Exampro A-level Physics A

Electromagnetic Induction

Name:

Class:

Author:

Date:

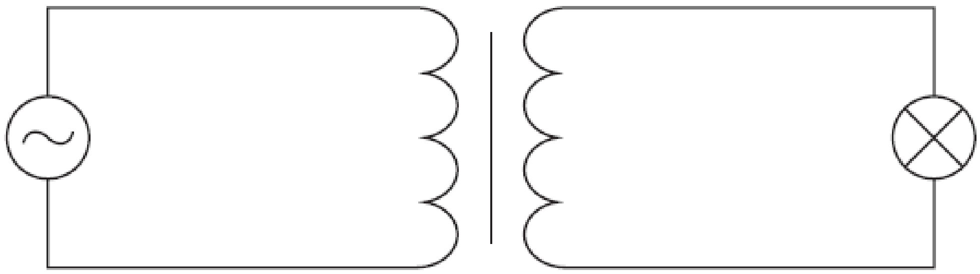
Time: 100

Marks: 70

Comments:

Q1. A transformer with 3000 turns in its primary coil is used to change an alternating pd from an rms value of 240 V to an rms value of 12 V.

When a 60 W, 12 V lamp is connected to the secondary coil, the lamp lights at normal brightness and a rms current of 0.26 A passes through the primary coil.

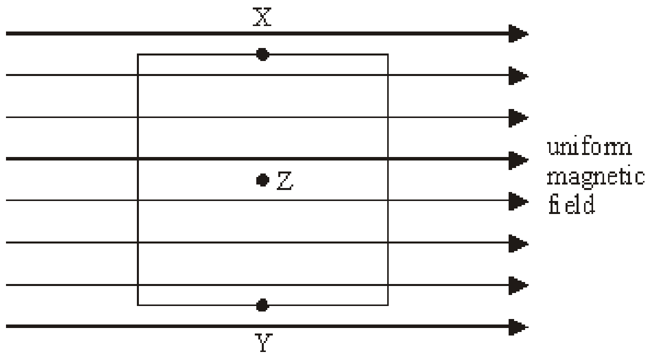


Which line, **A** to **D**, in the table gives correct values for the number of turns on the secondary coil and for the transformer efficiency?

	number of turns on the secondary coil	**efficiency**
A	150	96%
B	60 000	96%
C	150	90%
D	60 000	90%

(Total 1 mark)

Q2.



The diagram shows a square coil with its plane parallel to a uniform magnetic field. Which one of the following would induce an emf in the coil?

A movement of the coil slightly to the left

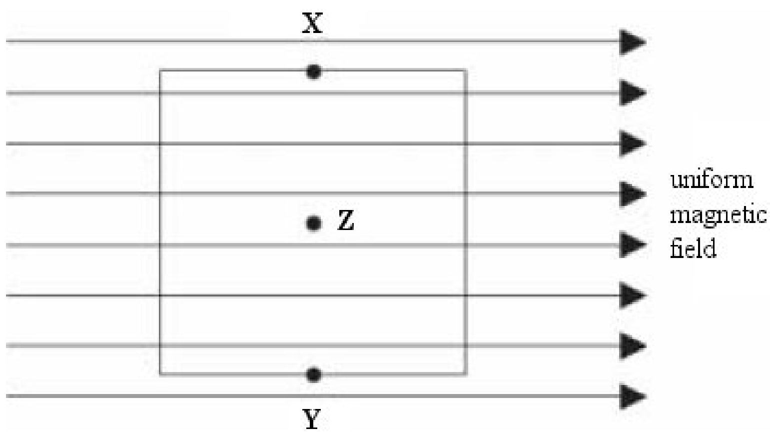
B movement of the coil slightly downwards

C rotation of the coil about an axis through XY

D rotation of the coil about an axis perpendicular to the plane of the coil through Z

(Total 1 mark)

Q3.



The diagram shows a square coil with its plane parallel to a uniform magnetic field. Which one of the following would induce an emf in the coil?

A movement of the coil slightly to the left

B movement of the coil slightly downwards

C rotation of the coil about an axis through XY

D rotation of the coil about an axis perpendicular to the plane of the coil through Z

(Total 1 mark)

Q4. The magnetic flux through a coil of N turns is increased uniformly from zero to a maximum value in a time t. An emf, E, is induced across the coil.
What is the maximum value of the magnetic flux through the coil?

