ELECTROMAGNETISM

Force on a current-carrying conductor

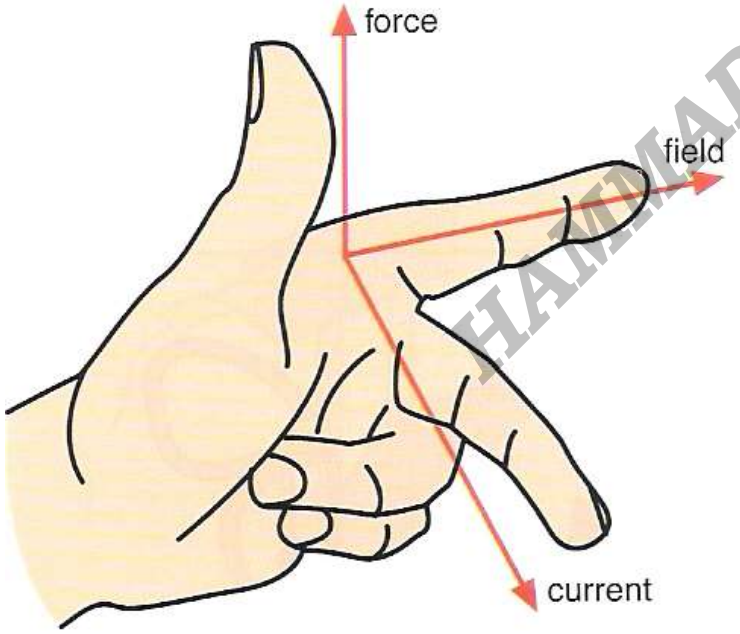
The d.c. motor

FORCE ON A CURRENT-CARRYING CONDUCTOR

State the relative directions of force, field and current.

Fleming's Left-Hand Rule

- When a wire carrying an electric current passes through a magnetic field, with the field at right-angles to the wire, the wire will experience a force at right-angles both to wire and to the magnetic field.

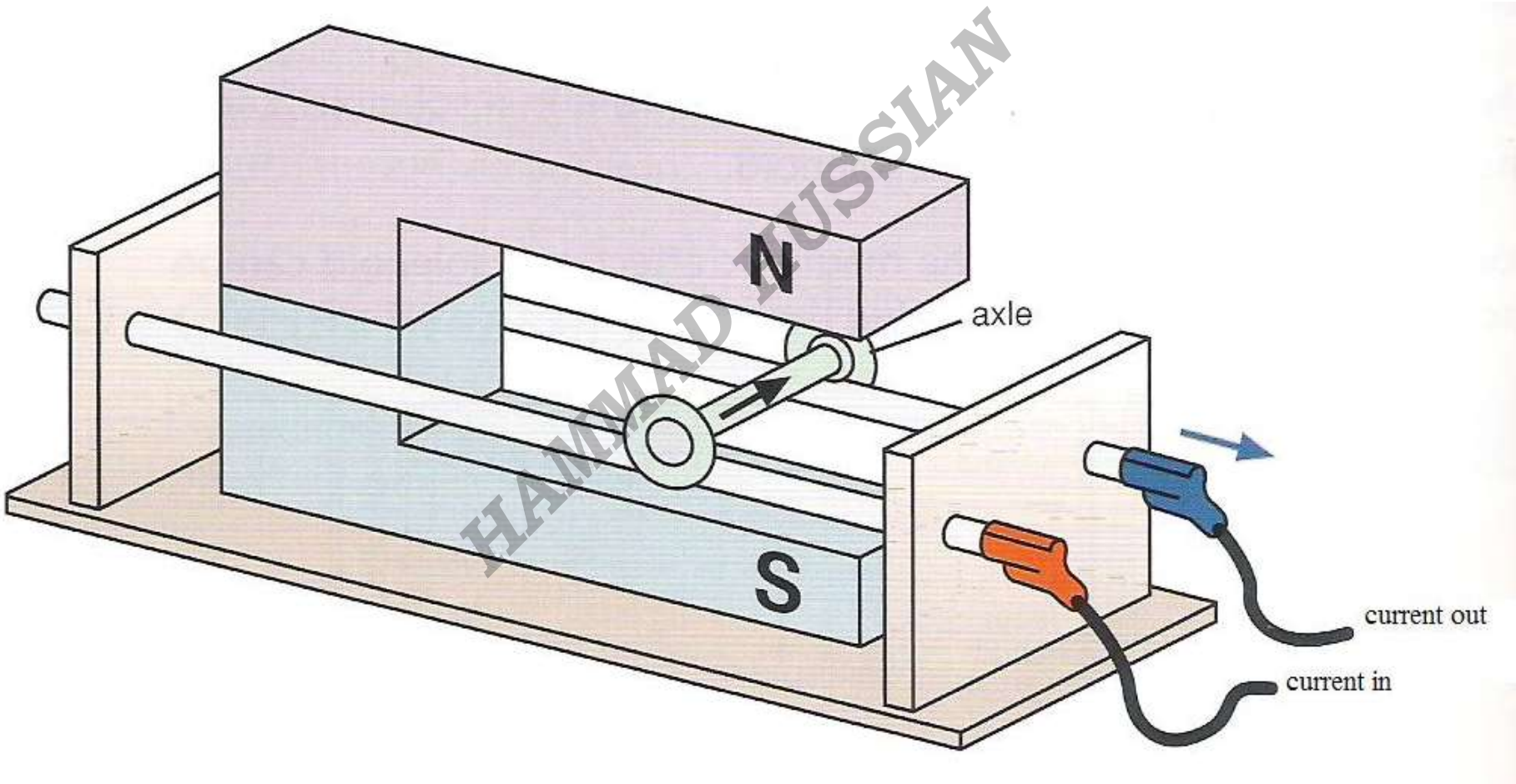


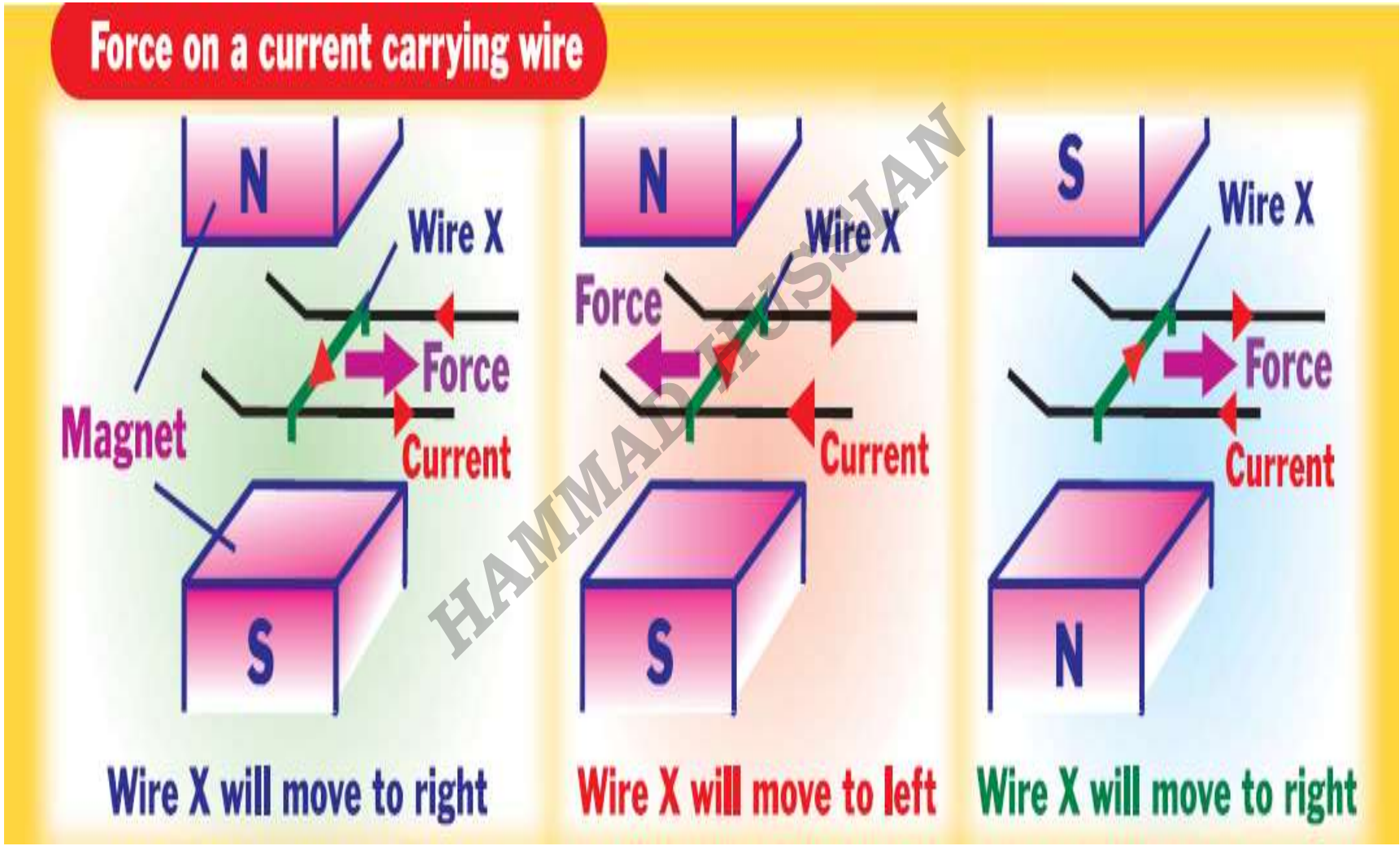
The direction in which the conductor moves can be deduced using Fleming's left-hand rule (or motor rule)

FORCE ON A CURRENT-CARRYING CONDUCTOR

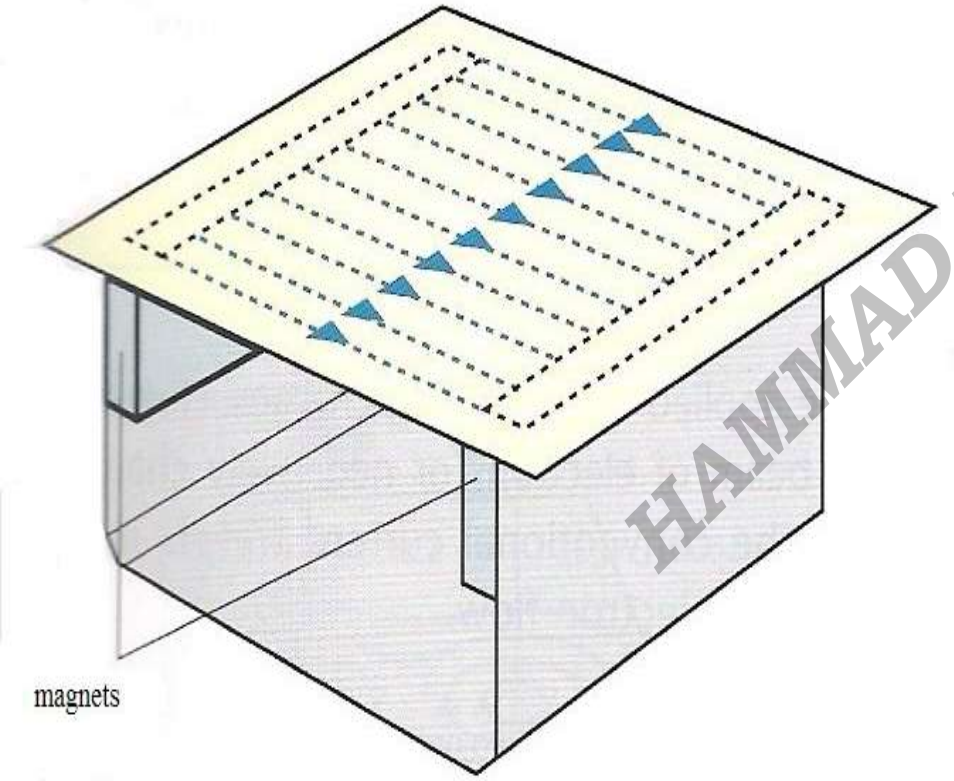
Describe experiments to show the force on a current-carrying conductor, and on a beam of charged particles, in a magnetic field, including the effect of reversing (1) the current, (2) the direction of the field.

