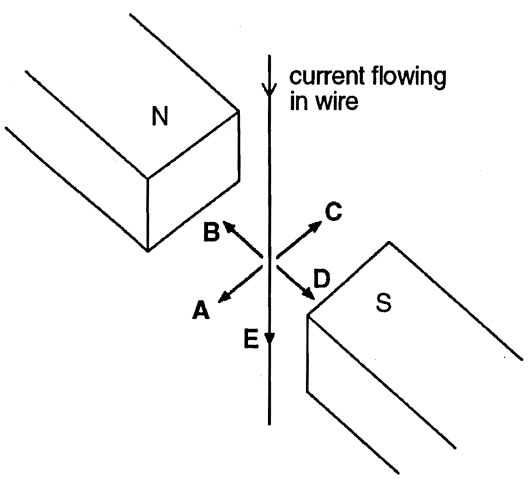
TOPIC 21 Electromagnetism

21.1 Force on a current-carrying conductor
21.2 The d.c. motor

1 A beam of electrons passes through a television tube to the screen. Why may the beam be deflected by a strong bar magnet?

A The magnet magnetises the sensitive coating of the screen.
B The electrons behave as an electric current in a magnetic field.
C The North pole of a magnet repels all negatively charged particles.
D The magnet neutralises the charge on the electrons.
E The magnet is positively charged. N90/I/36

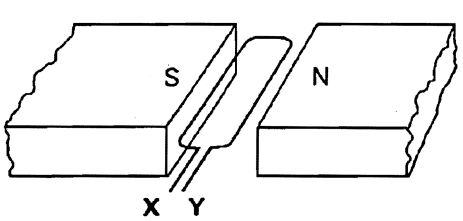
2 A current flows in a wire hanging between the poles of a magnet.



In which direction does the wire try to move?

J91/I/34 ; N94/I/34

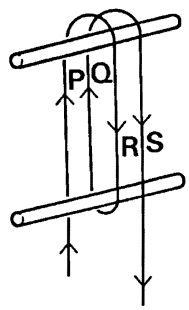
3 The diagram shows a coil in a magnetic field.



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

A a.c. supply
B d.c. supply
C slip rings
D soft iron core
E split-ring commutator N91/I/33 ; J94/I/34

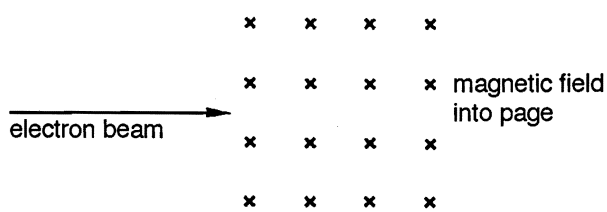
4 A long flexible wire is wrapped round two wooden pegs. A very large current is passed in the direction shown.



Which two lengths of wire attract each other?

A **P** and **R**
B **P** and **S**
C **Q** and **R**
D **Q** and **S**
E **R** and **S** J92/I/34

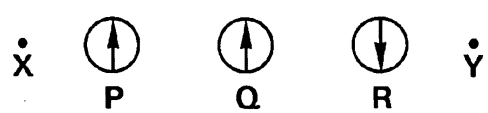
5 The diagram shows a beam of electrons about to enter a magnetic field. The direction of the field is into the page.



What will be the direction of the deflection, if any, as the beam passes through the field?

A towards the bottom of the page
B towards the top of the page
C into the page
D out of the page
E no deflection J92/I/35

6 **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.

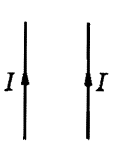


What is true about the direction and size of the currents?

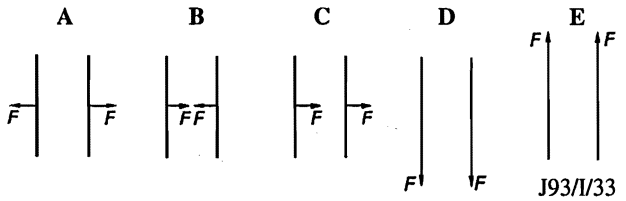
	direction of currents	*size of currents*
A	same	larger in **X** than in **Y**
B	same	same in **X** as in **Y**
C	same	smaller in **X** than in **Y**
D	different	larger in **X** than in **Y**
E	different	smaller in **X** than in **Y**

N92/I/34

7 Two parallel wires are carrying equal currents in the same direction.



Which diagram shows the forces acting on the wires due to the magnetic effect of these currents?

