4. Electricity and magnetism

4.5 Electromagnetic effects

Paper 3 and 4

Question Paper

Paper 3

Questions are applicable for both core and extended candidates

1 **(c)** The power supply includes a transformer.

The voltage (V_p) across the primary coil of the transformer is 228 V. The voltage (V_s) across the secondary coil of the transformer is 12 V. The number of turns on the primary coil (N_p) is 760.

Calculate the number of turns (N_s) on the secondary coil.

number of turns on secondary coil = ... [3]

[Total: 8]

2 **(a)** Fig. 9.1 represents part of a d.c. electric motor. The coil of wire rotates at a steady speed.

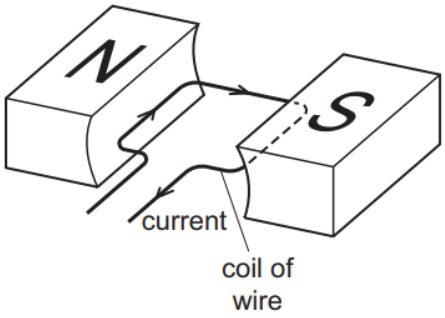


Fig. 9.1

State **two** ways to make the coil rotate faster.

1 .....

2 .....

[2]

(b) Fig. 9.2 shows an electric fan.

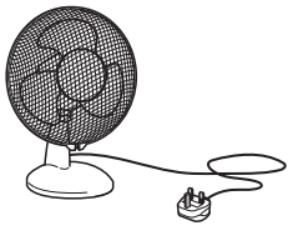


Fig. 9.2

The electric motor for the fan requires 120 V a.c. The mains voltage is 220 V a.c.
A transformer steps down the mains voltage as shown in Fig. 9.3.

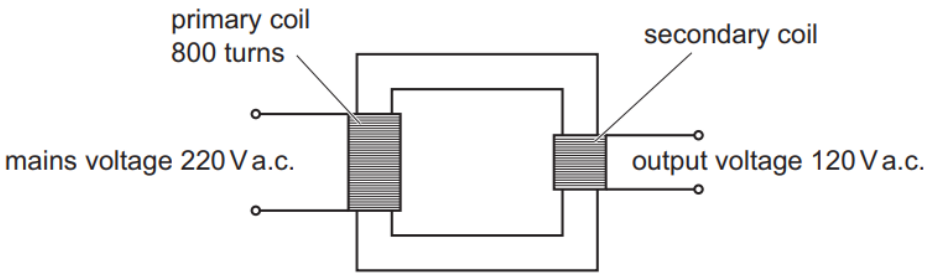


Fig. 9.3

Calculate the number of turns on the secondary coil. Use the information in Fig. 9.3.

number of turns on the secondary coil = ... [3]

3 Fig. 8.1 shows an arrangement for making an electromagnet. The electromagnet consists of a solenoid and a core.

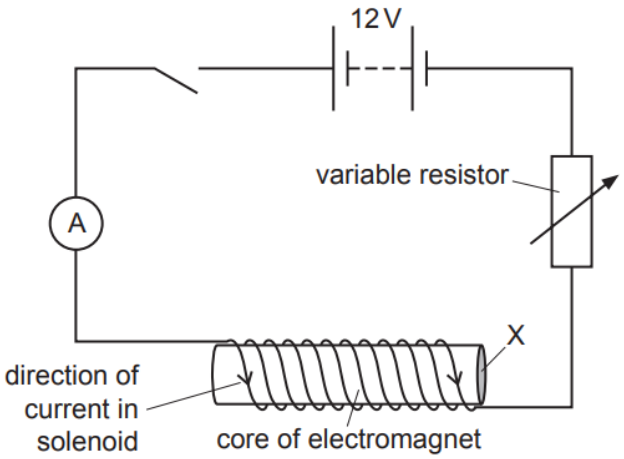


Fig. 8.1

(a) **(i)** The electromagnet is a temporary magnet.

State **one** material which is suitable for the core of the electromagnet.

..... [1]

(ii) The battery is made from cells connected in series. Each cell in the battery has an electromotive force (e.m.f.) of 1.5 V.

Calculate the number of cells in the battery in Fig. 8.1.

number of cells = ... [2]

(b) The switch is closed. The direction of the current in the solenoid is shown in Fig. 8.1.

(i) There is a magnetic field around the electromagnet.

State the name of a piece of equipment that can show the direction of a magnetic field.

..... [1]

(ii) State the name of the pole labelled X on the core of the electromagnet.

..... [1]

(c) The resistance of the solenoid is 8.0 Ω.
The current in the solenoid is 1.2 A.

Calculate the potential difference (p.d.) across the solenoid.

p.d. = ... V [3]

[Total: 8]

4 **(b)** There is a transformer in the desktop computer.
The input voltage to the primary coil V_p is 230 V (a.c.).
The number of turns on the primary coil N_p is 720.
The number of turns on the secondary coil N_s is 50.

(i) Calculate the output voltage V_s of the secondary coil.

secondary coil output voltage V_s = ... V [3]

(ii) The current in the input coil of the transformer is 1.4 A.

Calculate the input power to the desktop computer.

input power = ... W [3]

[Total: 9]

5 **(a)** The battery in a laptop computer is connected to a battery charger for 20 minutes. The potential difference (p.d.) across the battery is 14 V. The current in the battery is 1.8 A.

Calculate the energy transferred to the battery in 20 minutes.

energy transferred = ... J [4]

(b) The battery charger includes a transformer. Fig. 8.1 shows the transformer.

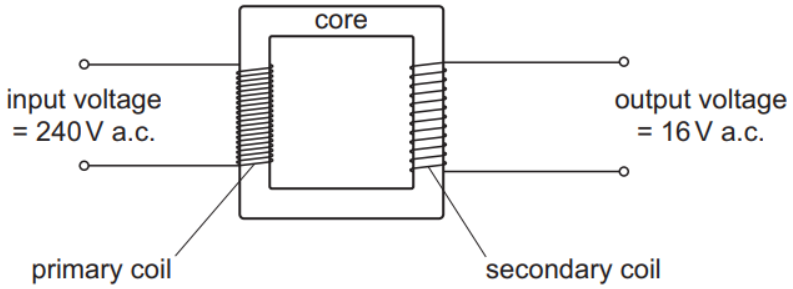


Fig. 8.1 (not to scale)

(i) State the name of the material used for the core of the transformer.

..... [1]

(ii) The transformer has 4800 turns on the primary (input) coil.

Calculate the number of turns on the secondary (output) coil.

Use information from Fig. 8.1.

number of turns = ... [3]

[Total: 8]

6 Fig. 8.1 shows a solenoid (long coil of wire) connected in a circuit. When the switch is closed, there is a large current in the circuit.

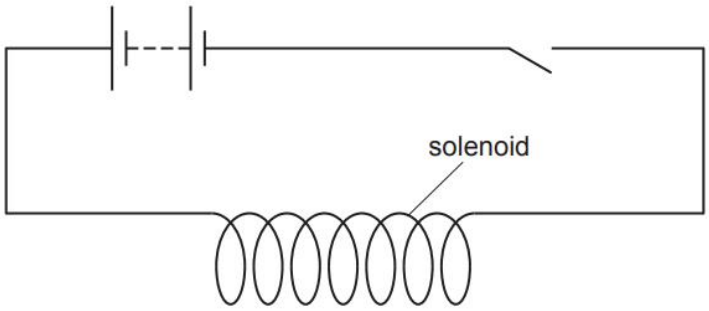


Fig. 8.1

(a) Describe an experiment to identify the pattern **and** direction of the magnetic field around the solenoid.