Force on a Current-Carrying Conductor

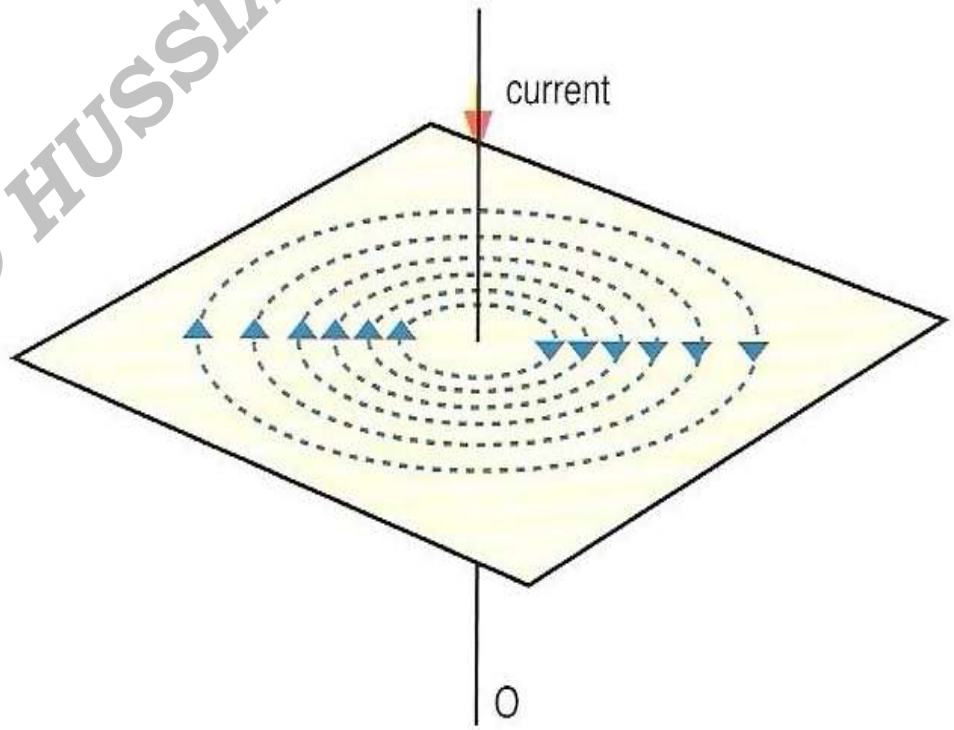



Force on a current carrying wire
N
Wire X
Force
Magnet
Current
S
Wire X will move to right
N
Wire X
Force
Current
S
Wire X will move to left
S
Wire X
Force
Current
N
Wire X will move to right
HAMMAD HUSSAIN

- The force exerted on the conductor can be explained by considering the combined fields due to current flowing through the straight conductor and the magnet.

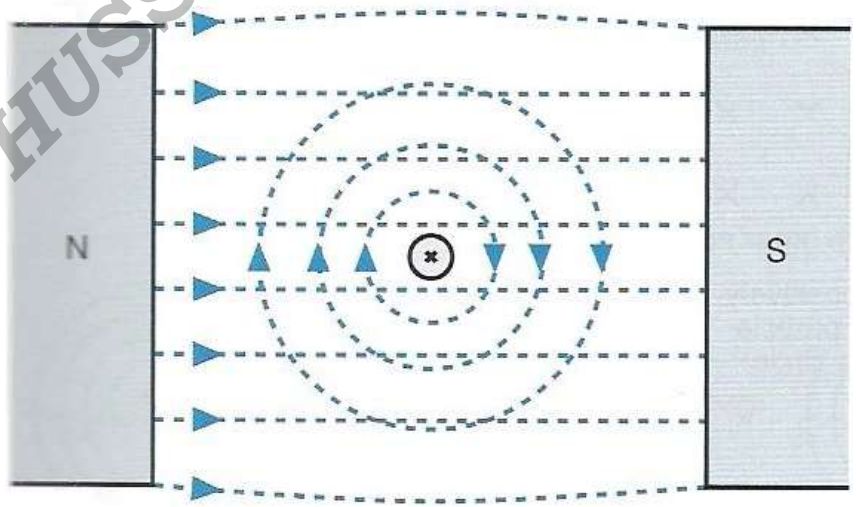


magnetics field between 2 magnets



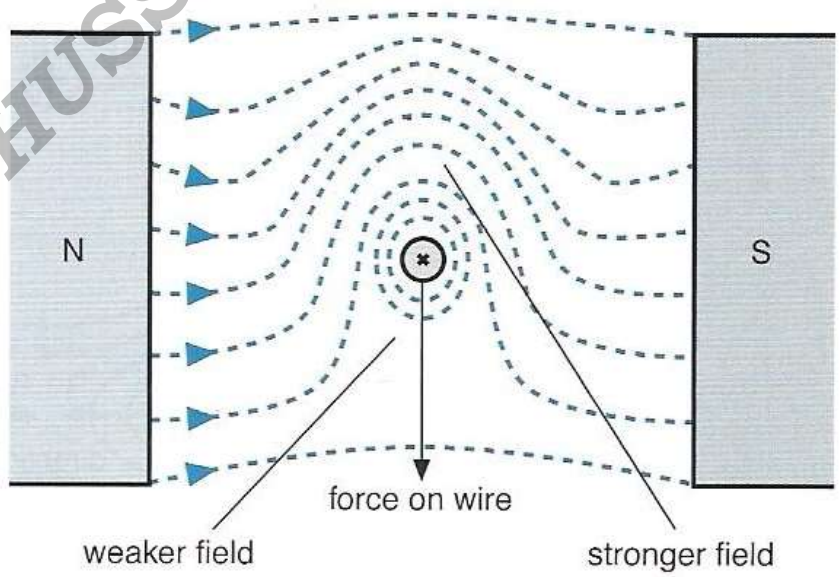
magnetic effect due to current in the wire

- The field shows that on one side of the conductor, the two fields are acting in the same direction and they will combine to give a stronger field.
- On the other side of the conductor, the two fields oppose each other and give a weaker field.



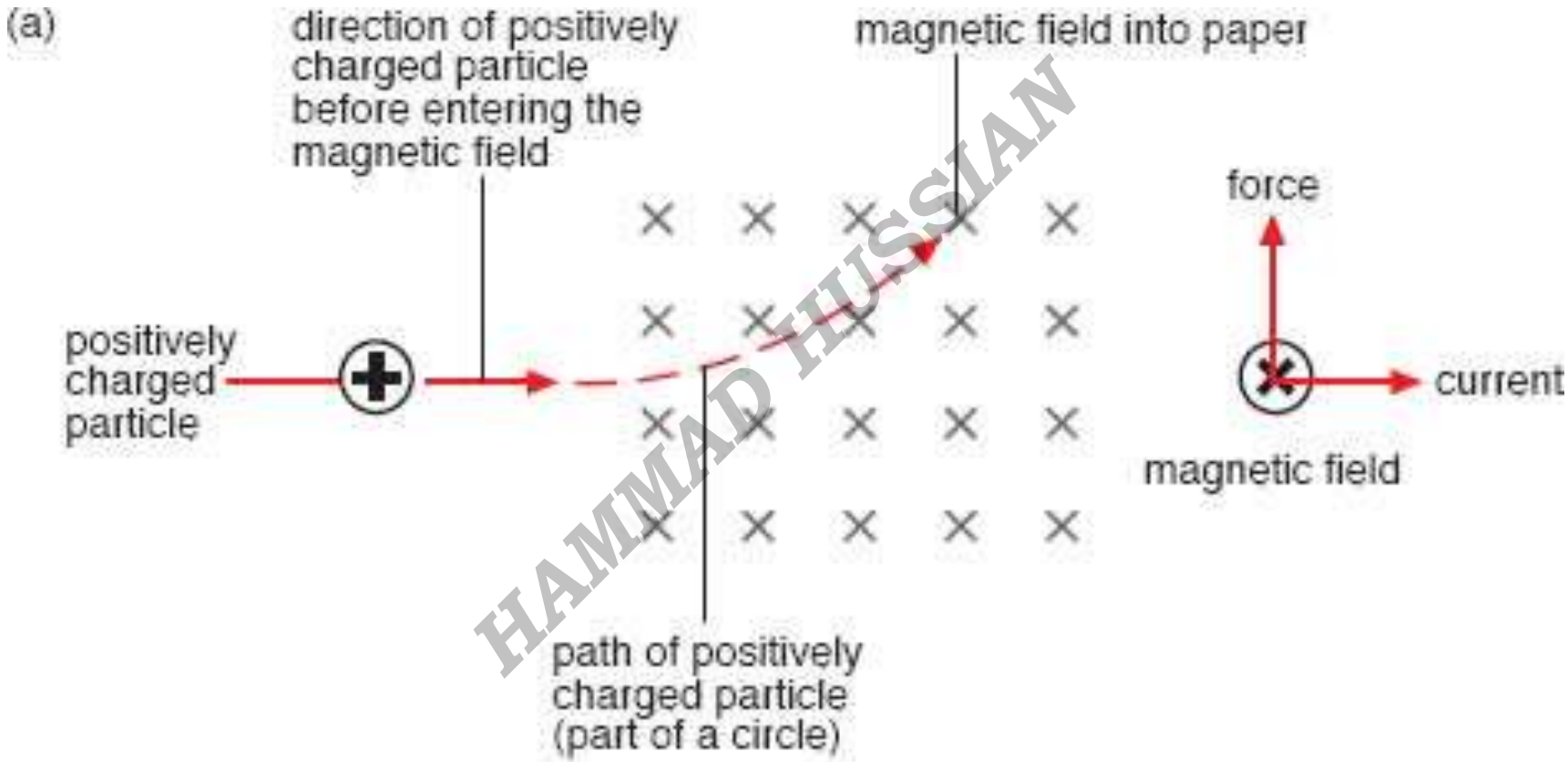
x = wire with current flowing into the paper

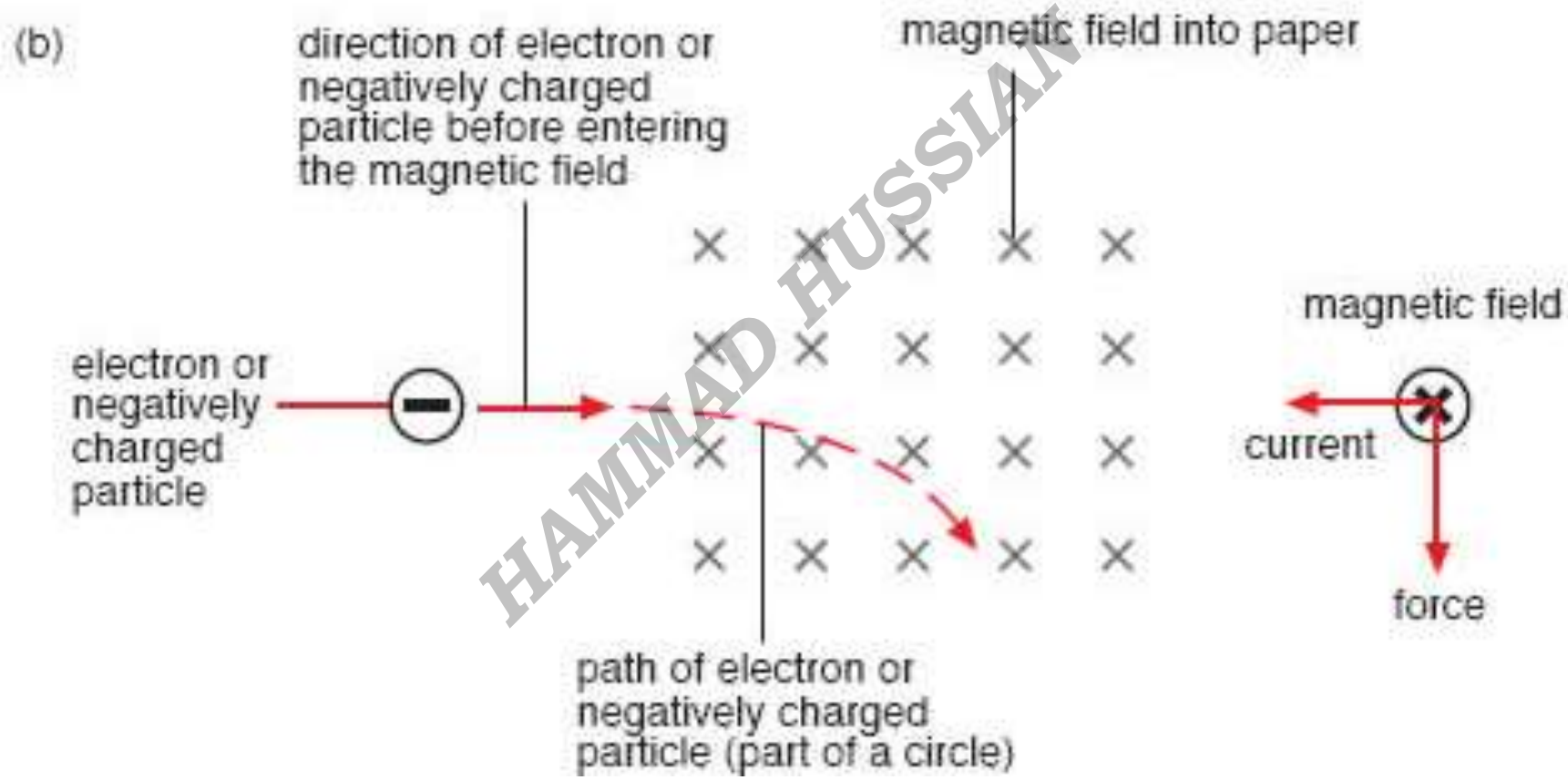
- The unbalanced fields on both sides of the conductor produce the force that is exerted on the conductor.



Force on Beam of Charge Particles

- In the deflection tube, the electron gun shoots out a beam of electrons across an evacuated tube.
- It hits a fluorescent screen placed in its path and when it does the screen glows.
- If a bar magnet is held at the side of the tube, the beam of electrons is seen to be deflected up or down.

