Electromagnetic Induction

Question paper 2

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Electromagnetic Induction
Sub Topic	
Paper Type	Theory
Booklet	Question paper 2

Time Allowed: **75 minutes**

Score: **/62**

Percentage: **/100**

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

1 **(a)** A constant current is maintained in a long straight vertical wire. A Hall probe is positioned a distance *r* from the centre of the wire, as shown in Fig. 5.1.

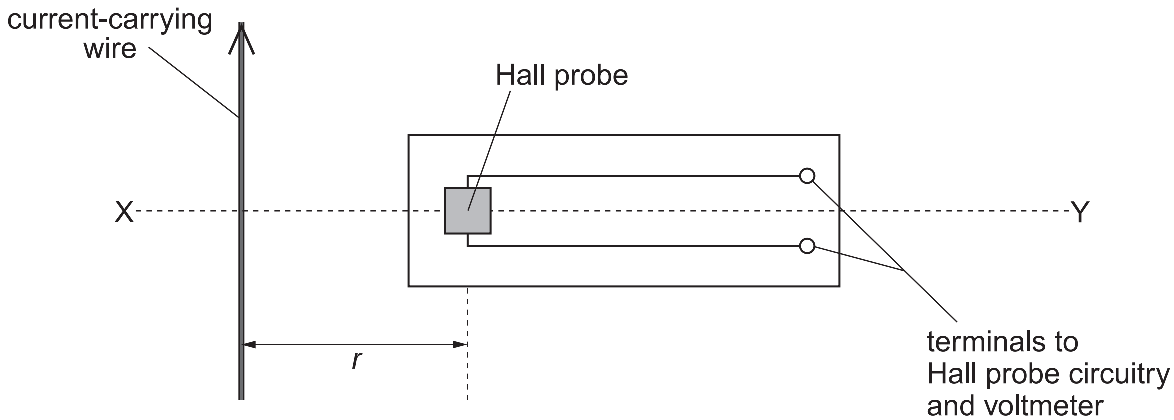

Fig. 5.1

(i) Explain why, when the Hall probe is rotated about the horizontal axis XY, the Hall voltage varies between a maximum positive value and a maximum negative value.

....

....

....[2]

(ii) The maximum Hall voltage V_H is measured at different distances *r*. Data for V_H and the corresponding values of *r* are shown in Fig. 5.2.

V_H / V	*r* / cm
0.290	1.0
0.190	1.5
0.140	2.0
0.097	3.0
0.073	4.0
0.060	5.0

Fig. 5.2

It is thought that V_H and *r* are related by an expression of the form

$$V_H = \frac{k}{r}$$

where *k* is a constant.

1. Without drawing a graph, use data from Fig. 5.2 to suggest whether the expression is valid.

[2]

2. A graph showing the variation with $\frac{1}{r}$ of V_H is plotted.

State the features of the graph that suggest that the expression is valid.

....

....[1]

(b) The Hall probe in **(a)** is now replaced with a small coil of wire connected to a sensitive voltmeter. The coil is arranged so that its plane is normal to the magnetic field of the wire.

(i) State Faraday's law of electromagnetic induction and hence explain why the voltmeter indicates a zero reading.

....

....

....

....[3]

(ii) State three different ways in which an e.m.f. may be induced in the coil.

1. ....

....

2. ....

....

3. ....

....

[3]