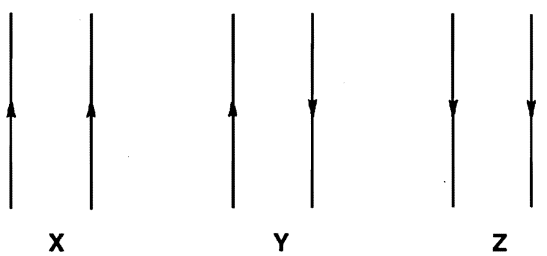


J93/I/33

8 A beam of electrons passes along a television tube to the screen. The beam may be deflected by a strong bar magnet because

- **A** the beam of electrons behaves as an electric current in a magnetic field.
- **B** the magnet is positively charged.
- **C** the magnet magnetises the sensitive coating of the screen.
- **D** the magnet neutralises the charge on the electrons.
- **E** the north pole of a magnet repels all negatively charged particles. N93/I/33

9 The diagram shows three pairs of parallel wires with currents in the directions shown.



Which forces do the pairs of wires experience?

	X	Y	Z
A	attraction	none	repulsion
B	attraction	repulsion	attraction
C	none	attraction	none
D	repulsion	attraction	repulsion

J95/I/32

10 Which part of a simple d.c. motor reverses the direction of current through the coil every half-cycle?

- **A** the armature
- **B** the brushes
- **C** the commutator
- **D** the slip rings J95/I/33

11 Why is a commutator used in a d.c. motor?

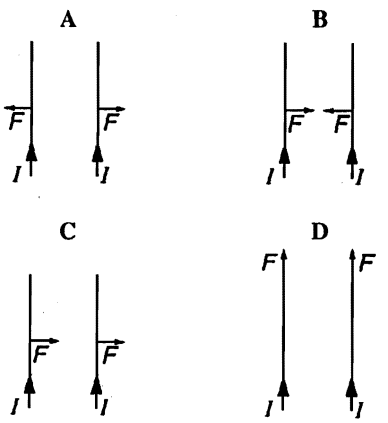
- **A** It allows the coil to rotate by preventing the wires from becoming tangled.
- **B** It allows the coil to rotate by reversing the current through the coil every half-turn.
- **C** It produces a greater turning effect by becoming magnetically induced.
- **D** It produces a greater turning effect by increasing the current through the coil. N95/I/34

12 An electric motor could be used as a

- **A** battery.
- **B** capacitor.
- **C** dynamo.
- **D** transformer. J96/I/32

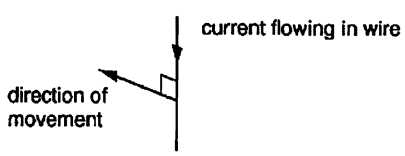
13 Two parallel wires are carrying equal currents in the same direction.

Which diagram shows the forces, *F*, acting on the wires due to the magnetic effect of these currents?

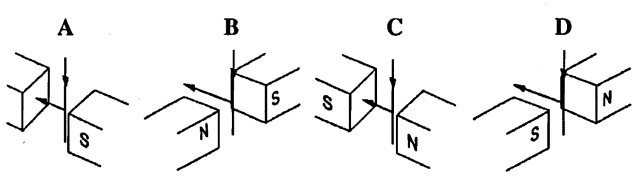


J96/I/34

14 A current flows in a wire hanging between the poles of a magnet. The wire starts to move in the direction shown.

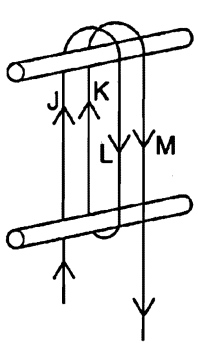


Which diagram shows the position and the polarity of the magnet?



N96/I/33

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



In which two pairs do the 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

N97/I/35

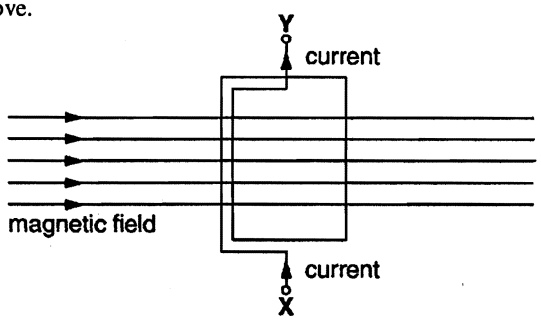
16 In a simple d.c. motor, the direction of the current in the motor is reversed every half-revolution to keep the motor turning in the same direction.

Which part of the motor does this?

A	brushes	**C**	commutator
B	coil	**D**	poles

J98/I/31

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

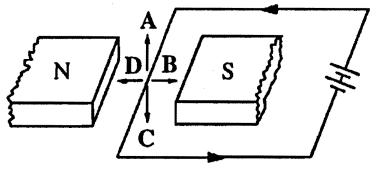


How does the coil move?