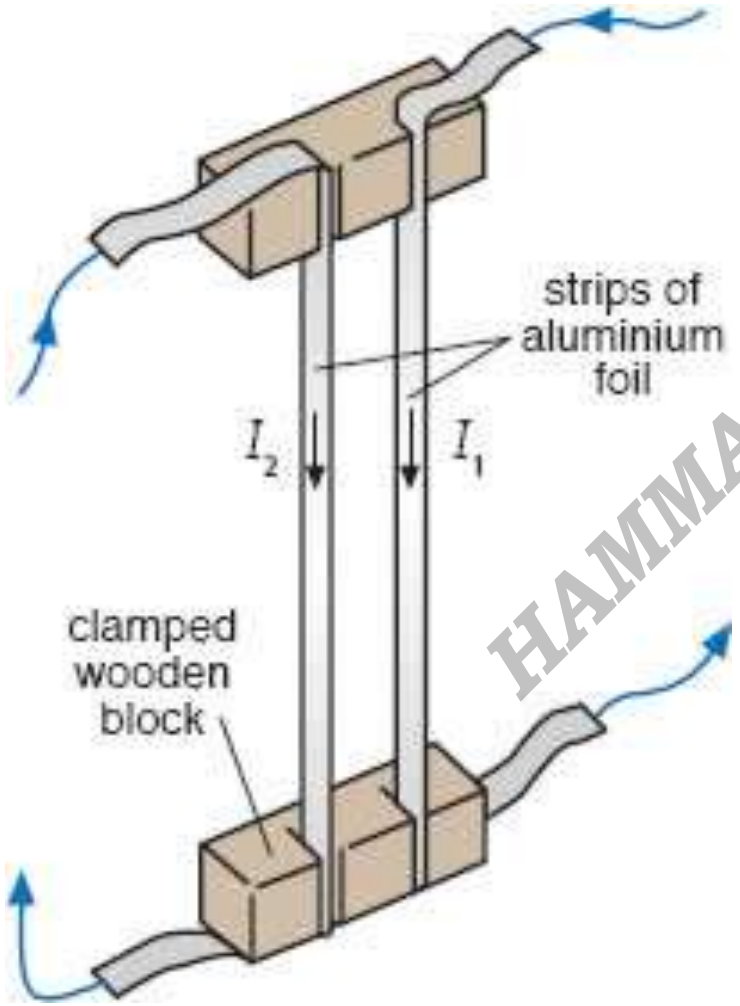




FORCE ON A CURRENT-CARRYING CONDUCTOR

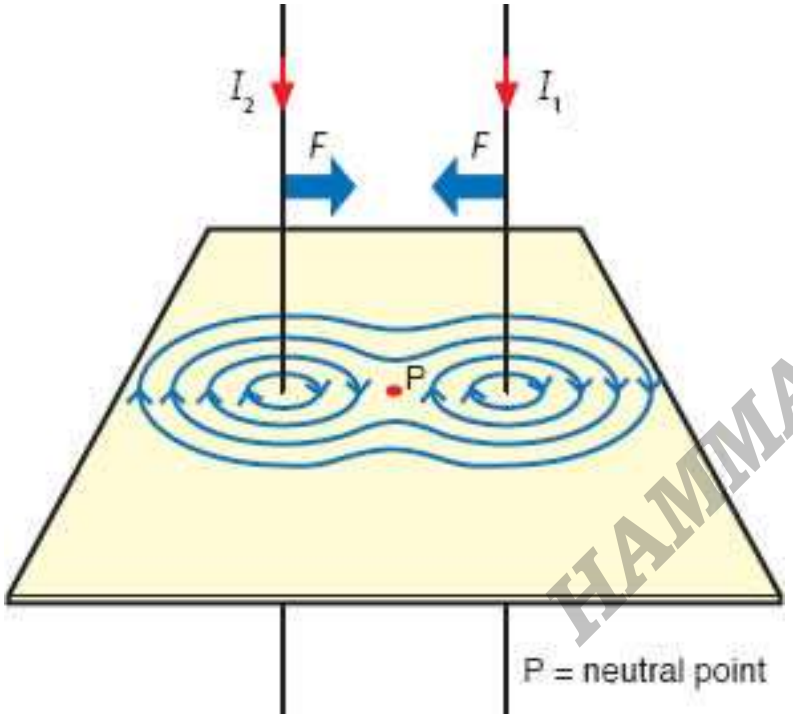
Describe the field patterns between currents in parallel conductors and relate these to the forces which exist between the conductors (excluding the Earth's field).

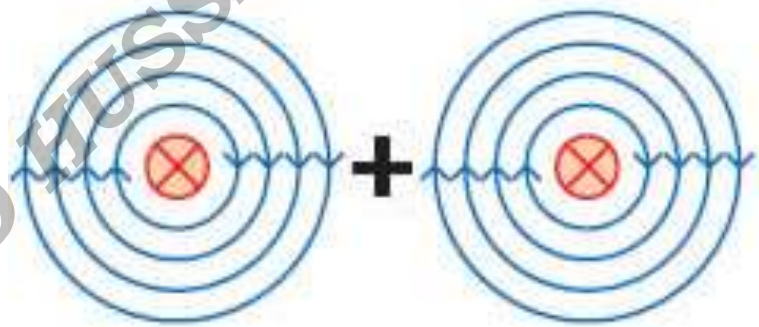
Force Between Two Parallel, Current-carrying Conductors

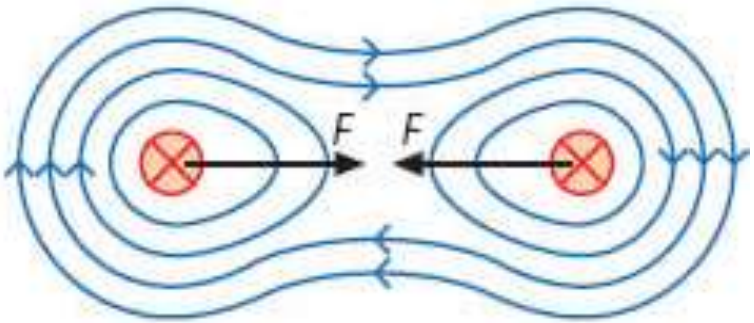


- When a current is set to flow on two parallel strips of aluminum, the magnetic fields due to each wire will interact and a force will act on each of the wires

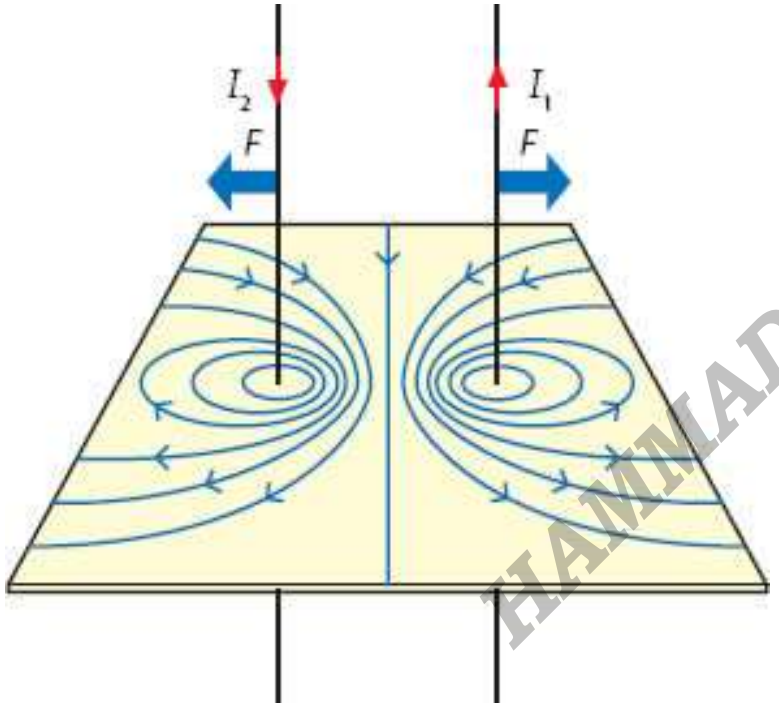
Conductors with currents flowing in the same direction attract

