

Magnetic Effects of Electric Current

Class 10 - CBSE Science | Chapter 12 | Worksheet & Test Paper

15 MCQs | 8 board questions | 7 practice problems

Video lesson, notes and an interactive quiz: learn.ultimatetools.io

SECTION A - Multiple Choice Questions (1 mark each)

1. Two magnetic field lines can never intersect each other because:

- (a) field lines are always smooth, closed, continuous curves
- (b) the field would have two directions at that one point
- (c) field lines always run from the north pole to the south pole
- (d) the magnetic field would become exactly zero at that point

2. The magnetic field produced around a long straight current-carrying conductor is in the form of:

- (a) straight lines parallel to the wire
- (b) straight lines pointing away from the wire
- (c) concentric circles around the wire
- (d) ellipses with the wire at one focus

3. In the right-hand thumb rule, the thumb points along the direction of the:

- (a) magnetic field
- (b) force on the conductor
- (c) induced current
- (d) current in the conductor

4. The strength of the magnetic field at the centre of a circular current-carrying loop can be increased by:

- (a) increasing the number of turns of the loop
- (b) increasing the radius of the loop
- (c) decreasing the current through the loop
- (d) using a thicker wire for the same single loop

5. Inside a current-carrying solenoid, the magnetic field is:

- (a) zero at every point inside the coil
- (b) strongest at the two ends and zero in the middle
- (c) uniform - same magnitude and direction throughout
- (d) in the form of concentric circles round the axis

6. Soft iron, rather than steel, is used as the core of an electromagnet because soft iron:

- (a) is a good deal cheaper than steel and easier to obtain
- (b) loses its magnetism the moment the current is switched off
- (c) keeps its magnetism permanently once it has been magnetised
- (d) has a very much higher melting point than steel does

7. The force experienced by a current-carrying conductor placed in a magnetic field is greatest when the angle between the current and the field is:

- (a) 0°
- (b) 45°
- (c) 90°
- (d) 180°

8. In Fleming's left-hand rule, the middle finger points in the direction of the:

- (a) force on the conductor
- (b) motion of the conductor
- (c) magnetic field
- (d) current in the conductor

9. At the moment a short circuit occurs, the current in the circuit:

- (a) increases very heavily
- (b) remains exactly as it was before
- (c) goes on varying continuously
- (d) falls to a very low value

- 10. A positively charged particle projected towards the WEST is deflected towards the NORTH by a magnetic field. The direction of the magnetic field is:**
- (a) towards the south
 - (b) towards the east
 - (c) vertically downward
 - (d) vertically upward
- 11. A 2 kW electric oven is switched on in a 220 V domestic circuit whose fuse is rated at 5 A. What will happen?**
- (a) It works normally, drawing a current of about 5 A
 - (b) It draws about 9 A, so the fuse melts and cuts it off
 - (c) It draws about 2 A and works perfectly normally
 - (d) It works, but the supply voltage falls to about 110 V
- 12. A straight wire carries current from north to south and lies in a magnetic field directed vertically downward. The force on the wire acts towards the:**
- (a) north
 - (b) west
 - (c) east
 - (d) vertically upward
- 13. In India, alternating current changes its direction after every 1/100 second. Its frequency is therefore:**
- (a) 100 Hz
 - (b) 50 Hz
 - (c) 25 Hz
 - (d) 200 Hz
- 14. The earth wire in a domestic circuit is connected to the metal body of an appliance in order to:**
- (a) give the current a low-resistance path to earth on a fault
 - (b) complete the circuit so that the appliance is able to work
 - (c) reduce the voltage that is supplied to the appliance
 - (d) stop the fuse from melting when the current rises
- 15. A fuse wire melts and breaks the circuit when too many appliances are switched on at one socket. This situation is called:**
- (a) short circuiting
 - (b) earthing
 - (c) insulation failure
 - (d) overloading