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

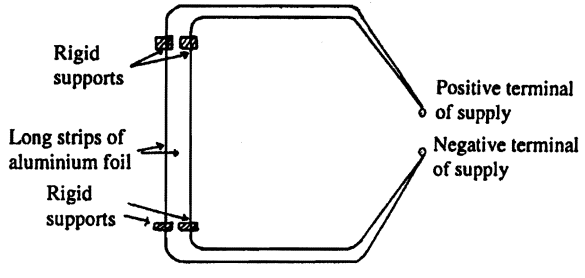
J98/I/33

18 A current-carrying wire is placed between the poles of a magnet.



In which direction will the force due to the current try to move the wire? N2000/I/32

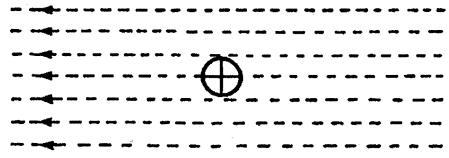
19 *(a)* The apparatus shown in the diagram is connected to a suitable low voltage d.c. supply. What is seen to happen and why does it occur?



(b) What would be the effect of interchanging the terminals of the supply?

(c) What would be the effect of changing the d.c. supply to an a.c. supply of frequency about 1 Hz? Give a reason for your answer. J79/I/12

20 The diagram illustrates the end-on view of a copper wire along which an electric current is to be passed into the plane of the paper. The wire is placed perpendicular to the paper, and at right angles to a uniform magnetic field in the direction shown by the arrows on the field lines.



When the current is flowing through the wire, a force acts on it due to the action of the magnetic field on the electric current. Draw on the diagram an arrow to show the direction in which the force acts.

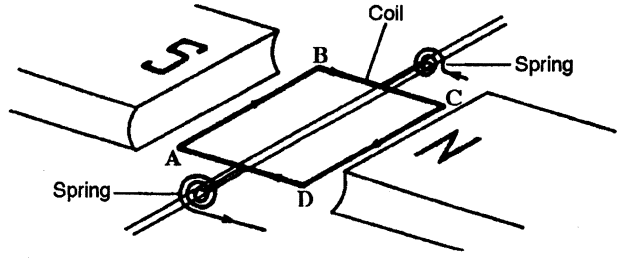
Suggest **two** factors which affect the magnitude of the force. N79/I/12

21 Describe experiments to demonstrate

(i) the pattern of the magnetic field produced by a long straight wire which is carrying a current, ignoring the effect of the Earth's magnetic field,

(ii) the behaviour of a wire supported perpendicular to the lines of force (field lines) of a magnetic field, so that it is free to move when a current is passed through the wire. J80/II/12 (part)

22 The diagram shows some of the parts of a simple moving coil galvanometer; the arrows indicate the direction of the current flowing through the coil.

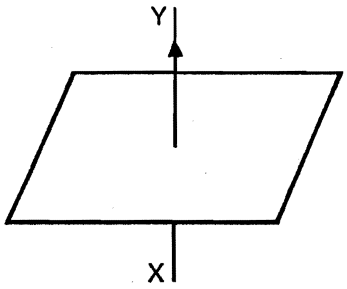


(a) Mark on the diagram the forces acting on sides AB and CD of the coil.

(b) The springs serve **two** purposes; what are they? N80/I/11

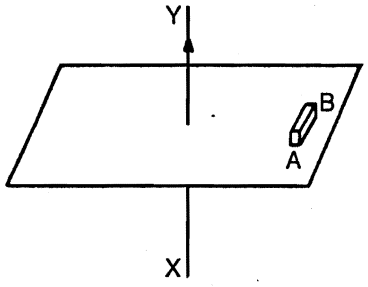
23 *(a)* Diagram *(a)* shows a wire XY carrying a steady electric current in the direction shown. Sketch magnetic field lines, in the horizontal plane indicated, to show the pattern of the magnetic field produced by the current in this plane. Mark clearly the direction of the field. Ignore the effects of the Earth's magnetic field.

(a)



(b) With the current switched off a short piece of unmagnetised soft iron, AB, is placed alongside the wire in a horizontal plane, as shown in diagram *(b)*. The current is switched on again.

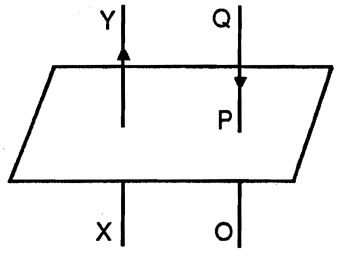
(b)



State clearly any effects produced in the soft iron by the current.

(c) Diagram *(c)* shows a second wire, OQ, parallel and close to XY, carrying a current in the opposite direction to the current in XY.

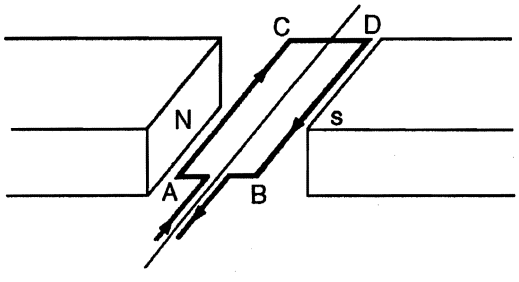
(c)



Indicate by means of a labelled arrow on diagram *(c)* the direction of the *magnetic field* due to the current in XY, at the point P, which is the point where OQ passes through the horizontal plane. Draw a second labelled arrow to show the direction of the *force* acting on OQ at P due to the current in XY.