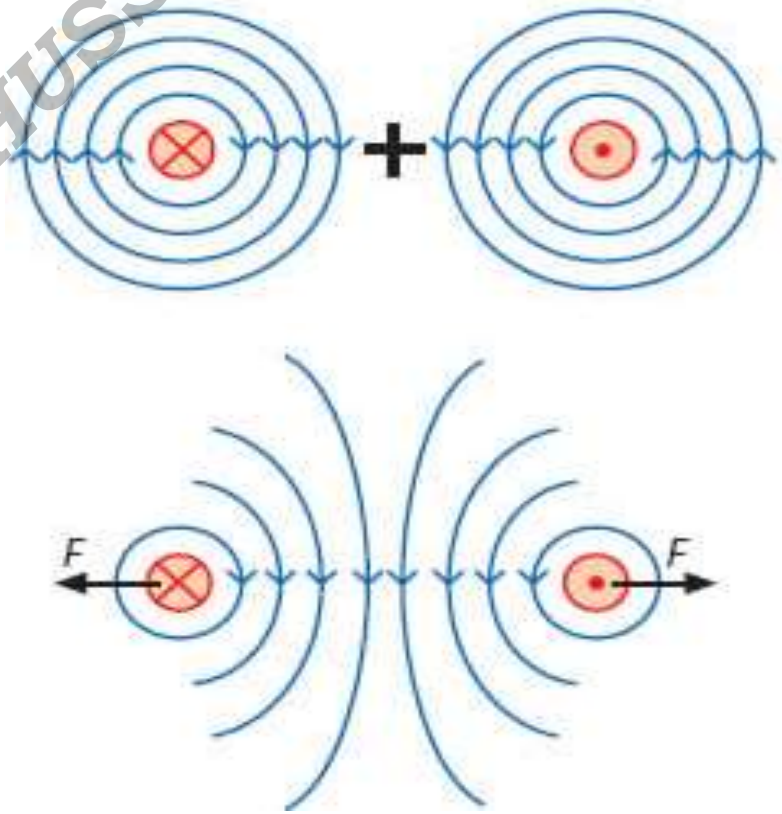






Conductors with currents flowing in the opposite direction repel

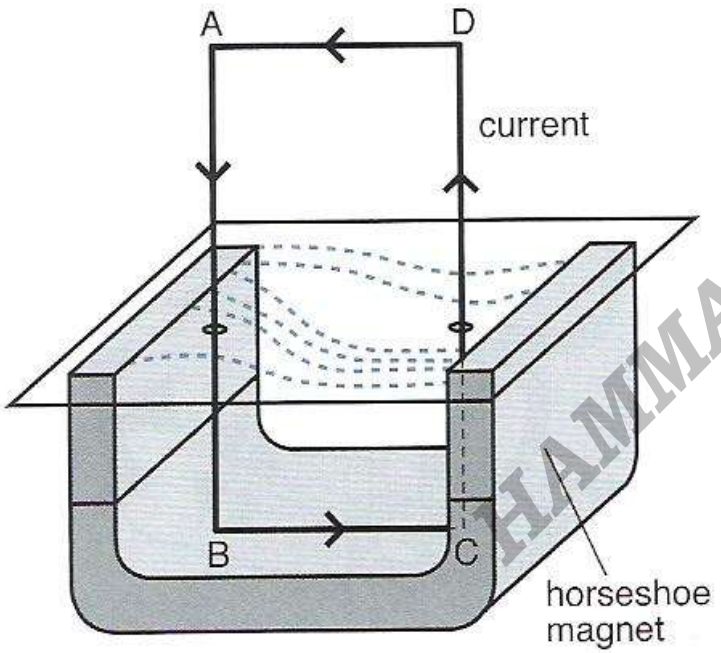




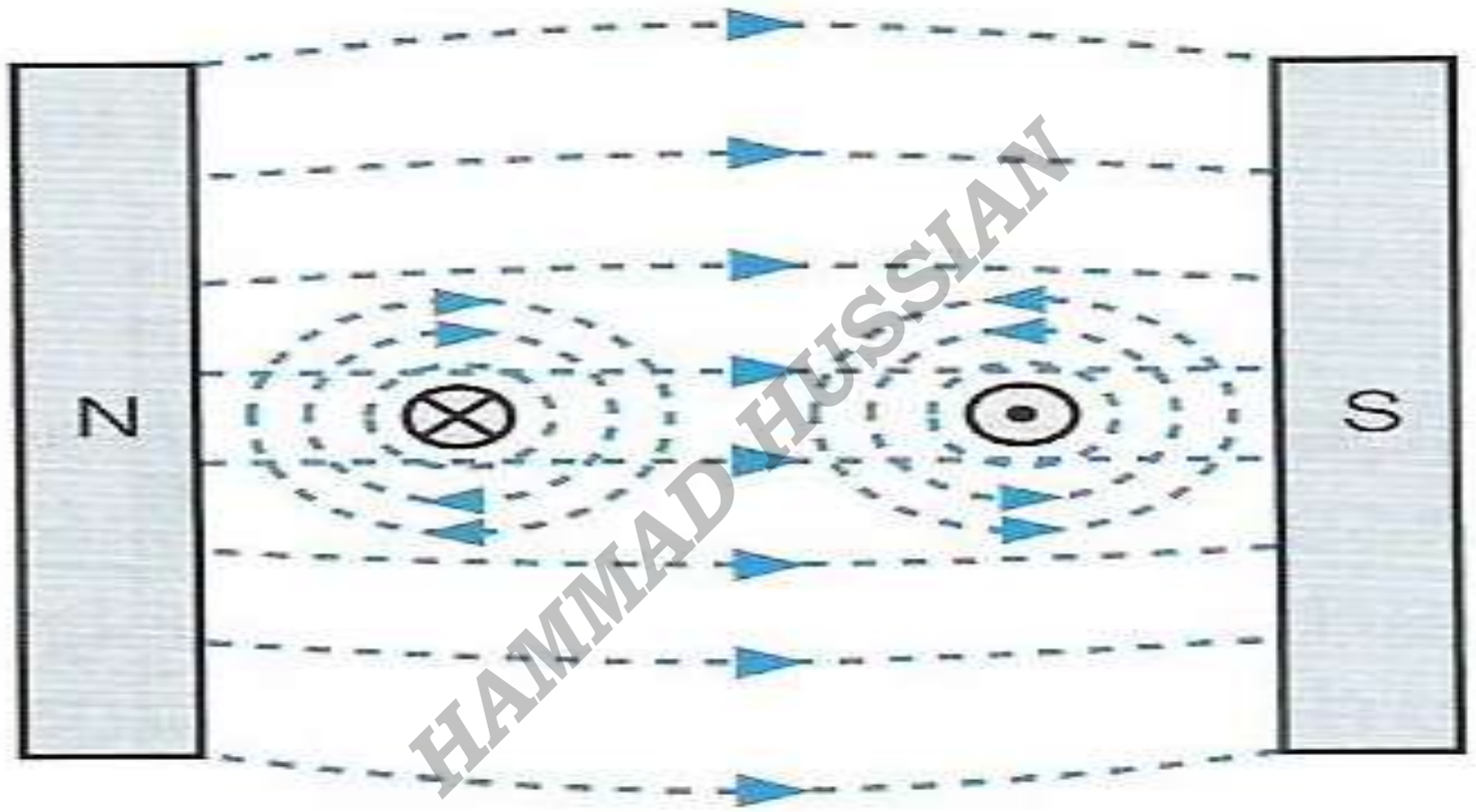
THE D.C. MOTOR

Explain how a current-carrying coil in a magnetic field experiences a turning effect and that the effect is increased by increasing (1) the number of turns on the coil, (2) the current.

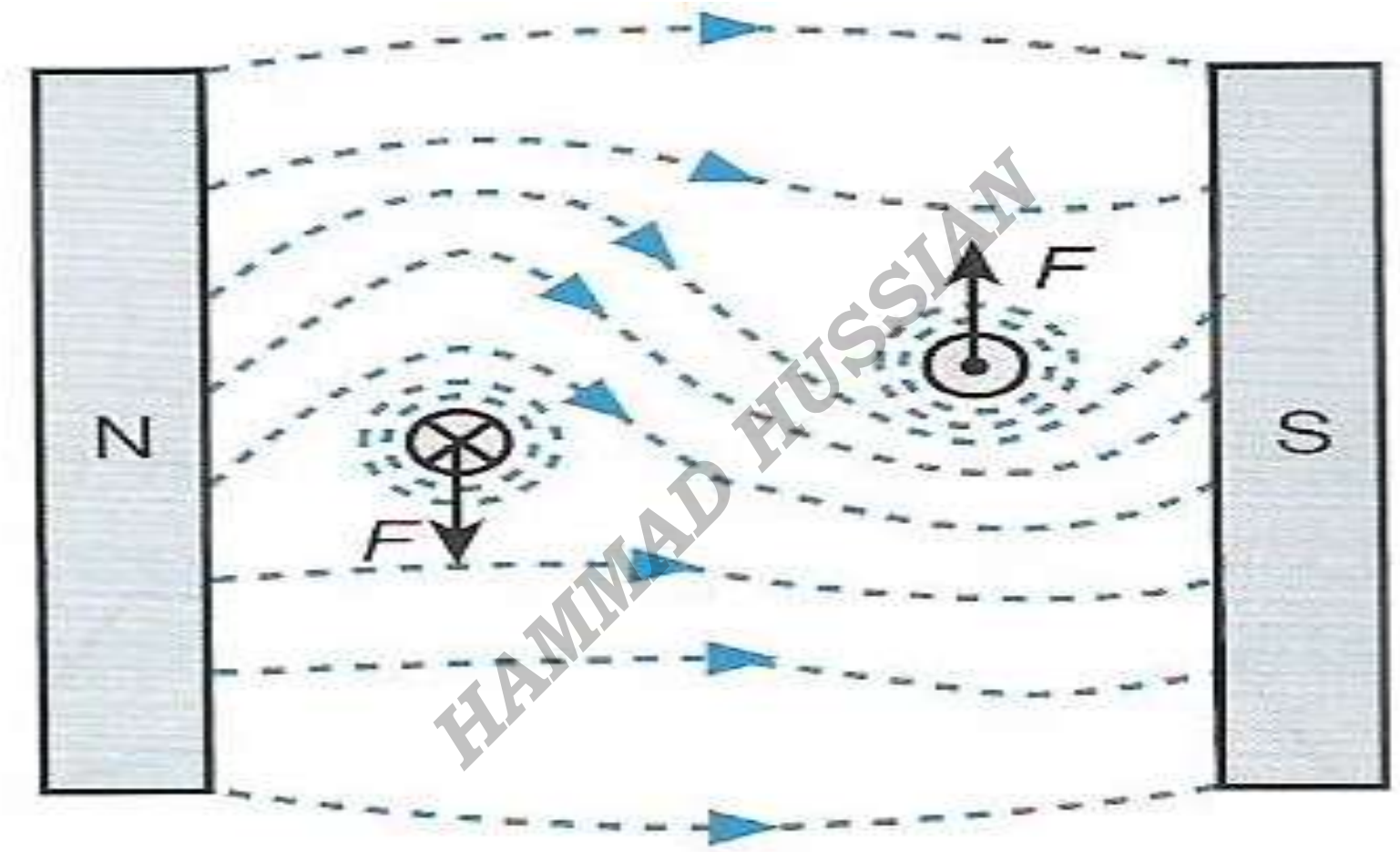
Turning Effect on a Current-Carrying Conductor



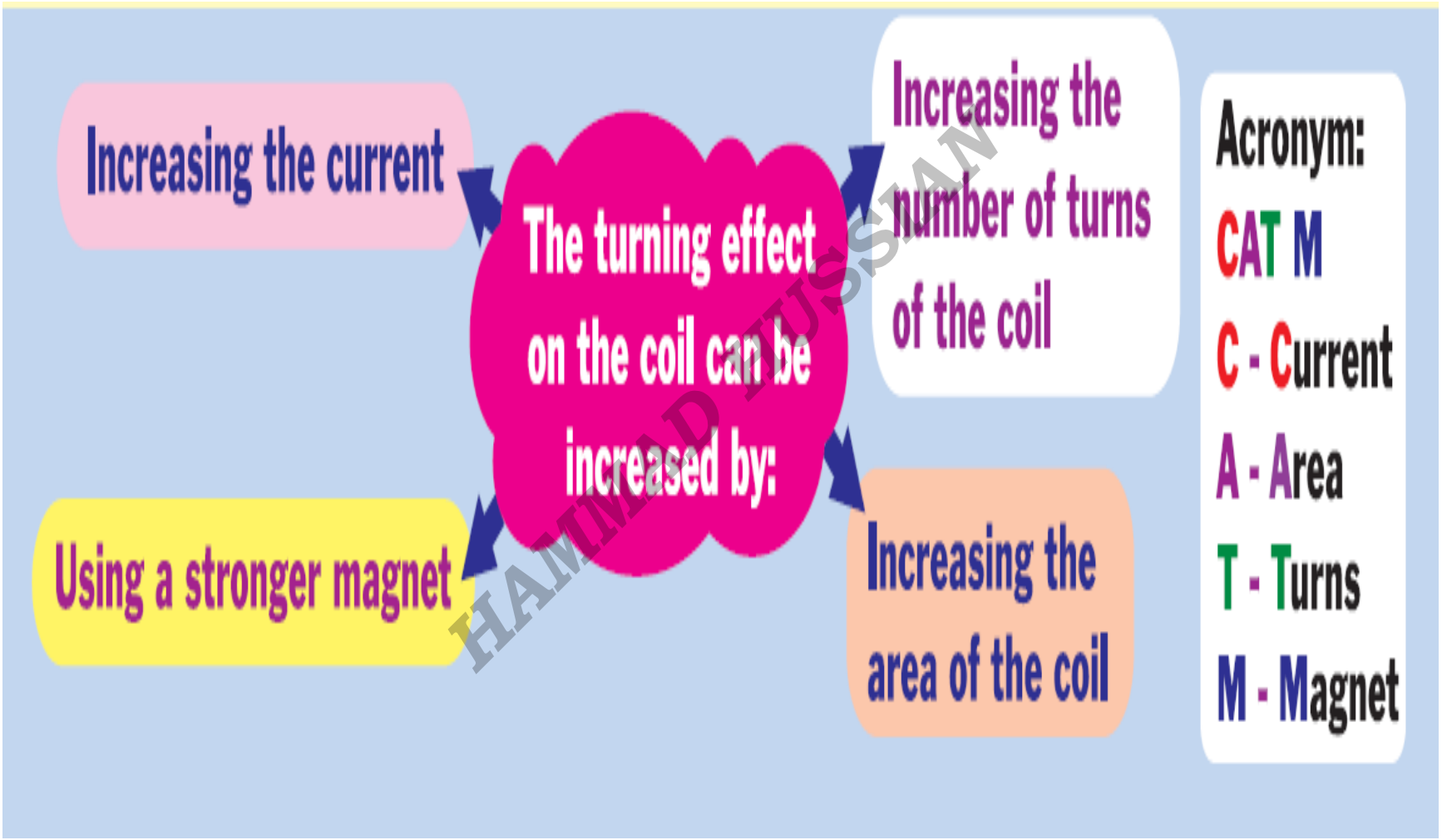
- If a current carrying coil is placed in a magnetic field, a pair of forrces will be produced on the coil.
- This is due to the interaction of the magnetic filed of the permanent magnet and the magnetic field of the current carrying coil.



- The field of a coil superimposed on the field of a horseshoe magnet



- Combined field results in a pair of equal and opposite forces *F*

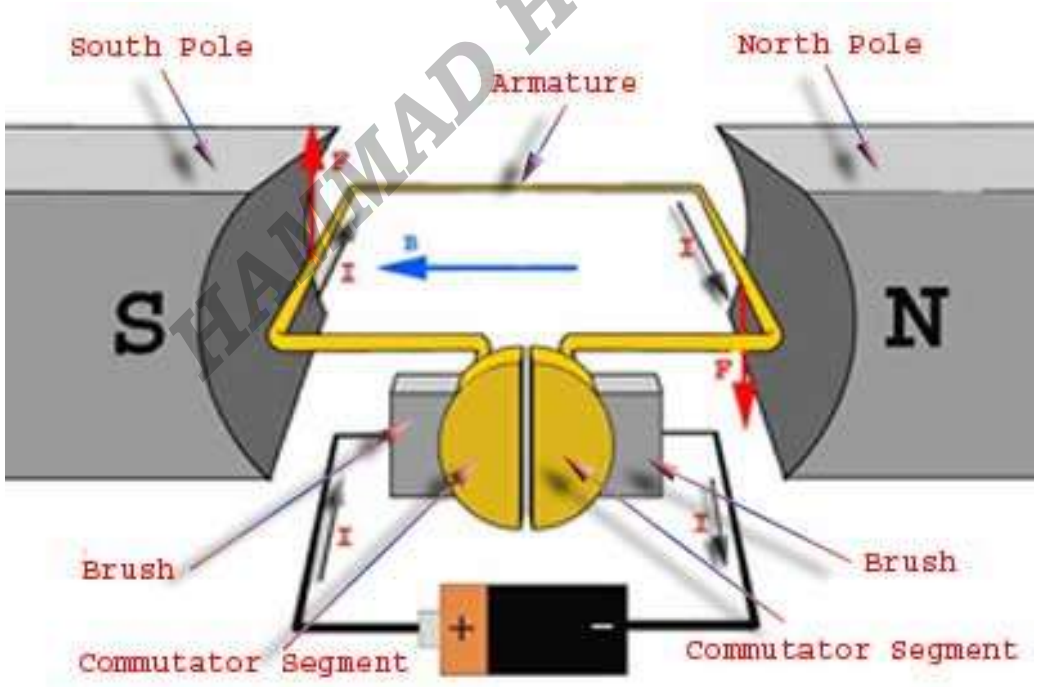

Increasing the current
The turning effect on the coil can be increased by:
Increasing the number of turns of the coil
Using a stronger magnet
Increasing the area of the coil
Acronym:
CAT M
C - Current
A - Area
T - Turns
M - Magnet
HAMMAD HUSSAIN