SECTION B - Board-style Questions

- 1. List any four properties of magnetic field lines. Why can two field lines never intersect each other? [5 marks]**
- 2. State the right-hand thumb rule. Draw a diagram showing the magnetic field produced around a long straight current-carrying conductor, and state how the field varies with the current and with the distance from the wire. [5 marks]**
- 3. (a) What is a solenoid? (b) Draw the field pattern of a current-carrying solenoid and state what it resembles. (c) How is an electromagnet made, and why is soft iron used for its core? [5 marks]**
- 4. State Fleming's left-hand rule. An aluminium rod AB is suspended horizontally between the poles of a horse-shoe magnet, and a current is passed through it so that the rod is displaced. State, with reasons, what happens to the displacement if (i) the current is increased, (ii) a stronger magnet is used, and (iii) the length of the rod inside the field is increased. [5 marks]**

5. Draw a labelled schematic diagram of a domestic electric circuit, showing the two sub-circuits. Explain how the appliances are connected, and state why the fuse is placed in the live wire rather than in the neutral wire. [5 marks]
6. What is meant by alternating current, and how does it differ from direct current? State the frequency of the AC supplied in India, showing how it follows from the time between reversals, and give the chief advantage of AC over DC. [3 marks]
7. Name the three wires in a domestic electric circuit with their colours and potentials. Explain the purpose of earthing, and name two situations in which the current in the circuit may become dangerously high. [5 marks]
8. A 2 kW electric oven is switched on in a domestic circuit rated at 5 A and operating at 220 V. Calculate the current drawn, state what will happen, and explain how this fault differs from a short circuit. [3 marks]

SECTION C - Practice Problems

1. A student places a compass needle below a long straight wire running from north to south, and then switches on a current flowing from south to north. The needle deflects. Explain why it deflects, and state what would happen to the deflection if (a) the current were increased, and (b) the compass were moved further from the wire.

Hint: What does a current produce around a wire, and what does a compass needle respond to?

2. A student holds a compass directly ABOVE a long straight wire that runs east-west, and passes a current through it from west to east. Predict which way the needle is deflected, explain using the appropriate rule, and state what would be different if the compass were held BELOW the wire.

Hint: Point your right thumb along the current and see which way the fingers curl above the wire.

3. A solenoid is connected to a battery and a soft iron rod is placed inside it. Describe the field produced, explain what happens to the rod, and state what would be different if the soft iron were replaced by a steel rod.

Hint: Think about what happens in each case at the moment the current is switched off.

4. A householder connects a heater, a geyser and an air-conditioner to one socket using a multi-plug, and the fuse melts. Name the fault, explain why the current became so large, and explain why replacing the fuse with a thick copper wire would be dangerous.

Hint: Think about what a fuse is designed to do, and what property makes it able to do it.

5. The metal body of a washing machine gives a slight shock. An electrician finds that the earth wire has come loose AND that the fuse has been replaced by a thick copper wire. Explain the danger created by each of these two faults separately.

Hint: One fault removes a safe path for the current; the other removes the automatic cut-off.

6. In India the mains supply is alternating current that reverses direction every $1/100$ second. Show clearly how the frequency of 50 Hz follows from this, and state one practical advantage of AC over DC.

Hint: How many reversals make one complete cycle?

7. A metal-bodied electric iron is not earthed. Its live wire works loose and touches the metal casing. Explain what happens when a person touches the iron, and explain how the earth wire would have prevented it.

Hint: Compare the resistance of the two possible paths to the ground.

ANSWER KEY

Magnetic Effects of Electric Current - Class 10 CBSE Science

Section A - MCQ answers

1. (b) the field would have two directions at that one point

At any point the magnetic field can have only ONE direction. If two lines crossed, the field at that point would have two different directions, which is impossible. The other statements are true of field lines but are not the reason.

2. (c) concentric circles around the wire

The field lines form concentric circles in a plane perpendicular to the conductor. Their direction is given by the right-hand thumb rule, and the circles get larger and weaker with distance.

3. (d) current in the conductor

Hold the wire in the RIGHT hand with the thumb along the CURRENT; the curled fingers then give the direction of the magnetic field lines. It is also called Maxwell's corkscrew rule.

4. (a) increasing the number of turns of the loop

With n turns the field becomes n times as strong, because the field due to each turn adds in the same direction. The field also increases with current but DECREASES as the radius grows, so increasing the radius weakens it.