A $\frac{Et}{N}$

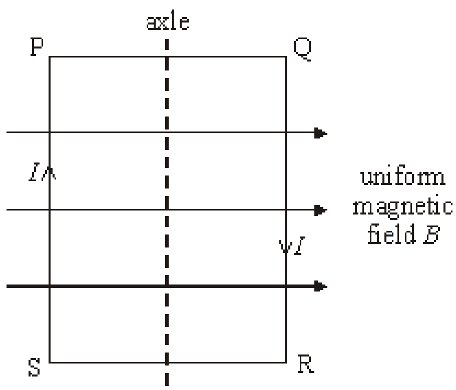
B $\frac{N}{Et}$

C $E\,t\,N$

D $\frac{E}{Nt}$

(Total 1 mark)

Q5.



A coil, mounted on an axle, has its plane parallel to the flux lines of a uniform magnetic field B, as shown. When a current I is switched on, and before the coil is allowed to move,

A there are no forces due to B on the sides PQ and RS.

B there are no forces due to B on the sides SP and QR.

C sides SP and QR attract each other.

D sides PQ and RS attract each other.

(Total 1 mark)

Q6. Why, when transporting electricity on the National Grid, are high voltages and low currents used?

A The energy lost by radiation from electromagnetic waves is reduced.

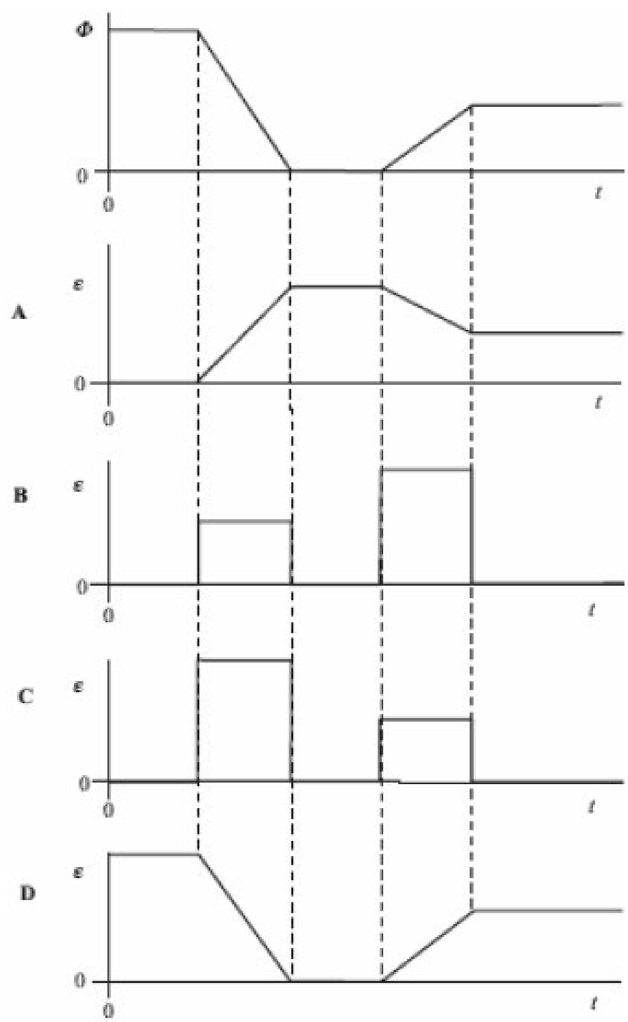
B The electrons move more rapidly.

C The heat losses are reduced.

D The resistance of the power lines is reduced.

(Total 1 mark)

Q7. The magnetic flux, Φ, through a coil varies with time, t, as shown by the first graph. Which one of the following graphs, A to D, best represents how the magnitude, ϵ, of the induced emf varies in this same period of time?



(Total 1 mark)

Q8. The primary winding of a perfectly efficient transformer has 200 turns and the secondary has 1000 turns. When a sinusoidal pd of rms value 10 V is applied to the input, there is a primary current of rms value 0.10 A rms. Which line in the following table, **A** to **D**, gives correct rms output values obtainable from the secondary when the primary is supplied in this way?

	rms output emf/V	rms output current/A
A	50	0.10
B	50	0.02
C	10	0.10
D	10	0.02

(Total 1 mark)

Q9. Which one of the following statements concerning power losses in a transformer is **incorrect**?