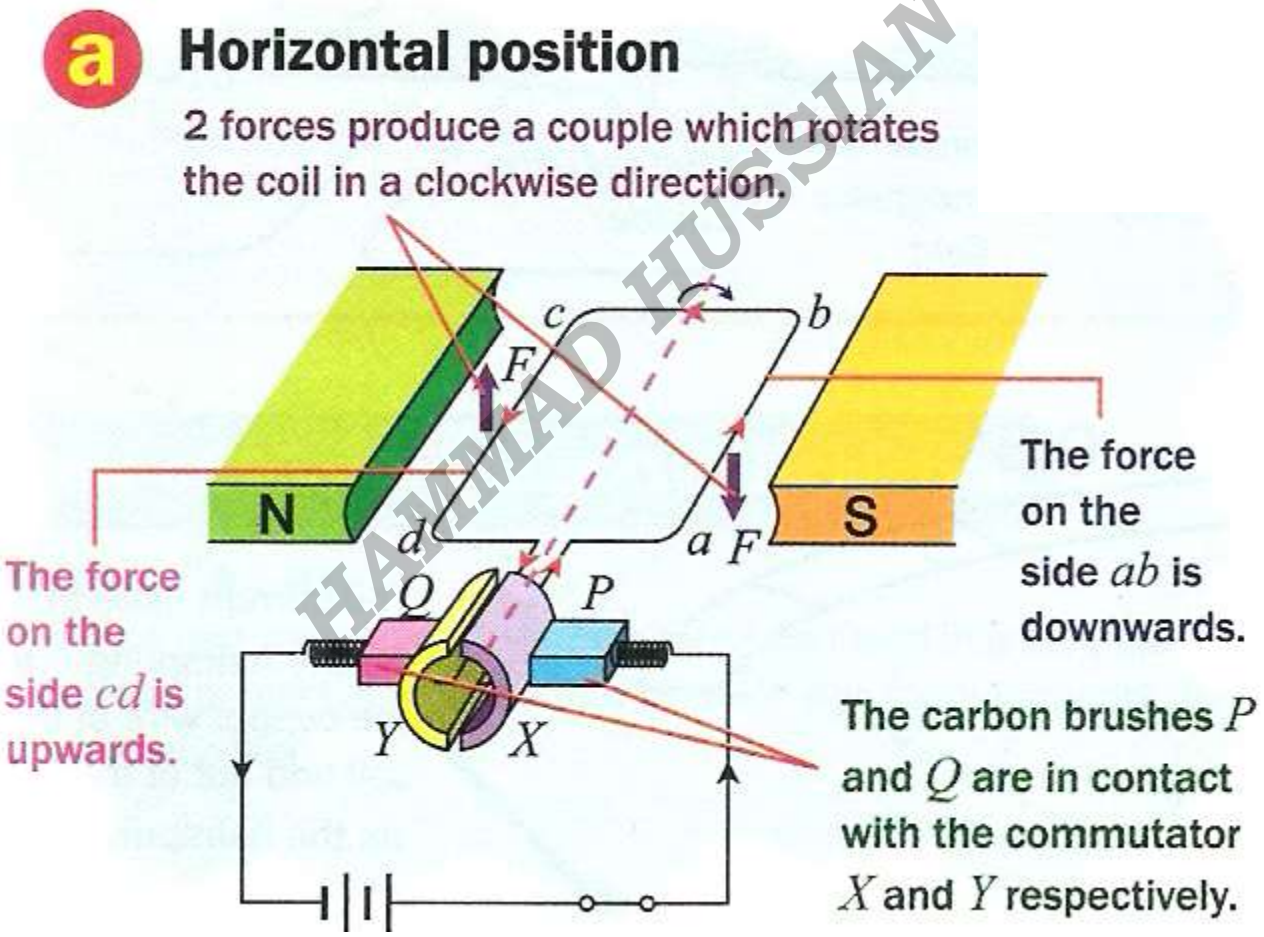
THE D.C. MOTOR

Discuss how this turning effect is used in the action of an electric motor.

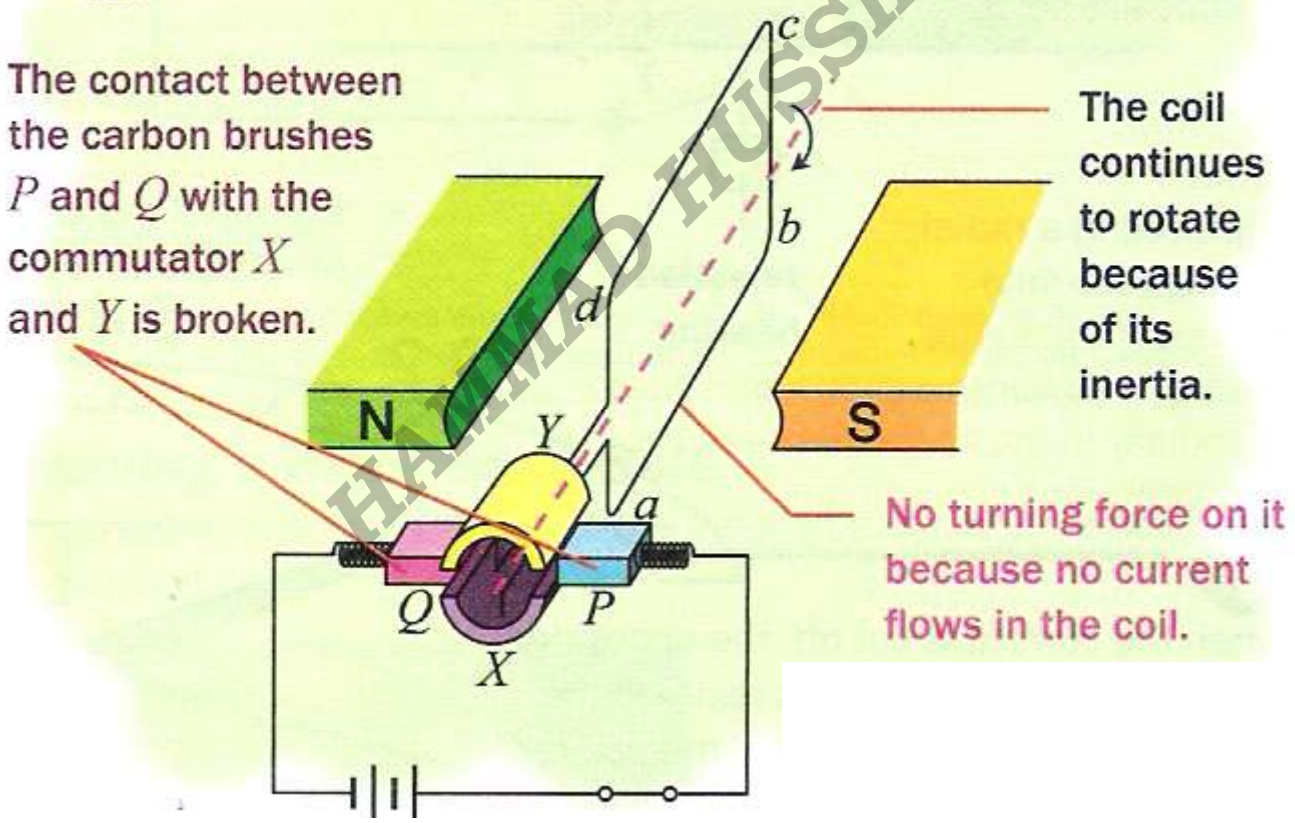
D.C Motor

- A simple electric motor can be built using a coil of wire that is free to rotate between two opposite magnetic poles. When an electric current flows through the coil, the coil experiences a force and moves.





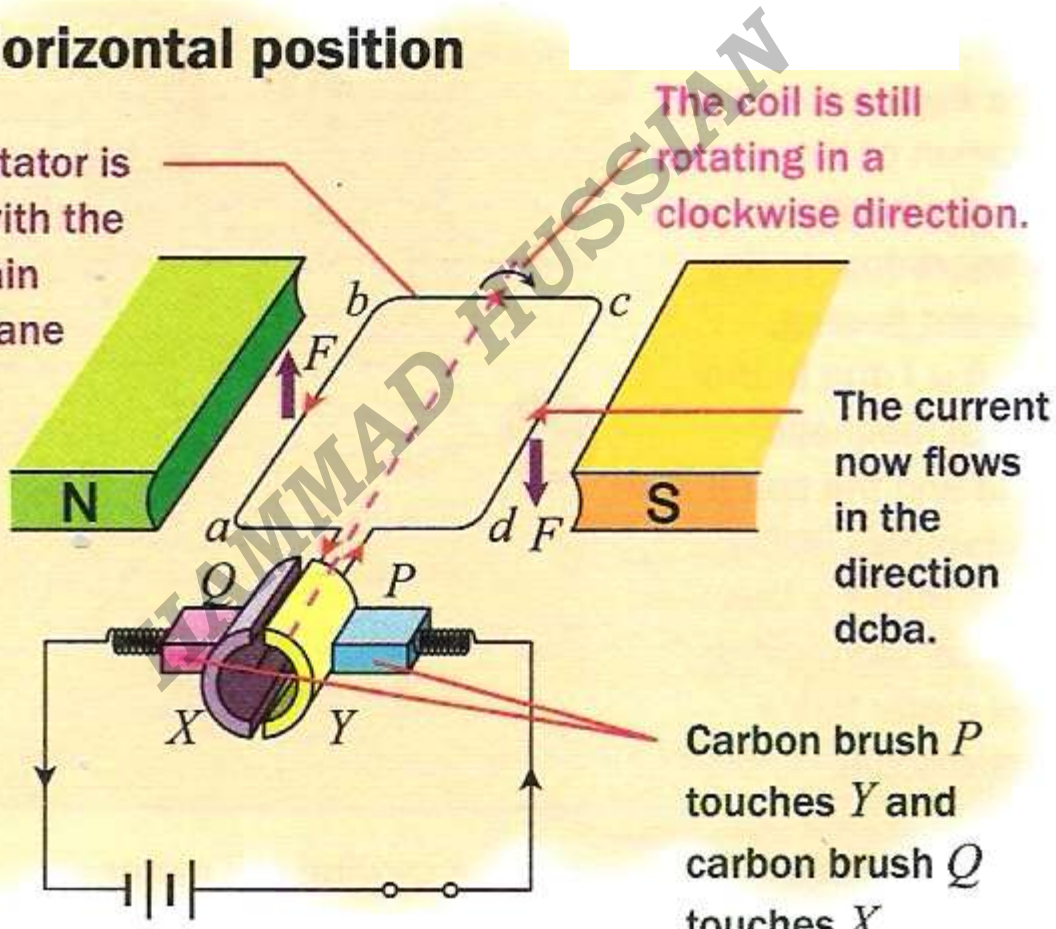
b Vertical/ Upright position



C Horizontal position

The commutator is in contact with the brushes again when the plane of the coil becomes horizontal again.

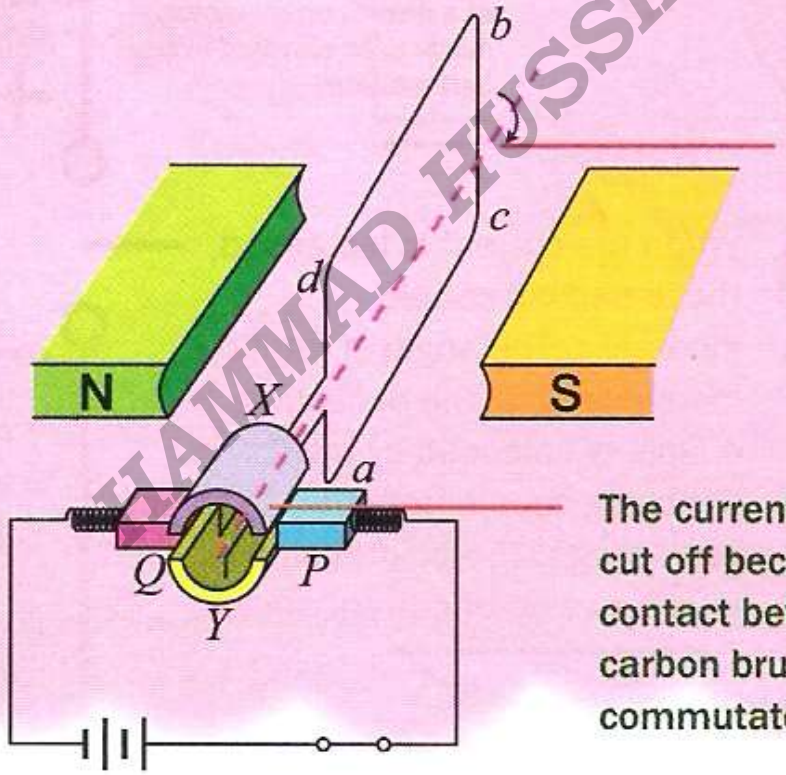
The coil is still rotating in a clockwise direction.



The current now flows in the direction dcba.

