Electromagnetic Induction
Question paper 3

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Electromagnetic Induction
Sub Topic	
Paper Type	Theory
Booklet	Question paper 3

Time Allowed: **77 minutes**

Score: **/64**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1   A metal disc is swinging freely between the poles of an electromagnet, as shown in Fig. 5.1.
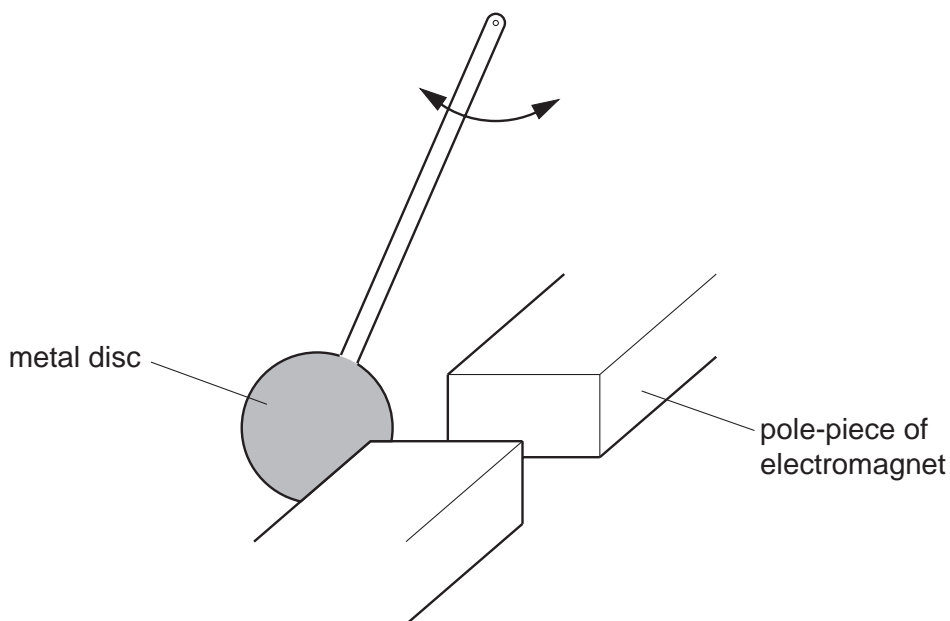

Fig. 5.1

When the electromagnet is switched on, the disc comes to rest after a few oscillations.

(a) (i)   State Faraday's law of electromagnetic induction and use the law to explain why an e.m.f. is induced in the disc.

....

....

....

.... [2]

(ii)   Explain why eddy currents are induced in the metal disc.

....

....

.... [2]

(b)   Use energy principles to explain why the disc comes to rest after a few oscillations.

....

....

....

.... [3]

2 **(a)** Define *magnetic flux density*.

....

....

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.... [3]

(b) A flat coil consists of *N* turns of wire and has area *A*. The coil is placed so that its plane is at an angle θ to a uniform magnetic field of flux density *B*, as shown in Fig. 6.1.
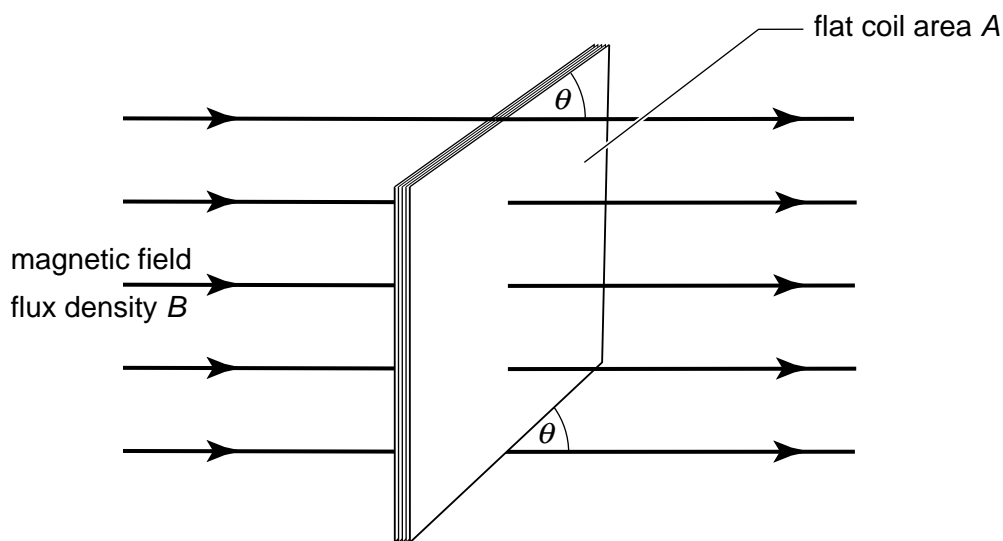
Fig. 6.1