5. (c) uniform - same magnitude and direction throughout

The field lines inside a solenoid are parallel straight lines, which means the field is uniform there. Outside, the pattern is exactly that of a bar magnet.

6. (b) loses its magnetism the moment the current is switched off

An electromagnet must be magnetic only while the current flows. Soft iron is a temporary magnet and loses its magnetism immediately, whereas steel retains it and would make a permanent magnet.

7. (c) 90°

The force is maximum when the current is at right angles to the field, and it is zero when the current is parallel (0°) or antiparallel (180°) to the field.

8. (d) current in the conductor

Forefinger = field, Middle finger = current, Thumb = force (motion). Remember it as Fore-Field, Middle-Current, Thumb-Motion. The left hand is used for the motor.

9. (a) increases very heavily

In a short circuit the live and neutral wires touch directly, so the current bypasses the appliance and meets almost no resistance. Since $I = V/R$ and R becomes very small, the current becomes very large - which is exactly why the fuse melts.

10. (d) vertically upward

Apply Fleming's left-hand rule, treating the motion of the positive charge as the direction of conventional current. With the middle finger (current) pointing west and the thumb (force) pointing north, the forefinger - which gives the field - points vertically UPWARD.

11. (b) It draws about 9 A, so the fuse melts and cuts it off

The current drawn is $I = P/V = 2000 / 220 = 9.09$ A, which is well above the 5 A rating of the circuit. The circuit is overloaded, so the fuse in the live wire melts and breaks the circuit.

12. (c) east

Apply Fleming's left-hand rule: the middle finger (current) points south and the forefinger (field) points vertically downward, so the thumb - the force - points towards the EAST.

13. (b) 50 Hz

The current reverses TWICE in each complete cycle, so one full cycle takes $2 \times 1/100 = 1/50$ second. Frequency = $1/\text{time period} = 50$ Hz.

14. (a) give the current a low-resistance path to earth on a fault

Earthing is purely a safety measure. If the live wire touches the metal casing, the current flows to earth through the low-resistance earth wire rather than through the person touching the appliance. The appliance works perfectly well without it.

15. (d) overloading

Overloading is when the total current drawn exceeds the safe value because too many appliances are connected. A short circuit is different - that is when the live and neutral wires touch each other directly.

Section B - Model answers

1. List any four properties of magnetic field lines. Why can two field lines never intersect each other?

FOUR PROPERTIES: (1) Outside a magnet, field lines run from the NORTH pole to the SOUTH pole; inside the magnet they run from south to north, so each line is a CLOSED continuous curve. (2) The direction of the field at any point is the direction in which the north pole of a small compass needle placed at that point comes to rest. (3) The lines are CROWDED together where the field is strong and are farther apart where it is weak. (4) Two field lines NEVER intersect one another. REASON: if two field lines were to intersect, then at the point of intersection the compass needle would have to point in two different directions at the same time - that is, the magnetic field would have two directions at one point, which is impossible.

2. State the right-hand thumb rule. Draw a diagram showing the magnetic field produced around a long straight current-carrying conductor, and state how the field varies with the current and with the distance from the wire.

RIGHT-HAND THUMB RULE: hold the current-carrying conductor in your RIGHT hand so that the THUMB points along the direction of the CURRENT; the direction in which the FINGERS CURL then gives the direction of the magnetic field lines. (It is also called Maxwell's corkscrew rule.) DIAGRAM: the straight conductor drawn with an arrow for the current, surrounded by CONCENTRIC CIRCLES in a plane perpendicular to the wire, with arrows on the circles showing the field direction; the circles are drawn closer together near the wire and farther apart away from it. VARIATION: the magnitude of the field is DIRECTLY proportional to the current (B is proportional to I) and INVERSELY proportional to the distance from the conductor (B is proportional to $1/r$), so the field weakens as you move away.

3. (a) What is a solenoid? (b) Draw the field pattern of a current-carrying solenoid and state what it resembles. (c) How is an electromagnet made, and why is soft iron used for its core?