2 An ideal transformer is illustrated in Fig. 6.1.

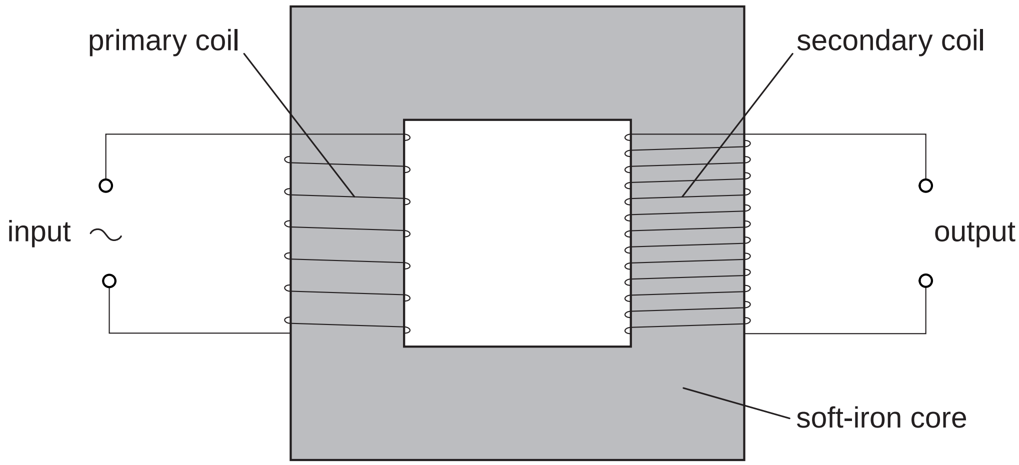

Fig. 6.1

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

....

....

.... [2]

(ii) Use the law to explain why a transformer will not operate using a direct current input.

....

....

.... [2]

(b) (i) State Lenz's law.

....

....

.... [2]

(ii) Use Lenz's law to explain why the input potential difference and the output e.m.f. are not in phase.

....

....

.... [2]

(c) Electrical energy is usually transmitted using alternating high voltages.

Suggest one advantage, for the transmission of electrical energy, of using

(i) alternating voltage, ...

.... [1]

(ii) high voltage. ....

.... [1]

3 You are provided with a coil of wire, a bar magnet and a sensitive ammeter.

Outline an experiment to verify Lenz's law.

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.... [6]

4 A simple iron-cored transformer is illustrated in Fig. 6.1.

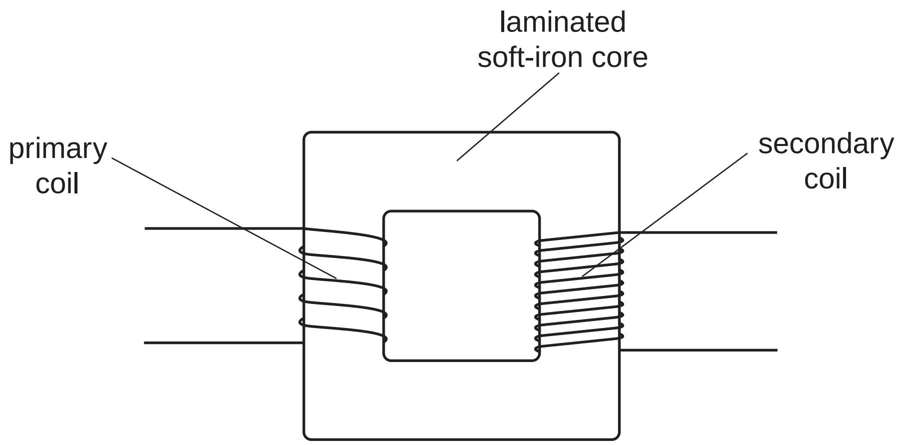

Fig. 6.1

(a) Suggest why the core is

(i) a continuous loop,

....

.... [1]

(ii) laminated.

....

....

.... [2]

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

....

....

.... [2]

(ii) Use Faraday's law to explain the operation of the transformer.

....

....

....

.... [3]

(c) State two advantages of the use of alternating voltages for the transmission and use of electrical energy.

1. ....

....

2. ....

....
[2]

5 A small rectangular coil ABCD contains 140 turns of wire. The sides AB and BC of the coil are of lengths 4.5 cm and 2.8 cm respectively, as shown in Fig. 6.1.