Power losses can be reduced by

A laminating the core.

B using high resistance windings.

C using thick wire.

D using a core made of special iron alloys which are easily magnetised.

(Total 1 mark)

Q10. The magnetic flux through a coil of 5 turns changes uniformly from 15×10^{-3} Wb to 7.0×10^{-3} Wb in 0.50 s. What is the magnitude of the emf induced in the coil due to this change in flux?

A 14 m V

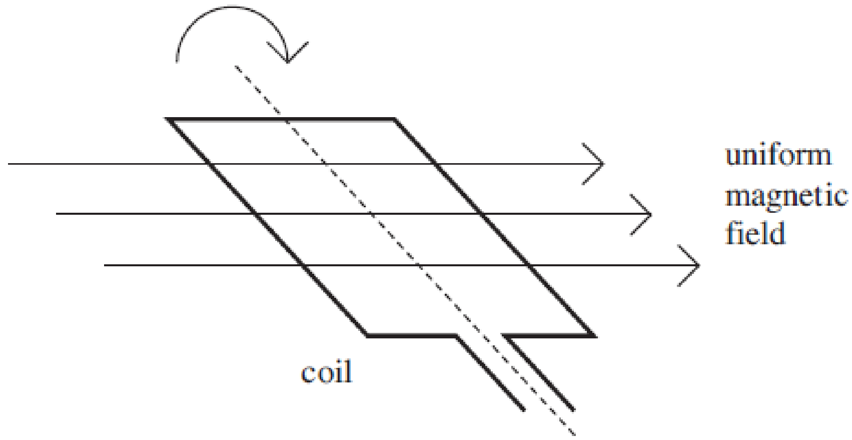
B 16 m V

C 30 m V

D 80 m V

(Total 1 mark)

Q11. A rectangular coil is rotated in a uniform magnetic field.



When the coil is rotated at a constant rate, an alternating emf ε is induced in it. The variation of emf ε, in volts, with time t, in seconds, is given by

$$\varepsilon = 20 \sin(100\,\pi t)$$

Which line, **A** to **D**, in the table gives the peak value ε_0 and the frequency f of the induced emf?

	ε_0 / V	f / Hz
A	10	50
B	10	100
C	20	50
D	20	100

(Total 1 mark)

Q12. A transformer has 1150 turns on the primary coil and 500 turns on the secondary coil. The primary coil draws a current of 0.26 A from a 230 V ac supply. The current in the secondary coil is 0.50 A. What is the efficiency of the transformer?

A 42%

B 50%

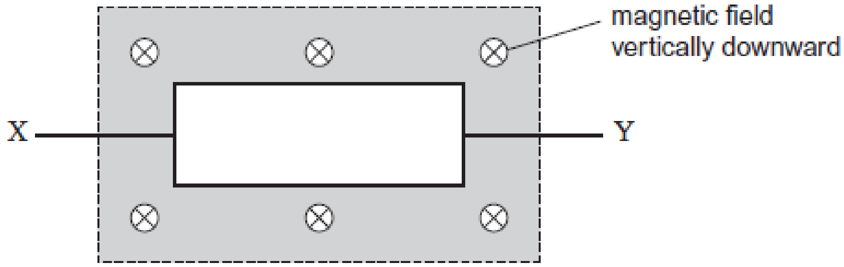
C 84%

D 100%

(Total 1 mark)

Q13. A rectangular coil of area A has N turns of wire. The coil is in a uniform magnetic field, as shown in the diagram.

When the coil is rotated at a constant frequency f about its axis XY, an alternating emf of peak value ε_0 is induced in it.



What is the maximum value of the magnetic flux linkage through the coil?