You may draw on Fig. 8.1 as part of your description.

.....

.....

..... [3]

(b) A solenoid P is placed close to another solenoid Q. Solenoid Q is connected to a sensitive voltmeter.
The arrangement is shown in Fig. 8.2.

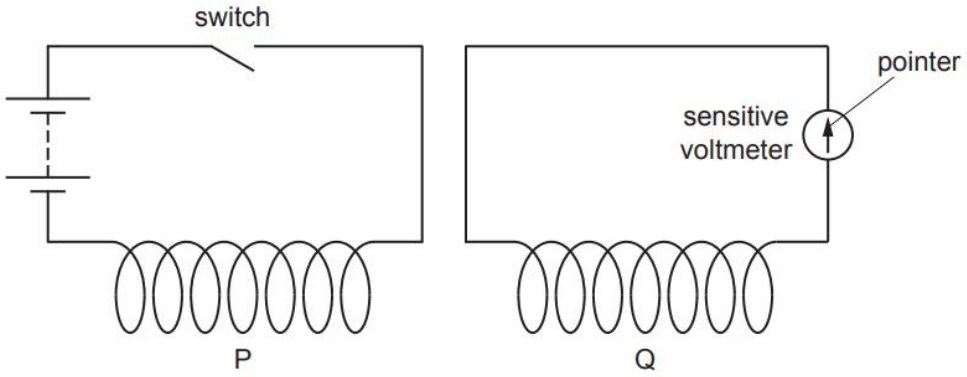


Fig. 8.2

Describe and explain what happens when the switch is closed.

.....

.....

.....

..... [4]

[Total: 7]

7 **(a)** Fig. 10.1 shows an arrangement used to demonstrate electromagnetic induction.

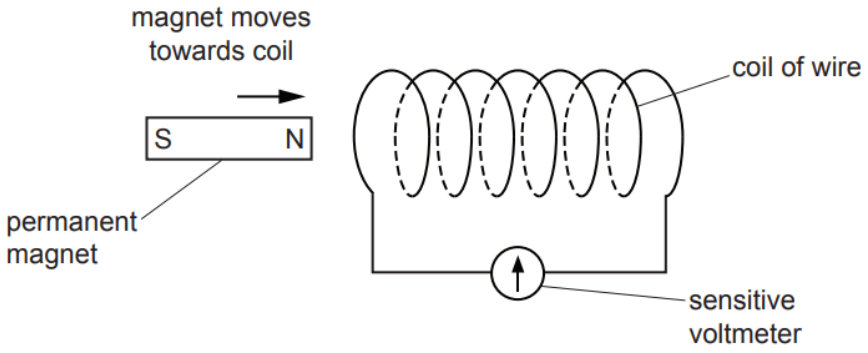


Fig. 10.1

(i) When the magnet moves towards the coil of wire, the pointer on the sensitive voltmeter deflects to the right.

Explain why the pointer deflects.

.....

..... [2]

(ii) State **two** changes that increase the deflection on the sensitive voltmeter.

1 .....

2 .....

[2]

(b) Fig. 10.2 shows the symbol for a transformer. The primary coil is connected to a voltage of 180 V a.c.

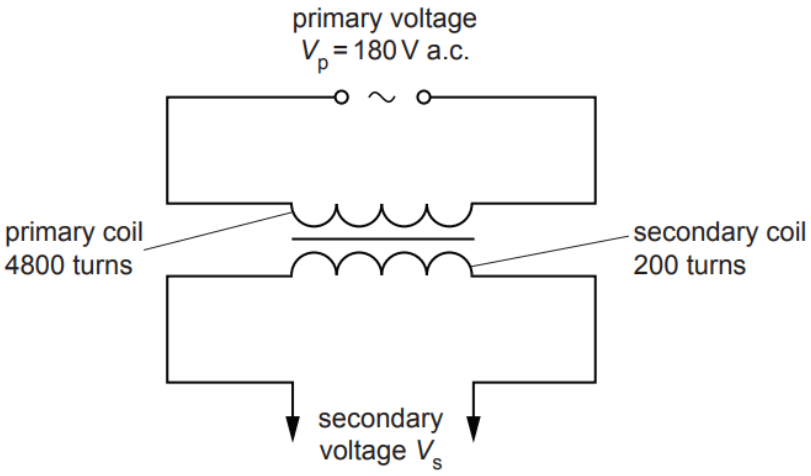


Fig. 10.2

Calculate the secondary voltage V_s for the transformer.

V_s = ... V [3]

[Total: 7]

8 A student has a desktop computer that connects to the 240 V a.c. mains electrical supply. Fig. 9.1 shows the desktop computer.

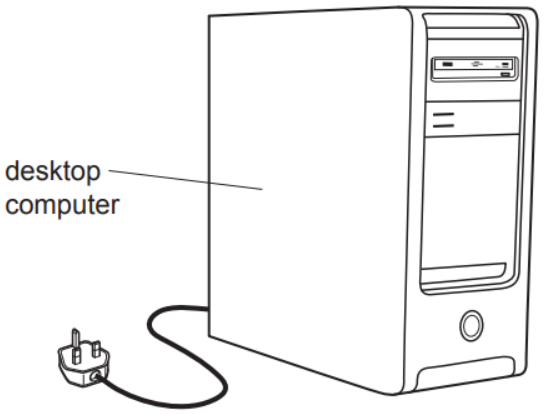


Fig. 9.1

(a) The desktop computer has an on-off switch in one of the wires that connect it to the mains supply.

State and explain which wire includes the switch.

.....

.....

..... [3]

(b) The desktop computer uses a transformer to change the 240 V a.c. voltage to a 12 V a.c. voltage.

(i) State the name of this type of transformer.

..... [1]

(ii) Describe the construction of this transformer. You may include a labelled diagram.

.....

.....

.....

..... [4]

[Total: 8]

9 (b) The mains input (primary) potential difference (p.d.) to the transformer is 230 V a.c.

The number of turns on the input (primary) coil is 314. The number of turns on the output (secondary) coil is 150.

Calculate the output (secondary) p.d. from the transformer.

output p.d. = ... V [3]

(c) Fig. 9.2 shows an outline of the transformer.

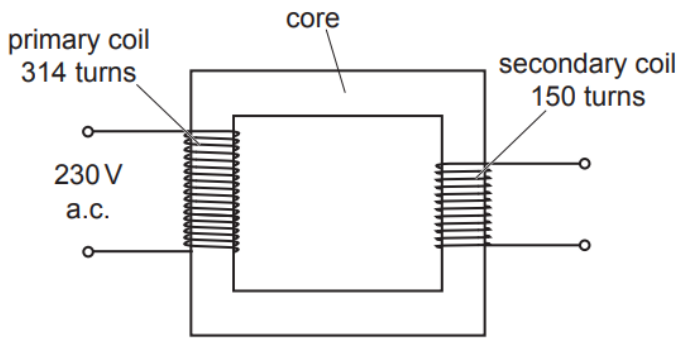


Fig. 9.2

(i) State a suitable material for the core of the transformer.

..... [1]

(ii) State a suitable material for the primary and secondary coils of the transformer.

..... [1]

(iii) Explain how Fig. 9.2 shows a step-down transformer.