(a) A SOLENOID is a coil of many circular turns of insulated copper wire wound closely in the shape of a cylinder. (b) The diagram should show the field lines emerging from one end and entering the other, with PARALLEL STRAIGHT LINES inside the solenoid. The pattern is exactly like that of a BAR MAGNET - one end behaves as a north pole and the other as a south pole. Because the lines inside are parallel and equally spaced, the field inside the solenoid is UNIFORM. (c) An ELECTROMAGNET is made by placing a SOFT IRON core inside the solenoid; when current flows, the iron is magnetised strongly. SOFT IRON is used because it loses its magnetism as soon as the current is switched off, so the magnetism can be switched on and off at will. Steel would retain the magnetism and become a permanent magnet, which is not what an electromagnet requires.

4. State Fleming's left-hand rule. An aluminium rod AB is suspended horizontally between the poles of a horse-shoe magnet, and a current is passed through it so that the rod is displaced. State, with reasons, what happens to the displacement if (i) the current is increased, (ii) a stronger magnet is used, and (iii) the length of the rod inside the field is increased.

FLEMING'S LEFT-HAND RULE: stretch the thumb, forefinger and middle finger of the LEFT hand so that they are mutually perpendicular. If the FOREFINGER points along the magnetic FIELD and the MIDDLE FINGER along the direction of the CURRENT, then the THUMB gives the direction of the FORCE on the conductor, and hence of its displacement. (i) INCREASING THE CURRENT: the force on the rod increases, so the displacement INCREASES. (ii) A STRONGER MAGNET: the magnetic field is stronger, so the force is greater and the displacement INCREASES. (iii) INCREASING THE LENGTH of the rod lying within the field: the force increases with the length of conductor in the field, so the displacement INCREASES. In every case the force is greatest when the current is at RIGHT ANGLES to the field, and would be zero if the rod were placed parallel to the field.

5. Draw a labelled schematic diagram of a domestic electric circuit, showing the two sub-circuits. Explain how the appliances are connected, and state why the fuse is placed in the live wire rather than in the neutral wire.

The diagram should show the supply entering through the ELECTRICITY METER and a MAIN FUSE, then dividing into two separate sub-circuits - a 15 A circuit for high-power appliances such as a geyser or air-conditioner, and a 5 A circuit for lower-power ones such as bulbs and fans. Label the LIVE (red or brown), NEUTRAL (black or blue) and EARTH (green) wires, the switches, and the earthed metal bodies of the appliances. HOW THE APPLIANCES ARE CONNECTED: all appliances are joined in PARALLEL between the live and neutral wires, so each one receives the full 220 V, each can be switched on and off independently by its own switch (placed in the live wire), and the failure of one does not stop the others. WHY THE FUSE GOES IN THE LIVE WIRE: the purpose of the fuse is to disconnect the appliance from the DANGEROUS high-potential side of the supply. If it were placed in the neutral wire, then when it melted the appliance would be cut off from the neutral but would STILL remain connected to the live wire at 220 V, so its casing and internal parts would stay at a high potential and could give a fatal shock. Placing the fuse in the live wire ensures the appliance is completely isolated when the fuse blows.

6. What is meant by alternating current, and how does it differ from direct current? State the frequency of the AC supplied in India, showing how it follows from the time between reversals, and give the chief advantage of AC over DC.

ALTERNATING CURRENT (AC) is a current that REVERSES its direction periodically. DIRECT CURRENT (DC), by contrast, always flows in the SAME direction - for example the current supplied by a cell. FREQUENCY IN INDIA: the alternating current changes its direction after every $1/100$ second. Since the current reverses TWICE in one complete cycle, the time period is $T = 2 \times 1/100 = 1/50$ second, and therefore the frequency is $f = 1/T = 50$ Hz. The domestic supply is thus AC at 220 V and 50 Hz. ADVANTAGE OF AC OVER DC: alternating current can be TRANSMITTED OVER LONG DISTANCES WITHOUT MUCH LOSS OF ENERGY, which is why electrical power is generated and distributed as AC.

7. Name the three wires in a domestic electric circuit with their colours and potentials. Explain the purpose of earthing, and name two situations in which the current in the circuit may become dangerously high.