Carbon brush P touches Y and carbon brush Q touches X.

d Vertical/ Upright position



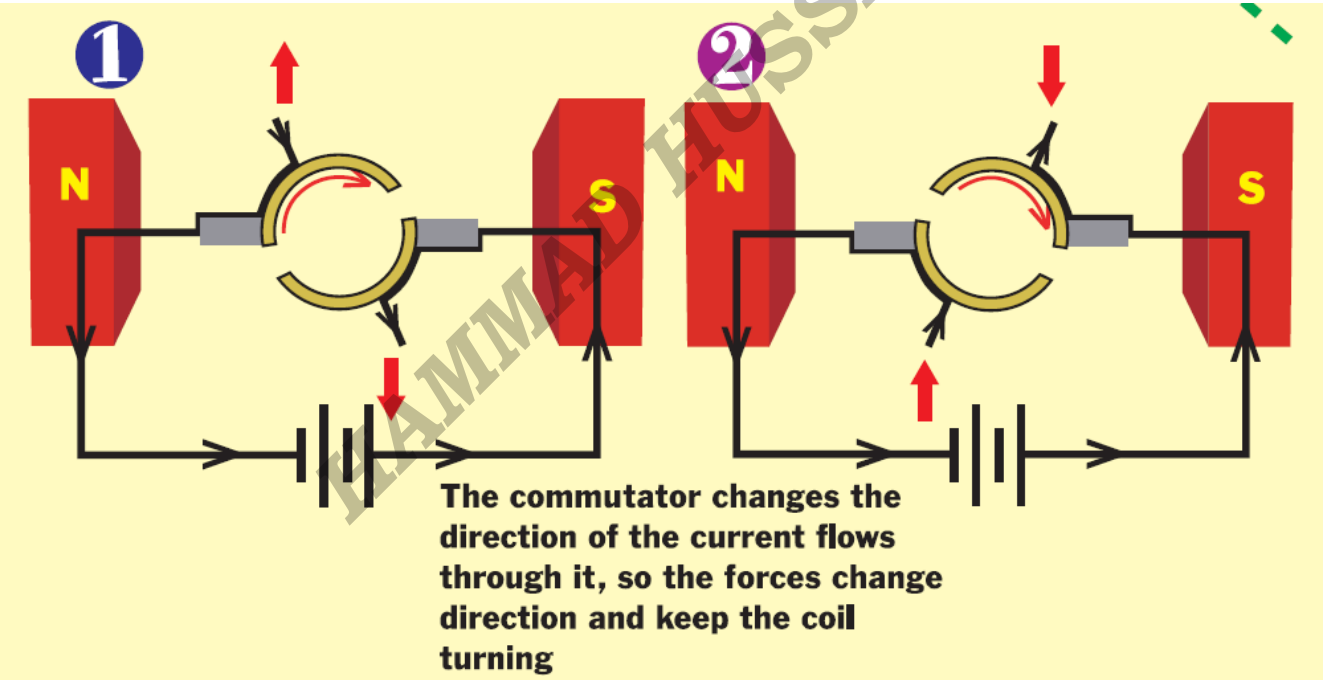
The lane of the coil becomes vertical

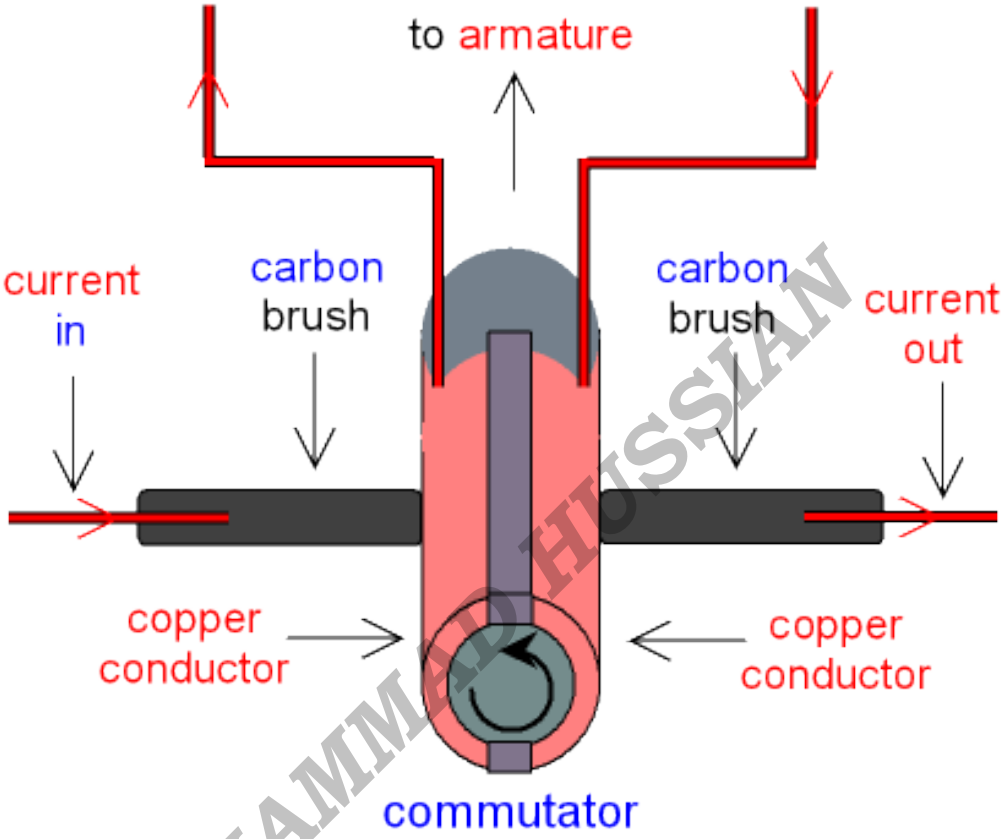
The current flow in cut off because the contact between the carbon brushes and the commutater is broken.

Describe the action of a split-ring commutator in a two-pole, single-coil motor and the effect of winding the coil onto a soft iron cylinder.

Action of Commutator

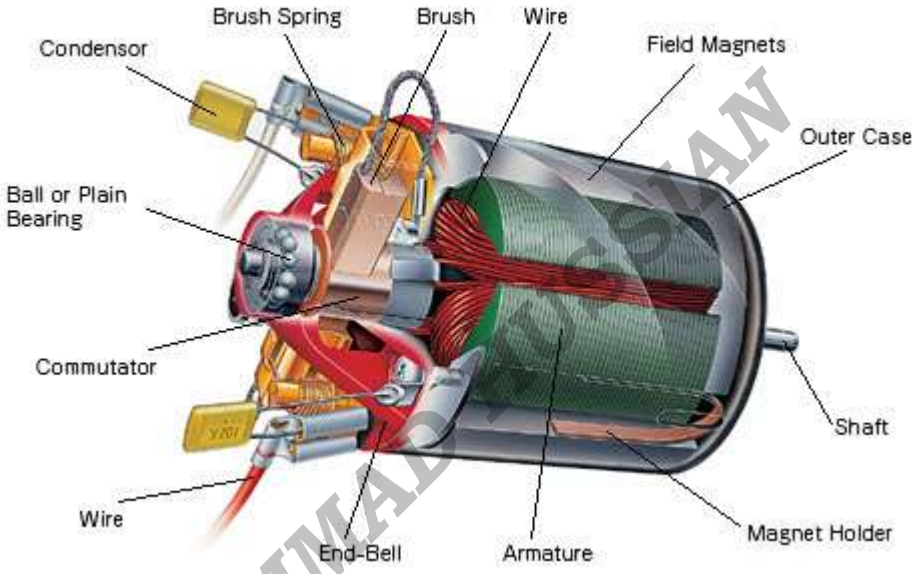
- A split-ring commutator is a device for reversing the current direction every half turn.





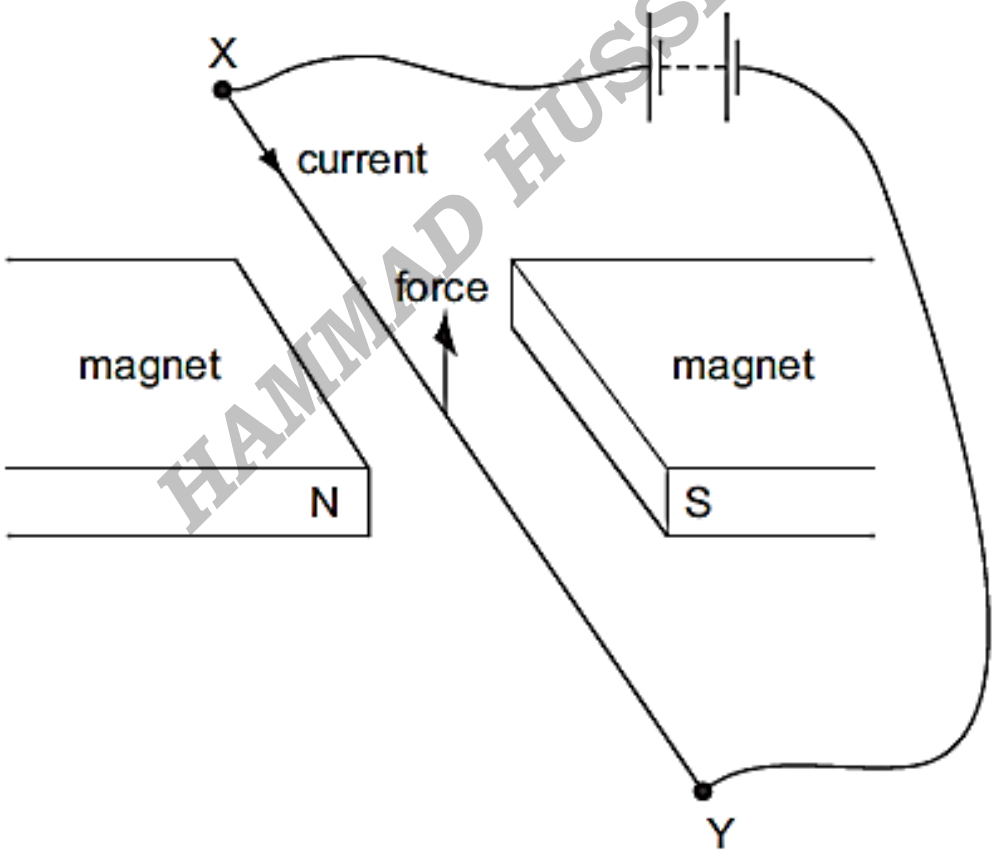
- As the motor rotates, first one piece of copper, then the next connects with the brush every half turn. The wire on the left side of the armature always has current flowing in the same direction, and so the armature will keep turning in the same direction

Soft Iron Cylinder



- The coils are wound on a iron core called armature makes the magnetic field stronger because it becomes a magnet itself when the current is flowing.
- It is used because it loses its magnetism as soon as the current stops flowing. In this way, the electromagnet can be switched on and off by turning the electricity on and off.

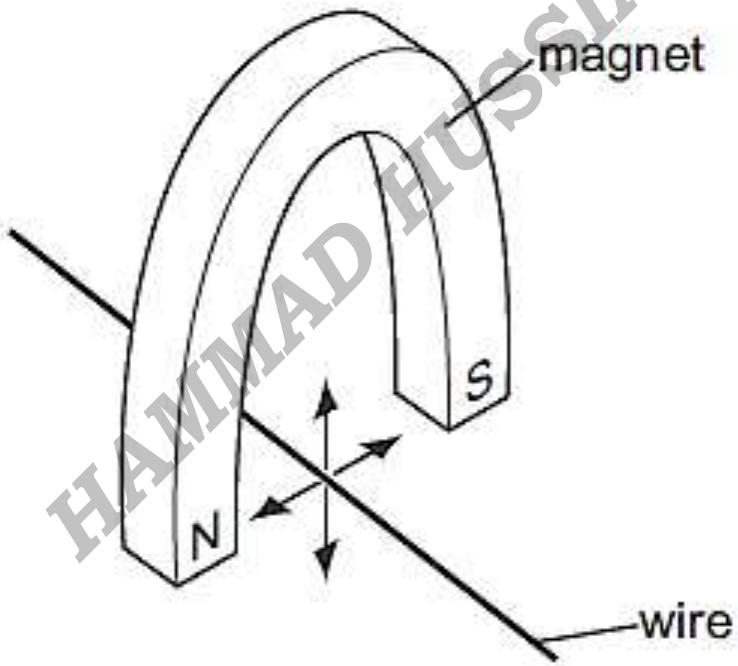
1. When the electric current in wire XY is in the direction shown, there is an upward force on the wire.



If the north and south poles of the magnet exchange positions, in which direction will the force on the wire act?