..... [1]

[Total: 9]

10 Fig. 9.1 shows a transformer. An a.c. voltmeter is connected to the output of the secondary coil.

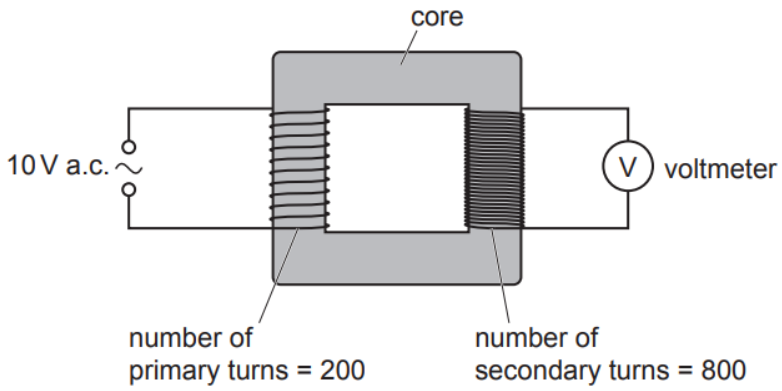


Fig. 9.1

(a) State the meaning of a.c.

..... [1]

(b) State the name of the type of transformer shown.

..... [1]

(c) State a suitable material for the core of the transformer in Fig. 9.1.

..... [1]

(d) Using the information in Fig. 9.1, calculate the reading on the voltmeter.

reading on voltmeter = ... V [3]

(e) The 10 V a.c. power supply is replaced by a 10 V d.c. battery.

State the reading on the voltmeter.

reading on voltmeter = ... V [1]

[Total: 7]

11 **(b)** The electric circuit for the microwave oven includes a transformer.
The voltage to the primary coil of the transformer V_p is 240 V.
The number of turns on the primary coil N_p is 70.

The number of turns on the secondary coil N_s is 560.

Calculate the secondary voltage V_s for the transformer.

V_s = ... V [3]

[Total: 7]

12 **(a)** Fig. 10.1 shows a wire passing through a card. There is a large electric current in the wire in the direction shown.
Fig. 10.2 shows the same arrangement when viewed from above the card.

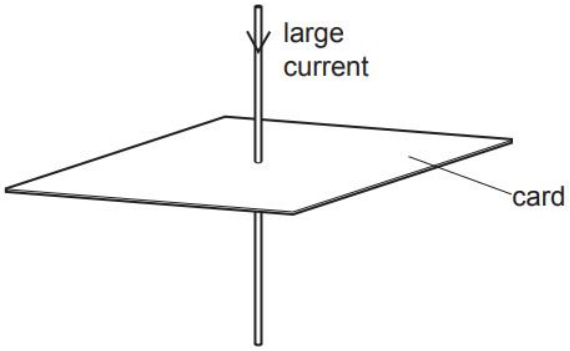


Fig. 10.1

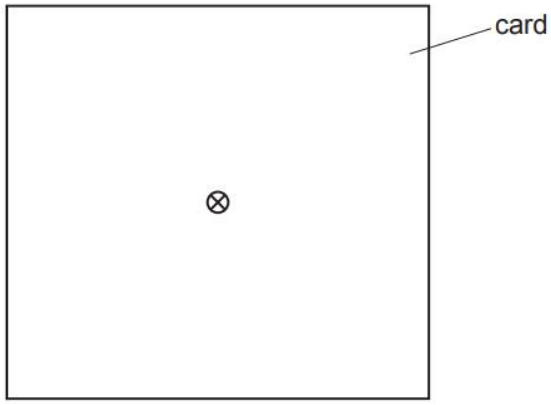


Fig. 10.2

There is a pattern of magnetic field lines around the wire due to the current in the wire.

On Fig. 10.2, draw the pattern and direction of the magnetic field as if viewed from above the card. [3]

(b) Fig. 10.3 shows a wire XY carrying a large electric current between the poles of a permanent magnet. There is an upward force on the wire XY.

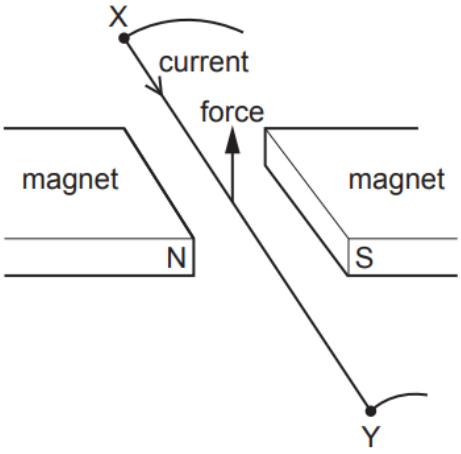


Fig. 10.3

(i) State **two** different ways of increasing the force due to the current in the wire XY.

.....

..... [2]

(ii) State **two** different ways of making the force on the wire XY act downwards.

.....

..... [2]

[Total: 7]

13 **(a)** A student plans to demonstrate the induction of an electromotive force (e.m.f.) in a wire.

He has a length of wire, a sensitive centre-reading galvanometer and a permanent magnet.

(i) Describe how the student uses the equipment.

.....

..... [2]

(ii) State **two** ways in which the student can increase the size of the induced e.m.f.

1 .....

2 .....

[2]

(b) Fig. 10.1 shows a d.c. motor.

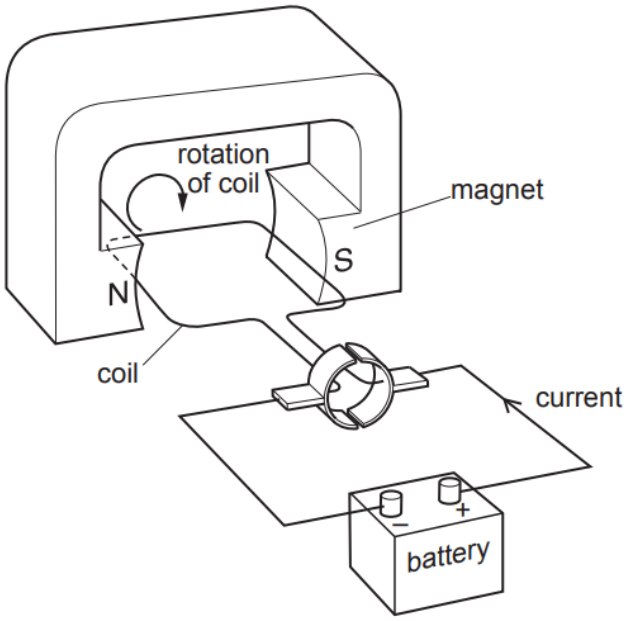


Fig. 10.1

(i) On Fig. 10.1, draw an arrow between the poles of the magnet to show the direction of the magnetic field. [1]

(ii) State **two** ways of making the coil spin faster.

1 .....

2 .....

[2]

(iii) State **one** way of making the coil spin in the opposite direction.

..... [1]

[Total: 8]

14 **(a)** Fig. 11.1 shows a magnet and a coil of wire connected to a galvanometer.

