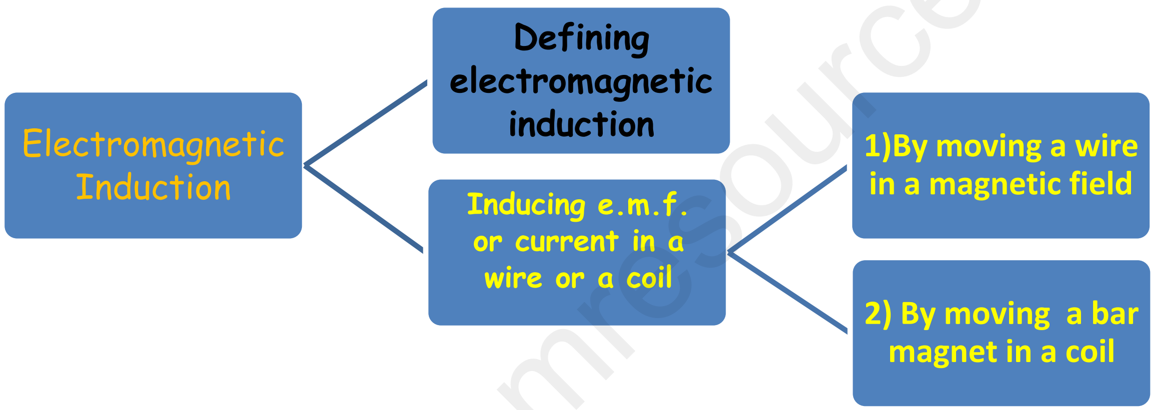
Electromagnetic Effects

Basic outline of the unit



Once a current has been induced in the coil, you need to know :

1. How to find the direction of the induced current
2. How to increase/decrease the induced current.
3. Ways of changing the direction of the induced current.
4. That the Lenz's law is used to find the direction of the induced current in the coil.
5. That the 'Right hand thumb rule " is used to find the direction of the induced current when a wire is moved in between the poles of a magnet.

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1. Electromagnetic induction: [2]

When a magnetic field is cut by a conductor(wire /coil or solenoid), a current (or an e.m.f.) is induced by it. This is called as electromagnetic induction

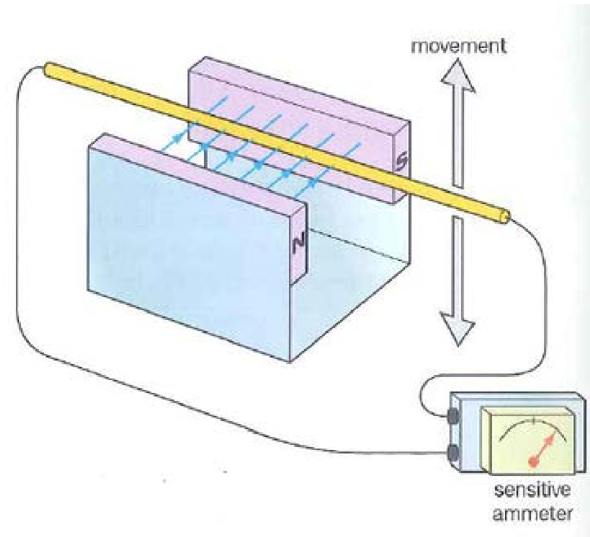
or

A changing magnetic field in the coil induces a current or an e.m.f. in it. This is said to be electromagnetic induction.

2.Understanding the two ways of generating an "induced e.m.f and current"

- by moving a wire in a magnetic field.

Diagram:



Steps to induce an e.m. f. and current.

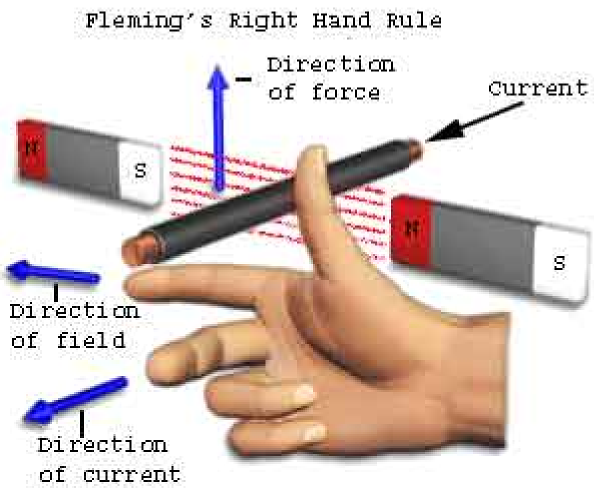
Step 1: Take 2 magnets. Then take a wire and connect it to a galvanometer as shown.

