PRESTON MANOR

A Level Physics Exam Packs

Induction

Name:

Form:

Question	Mark

Answer **all** the questions.

1 **(a)** Define *electromotive force.*

....

.... [1]

(b) Define *magnetic flux.*

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....

.... [1]

(c) Fig. 1.1 shows a simple transformer.

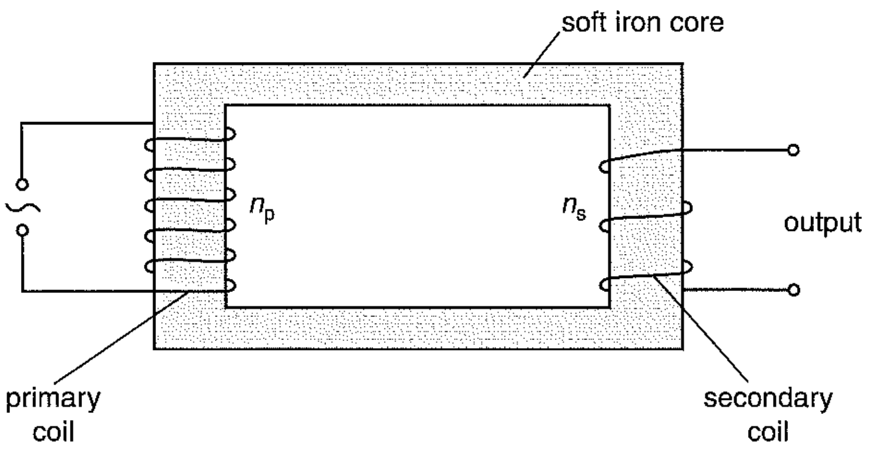

Fig. 1.1

(i) The primary coil is connected to an alternating voltage supply. Explain how an e.m.f. is induced in the secondary coil.

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.... [3]

(ii) State how you could change the transformer to increase the maximum e.m.f. induced in the secondary coil.

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....

.... [1]

(d) A transformer with 4200 turns in the primary coil is connected to a 230V mains supply. The e.m.f. across the output is 12V. Assume the transformer is 100% efficient.

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

number of turns = ... [2]

(ii) The transformer output terminals are connected to a lamp using leads that have a total resistance of 0.35 Ω. The p.d. across the lamp is 11.8V. Calculate

1 the current in the leads connected to the lamp

current = ... A [2]

2 the power dissipated in the leads.

power = ... W [2]

[Total: 12]

Question			Expected Answers	Marks	Additional guidance
1	(a)		Electromotive force is the energy transferred (from one form of energy) to electrical per unit charge	B1	**Allow:** 'electrical energy (gained) per unit charge' **Not:** electrical energy per coulomb
	(b)		Magnetic flux is the product of the (magnetic) flux density and the area (normal to the field)	B1	**Allow:** $\phi = BA$, where B = (magnetic) flux density and A = area. If $\phi = BA\cos\theta$ is used, then θ must be defined as the angle (between the normal to the plane of the area and the magnetic field) **Do not allow** 'field strength' for 'flux density'
	(c)	(i)	A changing (magnetic) flux is produced (in the primary coil / in the iron core)	B1	**Allow:** A changing (magnetic) flux density is produced (in the primary coil) but **not** '*changing (magnetic) field*'
			The iron core links this (magnetic) flux /(magnetic) flux density to the secondary coils	B1	
			The changing (magnetic) flux / (magnetic) flux density through secondary induces e.m.f. (in secondary coils)	B1	**Allow:** The rate of change of (magnetic) flux (linkage) induces an e.m.f. (in the secondary coil)
		(ii)	Any one from: More coils / turns on secondary Less coils / turns on primary Laminate the core	B1	**Not:** Increase frequency of alternating supply
	(d)	(i)	$\frac{n_s}{4200} = \frac{12}{230}$ (Any subject) number of turns = 219 or 220	C1 A1	**Note:** A bald answer 219 or 220 scores 2 marks
		(ii)	current = $(12.0 - 11.8)/0.35$ current = 0.57 (A)	C1 A1	
			$P = VI$ or $P = I^2R$ or $P = V^2/R$ $P = 0.2 \times 0.57$ or $P = 0.57^2 \times 0.35$ or $P = 0.2^2/0.35$ power = 0.114 (W) or 0.11 (W)	C1 A1	Possible e.c.f. from **(ii)1**
			Total	**12**	