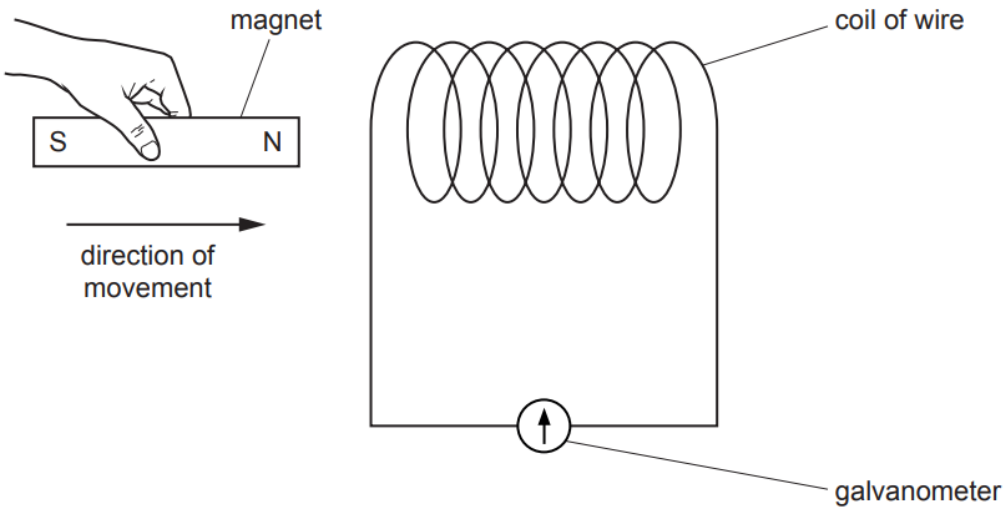


Fig. 11.1

A student slowly moves the magnet into the coil. The pointer on the galvanometer moves to the left. This deflection shows that an electromotive force (e.m.f.) is induced in the coil.

State **three** ways of increasing the size of the e.m.f. in the coil.

1 .....

2 .....

3 .....

[3]

(b) Fig. 11.2 shows a transformer.

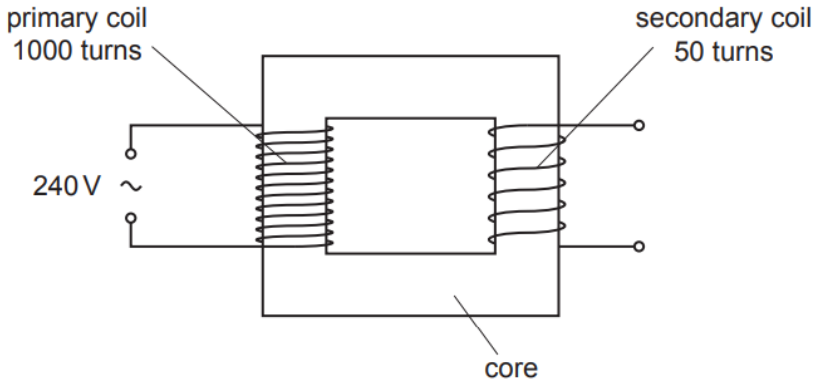


Fig. 11.2

(i) Name **one** material that is suitable for the core of the transformer.

..... [1]

(ii) The primary coil has 1000 turns and its input is 240 V a.c.
The secondary coil has 50 turns.

Calculate the output voltage across the secondary coil.

output voltage = ... V [3]

[Total: 7]

15 A student uses a coil and a magnet on a spring to generate an electromotive force (e.m.f.) that varies. He suspends the magnet above a coil as shown in Fig. 11.1.

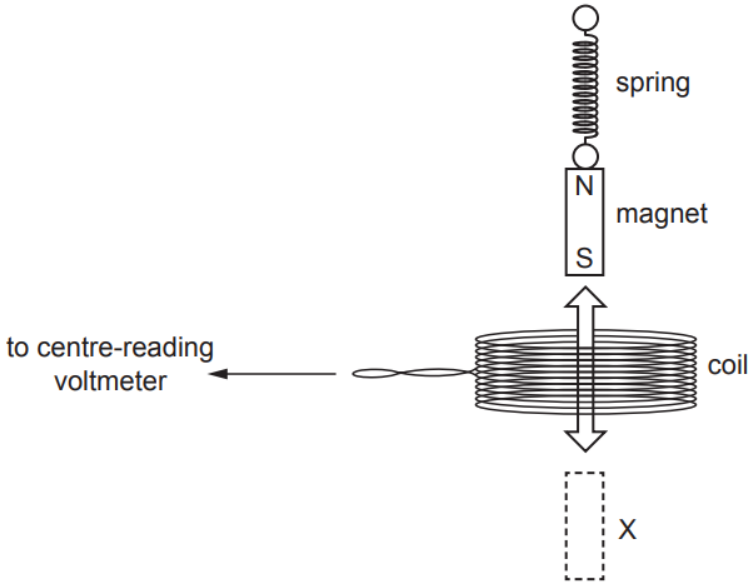


Fig. 11.1

(a) The student pulls the magnet through the coil to X and then releases it. The magnet moves up and down through the coil.

State the type of voltage induced in the coil. Tick (✓) **one** box.

alternating	☐
digital	☐
direct	☐

[1]

(b) State **two** ways of increasing the voltage induced in the coil.

1. .....

2. .....

[2]

[Total: 3]

16 Fig. 10.1 shows an electric screwdriver which has an electric motor and a battery.

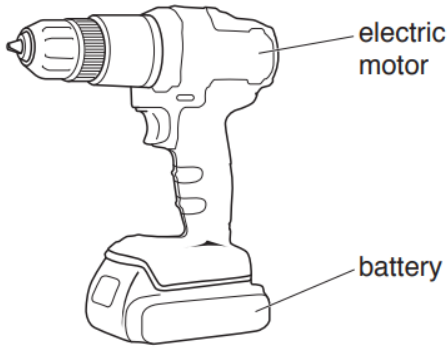


Fig. 10.1

(a) (i) The electric motor has a current-carrying coil in a magnetic field. The screwdriver's manufacturer decides that the turning effect of the coil is too small.

State **three** ways of increasing the turning effect of the coil.

1. .....

2. .....

3. .....

[3]

(ii) The coil in the motor can rotate in either direction.

State what happens in the coil to reverse the direction of rotation.

..... [1]

(b) The battery is charged using a transformer connected to an a.c. power supply.

The primary voltage V_p to the transformer is 234 V and the secondary voltage V_s of the transformer is 18 V.

The number of turns on the primary coil N_p is 2470 turns.

Calculate the number of turns on the secondary coil N_s.

N_s = ... [3]

[Total: 7]

17 Fig. 11.1 represents a transformer. The primary coil has 300 turns and the secondary coil has 30 turns. The input voltage is 230 V a.c.

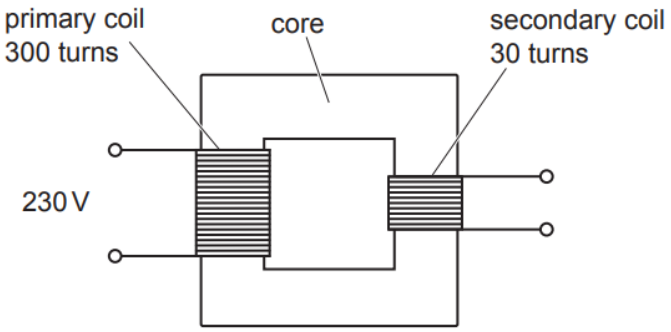


Fig. 11.1

(a) Calculate the voltage across the secondary coil.

voltage = ... V [3]

(b) State a suitable material for the core of the transformer.

..... [1]

(c) Some transformers produce high electrical voltage for the transmission of electrical energy. Describe **two** advantages of high-voltage transmission.

1. .....

.....

2. .....

.....

[2]

[Total: 6]

18 A model train uses an electric motor. The motor has a coil of wire in a magnetic field.

(a) Fig. 11.1 shows a coil of wire in a magnetic field.