Step 2: Move the wire between the poles of the magnet.

Observation:

- When the wire is moved up, the galvanometer needle points in one direction.
- When the wire is moved down, the galvanometer moves in the opposite direction.
- When the wire is held stationary , the galvanometer points to zero.

Finding the direction of the induced current

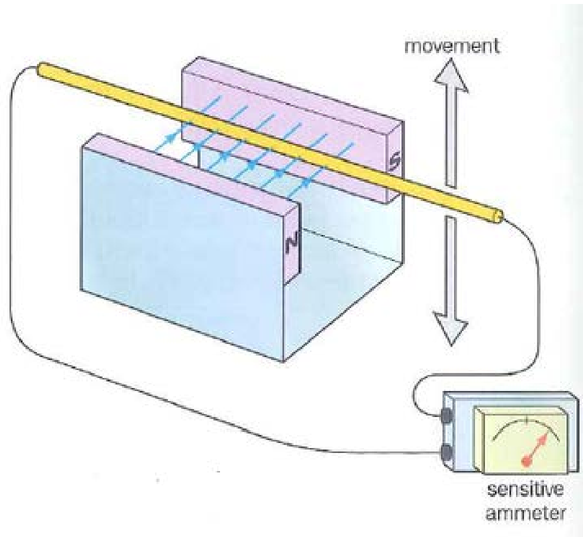


When a straight wire is **moved perpendicular** to the magnetic field, the direction of the induced e.m.f. can be found by using Flemings Right Hand **Rule.**

Note :

- The first finger always points in the north south direction as shown.
- The thumb points in the direction of the current.
- The second finger points in the direction of the induced current.

Different ways of increasing the magnitude of the induced e.m.f. and current.



1. Move the wire faster.
2. Use a stronger magnet.
3. Increase the length of the wire in the magnetic field.

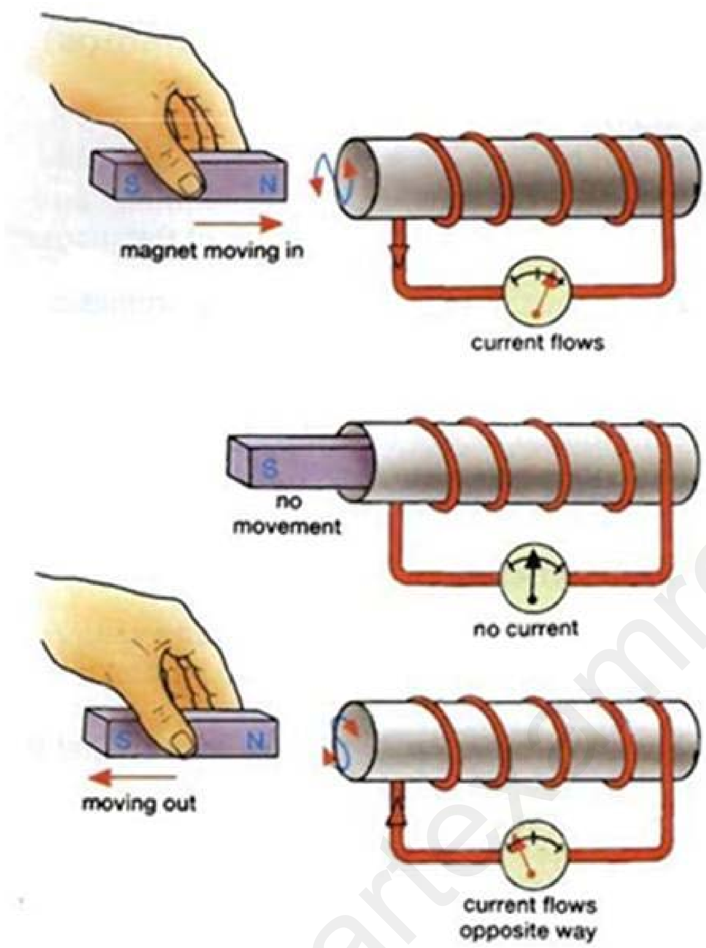
Ways of changing the direction of the induced e.m.f .and current.

1. Move the wire in the opposite direction.
2. Turn the magnet around so that the poles of the magnet are reversed.

Different reasons why the direction of the induced e.m.f. and current might not change:

1. The wire might be stationary
2. The wire might be moving parallel to the magnetic field lines.

2.Understanding the two ways of generating an "induced e.m.f and current" (continued)



- by moving a magnet in a steady coil (solenoid):

Diagram:

Steps to induce an e.m.f. and current.