A $\dfrac{\varepsilon_0}{2\pi f}$

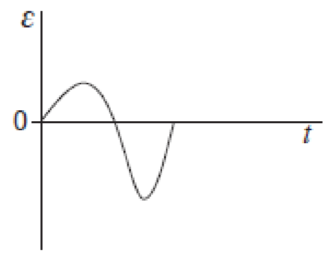
B $\dfrac{\varepsilon_0}{\pi f}$

C $\pi f \varepsilon_0$

D $2\pi f \varepsilon_0$

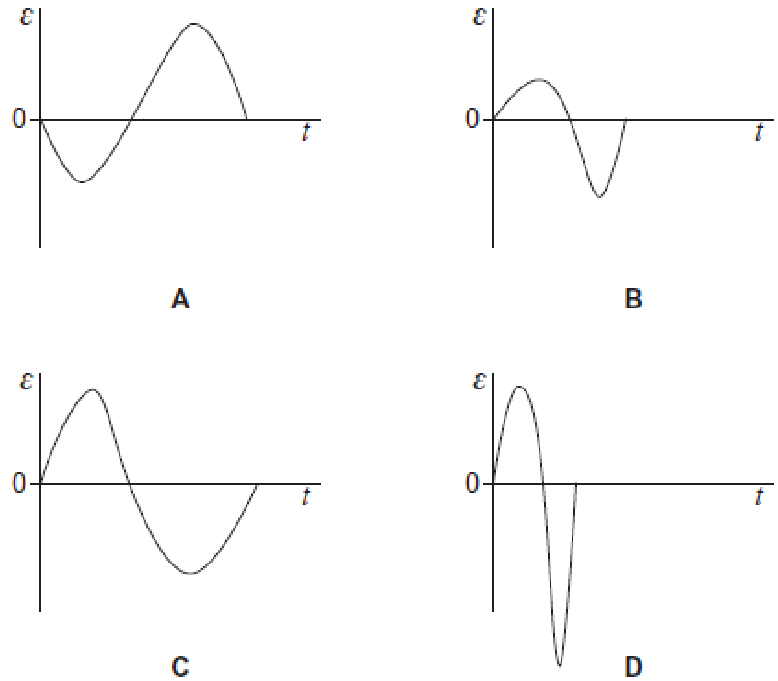
(Total 1 mark)

Q14. When a magnet is dropped through an aluminium ring an emf is induced. A data logger connected to the ring records the variation of the induced emf ε with time t as shown below.



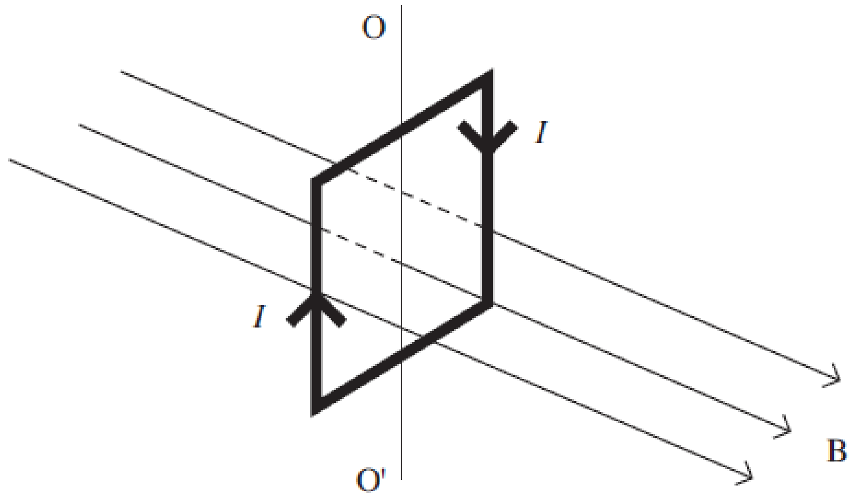
In a second experiment, the magnet is dropped from a greater height.

Which one of the following graphs best represents the induced emf in the second experiment?



(Total 1 mark)

Q15. The diagram shows a vertical square coil whose plane is at right angles to a horizontal uniform magnetic field B. A current, **I**, is passed through the coil, which is free to rotate about a vertical axis OO'.



Which one of the following statements is correct?

A The forces on the two vertical sides of the coil are equal and opposite.