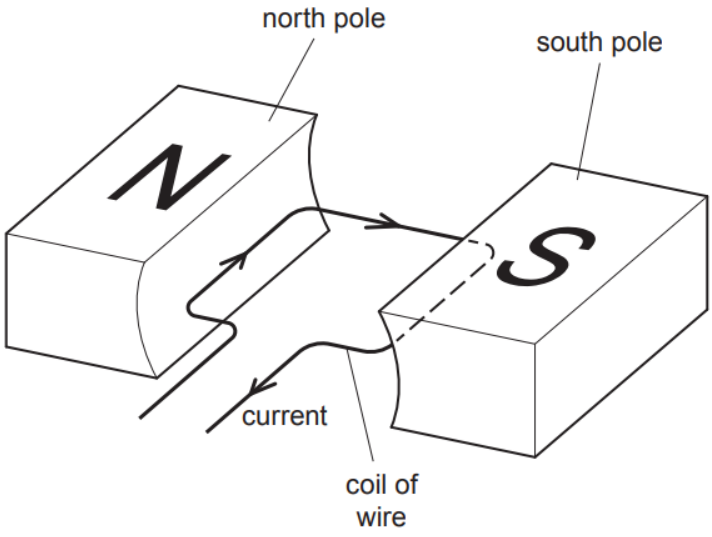


Fig. 11.1

Describe **two** ways of increasing the turning effect on the coil.

.....

..... [2]

(b) The motor for the model train uses an alternating voltage of 12 V. This is supplied by the secondary coil of a transformer.

The primary coil of the transformer is connected to a mains voltage of 240 V.

The primary coil has 900 turns.

Calculate the number of turns on the secondary coil.

number of turns on the secondary coil = ... [3]

[Total: 5]

19 A student is experimenting with electromagnetic effects.

(a) Describe an experiment, using any standard laboratory equipment, to demonstrate electromagnetic induction. You may draw a diagram.

.....

.....

.....

..... [3]

(b) Fig. 11.1 shows a transformer connected to an input voltage of 12 V a.c.

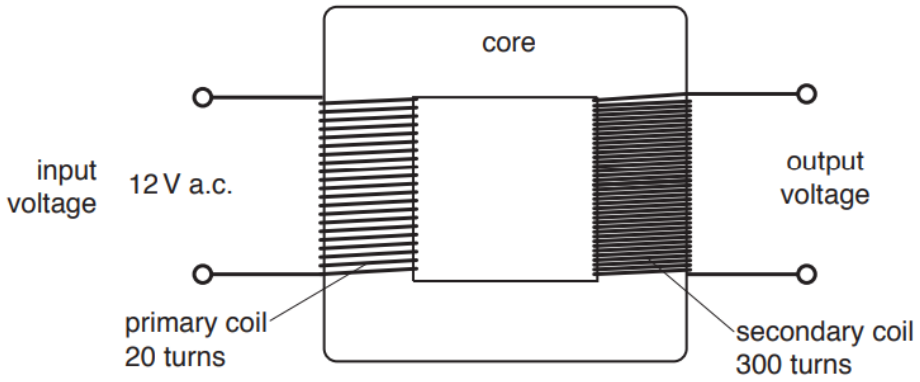


Fig. 11.1

(i) State the name of a suitable material for the core of the transformer.

..... [1]

(ii) Explain how the diagram in Fig. 11.1 shows a step-up transformer.

.....

..... [1]

(iii) Using the information in Fig. 11.1, calculate the output voltage of the transformer.

output voltage = ...V [3]

[Total: 8]

20 **(a)** Fig. 11.1 shows in each of the diagrams a current-carrying conductor and a magnetic field pattern.

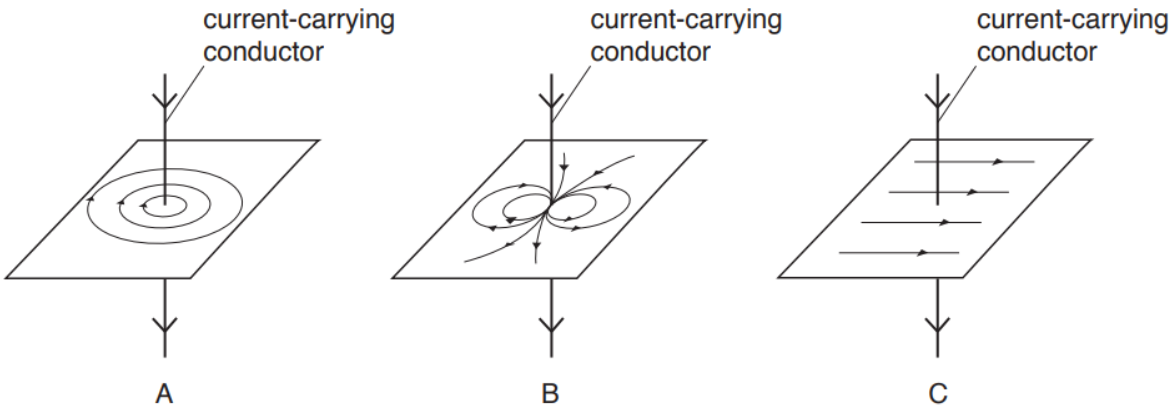
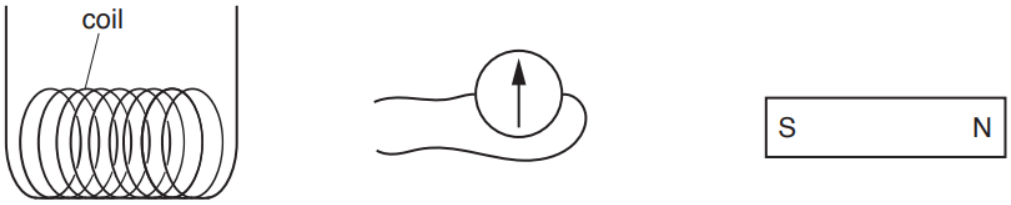


Fig. 11.1

State the diagram which correctly shows the magnetic field around a current-carrying conductor.

..... [1]

(b) Fig. 11.2 shows three pieces of equipment.



coil with 100 turns of wire

sensitive centre-zero meter

bar magnet

Fig. 11.2

(i) Describe how to generate and detect an electromotive force (e.m.f.) using the equipment in Fig. 11.2. You may draw a diagram.

.....

.....

.....

..... [3]

(ii) Describe **two** changes that will generate a larger e.m.f. using similar equipment to that in Fig. 11.2.

.....

.....

.....

..... [2]

(c) A student connects a lamp and centre-zero galvanometer in series with a generator, as shown in Fig. 11.3.

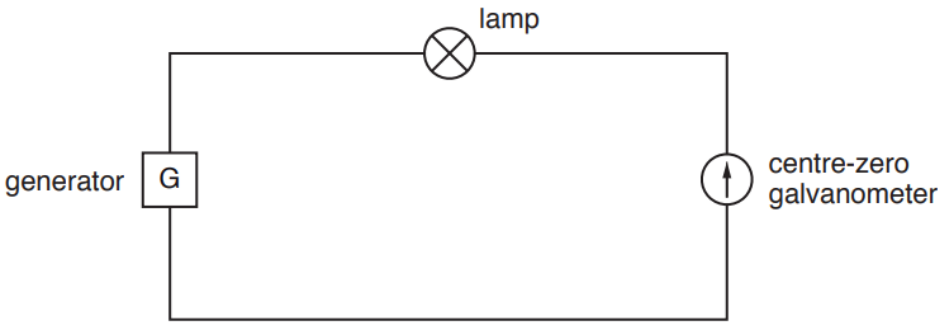


Fig. 11.3

The student observes the galvanometer needle moving from side-to-side repeatedly.