(d) Suggest any factors which you consider may affect the magnitude of the force on OQ at P. N80/II/4

24



The diagram shows a rectangular coil mounted on an axle and placed between the poles of a permanent magnet. Show clearly the direction in which the coil beings to rotate when a current flows through it in the direction shown.

Why is a commutator necessary in order to obtain continuous rotation?

Add a correctly oriented commutator to the diagram. J81/I/12

25 Describe an experiment which demonstrates the direction of the force acting on a wire which is at right angles to a magnetic field and carries an electric current.

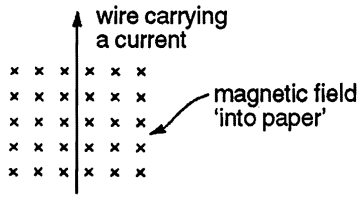
Rotation of the coil of a d.c. motor is produced by forces exerted on conductors in a magnetic field. In order to investigate the performance of such a motor it is necessary to measure

(i) the electrical power input from the d.c. source driving the motor,

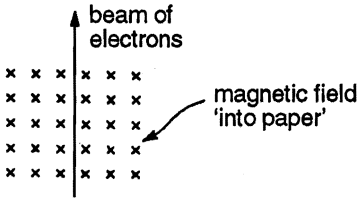
(ii) the rate at which the motor does work in lifting a load at a constant speed.

Describe experiments by which you could measure these two quantities. J82/I/II/2

26 *(a)*



(b)



The diagrams show *(a)* a current flowing in a wire, *(b)* a beam of electrons, each travelling in the indicated direction, perpendicular to an external magnetic field directed into the paper. Show clearly on the diagrams the direction of the force on

(i) the wire, (ii) the electron beam.

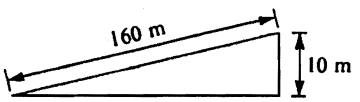
The wire carrying the current and the electron beam are then arranged to be close together, with the directions of flow as shown but *without* the external magnetic field. In the space below, draw a labelled diagram to show the forces acting between the wire and the beam of electrons. N83/I/13

27 Describe with the aid of a labelled diagram an experiment you could perform to show that a wire carrying an electric current perpendicular to a magnetic field experiences a force; indicate on the diagram the direction of the force.

Draw a labelled diagram of a simple d.c. motor and state the purpose of *four* of the components you have labelled.

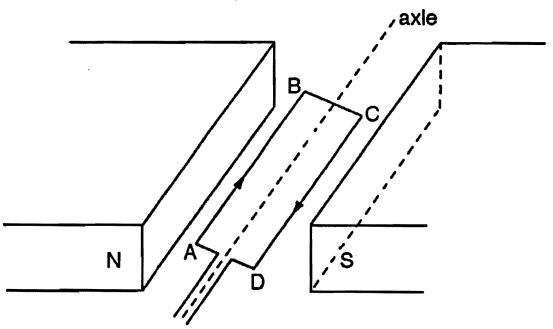
A small vehicle, mass 640 kg, is powered by a battery driven electric motor. Calculate the power the motor must develop to propel the vehicle up the incline illustrated below at a steady speed of 2 m/s. The frictional resistances to the motion are equal to a force of 200 N.

(Take the force of gravity on 1 kg to be 10 N.)



J85/II/12

28 The diagram shows a coil of wire mounted freely on an axle, between the poles of a permanent magnet. A direct current passes through the coil in the direction shown. Show on the diagram the directions of the forces acting on the sides AB and CD of the coil in this position.



In order to produce continuous rotation of the coil a commutator is needed. State clearly the function of the commutator.

N85/I/15

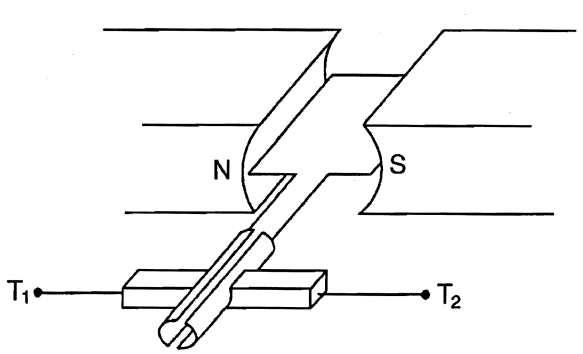
29 Describe an experiment to determine the shape of the magnetic field lines around a long straight wire carrying a current. Draw a diagram to show the result you would expect.

A second wire, identical to the first and carrying the same value of current in the same direction is placed parallel and close to the first wire. Draw a diagram of the arrangement and mark the directions of the forces acting on each wire.