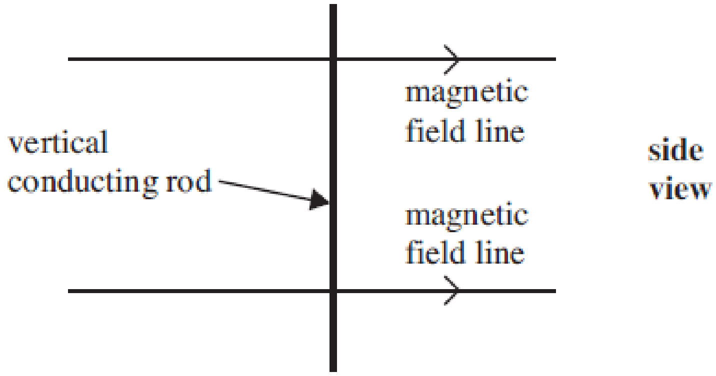
B A couple acts on the coil.

C No forces act on the horizontal sides of the coil.

D If the coil is turned through a small angle about OO' and released, it will remain in position.

(Total 1 mark)

Q16. A vertical conducting rod of length l is moved at a constant velocity v through a uniform horizontal magnetic field of flux density B.



Which line, **A** to **D**, in the table gives a correct expression for the induced emf for the stated direction of the motion of the rod?

	direction of motion	**induced emf**
A	vertical	$\frac{B}{lv}$
B	horizontal at right angles to the field	Blv
C	vertical	Blv
D	horizontal at right angles to the field	$\frac{B}{lv}$

(Total 1 mark)

Q17. A transformer, which is not perfectly efficient, is connected to a 230 V rms mains supply and is used to operate a 12 V rms, 60 W lamp at normal brightness. The secondary coil of the transformer has 24 turns.

Which line, **A** to **D**, in the table is correct?

	number of turns on primary coil	**rms current in primary coil**
A	92	less than 0.26 A
B	92	more than 0.26 A
C	460	less than 0.26 A
D	460	more than 0.26 A

(Total 1 mark)

Q18. In which one of the following applications does electromagnetic induction **not** take place?

A the generators at a nuclear power station

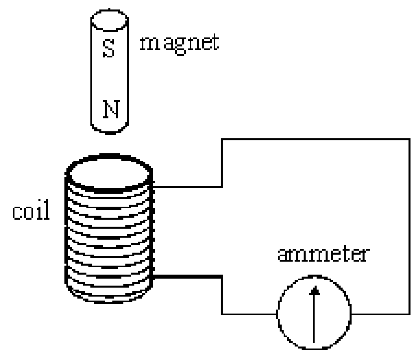
B the ac power adapter for a laptop computer

C the wings of an aircraft cutting through the Earth's magnetic field

D the back up capacitor of an electric timer

(Total 1 mark)

Q19. A coil is connected to a centre zero ammeter, as shown. A student drops a magnet so that it falls vertically and completely through the coil.



(a) Describe what the student would observe on the ammeter as the magnet falls through the coil.

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(2)

(b) If the coil were not present the magnet would accelerate downwards at the acceleration due to gravity. State and explain how its acceleration in the student's experiment would be affected, if at all,

(i) as it entered the coil,

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(ii) as it left the coil.

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(4)

(c) Suppose the student forgot to connect the ammeter to the coil, therefore leaving the circuit incomplete, before carrying out the experiment. Describe and explain what difference this would make to your conclusions in part (b).

You may be awarded marks for the quality of written communication provided in your answer.

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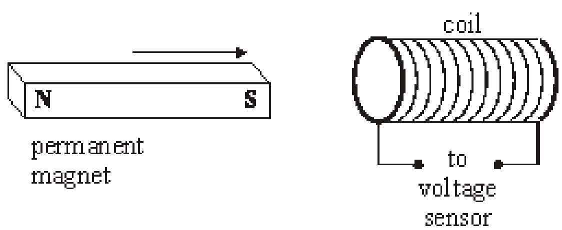
(3)
(Total 9 marks)

Q20. (a) In an experiment to illustrate electromagnetic induction, a permanent magnet is moved towards a coil, as shown in **Figure 1**, causing an emf to be induced across the coil.