Step 1: Take a bar magnet and push it into a solenoid connected to a galvanometer as shown above.

Observation:

- When the bar magnet is moved in , the galvanometer needle points in one direction.
- When the bar magnet is moved out , the galvanometer moves in the opposite direction.
- When the magnet is held stationary , the galvanometer points to zero (shows no deflection)

Different ways of increasing the magnitude of the induced e.m.f. and current.

1. Move the magnet faster.
2. Use a stronger magnet.
3. Increase the number of turns of the coil of the wire in the magnetic field.

Ways of changing the direction of the induced e.m.f .and current.

1. Pull the magnet out of the solenoid if earlier you had pushed it in.
2. Push the North pole of the magnet in the solenoid instead of the South pole
3. Turn the magnet around so that the poles of the magnet are reversed.

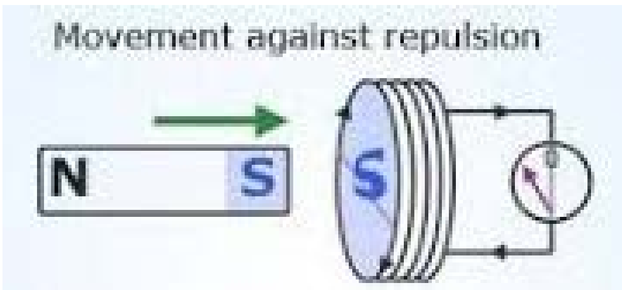
Different reasons why the direction of the induced e.m.f. and current might not change:

1. The magnet might have been held still

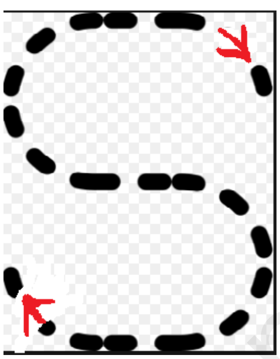
Finding the direction of the induced current -Lenz's law

Lenz's law states that

" An induced current always flows in a direction so as to oppose the change that created it"



For example: When a magnet approaches a coil with its south pole facing the coil, a current is induced in the coil. This induced current turns the coil into a weak electromagnet with an induced south pole as shown in the diagram .



To find the direction of the current:

Step 1: Check the polarity induced in the coil: In our example , it is the South pole.

Step 2: Write the alphabet S as as shown above along with the arrows.

Step 3: The direction of the arrows shows the

Hence When the South pole of a magnet approaches a coil , a current in the clockwise direction is induced in the coil and that part of the coil develops a South pole on it.

The table on the next page summarises all the possible directions and polarites that can be induced in the coil

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The following table will help you identify the polarity induced and the direction of flow of the current in the coil.

	Bar magnet	What will the coil try to do as per Lenz's law	Polarity induced in the coil	Direction of current in the coil
1	Enters the coil with its North pole facing the coil	Stop it from entering the coil by offering it repulsion	North	Anticlockwise 
2	Enters the coil South pole facing the coil	Stop it from entering the coil by offering it repulsion	South	Clockwise 
3	Leaves the coil with its North pole facing the coil	Stop it from leaving by attracting it towards it	South	Clockwise 
4	Leaves the coil with its South pole facing the coil	Stop it from leaving by attracting it towards it	North	Anticlockwise 

[As like poles repel, so as per lenz's law, the direction of the induced e.m.f. tried to stop the approaching magnet from moving towards it and hence developed a South pole on it]

Type of application based questions asked so far:

MCQ's:

1. Know that e.m.f. and current can only be induced in conductors and not in insulators like nylon.

37 The diagram shows an experiment to demonstrate electromagnetic induction. 326

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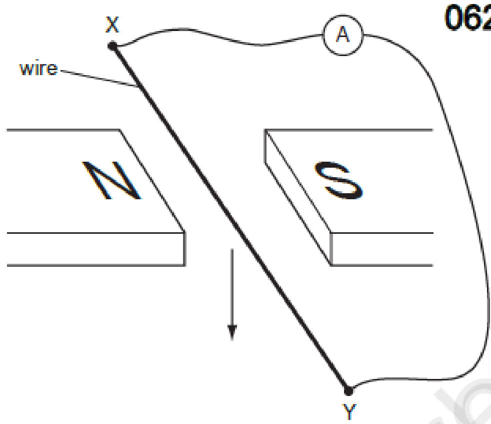

X and Y are joined, in turn, by four wires, each made of a different material.