Describe the effect on these forces of (i) increasing the current, (ii) moving the wires closer together.

N85/II/10 (part)

30



The diagram represents a simple d.c. motor with input terminals T_1 and T_2.

In order to work the motor must be connected to a power supply.

(a) Complete the diagram to show an electric circuit which includes:

(i) a power supply of fixed voltage,

(ii) an ammeter to measure the motor current,

(iii) a switch,

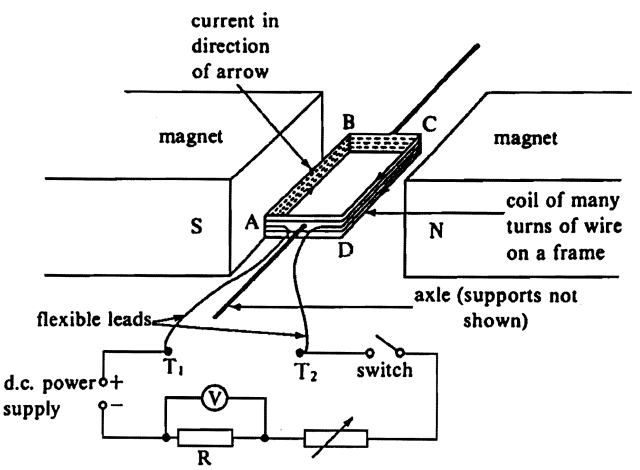
(iv) a rheostat arranged so that the current may be altered.

(b) Mark the positive terminal of items (i) and (ii).

(c) By reference to your diagram explain carefully the setting of the rheostat which would result in the smallest possible value for the motor starting current.

J86/I/II/3

31 The diagram shows a coil of many turns wound on an insulating frame which is mounted on a horizontal axle between the pole pieces of a powerful magnet.



(a) The frame is initially set in the position shown in the diagram. When the switch is closed an electric current is passed through the coil in the direction ABCD. Explain why the frame begins to turn so that side AB moves above CD.

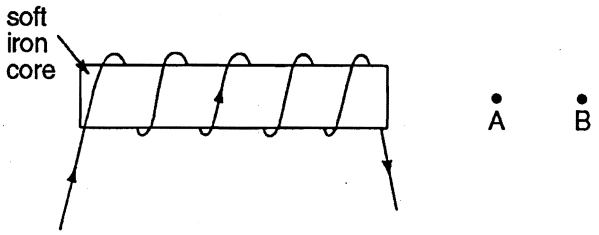
(b) (i) Draw and label on the diagram the additions necessary to make the device useful as a moving coil instrument for measuring current.

(ii) Describe how you would determine the deflection corresponding to a current of 1.0 A through the coil ABCD. V is an accurate voltmeter and R, the resistor shown, has a resistance of 5.0 Ω.

(c) It is observed that when a small resistance is connected between T_1 and T_2, the deflection produced for a circuit current of 1.0 A is reduced. Explain why this is so.

J86/II/5

32 The diagram shows a coil of wire wound on a soft iron core. A current is passed through the coil in the direction indicated by the arrows.

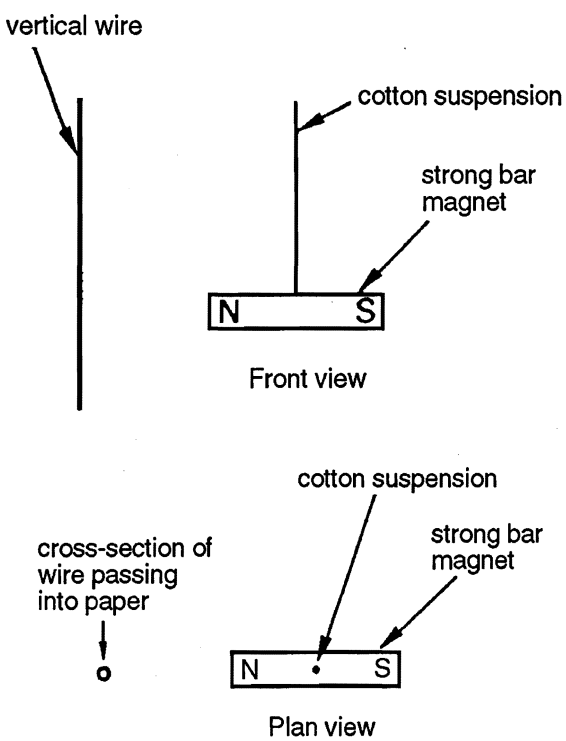


(a) Mark the N and S poles produced in the iron core.

(b) Show by an arrow the direction in which the N end of a compass needle would point when placed at A.