3 Fig. 3.1 shows the variation of the magnetic flux **linkage** with time *t* for a small generator.

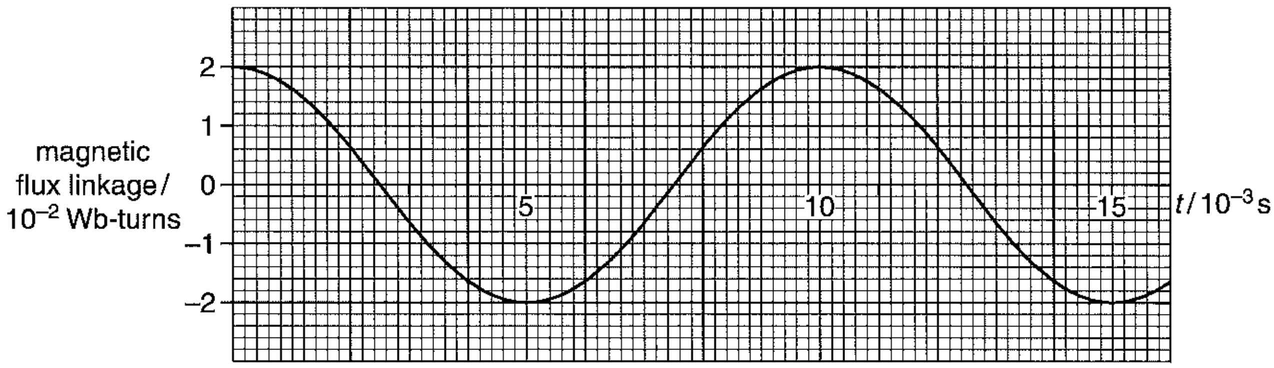

Fig. 3.1

The generator has a flat coil of negligible resistance that is rotated at a steady frequency in a uniform magnetic field. The coil has 400 turns and cross-sectional area $1.6 \times 10^{-3}\,m^2$. The output from the generator is connected to a resistor of resistance 150 Ω.

(a) Use Fig. 3.1 to

(i) calculate the frequency of rotation of the coil

frequency = ... Hz **[1]**

(ii) calculate the magnetic flux density *B* of the magnetic field

B = ... T **[3]**

(iii) show that the **maximum** electromotive force (e.m.f.) induced in the coil is about 12V.

[3]

(b) Hence calculate the **maximum** power dissipated in the resistor.

power = ... W **[2]**

[Total: 9]

Question			Answer	Marks	Guidance
3	(a)	(i)	$f=\frac{1}{T}=\frac{1}{10\times10^{-3}}$ frequency = 100 (Hz)	B1	
		(ii)	$2.0\times10^{-2}=B\times1.6\times10^{-3}\times400$ $B=\frac{2.0\times10^{-2}}{1.6\times10^{-3}\times400}$ $B = 3.1\times10^{-2}$ (T)	C1 C1 A1	**Allow:** 2 mark for 3.1×10^{n}; $n\neq -2$ (POT error) Answer to 3 sf is 3.13×10^{-2} (T) **Special case**: 12.5 scores 1 mark; number of turns omitted
		(iii)	(e.m.f. = -) rate of change of flux <u>linkage</u> <u>Tangent</u> drawn on Fig. 3.1 at 2.5 (ms) or 7.5 (ms) or 12.5 (ms) Values substituted to determine the gradient. The gradient must be 12.5 ± 1.0 (V)	B1 B1 B1	**Allow:** $E=(-)\frac{\Delta(N\phi)}{\Delta t}$ or (e.m.f. =) gradient **Alternative**: maximum e.m.f. = $2\pi f\times$ maximum flux linkage C1 maximum e.m.f. = $2\pi\times100\times2\times10^{-2}$ C1 maximum e.m.f. = 12.6 (V) or 4π (V) A1
	(b)		$P=\frac{V^2}{R}$ $P=\frac{12^2}{150}$ power = 0.96 (W)	C1 A1	Possible ecf from **(a)(iii)**
			Total	**9**	

4 **(a)** Define *magnetic flux*.

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....

.... **[1]**

(b) Fig. 4.1 shows a solenoid connected to a battery and the magnetic field through it when the switch **S** is closed.

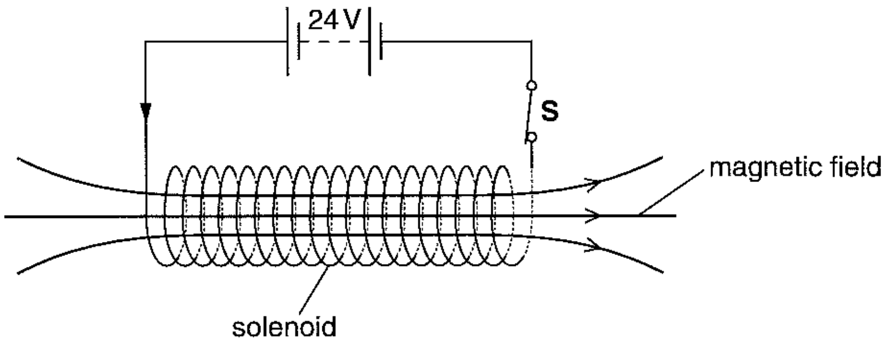

Fig. 4.1

(i) The battery has an e.m.f. of 24 V and negligible internal resistance. The solenoid is made from copper wire. The wire has radius 4.6×10^{-4} m and total length 130 m. The resistivity of copper is $1.7 \times 10^{-8}\ \Omega$ m. Calculate the current in the solenoid.

current = ... A **[3]**

(ii) A tiny electrical spark is created between the contacts of the switch **S** as it is opened. The spark is produced because an e.m.f. is induced across the ends of the solenoid by the collapse of the magnetic flux linked with the solenoid.