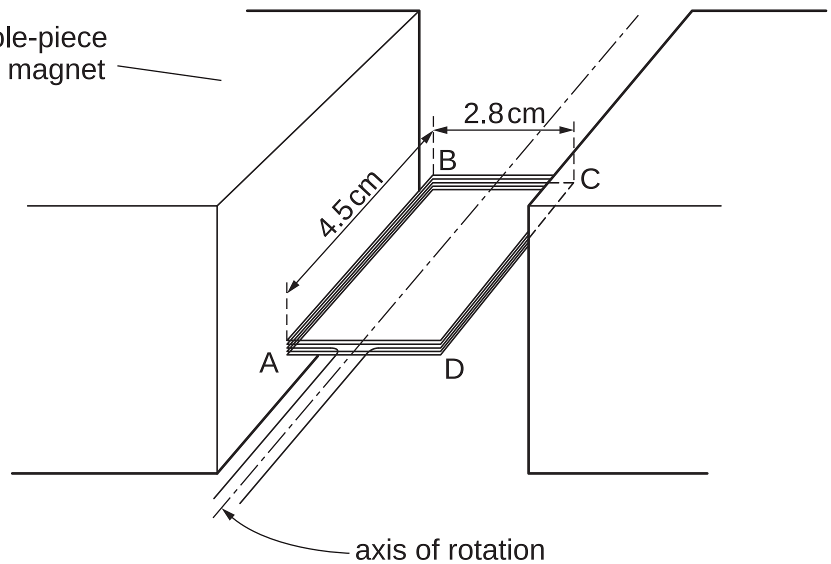

Fig. 6.1

The coil is held between the poles of a large magnet so that the coil can rotate about an axis through its centre.
The magnet produces a uniform magnetic field of flux density *B* between its poles.
When the current in the coil is 170 mA, the maximum torque produced in the coil is 2.1×10^{-3} N m.

(a) For the coil in the position for maximum torque, state whether the plane of the coil is parallel to, or normal to, the direction of the magnetic field.

.... [1]

(b) For the coil in the position shown in Fig. 6.1, calculate the magnitude of the force on

(i) side AB of the coil,

force = ... N [2]

(ii) side BC of the coil.

force = ... N [1]

(c) Use your answer to **(b)(i)** to show that the magnetic flux density *B* between the poles of the magnet is 70 mT.

[2]

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

....

....

....[2]

(ii) The current in the coil in **(a)** is switched off and the coil is positioned as shown in Fig. 6.1.
The coil is then turned through an angle of 90° in a time of 0.14 s.
Calculate the average e.m.f. induced in the coil.

e.m.f. = ... V [3]

6 A magnet is suspended vertically from a fixed point by means of a spring, as shown in Fig. 7.1.

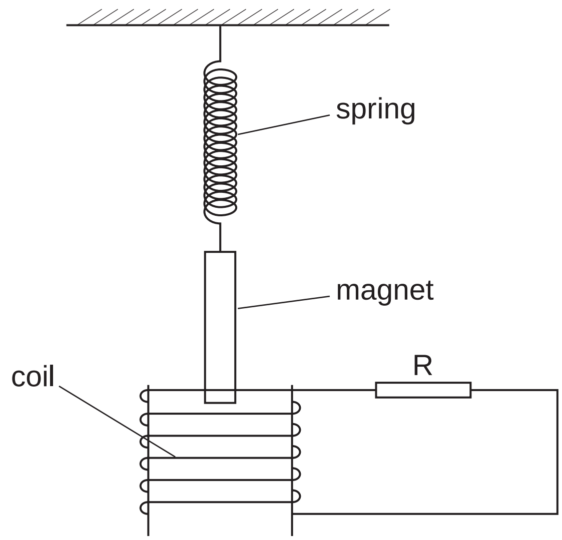

Fig. 7.1

One end of the magnet hangs inside a coil of wire. The coil is connected in series with a resistor R.

(a) The magnet is displaced vertically a small distance *D* and then released.
Fig. 7.2 shows the variation with time *t* of the vertical displacement *d* of the magnet from its equilibrium position.