(c) A beam of electrons flows through the point B in a direction that is perpendicularly downwards into the paper. Show clearly by an arrow labelled F, the direction of the force exerted by the magnetic field on the electron beam. N86/I/12

33 Describe with the aid of a labelled diagram how you would carry out an experiment to find the pattern of the magnetic field lines in a plane at right angles to a long straight wire carrying a current. [6]



Two views of an arrangement of a fixed rigid wire and a suspended magnet are shown above. The vertical wire is connected to a d.c. supply and the current switched on. With the aid of a sketch, describe and explain the *initial* movement of the magnet. Neglect the Earth's magnetic field. [4]

State **three** changes which could be made to the apparatus in order to produce a stronger *initial* effect. [3]

Suggest what energy transformations take place when the current in the wire is switched on and the magnet starts to move.

Name **one** practical device based on the principle that a current flowing in a wire near a magnet causes movement.[4] N87/II/10

34

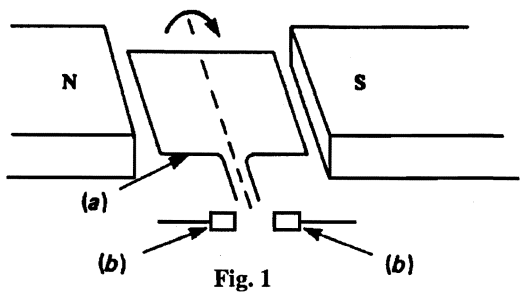


Fig. 1

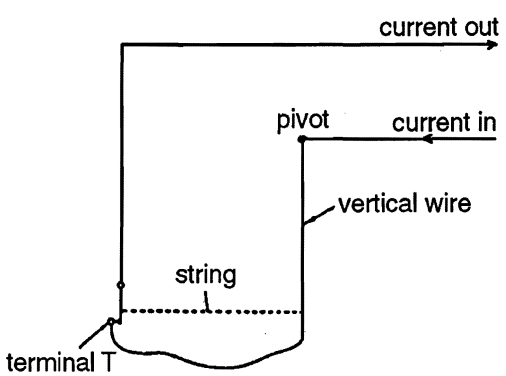
Fig. 1 shows some parts of a d.c. electric motor; name the parts *(a)* and *(b)*. [1]

Add to the diagram, and label, the component making contact with the parts *(b)* and complete the external circuit showing connections to a resistor R and a cell E. [2]

What is the effect on the speed of the motor of decreasing the resistance of R? [1] J88/I/12

35 *(a)* Explain how you would carry out an experiment to determine the pattern of the magnetic field around a vertical wire, in a plane at right angles to it, when a current passes through the wire. Sketch the result you would expect. [5]

(b) The arrangement shown in the diagram is a student's experimental device which controls the contact at terminal T by means of a length of string.



The labelled vertical wire is free to rotate in the plane of the diagram about the pivot at its upper end and the flexible connecting wire attached to its lower end allows this. Suitable positioning of a magnet enables the current through the wire to be switched off at a particular value.

(i) Describe carefully where the magnet should be placed and how it should be oriented. Explain how the required action is brought about. [4]

(ii) State *two* changes which could be made so that the string does not open the switch until a higher value of current is passed through the wire. [2]

(c) By means of a labelled diagram, show the arrangement you would use to produce a beam of electrons and then demonstrate the deflection of the beam by a magnet. [6]

N88/II/11

36 Fig. 2.1 and Fig. 2.2 show two views of some of the essential parts of a moving coil ammeter.

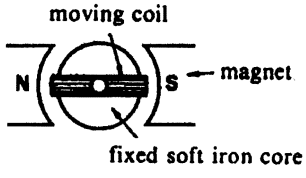


Fig. 2.1

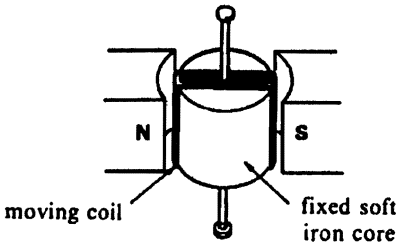


Fig. 2.2

(a) Mark on Fig. 2.1 the directions of the forces acting on the sides of the coil when there is a current in the coil. [2]

(b) Add to Fig. 2.2 a labelled component which will control the movement of the coil. [1]

(c) What other useful purpose does the control component in *(b)* serve when the current is switched off? [1]

J89/I/13

37 *(a)* Fig. 3.1 shows a solenoid which is connected to a battery so that the current in the solenoid is in the direction shown.

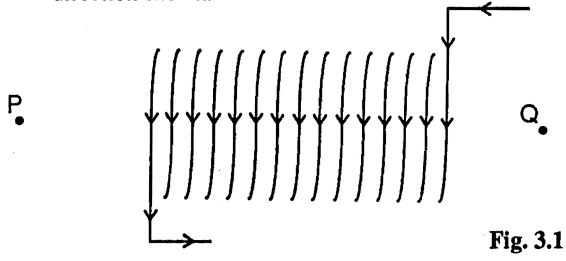


Fig. 3.1

(i) Draw the pattern of the magnetic field due to the current, bot h inside and outside the solenoid.