Using the symbols *A*, *B*, *N* and θ and making reference to the magnetic flux in the coil, derive an expression for the magnetic flux linkage through the coil.

[2]

(c) (i) State Faraday's law of electromagnetic induction.

....

....

.... [2]

(ii) The magnetic flux density B in the coil is now made to vary with time t as shown in Fig. 6.2.
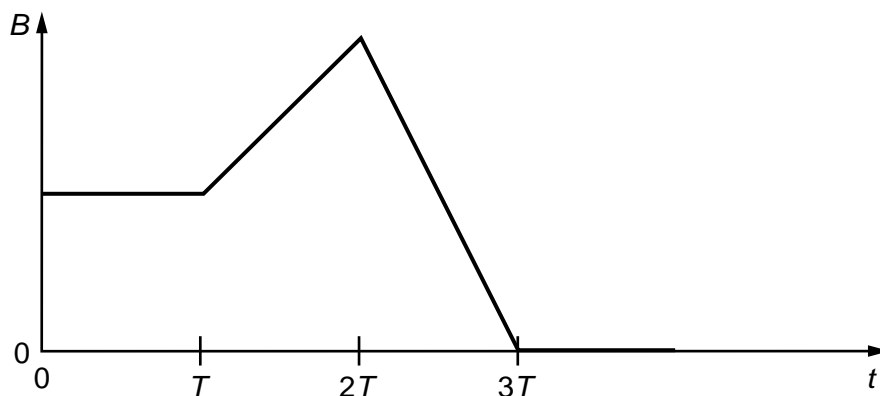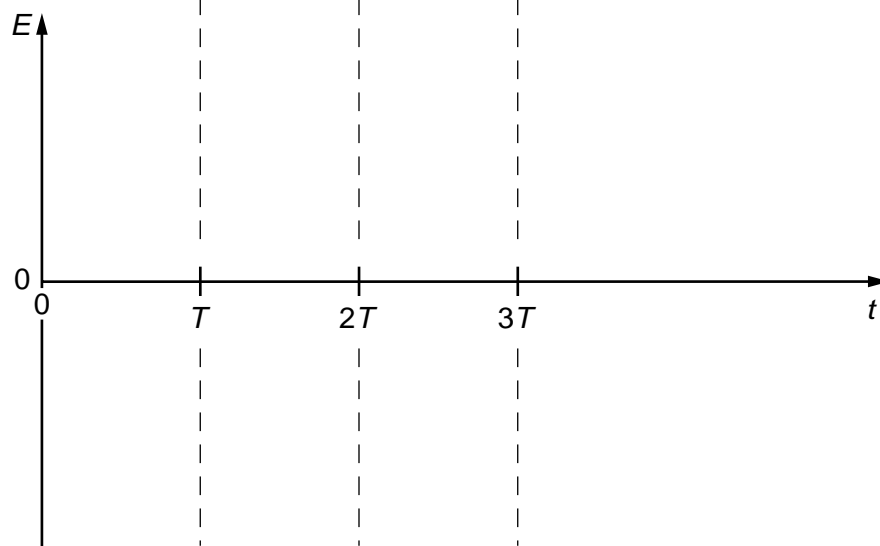

Fig. 6.2

Fig. 6.3

On Fig. 6.3, sketch the variation with time t of the e.m.f. E induced in the coil. [3]