A. downwards
B. upwards
C. to the left
D. to the right

2. A copper wire is held between the poles of a magnet.

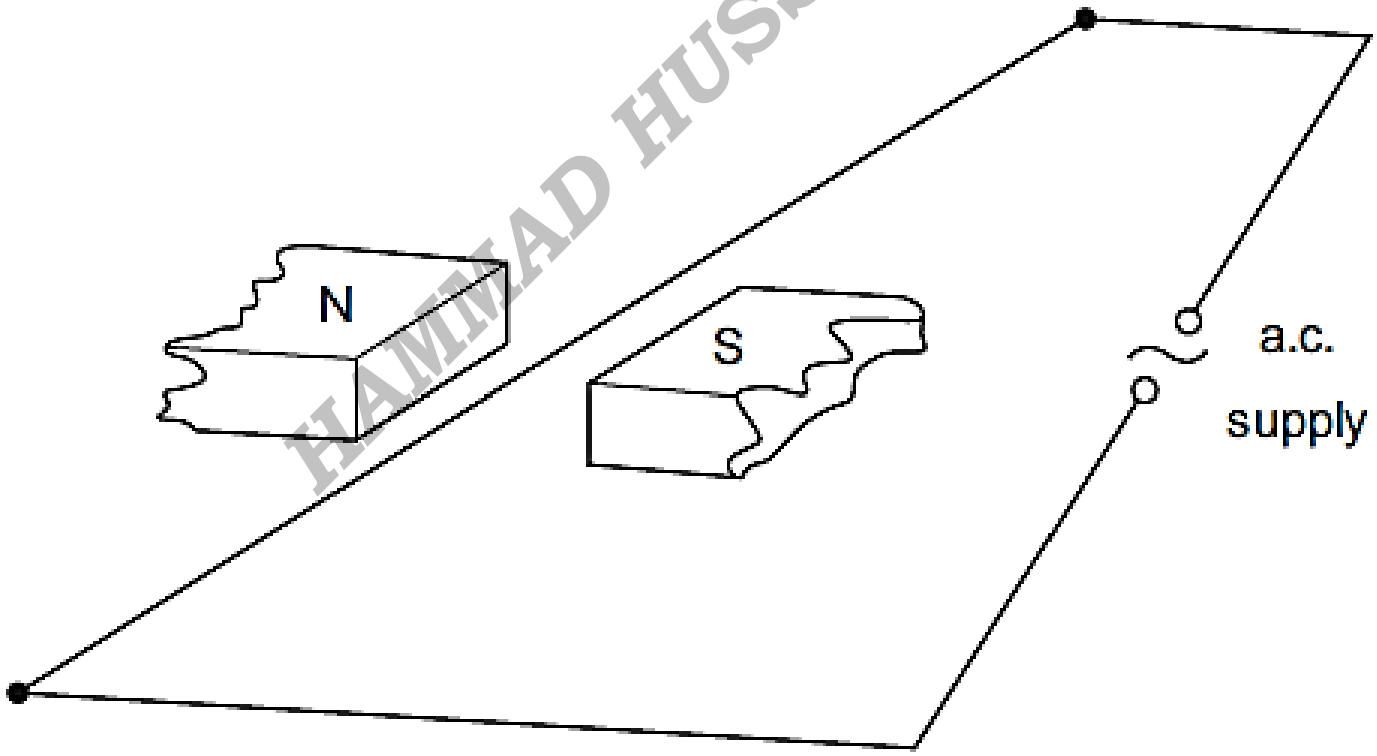


The current in the wire can be reversed. The poles of the magnet can also be changed over.

In how many of the four directions shown can the force act on the wire?

A. 1
B. 2
C. 3
D. 4

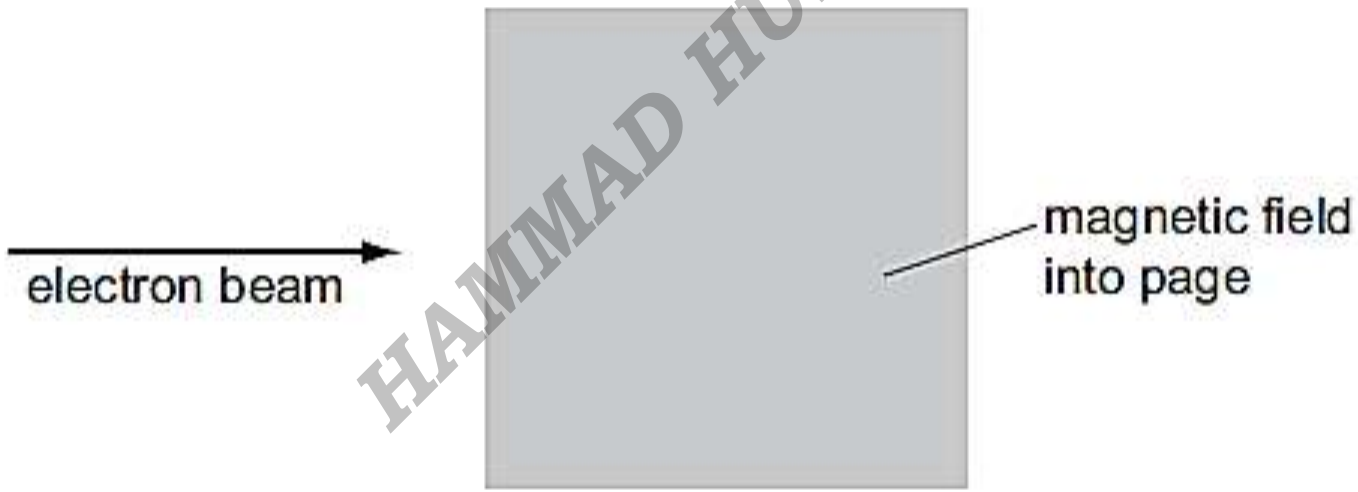
3. An a.c. supply is connected to a wire stretched between the poles of a magnet.



Which way will the wire move?

A. left and right
B. right only
C. up and down
D. up only

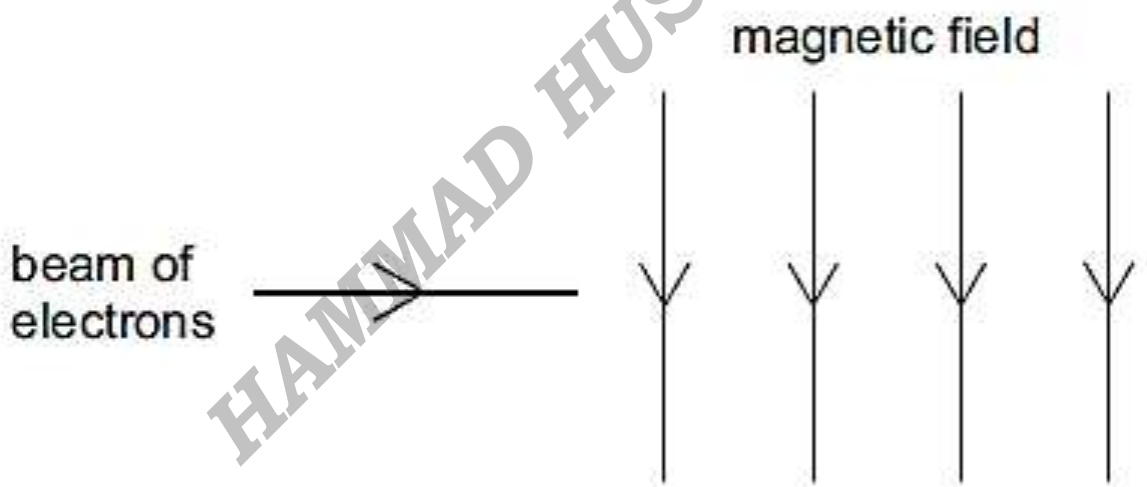
4. The diagram shows a beam of electrons entering a magnetic field. The direction of the field is into the page.



In which direction are the electrons deflected?

A. into the page
B. out of the page
C. towards the bottom of the page
D. towards the top of the page

5. The diagram shows a beam of electrons entering a magnetic field.



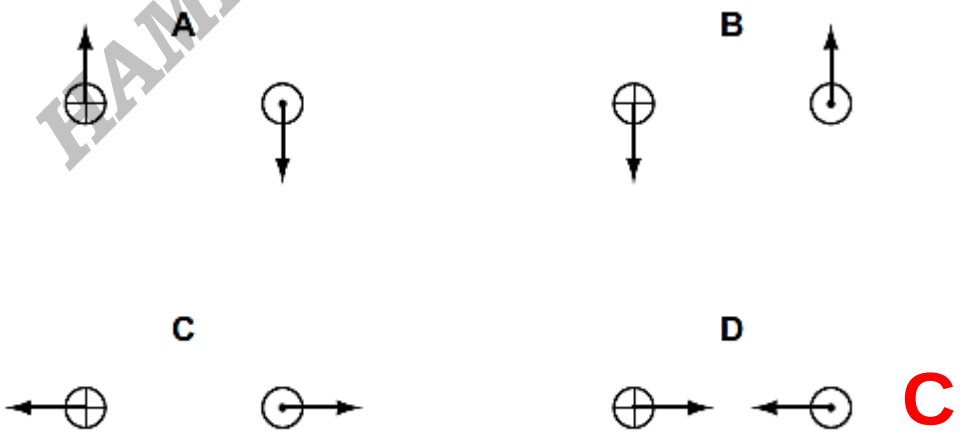
What is the effect of the magnetic field on the electrons?

A. They are deflected into the plane of the diagram.
B. They are deflected out of the plane of the diagram.
C. They are deflected towards the bottom of the diagram.
D. They are deflected towards the top of the diagram.

6. Each diagram shows a cross-section through two parallel conductors, each carrying an electric current.

   In the conductor on the left, the current is into the page; on the right, it is out of the page.

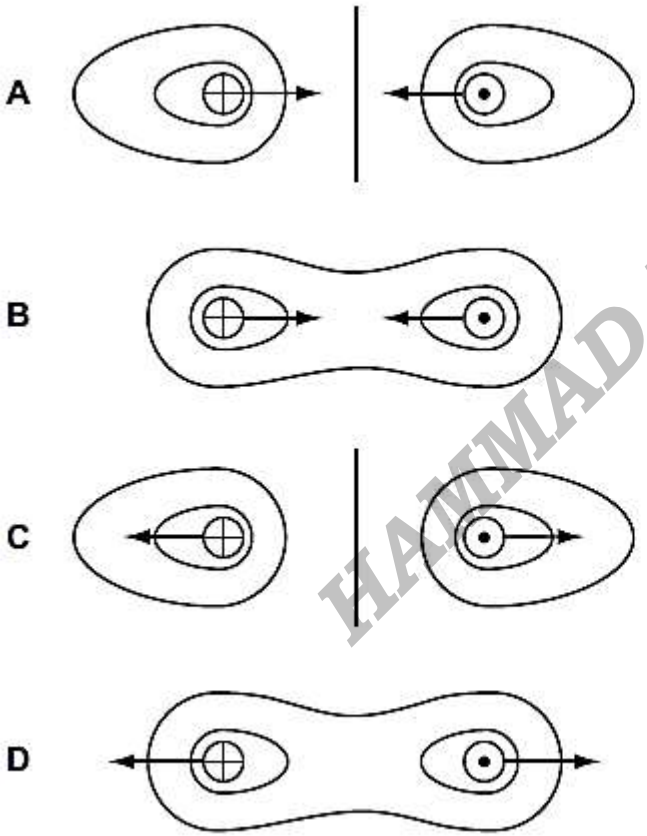
   Which diagram shows the directions of the forces on the two conductors?



C

7. Each of the diagrams is a cross-section through two parallel, current-carrying conductors.

   Which diagram shows correctly the magnetic field pattern and the directions of the forces on the two conductors?



key

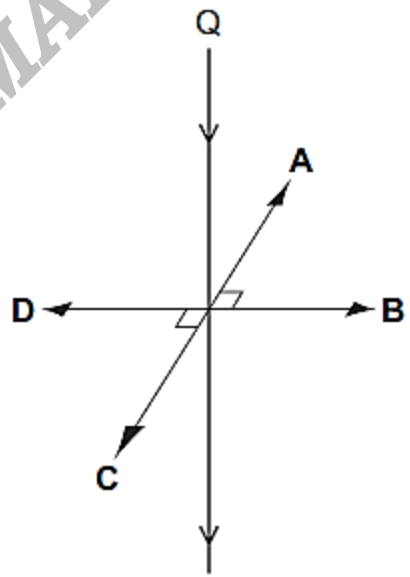
⊕ conductor carrying current into page

⊙ conductor carrying current out of page

C

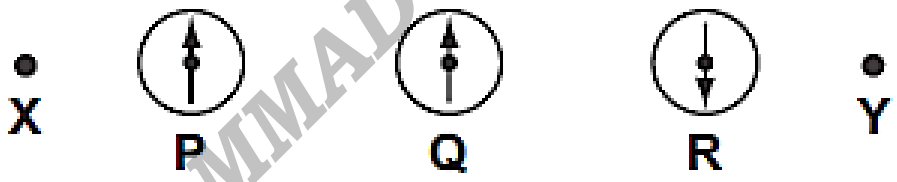
8. Two parallel vertical wires P and Q are a small distance apart in air. There is a downwards electric current in both wires. A force acts on Q owing to the current in P. This force is perpendicular to the wire Q.

   What is the direction of the force on Q?



D

9. X and Y are wires carrying electric currents at right angles to the page. P, Q and R are plotting compasses. Any effect of the Earth's magnetic field has been ignored.