Explain why the needle moves in this way.

.....

.....

..... [1]

[Total: 7]

21 Fig. 11.1 shows a transformer that can provide two different output voltages from a 240 volt mains a.c. supply.

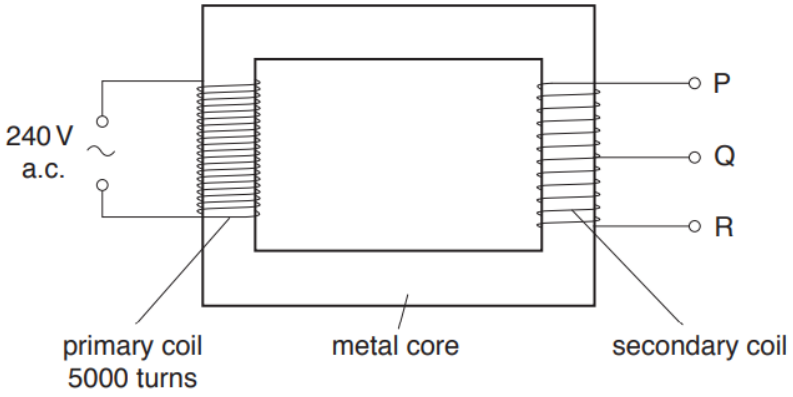


Fig. 11.1

In the transformer, the primary coil has 5000 turns.

The secondary coil has 250 turns between P and R.

(a) State the term used to describe this type of transformer.

..... [1]

(b) The primary and secondary coils are mounted on a metal core.

State the metal used for the core and explain why it is suitable.

metal .....

explanation .....

.....

[2]

(c) **(i)** The secondary coil has 125 turns between P and Q. Calculate the output voltage between connections P and Q.

voltage = ... V [3]

(ii) Compare the output voltage between P and Q with the output voltage between P and R.

Explain your answer.

comparison .....

explanation .....

[2]

[Total: 8]

22 **(a)** A student has a model electric railway. The model railway uses a step-down transformer.

The input voltage is 230 V. The transformer has 1710 turns on the input coil and 90 turns on the output coil.

Calculate the output voltage of the transformer.

output voltage = ... V [3]

(b) A step-up transformer is used to increase voltage.

Step-up transformers and step-down transformers have different coil arrangements.

Describe the differences in the coil arrangement for the two types of transformer.

.....

.....

.....

.....

.....[2]

(c) Explain the advantage of transmitting electricity at high voltages, rather than at low voltages.

.....

.....

.....

.....[2]

[Total: 7]

23 Fig. 11.1 represents a transformer.

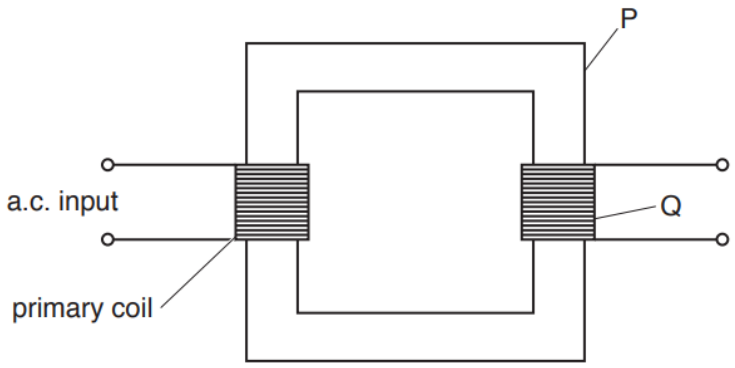


Fig. 11.1

(a) (i) State the name of the part of the transformer labelled Q in Fig. 11.1.

.....[1]

(ii) In Fig. 11.1, part P is made from a metal.

1. State the metal used to make part P. .....

2. State the term given to part P. .....

[2]

(iii) There is an alternating current (a.c.) in the primary coil.

Describe what this current produces in part P.

.....

.....[2]

(iv) Complete the sentence using terms from the box.

more	fewer	step-up	step-down

When there are ..... turns in the primary coil than in Q, the device is called a

..... transformer. [1]

(b) The high-voltage transmission of electricity uses transformers.

Describe **two** advantages of transmitting electricity at high voltages rather than at low voltages.

1. .....

.....

2. .....

.....

[2]

[Total: 8]

Paper 4

Questions are applicable for both core and extended candidates unless indicated in the question

24 A solid bar is inside a copper solenoid. Fig. 7.1 shows that the copper solenoid is connected in series with a battery and a variable resistor.

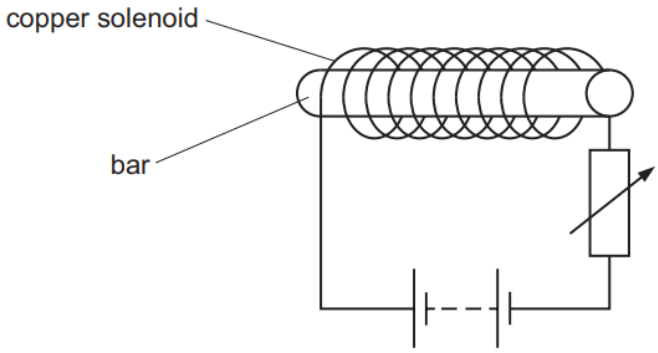


Fig. 7.1

The device shown in Fig. 7.1 is an electromagnet.

(a) Suggest a suitable material for the bar.

..... [1]

(b) The right-hand end of the bar is the S pole.

(i) Fig. 7.2 shows the bar viewed from above.

On Fig. 7.2, draw at least six field lines to show the pattern and direction of the magnetic field surrounding the bar.

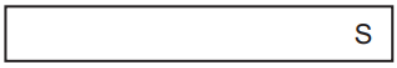


Fig. 7.2

[3]

(ii) The resistance of the variable resistor increases. **(extended only)**

Explain what happens to the magnetic field surrounding the bar and state how the pattern of field lines that represents the field changes.

.....

.....

.....

..... [3]

(c) A square coil of many turns is placed close to the bar. Fig. 7.3 shows the plane of the square coil parallel to the flat circular surface at the right-hand end of the bar.

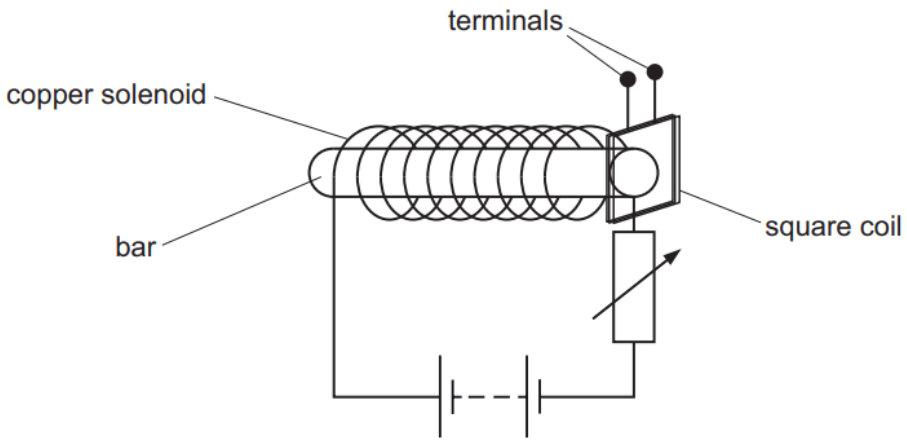


Fig. 7.3

The resistance of the variable resistor is alternately increased and decreased.