3 A small coil is positioned so that its axis lies along the axis of a large bar magnet, as shown in Fig. 4.1.
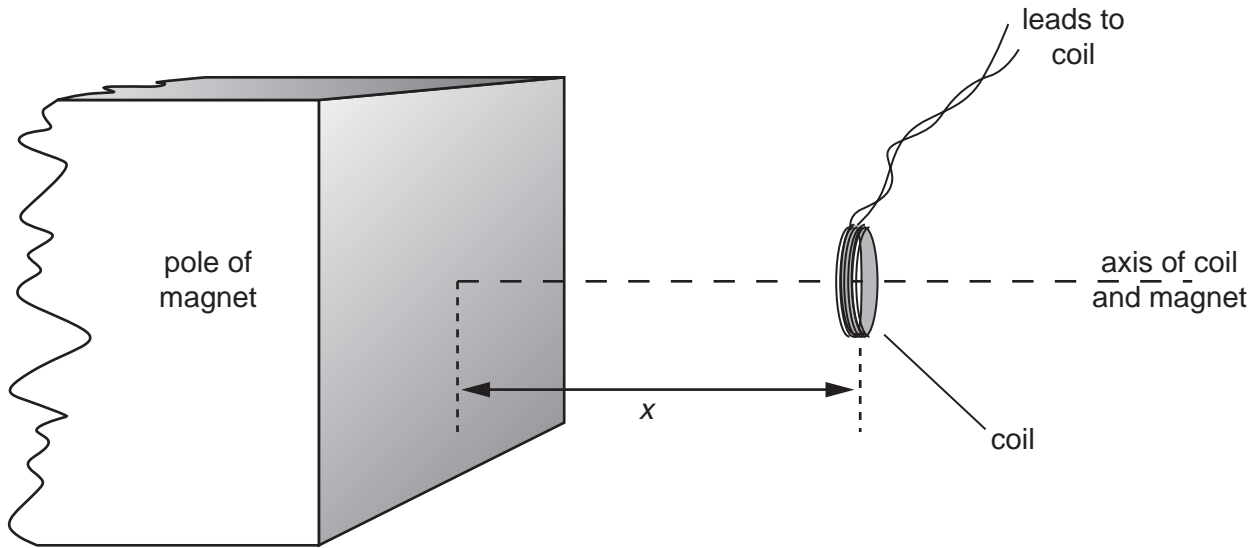

Fig. 4.1

The coil has a cross-sectional area of 0.40 cm^2 and contains 150 turns of wire.

The average magnetic flux density B through the coil varies with the distance x between the face of the magnet and the plane of the coil as shown in Fig. 4.2.
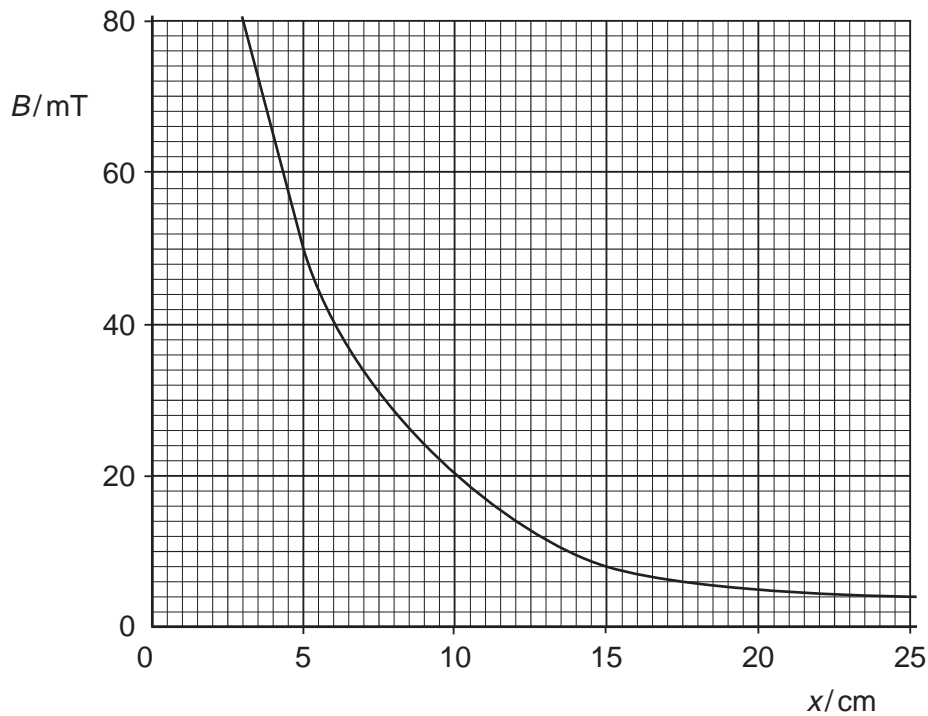