Each wire is then moved quickly downwards between the magnets.

Which material will **not** give rise to an induced current in the wire?

A aluminium

B copper

C iron

D nylon

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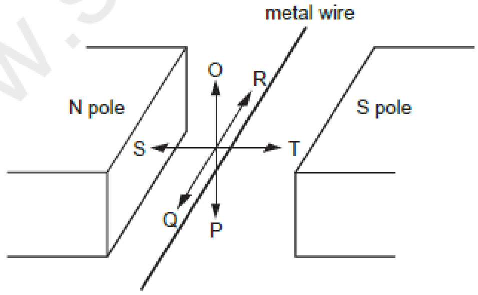
2. Know that a current is induced only when the wire is moved perpendicular to the magnetic field

35 A metal wire is placed between the poles of a magnet.

The wire can be moved in each of three directions OP, QR and ST. **0625/12/M/J/14**



In which direction or directions must the wire be moved to induce an e.m.f. across the ends of the wire?

A OP only **B** OP or ST **C** QR **D** ST only

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3. Know that if an alternating force is applied on the wire in a magnetic field , then the current keeps changing about a fixed value

35 The diagram shows a wire in the magnetic field between two poles of a magnet. 374

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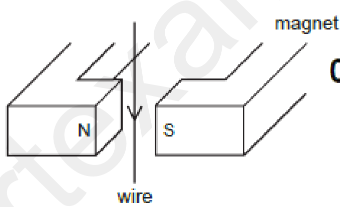
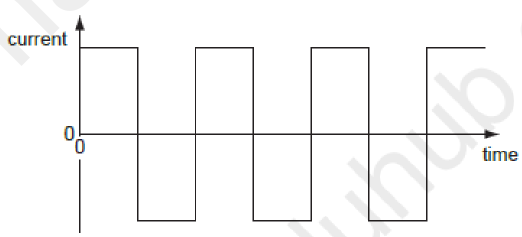


The current in the wire repeatedly changes between a constant value in one direction and a constant value in the opposite direction. This is shown on the graph.



What is the effect on the wire?

A The force on the wire alternates between one direction and the opposite direction.

B The force on the wire is constant in size and direction.

C There is no force acting on the wire at any time.

D There is only a force on the wire when the current reverses.

Extended theory:

9 Electromagnetic induction may be demonstrated using a magnet, a solenoid and other necessary apparatus.

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(a) Explain what is meant by *electromagnetic induction*.

....

....

....

.... [2]

(b) In the space below, draw a labelled diagram of the apparatus set up so that electromagnetic induction may be demonstrated. [2]

(c) Describe how you would use the apparatus to demonstrate electromagnetic induction.

....

....

....

.... [2]

(d) State two ways of increasing the magnitude of the induced e.m.f. in this experiment.

1. ....

....

2. ....

.... [2]

[Total: 8]

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33 A wire passes between the poles of a horseshoe magnet. There is a current in the wire in the direction shown, and this causes a force to act on the wire.

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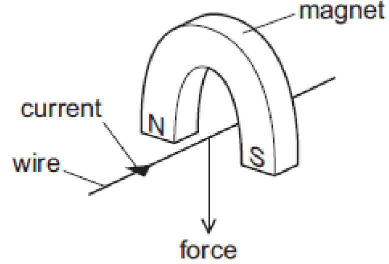
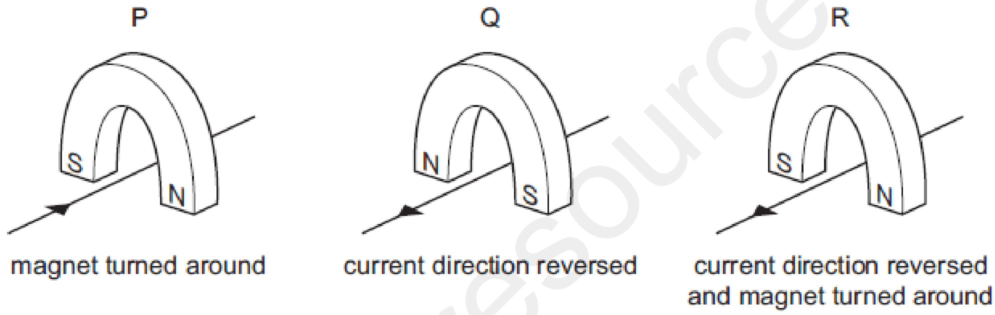