Explain what happens in the wires of the square coil.

.....

.....

.....

..... [3]

[Total: 10]

25 Fig. 9.1 shows a wireless charging plate used to charge the battery in a mobile phone (cell phone). The coil of wire is part of an electric circuit.

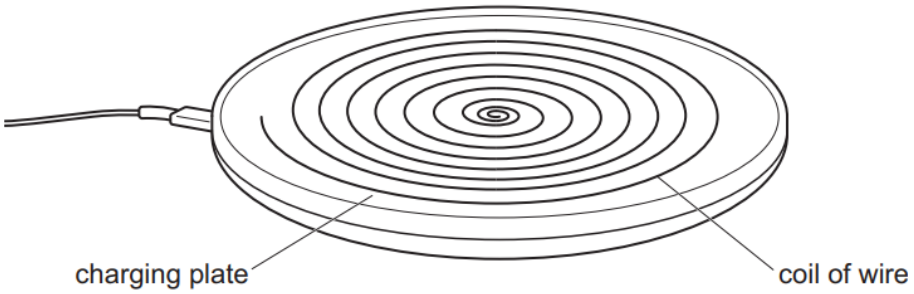


Fig. 9.1

The charging plate is connected to an a.c. power supply. The power supply is turned on.

(a) Describe the magnetic field around the charging plate in terms of its magnitude and direction. **(extended only)**

.....

.....

..... [2]

(b) A mobile phone is placed on the charging plate as shown in Fig. 9.2. The coil in the mobile phone is part of a separate circuit that charges the battery.

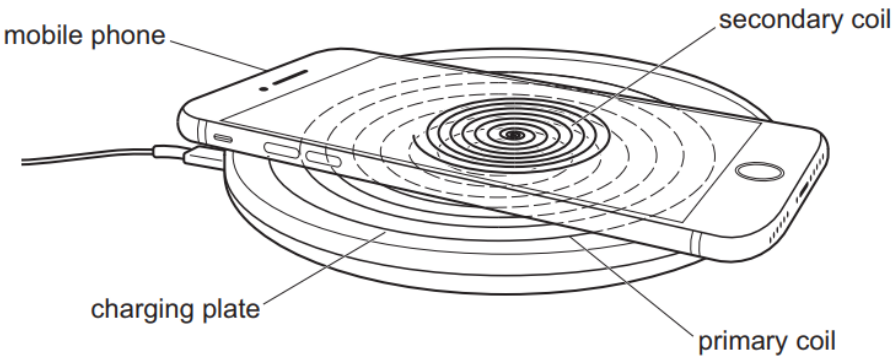


Fig. 9.2

The coil in the charging plate and the coil in the mobile phone act like a transformer.

(i) Explain why there is a current in the secondary coil shown in Fig. 9.2.

.....

.....

..... [2]

(ii) Suggest why the transformer made from the charging plate and mobile phone is not 100% efficient. **(extended only)**

.....

..... [1]

(c) The mobile phone battery can be recharged using this charging plate and stores 4.5×10^4 J of energy when fully recharged. The current in the secondary coil is 0.63 A when the output voltage is 12 V.

(i) Calculate the time taken to fully recharge a completely uncharged battery.

time = ... [2]

(ii) Calculate the charge passing through the battery in 60 s. **(extended only)**

charge = ... [2]

[Total: 9]

26 **(b)** Fig. 7.2 shows a circuit diagram of a step-down transformer.

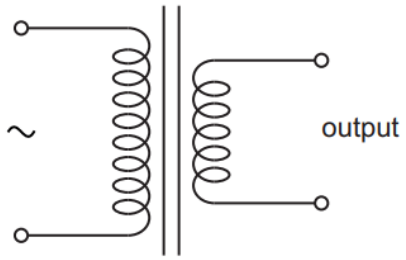


Fig. 7.2

(i) The mains voltage supplied to the transformer is 240 V. The output power of the transformer is 45 W. The transformer is 100% efficient. **(extended only)**

Calculate the input current to the transformer.

input current = ... [3]

(ii) Draw a labelled diagram of a step-down transformer. On the labels, state a suitable material for each of the components.

[3]

27 The electricity supplied to a town is transmitted using a high-voltage cable. A transformer in the town has a soft-iron core.

(a) Explain the principle of operation of a simple iron-cored transformer. **(extended only)**

.....

.....

.....

.....

..... [4]

(b) The transformer steps the supply voltage down from 220 000 V to 33 000 V.

(i) There are 450 turns on the secondary coil.

Calculate the number of turns on the primary coil.

number of turns = ... [2]

(ii) The electrical power transferred to the transformer by the high-voltage cable is 77 MW.

Calculate the current in the primary coil.

current = ... [3]

[Total: 9]

28 The electric starter motor in a car is switched on and off using a relay.

The relay consists of a plastic case and two flexible springy strips, X and Y, which are made of soft iron. These iron strips act as the switch when a circuit is connected between the terminals W and Z.

Fig. 7.1 shows X, Y and the plastic case.

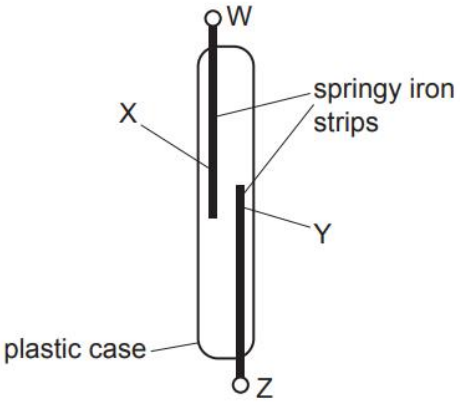


Fig. 7.1

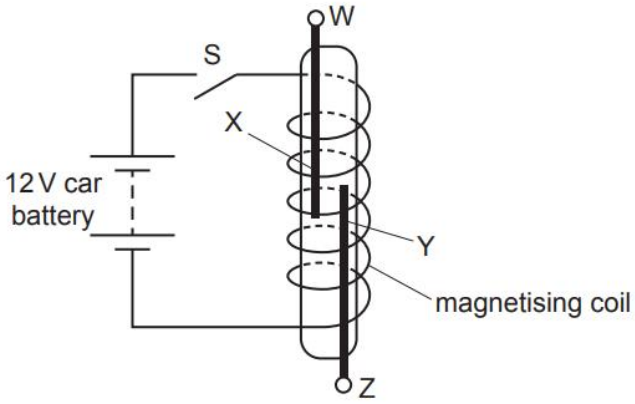


Fig. 7.2

Fig. 7.2 shows the equipment from Fig. 7.1 inside a magnetising coil. The magnetising coil is in series with the 12 V car battery and switch S, which is open.

(a) Switch S is now closed.

Explain what happens to the springy iron strips X and Y.

.....

.....

.....

..... [3]

(b) The power of the starter motor is 1.8 kW and it is also operated by the car battery.

(i) Calculate the current in the starter motor when it is used.

current = ... [2]

(ii) The starter motor circuit is connected between terminals W and Z.

Explain why copper wires with a large cross-sectional area are used for this circuit.

.....

.....

..... [2]

(c) Fig. 7.3 shows the relay and the symbols for the car battery and the starter motor.