(ii) Draw arrows at **P** and **Q** to show the direction of the magnetic field at each of these points.

(iii) A beam of electrons is now directed at **P** such that the beam passes into the diagram in a direction which is at right angles to the plane of the diagram. Draw an arrow at **P** to show the direction of the force exerted on the electrons by the magnetic field due to the current in the solenoid. Label the arrow with the letter **R**. [6]

(b) Fig. 3.2 shows a rigid rectangular coil mounted on the axle **XY** which is perpendicular to the axis of the solenoid. The coil is connected through slip rings and brushes to a battery in a circuit which includes a switch.

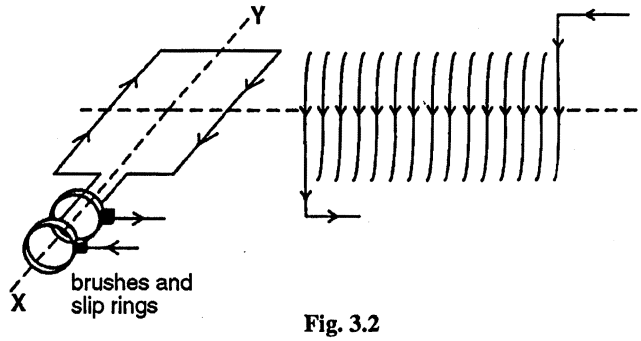


Fig. 3.2

(i) Explain why the coil begins to rotate when the switch is closed and the direction of the current in the rectangular coil is as shown.

(ii) Continuous rotation of the coil does not take place. Explain why this is so. [4]

N89/II/4

38 *(a)* Fig. 4 shows a cross-sectional view of a simple d.c. motor. The circles represent the sides of a rectangular coil which is placed between the poles of a permanent magnet. The current in the right-hand side of the coil flows into the diagram; the current in the left-hand side of the coil flows out of the plane of the diagram.

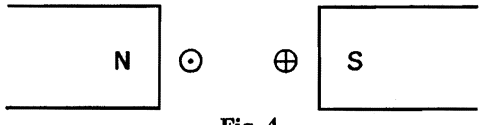


Fig. 4

(i) Copy Fig. 4 and draw lines to indicate the direction of the force experienced by each side of the coil.

(ii) Explain how the forces you have shown in (i) make the coil rotate.

(iii) State **two** ways in which the turning effect experienced by the coil could be increased. In each case, explain why the turning effect is increased.

(iv) State **two** ways in which a practical motor will be different from the simple motor drawn in Fig. 4. [8]

N90/II/9*(a)*

39 **Figure 5.1** shows a cross-section through a conductor carrying a current into the page.

Figure 5.2 shows a cross-section through a conductor carrying a current out of the page.

Figures 5.3 and **5.4** show cross-sections through pairs of current-carrying conductors.

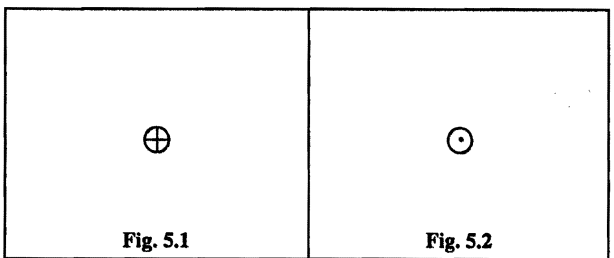


Fig. 5.1

Fig. 5.2

Fig. 5.3

Fig. 5.4

On each figure draw the magnetic field due to the current or currents in the conductor or conductors. [5]

J93/II/6

40 Figure 6.1 shows two similar narrow strips of aluminium foil, **P** and **Q**, held vertically and parallel to each other. When the same current is passed through each strip from top to bottom, the centre of the strips bow inwards as shown in Fig. 6.2.

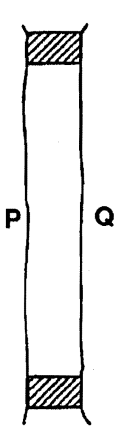


Fig. 6.1

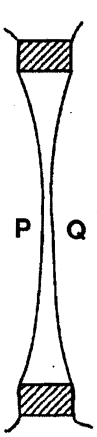


Fig. 6.2

(a) Draw diagrams to show the effects, if any, of

(i) sending the same current through each from bottom to top,

(ii) sending the same current through each, from top to bottom in **P** and from bottom to top in **Q**,

(iii) sending **half** the original current through each, both from top to bottom. [4]

(b) Explain, with the aid of carefully drawn diagrams, the strip movements shown by means of Figs. 6.1 and 6.2, and also those described in your answers to *(a)*. [7]

(c) You have available a battery of e.m.f. 12.0V, an ammeter of negligible resistance, a switch and a range of resistors.