Fig. 4.2

(a) (i) The coil is 5.0 cm from the face of the magnet. Use Fig. 4.2 to determine the magnetic flux density in the coil.

magnetic flux density = ... T

(ii) Hence show that the magnetic flux linkage of the coil is 3.0×10^{-4} Wb.

[3]

(b) State Faraday's law of electromagnetic induction.

....

....

....[2]

(c) The coil is moved along the axis of the magnet so that the distance x changes from $x = 5.0$ cm to $x = 15.0$ cm in a time of 0.30 s. Calculate

(i) the change in flux linkage of the coil,

change = ... Wb [2]

(ii) the average e.m.f. induced in the coil.

e.m.f. = ... V [2]

(d) State and explain the variation, if any, of the speed of the coil so that the induced e.m.f. remains constant during the movement in **(c)**.

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....

....

....[3]

4 **(a)** Define the tesla, the unit of magnetic flux density.

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.... [2]

(b) The aluminium frame ABCD of a window measures $85\,\text{cm} \times 60\,\text{cm}$, as illustrated in Fig. 5.1.
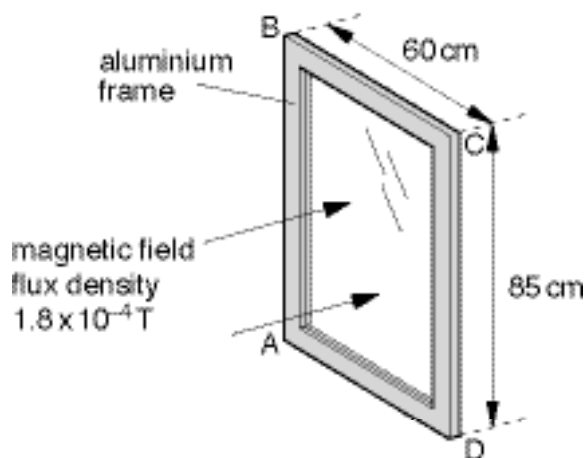

Fig. 5.1

The window is hinged along the edge AB.

When the window is closed, the horizontal component of the Earth's magnetic field, of flux density $1.8 \times 10^{-4}\,\text{T}$, is normal to the window.

(i) Calculate the magnetic flux through the window.

magnetic flux = ………………………………. Wb [2]

(ii) The window is now opened in a time of 0.20 s. When open, the plane of the window is parallel to the Earth's magnetic field.

For the opening of the window,

1. state the change in flux through the window,

change = …………………………………… Wb

2. calculate the average e.m.f. induced in side CD of the frame.

e.m.f. = ………………………………….. V

[3]

(iii) Suggest, with a reason, whether the e.m.f. calculated in **(ii)2** gives rise to a current in the frame ABCD.

....