The initial magnetic flux density within the solenoid is 0.090T and may be assumed to be uniform. The solenoid has 1100 turns and cross-sectional area $1.3 \times 10^{-3}\,m^2$.

The average e.m.f. induced across the ends of the solenoid is 150V. Estimate the time taken for the magnetic flux to collapse to zero.

time = ... s **[3]**

[Total: 7]

Question			Answer	Marks	Guidance
4	(a)		magnetic flux = magnetic flux density × area <u>normal</u> to the field	B1	**Allow**: $\phi = BA$, with terms defined; B = magnetic flux density or magnetic field strength and A = area normal to the field **Note**: If angle is used in the definition then it must be defined correctly
	(b)	(i)	$R = \frac{1.7 \times 10^{-8} \times 130}{\pi \times (4.6 \times 10^{-4})^2}$ (Any subject)	C1	
			R = 3.3(2) (Ω)	C1	
			current = $\frac{24}{3.32}$ current = 7.2 (A)	A1	**Allow**: Possible ecf if value for R is incorrect after attempted use of the equation $R = \frac{\rho L}{\pi r^2}$.
		(ii)	e.m.f. = rate of change of magnetic flux linkage		
			(initial ϕ =) 0.090 × 1.3 × 10^{-3} or 1.17 × 10^{-4}	C1	**Allow**: (initial $N\phi$ =) 0.090 × 1.3 × 10^{-3} × 1100 or 0.129
			150 = $\frac{1100 \times 0.090 \times 1.3 \times 10^{-3}}{t}$ (Any subject)	C1	
			time = 8.6 × 10^{-4} (s)	A1	**Allow**: 2 marks for 7.8 × 10^{-7} (s) if 1100 turns omitted
			Total	**7**	

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

....

.... [1]

(b) Fig. 5.1 shows a magnet being moved towards the centre of a flat coil.

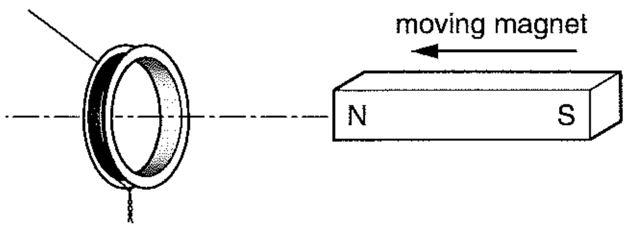

Fig. 5.1

A current is induced in the coil. Use ideas about energy conservation to state and explain the polarity of the face of the coil nearer the magnet.

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.... [1]

(c) Fig. 5.2 shows the magnetic field from the north pole of a vertically held bar magnet.

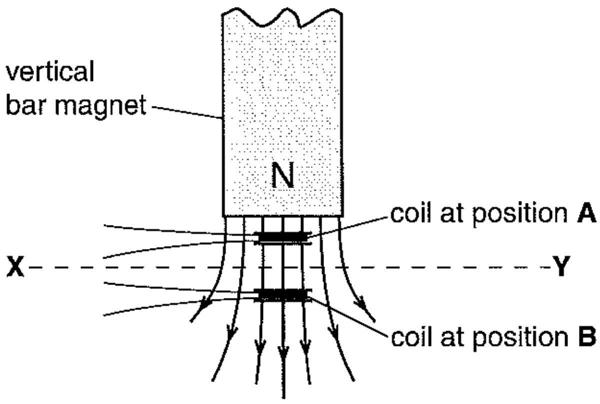

Fig. 5.2

(i) A small flat coil is placed at **A**. The coil is moved downwards from position **A** to position **B**. The plane of the coil remains horizontal between these two positions. Explain why there is no induced e.m.f. across the ends of the coil.

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.... [1]

(ii) Fig. 5.3 is a graph showing how the magnetic flux density *B* varies along the horizontal line **XY** in Fig. 5.2.