Figure 1



Using Faraday's law, explain why a larger emf would be induced in this experiment if a stronger magnet were moved at the same speed.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

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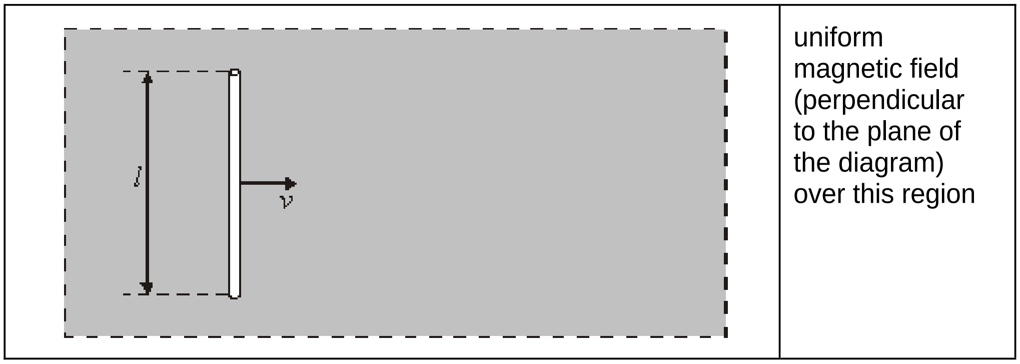
(3)

(b) A conductor of length *l* is moved at a constant speed *v* so that it passes perpendicularly through a uniform magnetic field of flux density *B*, as shown in **Figure 2**.

Figure 2



(i) Give an expression for the area of the magnetic field swept out by the conductor in time Δt.

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(ii) Show that the induced emf, ϵ, across the ends of the conductor is given by $\epsilon = Blv$.

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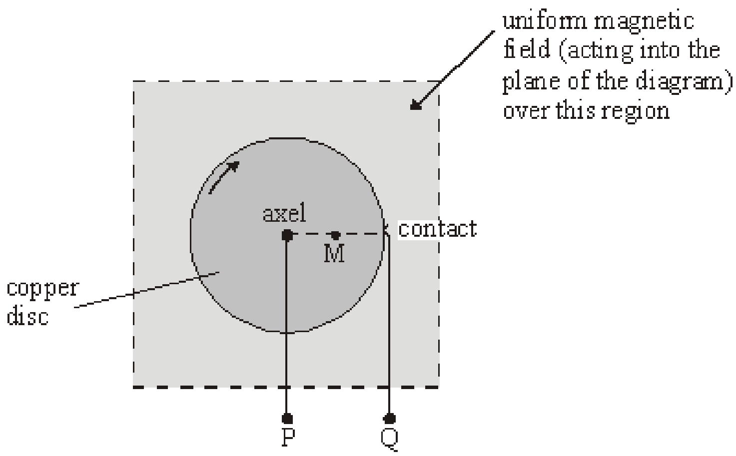
(3)

(c) A simple electrical generator can be made from a copper disc, which is rotated at right angles to a uniform magnetic field, directed into the plane of the diagram (**Figure 3**). An emf is developed across terminals P (connected to the axle) and Q (connected to a contact on the edge of the disc).

Figure 3



The radius of the disc is 64 mm and it is rotated at 16 revolutions per second in a uniform magnetic field of flux density 28 mT.

(i) Calculate the angular speed of the disc.

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(ii) Calculate the linear speed of the mid-point M of a radius of the disc.

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(iii) Hence, or otherwise, calculate the emf induced across terminals P and Q.

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(5)
(Total 11 marks)

Q21. (a) State Lenz's law.

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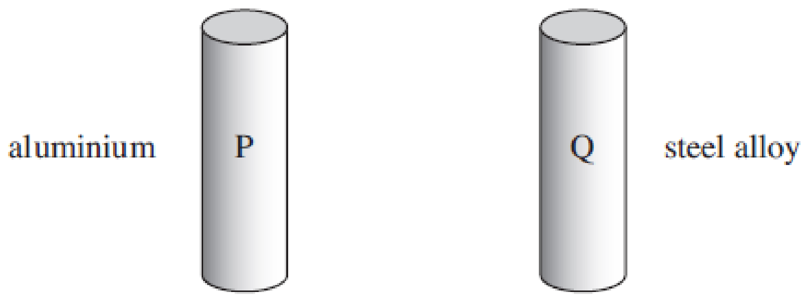
(2)

(b) **Figure 1** shows two small, solid metal cylinders, **P** and **Q**. **P** is made from aluminium. **Q** is made from a steel alloy.

Figure 1



(i) The dimensions of **P** and **Q** are identical but **Q** has a greater mass than **P**. Explain what material property is responsible for this difference.