.... [1]

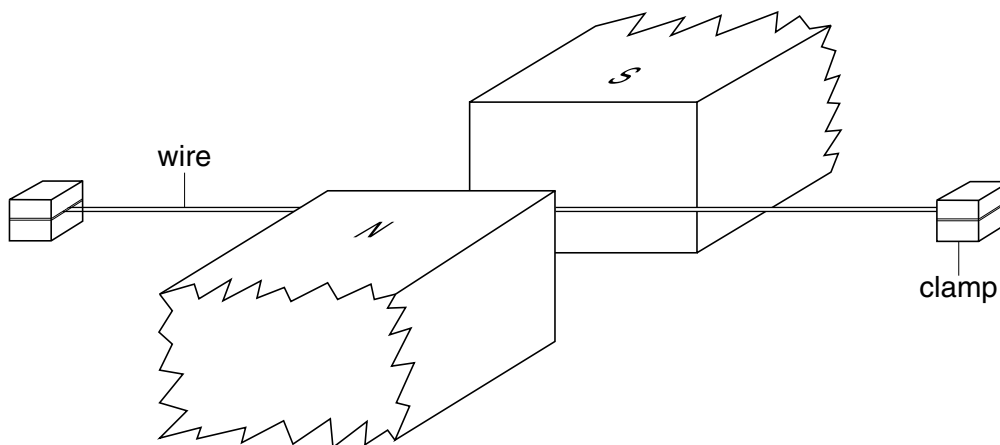**5**   A metal wire is held taut between the poles of a permanent magnet, as illustrated in Fig. 7.1.

Fig. 7.1

A cathode-ray oscilloscope (c.r.o.) is connected between the ends of the wire. The Y-plate sensitivity is adjusted to $1.0\,\text{mV}\,\text{cm}^{-1}$ and the time base is $0.5\,\text{ms}\,\text{cm}^{-1}$.

The wire is plucked at its centre. Fig. 7.2 shows the trace seen on the c.r.o.

1.0 cm

1.0 cm

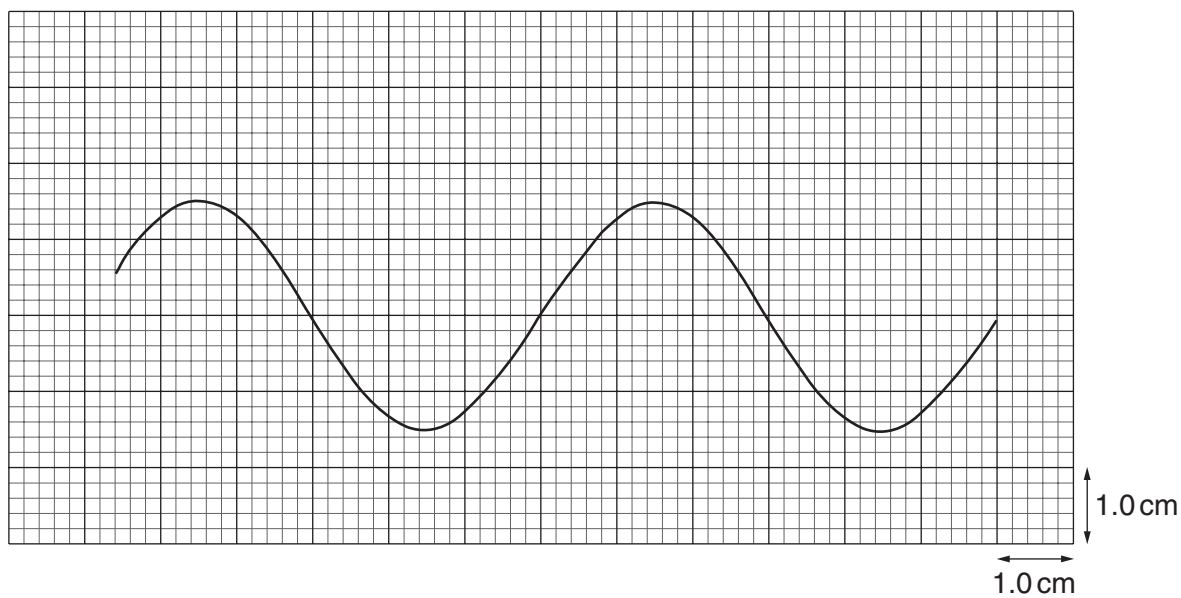**Fig. 7.2**

(a) Making reference to the laws of electromagnetic induction, suggest why

    (i) an e.m.f. is induced in the wire,

    ....

    ....

    ....

    (ii) the e.m.f. is alternating.

    ....

    ....

