting, circuit breakers can be reset and reused
- They immediately disconnect the power supply when fault occurs, preventing fire and damage to appliances

(iii) Importance of earthing for metallic bodies - Protection mechanism: (2 marks)

Why earthing is especially important for metallic bodies:

Appliances with metallic bodies (refrigerator, washing machine, microwave) need earthing because:

- Metal is a good conductor of electricity
- If any internal wire's insulation gets damaged and the live wire touches the metal body, the entire body becomes live (at 220V potential)
- Anyone touching the appliance would complete the circuit to ground through their body and receive a fatal electric shock
- Metal bodies have large surface area, making accidental contact more likely

How earthing protects from electric shock:

Normal operation (no fault):

- Earth wire is connected to metal body but no current flows through it
- Metal body remains at zero potential (earth potential)
- Safe to touch

When fault occurs (live wire touches body):

Step 1 - Path of least resistance:

- If live wire (220V) touches the metal body without earthing, the body becomes live
- When a person touches it, current flows through their body to earth (high resistance path $\approx 1000\Omega$)
- Even 0.05A current through human body can be fatal

Step 2 - With proper earthing:

- Earth wire provides a very low resistance path ($< 1\Omega$) directly to earth
- When live wire touches metal body, huge current immediately flows through earth wire to ground
- This path has much lower resistance than human body
- Most current (almost all) flows through earth wire, very little through person's body if they touch

Step 3 - Circuit breaker operation:

- The large leakage current through earth wire exceeds the circuit breaker rating

- Circuit breaker trips immediately, cutting off power supply
- Fault is isolated before serious harm can occur

Mathematical explanation:

- Without earthing: Current through person = $220\text{V} / 1000\Omega = 0.22\text{A}$ (fatal!)
- With earthing: Total current divides inversely as resistance
- If earth wire resistance = 1Ω , person resistance = 1000Ω
- Person gets only 1/1000th of total current (negligible, safe)
- Earth wire carries 999/1000th of current (safely to ground)

Additional safety:

- Earth connection ensures metal body stays at zero potential
- Even if touched during fault, the potential difference across person's body is minimized
- No current flows through person as both they and appliance are at earth potential

Real-world importance:

In Rajesh's solar system:

- Inverter, batteries, and metallic junction boxes all need earthing
- Any insulation failure could be dangerous without earthing
- Green earth wire provides life-saving protection
- Regular checking of earth connection is important for safety

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