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(1)

(ii) When **P** and **Q** are released from rest and allowed to fall freely through a vertical distance of 1.0 m, they each take 0.45 s to do so. Justify this time value and explain why the times are the same.

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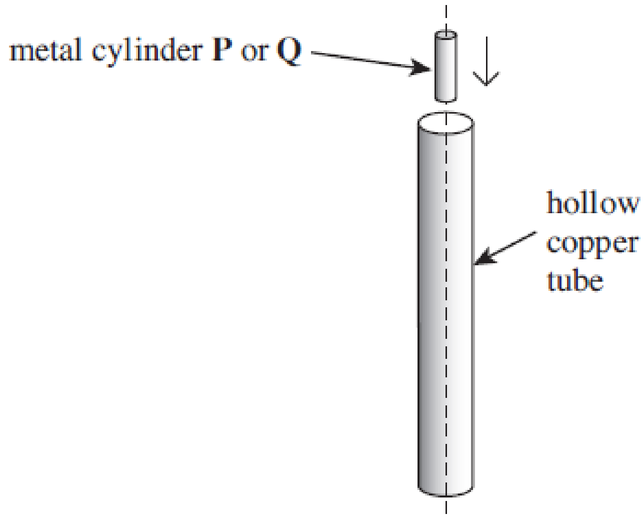
(2)

(c) The steel cylinder **Q** is a strong permanent magnet. **P** and **Q** are released separately from the top of a long, vertical copper tube so that they pass down the centre of the tube, as shown in **Figure 2**.

Figure 2



The time taken for **Q** to pass through the tube is much longer than that taken by **P**.

(i) Explain why you would expect an emf to be induced in the tube as **Q** passes through it.

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(2)

(ii) State the consequences of this induced emf, and hence explain why **Q** takes longer than **P** to pass through the tube.

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(3)

(d) The copper tube is replaced by a tube of the same dimensions made from brass. The resistivity of brass is much greater than that of copper. Describe and explain how, if at all, the times taken by **P** and **Q** to pass through the tube would be affected.

P: ....

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Q: ....

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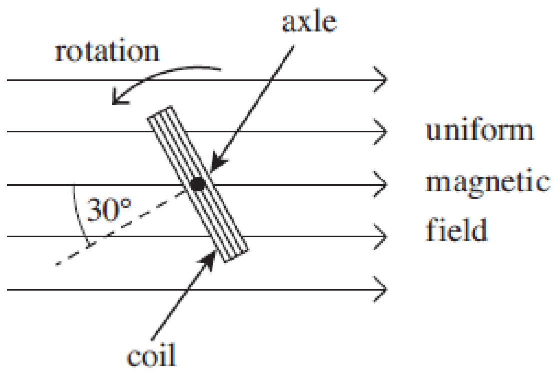
(3)
(Total 13 marks)

Q22. A rectangular coil is rotating anticlockwise at constant angular speed with its axle at right angles to a uniform magnetic field. **Figure 1** shows an end-on view of the coil at a particular instant.

Figure 1



(a) At the instant shown in **Figure 1**, the angle between the normal to the plane of the coil and the direction of the magnetic field is 30°.

(i) State the minimum angle, in degrees, through which the coil must rotate from its position in **Figure 1** for the emf to reach its maximum value.

angle .... degrees

(1)

(ii) Calculate the minimum angle, in radians, through which the coil must rotate from its position in **Figure 1** for the flux linkage to reach its maximum value.

angle .... radians

(2)

(b) **Figure 2** shows how, starting in a different position, the flux linkage through the coil varies with time.

(i) What physical quantity is represented by the gradient of the graph shown in **Figure 2**?

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(1)

(ii) Calculate the number of revolutions per minute made by the coil.

revolutions per minute ....