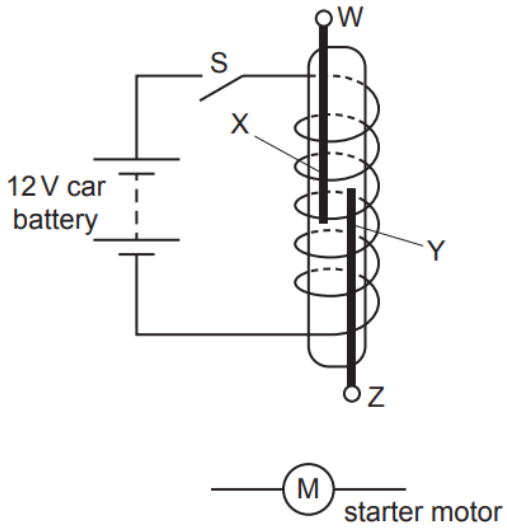


Fig. 7.3

The springy iron strips X and Y act as the switch for the starter motor circuit.

Complete the circuit diagram for the motor circuit. [2]

[Total: 9]

29 A student turns the handle of an alternating current (a.c.) generator and the coil rotates.

Fig. 8.1 represents the structure of the a.c. generator.

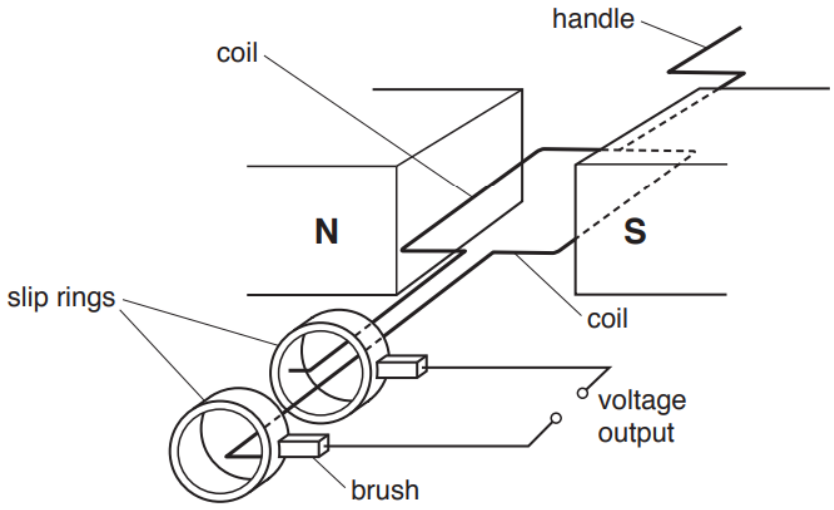


Fig. 8.1

(a) There is an alternating voltage output between the two terminals.

(i) Explain why rotating the coil produces an output voltage.

.....

.....

.....

..... [3]

(ii) State the position of the rotating coil when the alternating output voltage is at a maximum value and explain why the maximum output occurs at this position. **(extended only)**

.....

.....

..... [2]

30 **(a)** Describe how to demagnetise a bar magnet using alternating current (a.c.) in a coil.

.....

.....

.....

..... [3]

(b) Fig. 9.1 shows a simple direct current (d.c.) motor.

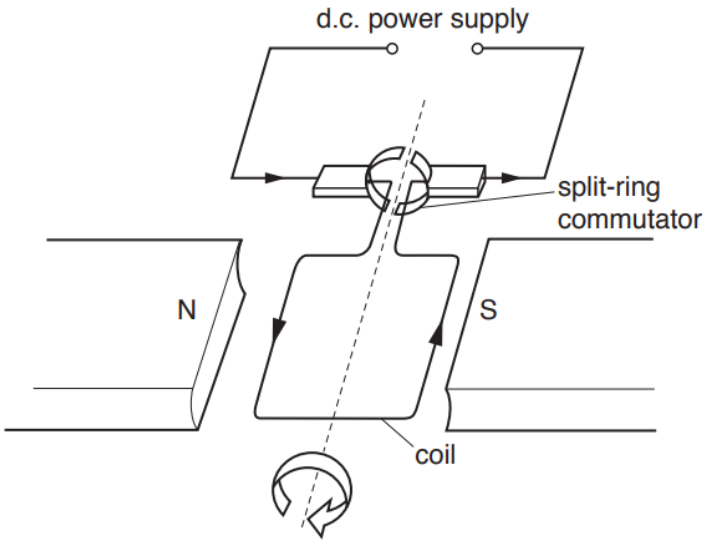


Fig. 9.1

(i) Explain the purpose of the split-ring commutator. **(extended only)**

.....

.....

.....

..... [3]

(ii) The voltage of the power supply is increased.

State the effect this has on the motor.

..... [1]

[Total: 7]

31 A transformer consists of two coils of wire wound on a metal core. Fig. 10.1 represents the transformer.

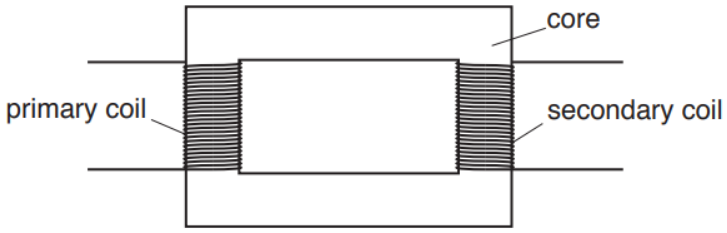


Fig. 10.1

(a) State the name of the metal from which the core is made.

.....[1]

(b) The primary coil of the transformer is connected to the output voltage of an a.c. generator which supplies an alternating current.

(i) Explain why there is a voltage between the two terminals of the secondary coil. **(extended only)**

.....

.....

.....

.....[3]

(ii) There are 560 turns on the primary coil and 910 turns on the secondary coil of the transformer. The voltage between the two terminals of the secondary coil is 78 V.

Calculate the voltage supplied by the a.c. generator.

generator voltage = ...[2]

(c) Transformers are used to increase the voltage when electrical energy is transmitted in cables across long distances.

Explain why power losses in the cables are lower when the voltage is high.

.....

.....

.....[2]

[Total: 8]

32 **(a)** Explain why the voltage of the supply to the primary coil of a transformer must be alternating. **(extended only)**

.....

.....

.....

.....[2]

(b) Fig. 10.1 shows a transformer.

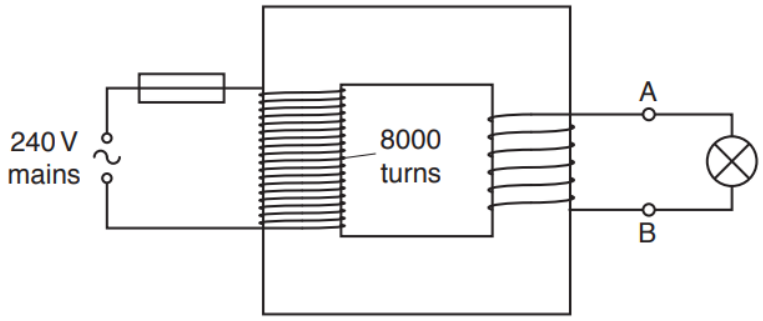


Fig. 10.1

There are 8000 turns in the primary coil of the transformer. The primary coil is connected to a 240 V mains supply. A 6.0 V lamp connected to the secondary coil operates at full brightness.

(i) Calculate the number of turns in the secondary coil,

number of turns = ...[2]

(ii) The current in the lamp is 2.0 A. The transformer operates with 100% efficiency.

Calculate the current in the primary circuit. **(extended only)**

current = ...[2]

(iii) The primary circuit contains a 2 A fuse.

Calculate the maximum number of lamps, identical to the lamp in **(ii)**, that can be connected in parallel in the secondary circuit without blowing the fuse.

number of lamps = ...[1]

[Total: 7]