THE THREE WIRES: (1) LIVE wire - RED or brown insulation, at a potential of 220 V; (2) NEUTRAL wire - BLACK or blue insulation, at 0 V; (3) EARTH wire - GREEN insulation, connected to a metal plate buried deep in the ground. The potential difference between the live and the neutral wire is 220 V. PURPOSE OF EARTHING: the earth wire is connected to the METAL BODY of appliances such as an electric iron, toaster or refrigerator. It provides a LOW-RESISTANCE path to the earth, so that if the live wire accidentally touches the metal casing, the current flows safely into the ground instead of through the body of a person who touches the appliance. This prevents a severe electric shock. TWO DANGEROUS SITUATIONS: (a) SHORT CIRCUIT - the live and neutral wires come into direct contact, so the resistance of the circuit becomes very small and the current becomes very large; (b) OVERLOADING - too many appliances are connected to a single socket, so the total current drawn exceeds the safe limit. In both cases the FUSE, which is connected in the live wire, melts and breaks the circuit before any damage or fire occurs.

8. A 2 kW electric oven is switched on in a domestic circuit rated at 5 A and operating at 220 V. Calculate the current drawn, state what will happen, and explain how this fault differs from a short circuit.

CURRENT DRAWN: from $P = VI$, $I = P/V = 2000 \text{ W} / 220 \text{ V} = 9.09 \text{ A}$, that is about 9 A. WHAT HAPPENS: the current drawn (9.09 A) is far greater than the 5 A rating of the circuit, so the circuit is OVERLOADED. The fuse connected in the live wire melts and breaks the circuit, protecting the wiring and the appliances. HOW IT DIFFERS FROM A SHORT CIRCUIT: this is OVERLOADING - every appliance is connected correctly, but together they demand more current than the circuit is designed to carry. In a SHORT CIRCUIT the LIVE and NEUTRAL wires come into DIRECT contact, so the resistance of the path falls almost to zero and the current becomes enormous. Both faults produce an excessive current and both are guarded against by the fuse, but their causes are quite different.

Section C - Solutions

1. A student places a compass needle below a long straight wire running from north to south, and then switches on a current flowing from south to north. The needle deflects. Explain why it deflects, and state what would happen to the deflection if (a) the current were increased, and (b) the compass were moved further from the wire.

A current-carrying conductor produces a MAGNETIC FIELD around it, in the form of concentric circles in a plane perpendicular to the wire. The compass needle is a tiny magnet, so it aligns itself along the direction of this magnetic field, and therefore deflects from its original north-south position. The direction of the deflection is given by the RIGHT-HAND THUMB RULE. (a) If the CURRENT is increased, the magnetic field becomes STRONGER, because B is proportional to I , so the deflection of the needle INCREASES. (b) If the compass is moved FURTHER from the wire, the field becomes WEAKER, because B is proportional to $1/r$, so the deflection DECREASES.

2. A student holds a compass directly ABOVE a long straight wire that runs east-west, and passes a current through it from west to east. Predict which way the needle is deflected, explain using the appropriate rule, and state what would be different if the compass were held BELOW the wire.

Use the RIGHT-HAND THUMB RULE. Grip the wire in the right hand with the THUMB pointing along the current, that is from west to east; the curled FINGERS then give the direction of the magnetic field lines, which are concentric circles around the wire. ABOVE the wire the field points towards the NORTH, so the north pole of the compass needle is deflected northward. BELOW the wire the same circular field lines run the OTHER way - towards the south - so the needle there is deflected in the OPPOSITE direction. This reversal above and below the conductor is itself a common question, and it also shows why the field is circular rather than straight.

3. A solenoid is connected to a battery and a soft iron rod is placed inside it. Describe the field produced, explain what happens to the rod, and state what would be different if the soft iron were replaced by a steel rod.