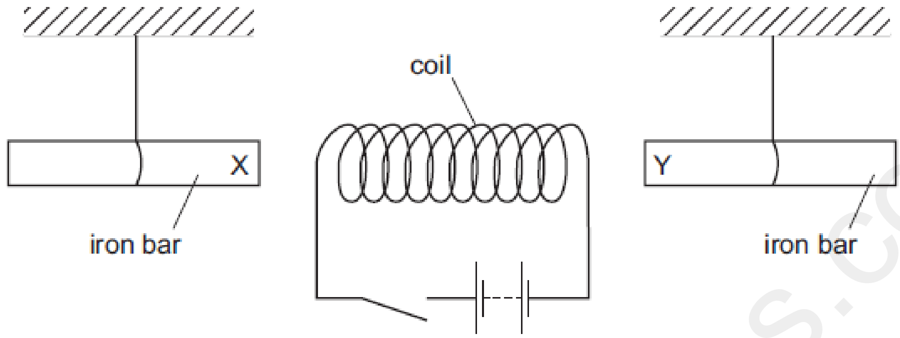
Three other arrangements, P, Q and R, of the wire and magnet are set up as shown.



Which arrangement or arrangements will cause a force in the same direction as the original arrangement?

A P, Q and R **B** P and Q only **C** P only **D** R only

36 The diagram shows a coil connected to a battery and a switch. Two unmagnetised iron bars hang freely near opposite ends of the coil.



What happens to the iron bars when the switch is closed?

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A Both X and Y move away from the coil.

B Both X and Y move towards the coil.

C X moves towards the coil, Y moves away from the coil.

D Y moves towards the coil, X moves away from the coil.

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37 The diagram shows an experiment to demonstrate electromagnetic induction.

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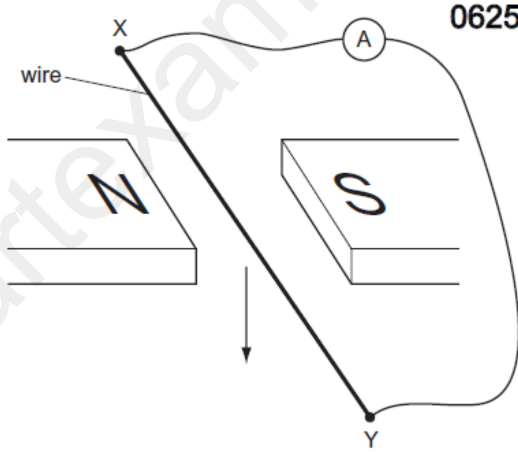

X and Y are joined, in turn, by four wires, each made of a different material.

Each wire is then moved quickly downwards between the magnets.

Which material will **not** give rise to an induced current in the wire?

A aluminium

B copper

C iron

D nylon

APPLICATION BASED QUESTION-EXTENDED THEORY

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9 Fig. 9.1 shows apparatus used to investigate electromagnetic effects around straight wires.

M/J/08-p31

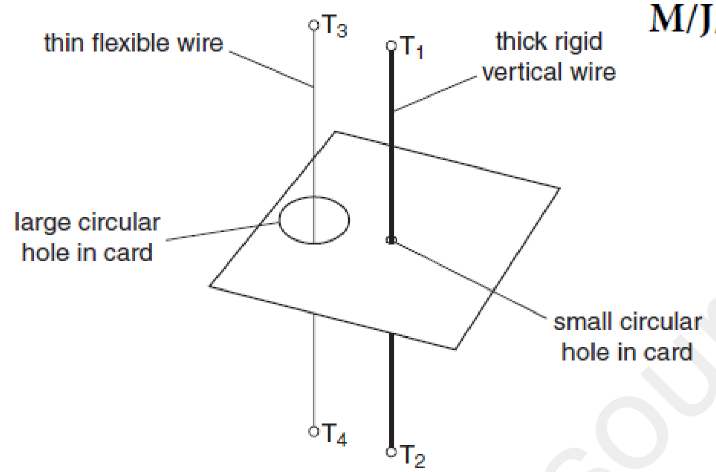

Fig. 9.1

Fig. 9.2 is a view looking down on the apparatus shown in Fig. 9.1.

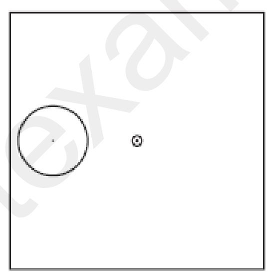

Fig. 9.2

(a) A battery is connected to T_1 and T_2 so that there is a current vertically down the thick wire.