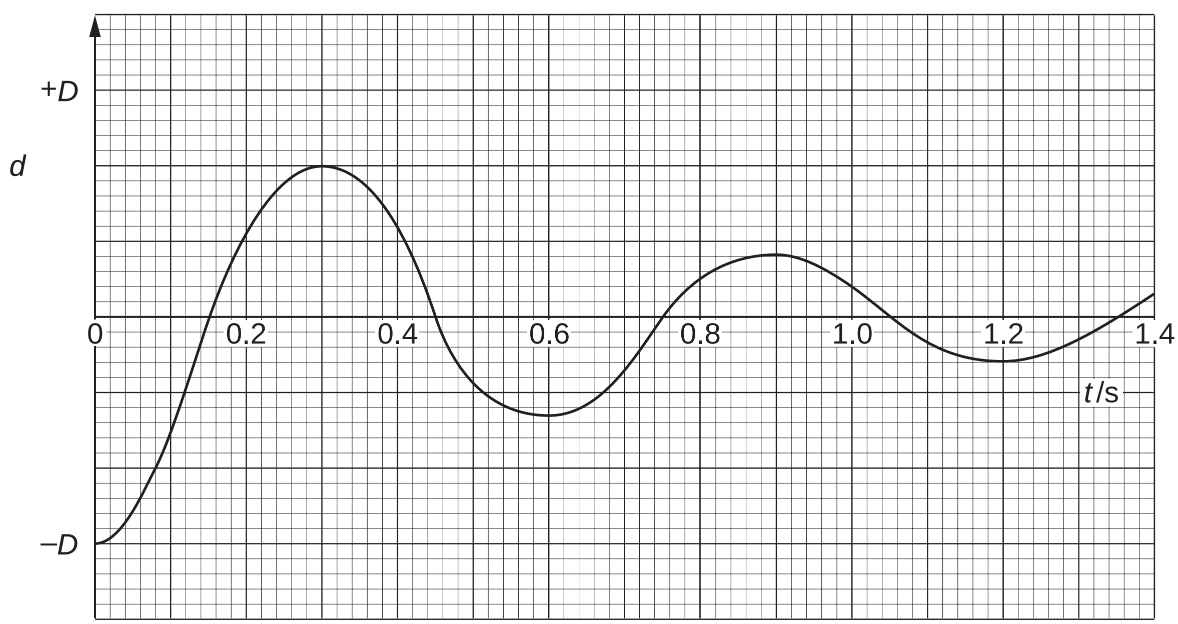

Fig. 7.2

(i) State and explain, by reference to electromagnetic induction, the nature of the oscillations of the magnet.

....

....

....

....

....

.... [5]

(ii) Calculate the angular frequency ω_0 of the oscillations.

ω_0 = ... rad s^{-1} [2]

(b) The resistance of the resistor R is increased.
The magnet is again displaced a vertical distance *D* and released.
On Fig. 7.2, sketch the variation with time *t* of the displacement *d* of the magnet. [2]

(c) The resistor R in Fig. 7.1 is replaced by a variable-frequency signal generator of constant r.m.s. output voltage.
The angular frequency ω of the generator is gradually increased from about $0.7\omega_0$ to about $1.3\omega_0$, where ω_0 is the angular frequency calculated in **(a)(ii)**.

(i) On the axes of Fig. 7.3, sketch a graph to show the variation with ω of the amplitude *A* of the oscillations of the magnet. [2]

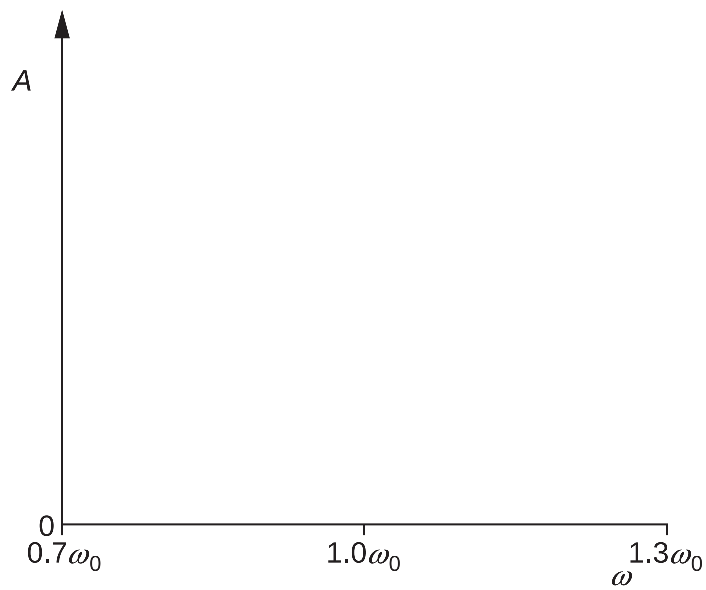

Fig. 7.3

(ii) State the name of the phenomenon illustrated in the graph of Fig. 7.3.

.... [1]

(iii) Briefly describe one situation where the phenomenon named in **(ii)** is useful and one situation where it should be avoided.

useful: ....

....

avoid: ....

.... [2]