THE FIELD: the current through the solenoid produces a magnetic field whose pattern is EXACTLY that of a BAR MAGNET - one end behaves as a north pole and the other as a south pole. INSIDE the solenoid the field lines are PARALLEL STRAIGHT LINES, equally spaced, so the field there is UNIFORM: the same in magnitude and direction at every point. THE ROD: the soft iron rod becomes strongly MAGNETISED, and the arrangement is an ELECTROMAGNET, far stronger than the solenoid alone. WITH STEEL INSTEAD: steel would RETAIN its magnetism even after the current was switched off, so it would become a PERMANENT magnet. Soft iron is used for an electromagnet precisely because it LOSES its magnetism as soon as the current stops, which is what

allows the magnetism to be switched on and off.

4. A householder connects a heater, a geyser and an air-conditioner to one socket using a multi-plug, and the fuse melts. Name the fault, explain why the current became so large, and explain why replacing the fuse with a thick copper wire would be dangerous.

The fault is OVERLOADING. Each appliance draws its own current from the supply, and because domestic appliances are connected in PARALLEL the total current drawn from the socket is the SUM of the individual currents. Three high-power appliances on one socket therefore draw a total current far above the safe value for that circuit, and the fuse - which is deliberately made of a wire of HIGH resistance and LOW melting point - melts and breaks the circuit. Replacing it with a THICK COPPER WIRE would be dangerous because copper has a very LOW resistance and a very HIGH melting point, so it would NOT melt even when the current became excessive. The protection would be removed: the wiring would overheat, the insulation could catch fire, and the appliances could be destroyed.

5. The metal body of a washing machine gives a slight shock. An electrician finds that the earth wire has come loose AND that the fuse has been replaced by a thick copper wire. Explain the danger created by each of these two faults separately.

FAULT 1 - THE EARTH WIRE IS DISCONNECTED. The earth wire normally connects the metal body of the appliance to a metal plate buried deep in the ground, providing a LOW-RESISTANCE path to earth. If the live wire touches the casing, the current then flows harmlessly into the ground. With the earth wire loose that safe path is gone, so the casing sits at the live potential of 220 V, and the only route to earth is THROUGH THE PERSON who touches it - hence the shock, and a firmer contact could be fatal. FAULT 2 - THE FUSE HAS BEEN REPLACED BY THICK COPPER WIRE. A fuse is deliberately made of wire of HIGH resistance and LOW melting point, so that it melts and breaks the circuit when the current becomes excessive. Thick copper has a very LOW resistance and a very HIGH melting point, so it will NOT melt. The circuit is therefore left with no protection at all: during an overload or a short circuit the wiring would overheat, the insulation could catch fire and the appliances would be destroyed. Between them, the two faults remove both the safe discharge path and the automatic cut-off.

6. In India the mains supply is alternating current that reverses direction every 1/100 second. Show clearly how the frequency of 50 Hz follows from this, and state one practical advantage of AC over DC.

In ONE complete cycle the current reverses TWICE - once from the forward direction to the reverse direction, and once back again. If a single reversal takes 1/100 second, then one complete cycle takes $T = 2 \times 1/100 = 2/100 = 1/50$ second. Frequency is the number of cycles per second, that is $f = 1/T = 1 / (1/50) = 50$ Hz. So the frequency of the AC mains in India is 50 Hz. PRACTICAL ADVANTAGE OF AC: alternating current can be transmitted over long distances without much loss of energy, which is why electrical power is generated and distributed as AC rather than DC.

7. A metal-bodied electric iron is not earthed. Its live wire works loose and touches the metal casing. Explain what happens when a person touches the iron, and explain how the earth wire would have prevented it.

With no earth wire, the metal casing is now at the potential of the LIVE wire, 220 V. When a person touches the iron, their body offers a path to the ground, so a current passes THROUGH the person to earth, giving a severe and possibly fatal electric shock. If the appliance HAD been earthed, the metal casing would be connected by the EARTH WIRE to a metal plate buried deep in the ground. The earth wire has a VERY LOW resistance, far lower than that of the human body, so when the live wire touched the casing the current would have flowed through the earth wire instead - the path of least resistance - and safely into the ground. In practice this large current also causes the FUSE in the live wire to melt, which disconnects the appliance altogether. This is why earthing is essential for all appliances with metal bodies.