On Fig. 9.2, draw three magnetic field lines and indicate, with arrows, the direction of all three. [2]

(b) Using a variable resistor, the p.d. between terminals T_1 and T_2 is gradually reduced.

State the effect, if any, that this will have on

(i) the strength of the magnetic field, ... [1]

(ii) the direction of the magnetic field. .... [1]

(c) The battery is now connected to terminals T_3 and T_4, as well as to terminals T_1 and T_2, so that there is a current down both wires. This causes the flexible wire to move.

(i) Explain why the flexible wire moves.

....

....

....

.... [2]

(ii) State the direction of the movement of the flexible wire.

.... [1]

(iii) The battery is replaced by one that delivers a smaller current.

State the effect that this will have on the force acting on the flexible wire.

....

.... [1]

[Total: 8]

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9 (a) Fig. 9.1 illustrates the left hand rule, which helps when describing the force on a current-carrying conductor in a magnetic field.

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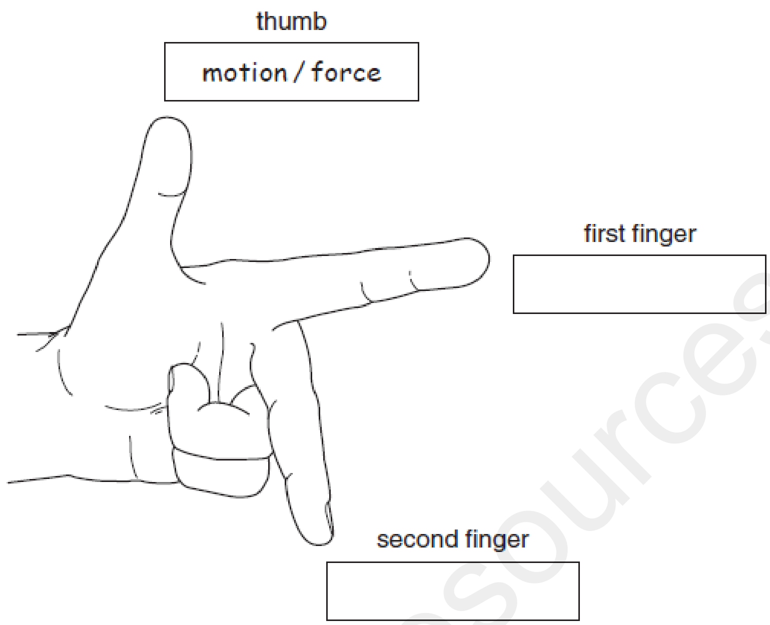

Fig. 9.1

One direction has been labelled for you.

In each of the other two boxes, write the name of the quantity that direction represents. [1]

(b) Fig. 9.2 shows a simple d.c. motor connected to a battery and a switch.

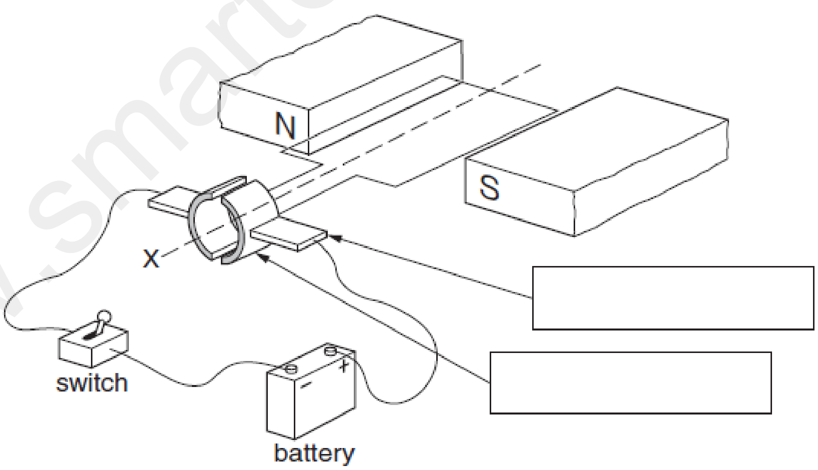

Fig. 9.2

(i) On Fig. 9.2, write in each of the boxes the name of the part of the motor to which the arrow is pointing. [2]

(ii) State which way the coil of the motor will rotate when the switch is closed, when viewed from the position X.

.... [1]

(iii) State two things which could be done to increase the speed of rotation of the coil.

1. ....

2. .... [2]

[Total: 6]