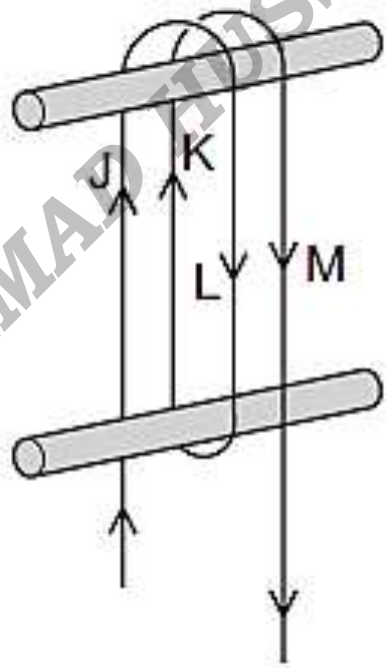


What is true about the direction and size of the currents?

	direction of currents	size of currents
A	same	larger in **X** than in **Y**
B	same	smaller in **X** than in **Y**
C	different	larger in **X** than in **Y**
D	different	smaller in **X** than in **Y**

A

10. A long flexible wire is wrapped round two wooden pegs. A large current is passed in the direction shown.

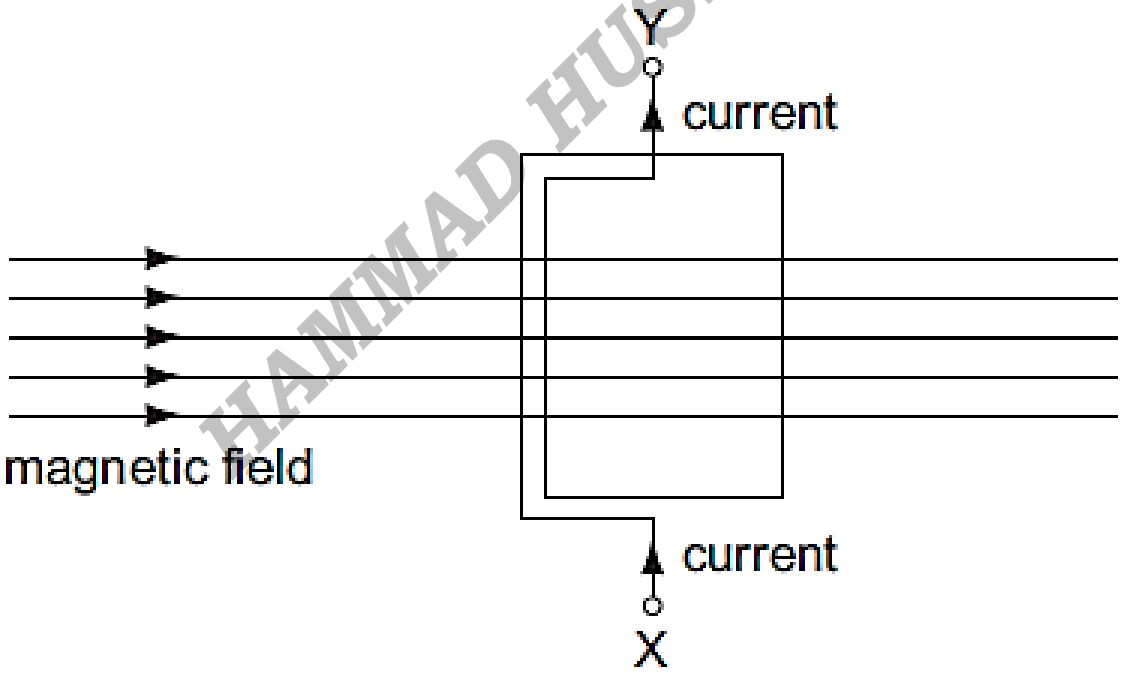


Which two pairs of lengths of wire attract each other?

	first pair	second pair
A	J and K	K and M
B	J and K	L and M
C	J and L	K and M
D	J and L	L and M

B

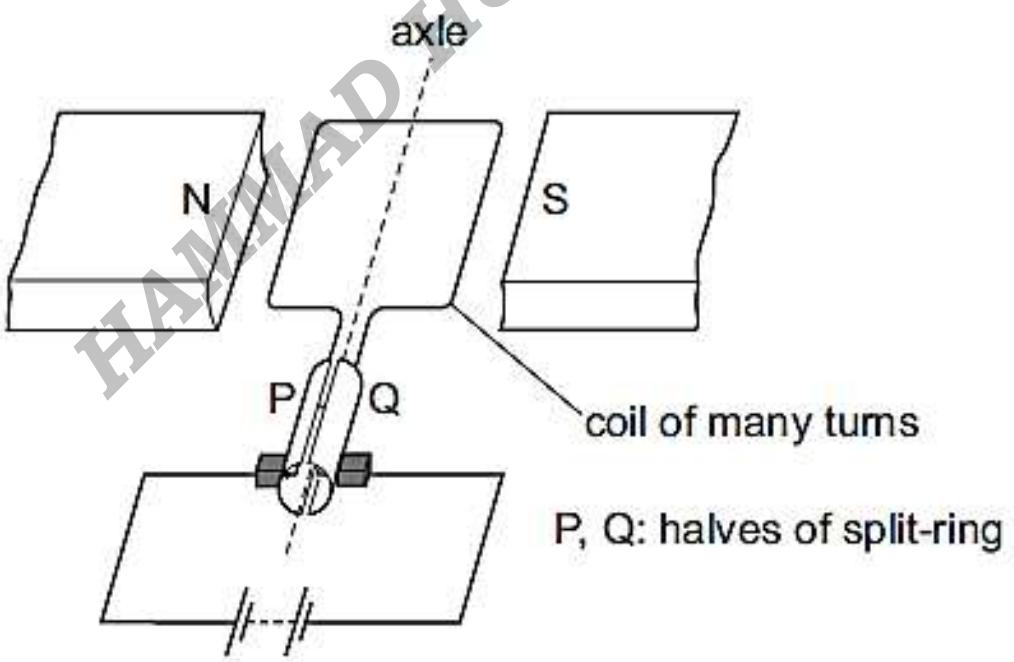
11. A coil, carrying a current, is arranged within a magnetic field. The coil experiences forces that can make it move.



In which direction does the coil move?

A. along the magnetic field
B. from X to Y
C. out of the paper
D. turns about the axis XY

12. A d.c. motor consists of a coil of many turns rotating in a fixed magnetic field. The coil is connected to a d.c. supply through a split-ring commutator.



Some changes are made, one at a time.

- The d.c. supply is reversed.
- The coil is turned before switching on, so that P starts on the right and Q on the left.
- The poles of the magnet are reversed.
- The turns on the coil are increased in number.

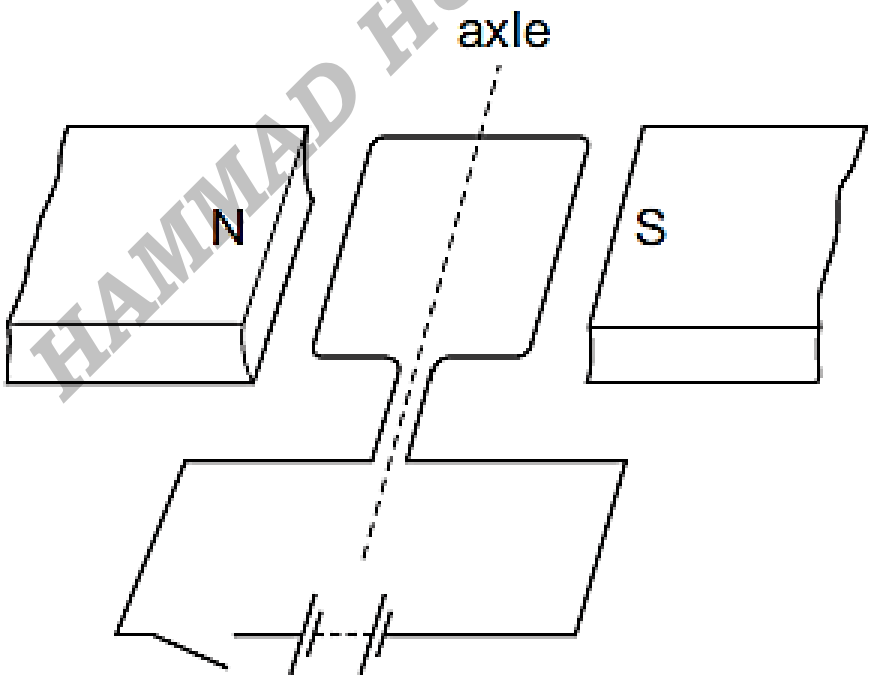
How many of these changes make the coil rotate in the opposite direction?

A. 1
B. 2
C. 3
D. 4

13. What does not alter the size of the turning effect on the coil of an electric motor?

A. the direction of the current in the coil
B. the number of turns in the coil
C. the size of the current in the coil
D. the strength of the magnetic field

14. A simple model of a d.c. motor is made. By mistake, the split-ring commutator is left out. The coil can turn, but is always connected to the battery in the same way.

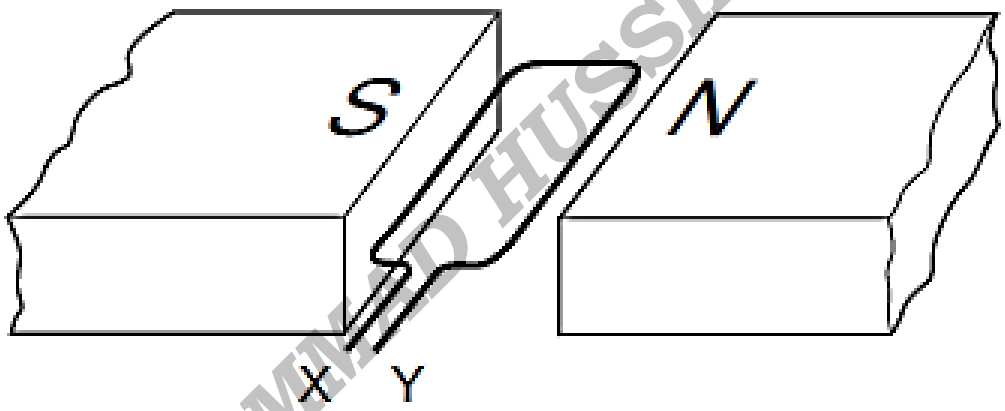


The coil starts in the horizontal position.

What happens to the coil when the circuit is switched on?

A. It does not move at all.
B. It moves upwards, out of the magnetic field.
C. It turns to the vertical position and eventually stops there.
D. It turns to the vertical position then comes back to the horizontal position.

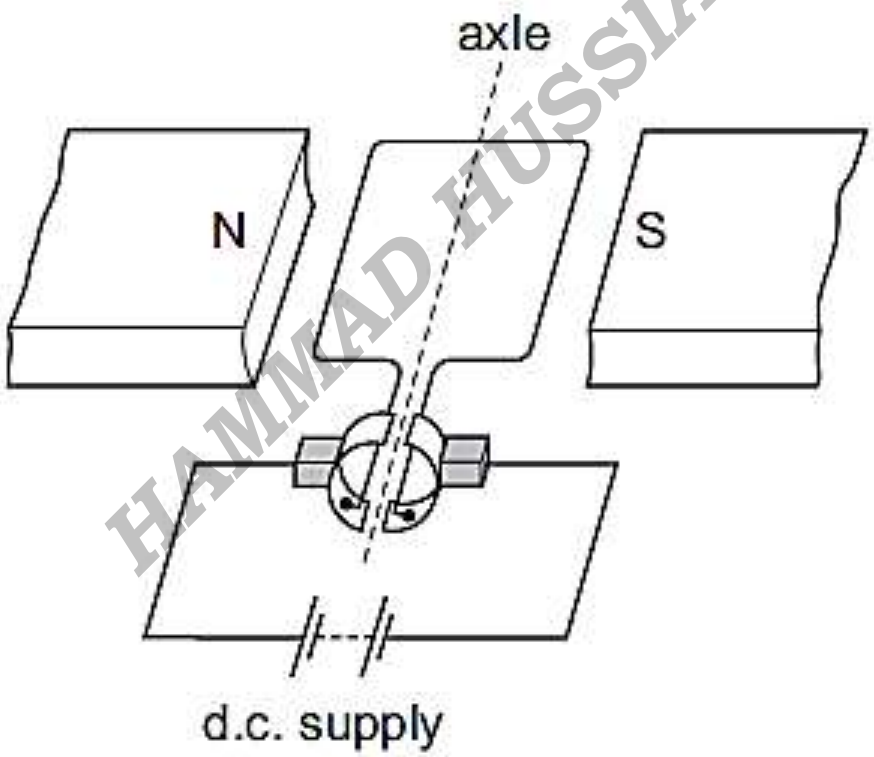
15. The diagram shows a coil in a magnetic field.



When the coil is part of a d.c. motor, what must be connected directly to X and Y?

A. d.c. supply
B. slip rings
C. soft-iron core
D. split-ring commutator

16. The diagram shows a d.c. motor.



Why is a split-ring commutator used?

A. to change the current direction in the coil as the coil passes the horizontal position
B. to change the current direction in the coil as the coil passes the vertical position
C. to change the current direction in the d.c. supply as the coil passes the horizontal position
D. to change the current direction in the d.c. supply as the coil passes the vertical position

17. In a d.c. motor, the coil is wound on a soft iron cylinder. Why is soft iron used?

A. to increase the strength of the magnetic field
B. to increase the weight of the coil
C. to insulate the coil from the magnet
D. to prevent the coil from spinning too quickly