(i) Draw a diagram to show the circuit you would use to enable the same current of 8.0 A to flow through each of the strips. Represent the strips by two thick lines labelled **P** and **Q**. Indicate on your diagram the value of any resistor and the range of any meter used. You may assume that the resistance of each of the strips is the same and that its value is very small.

(ii) Draw a second circuit diagram, **using exactly the same components**, to show how you would arrange for a current of 4.0 A to flow through each strip. [4]

N93/II/11

41 Fig. 7 shows a rectangular current-carrying coil mounted on a freely-pivoted horizontal shaft between the poles of a permanent magnet. The connections to a battery and the direction of the current in each side of the coil are shown; the sides of the coil are labelled **J, K, L** and **M.**

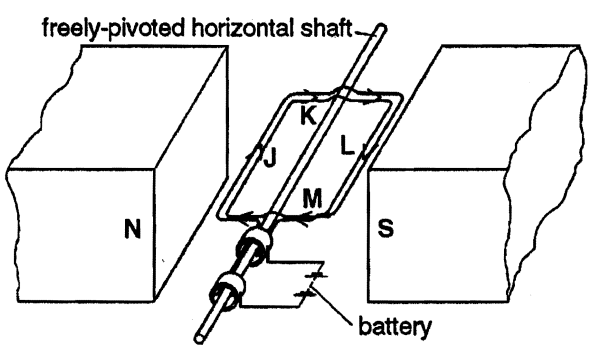


Fig. 7

(a) On Fig. 7, draw arrows to show the directions of the forces, if any, acting on the sides **J, K, L,** and **M.** [3]

(b) State what will happen to the coil as a result of these forces acting on it. [2]

J97/II/7

42 Fig. 8 is a diagram of a d.c. motor.

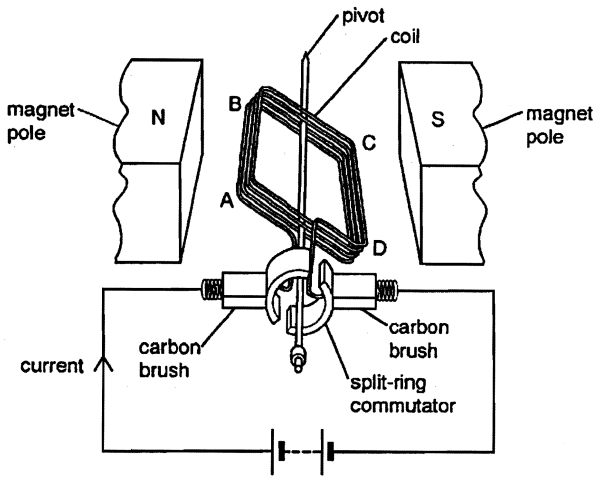


Fig. 8

(a) (i) State the direction of movement of side AB and of side CD when the current is in the direction shown in Fig. 8.

(ii) Explain the reason for your choices of direction. [3]

(b) When the coil ABCD is vertical, the brushes line up with the gaps in the split-ring commutator.

The coil rotates past the vertical position. Explain what happens

(i) to the current in the coil,

(ii) to the forces on the sides AB and CD of the coil. [2]

J99/II/6

43 Fig. 9 shows a light aluminium rod resting between the poles of a magnet. A current is passed through the rod from two brass strips connected to a power supply.

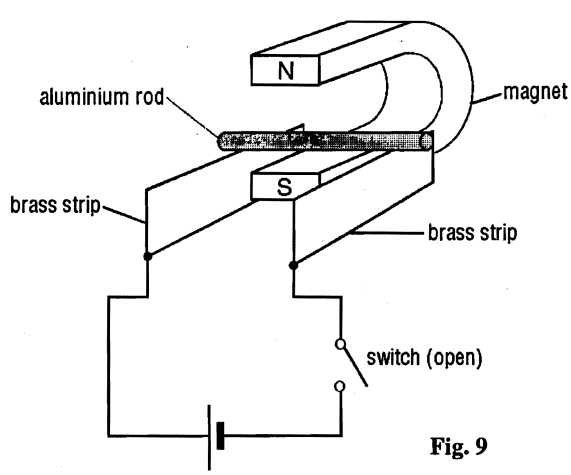


Fig. 9

(a) On Fig. 9, draw the direction of the current in the rod when the switch is closed. [1]

(b) State which way the rod moves when the switch is closed. Give a reason for your answer. [3]

(c) State the effect on the movement of the rod when

(i) the current is increased,

(ii) the current is reversed. [2]

N99/II/3

ANSWERS

1. **B**	2. **A**	3. **E**	4. **E**	5. **A**
6. **D**	7. **B**	8. **A**	9. **B**	10. **C**
11. **B**	12. **C**	13. **B**	14. **D**	15. **B**
16. **C**	17. **D**	18. **A**		