    ....

                                                                                         [4]

(b) Use Fig. 7.2 and the c.r.o. settings to determine the equation representing the induced alternating e.m.f.
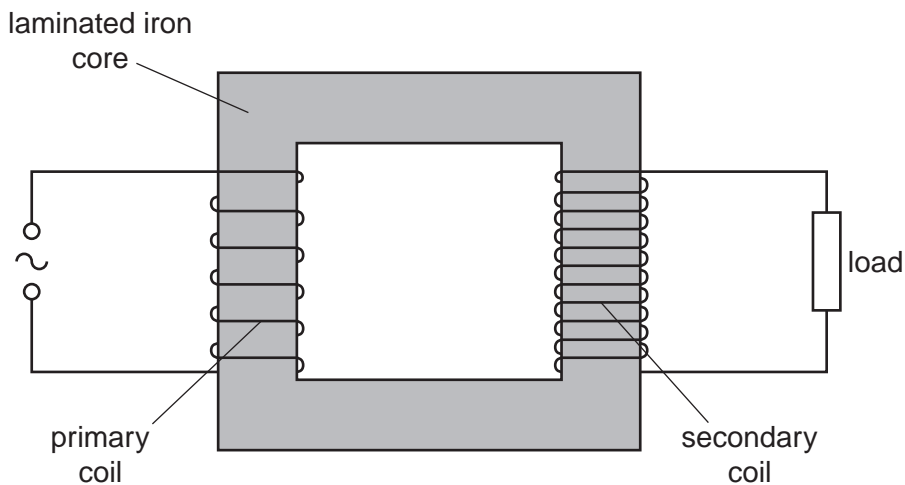
equation: .... [4]

6 A transformer is illustrated in Fig. 6.1.

Fig. 6.1

(a) (i) Explain why the coils are wound on a core made of iron.

....

....[1]

(ii) Suggest why thermal energy is generated in the core.

....

....

....[2]

(b) (i) State Faraday's law of electromagnetic induction.

....

....

....[2]

(ii) Use Faraday's law to explain why the potential difference across the load and the e.m.f. of the supply are not in phase.

....

....

....

....[2]

(c) Electrical energy is usually transmitted using alternating current. Suggest why the transmission is achieved using

(i) high voltages,

....

....

....[2]

(ii) alternating current.

....

....[1]

7 An ideal iron-cored transformer is illustrated in Fig. 6.1.
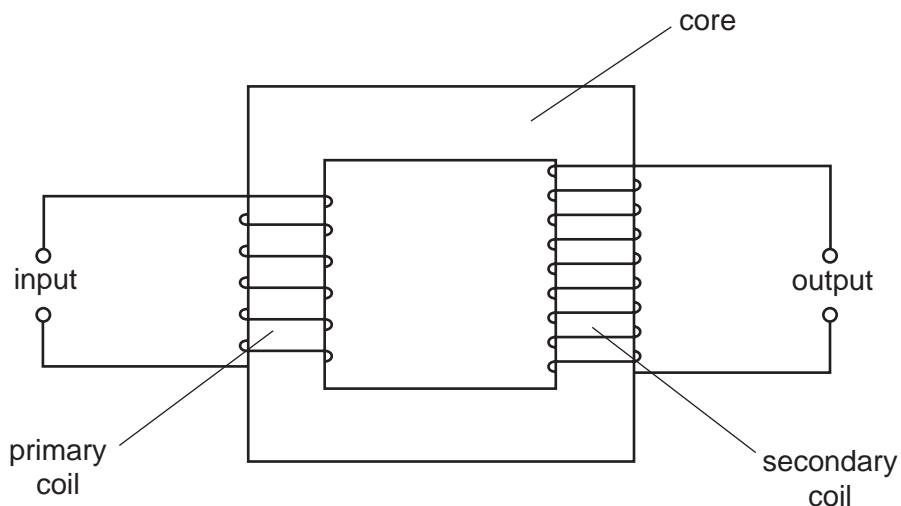
Fig. 6.1

(a) Explain why

(i) the supply to the primary coil must be alternating current, not direct current,

....