(2)

Figure 2

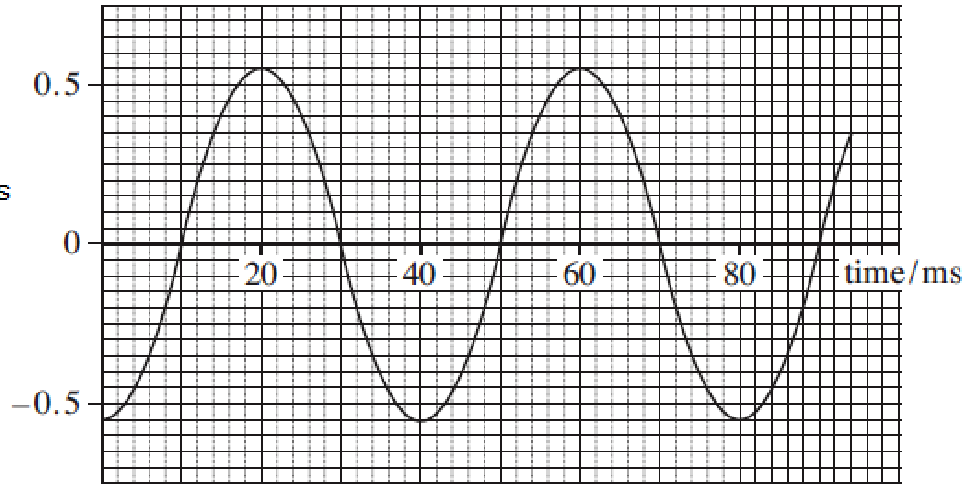
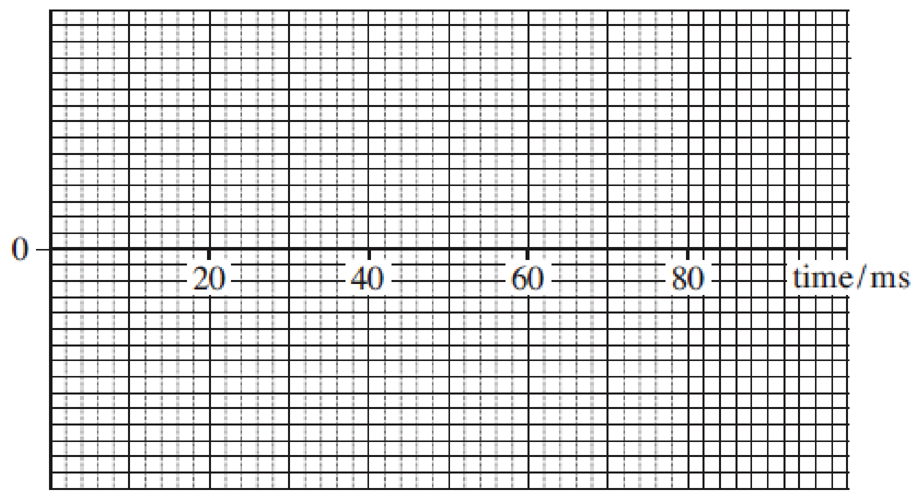


Figure 3



(iii) Calculate the peak value of the emf generated.

peak emf V

(3)

(c) Sketch a graph on the axes shown in **Figure 3** above to show how the induced emf varies with time over the time interval shown in **Figure 2**.

(2)

(d) The coil has 550 turns and a cross-sectional area of $4.0 \times 10^{-3} m^2$.

Calculate the flux density of the uniform magnetic field.

flux density .... T

(2)
(Total 13 marks)

Q23.

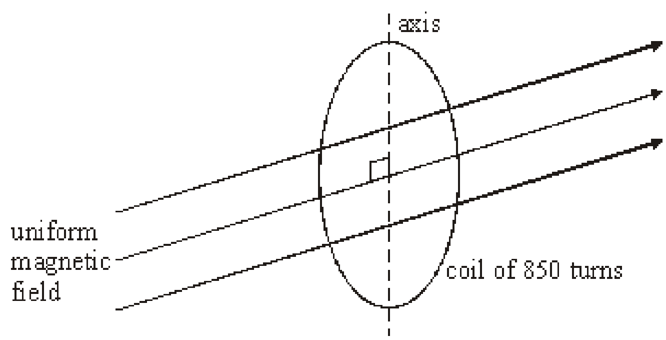


Figure 1

A circular coil of diameter 140 mm has 850 turns. It is placed so that its plane is perpendicular to a horizontal magnetic field of uniform flux density 45 mT, as shown in **Figure 1**.

(a) Calculate the magnetic flux passing through the coil when in this position.

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(2)

(b) The coil is rotated through 90° about a vertical axis in a time of 120 ms.

Calculate

(i) the change of magnetic flux linkage produced by this rotation,

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(ii) the average emf induced in the coil when it is rotated.

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(4)
(Total 6 marks)