....

....[2]

(ii) for constant input power, the output current must decrease if the output voltage increases.

....

....

....[2]

(b) Fig. 6.2 shows the variation with time t of the current I_p in the primary coil. There is no current in the secondary coil.
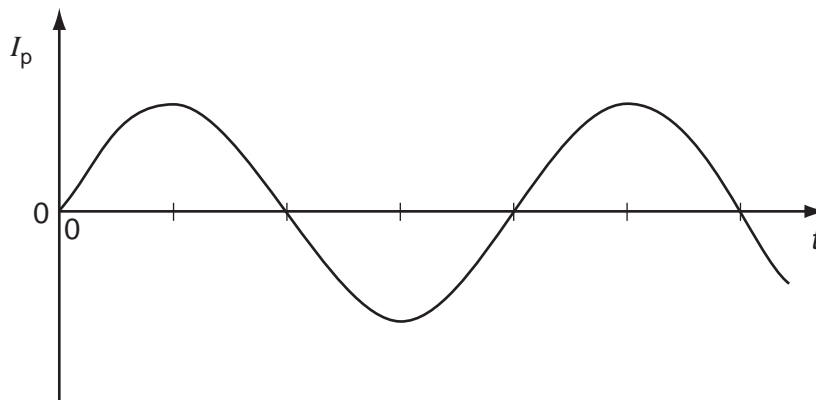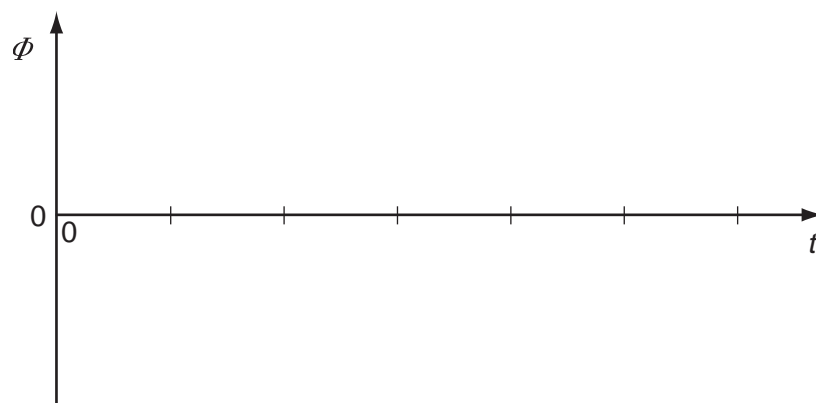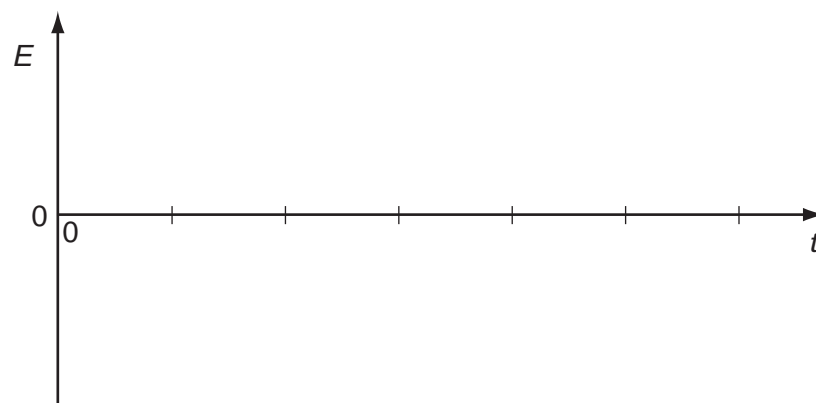

Fig. 6.2

Fig. 6.3

Fig. 6.4

(i) Complete Fig. 6.3 to show the variation with time t of the magnetic flux Φ in the core. [1]

(ii) Complete Fig. 6.4 to show the variation with time t of the e.m.f. E induced in the secondary coil. [2]

(iii) Hence state the phase difference between the current I_p in the primary coil and the e.m.f. E induced in the secondary coil.

phase difference = ... [1]