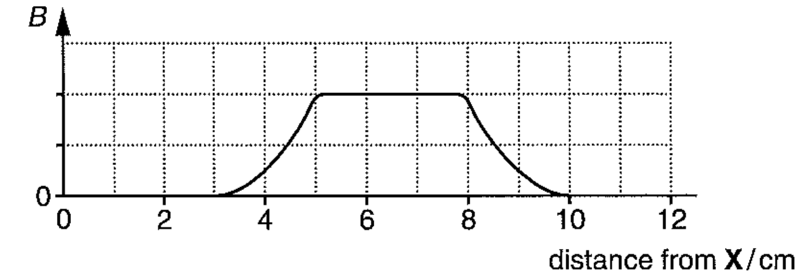

Fig. 5.3

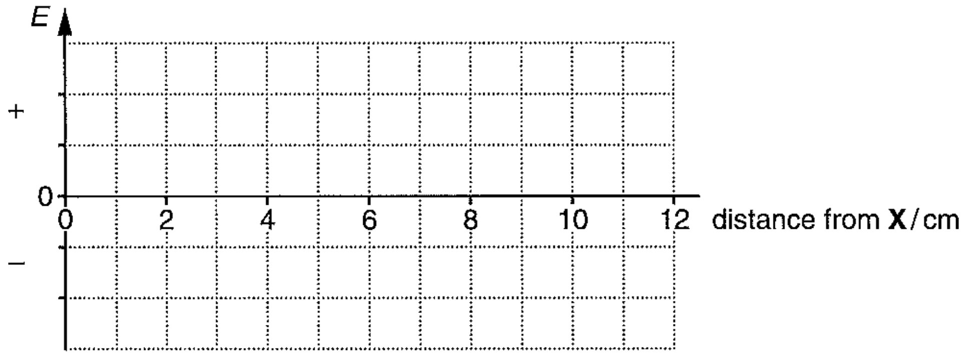

Fig. 5.4

The same small flat coil from **(i)** is moved at a constant speed from **X** to **Y**. The plane of the coil remains horizontal between **X** and **Y**.

On the axis provided in Fig. 5.4, sketch a graph to show the variation of the induced e.m.f. *E* across the ends of the coil with distance from **X**. **[3]**

[Total: 6]

Question 6 begins on page 14

Question			Answers	Marks	Guidance
5	(a)		The induced e.m.f. is (directly) proportional / equal to the rate of change of (magnetic) flux linkage.	B1	**Allow** $E = \frac{\Delta\Phi}{\Delta t}$ with all terms defined; E = induced e.m.f., Φ = (magnetic) flux linkage and t = time.
	(b)		North / N (pole). There is a repulsive force (between magnet and coil and the work done against this repulsive force is transferred to electrical energy in the coil).	B1	**Allow** - A south (pole) would cause attraction (between the coil and magnet) or there is gain in KE (of magnet which cannot happen hence it must be north pole).
	(c)	(i)	There is no change in (magnetic) flux (linkage) or there is no change in the (magnetic) flux density.	B1	**Allow** 'no change in (magnetic) field strength'.
		(ii)	E = 0 between 0 to 3 cm, 5 – 8 cm and 10 - 12 cm. Two 'pulses' where B is changing. The pulses have opposite signs.	B1 M1 A1	Tolerance: ± ¼ large square **Note**: The pulses must have E = 0 at 3 cm, 5 cm, 8 cm and 10 cm; tolerance ± ¼ large square.
			Total	**6**	

2 **(a)** Fig. 2.1 shows a horizontal current-carrying wire placed in a uniform magnetic field.

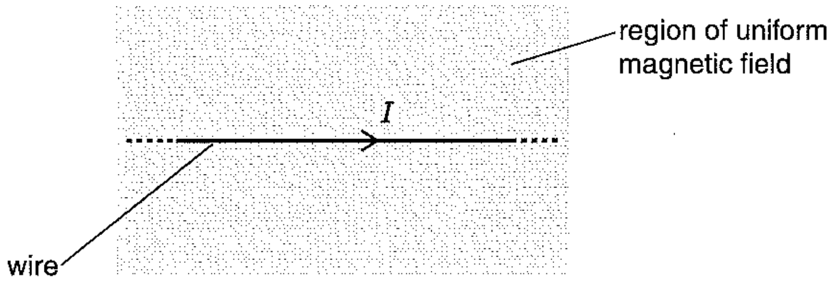

Fig. 2.1

The magnetic field of flux density 0.070T is at right angles to the wire and into the plane of the paper. The weight of a 1.0cm length of the wire is 6.8×10^{-5} N. The current I in the wire is such that the vertical upward force on the wire due to the magnetic field is equal to the weight of the wire.

(i) Calculate the current I in the wire.

I = ... A **[2]**

(ii) Suggest why it would be impossible for overhead cables carrying an alternating current to float in the Earth's magnetic field.

....

.... **[1]**

(b) A charged particle enters a region of uniform magnetic field. Fig. 2.2 shows the path of this particle.

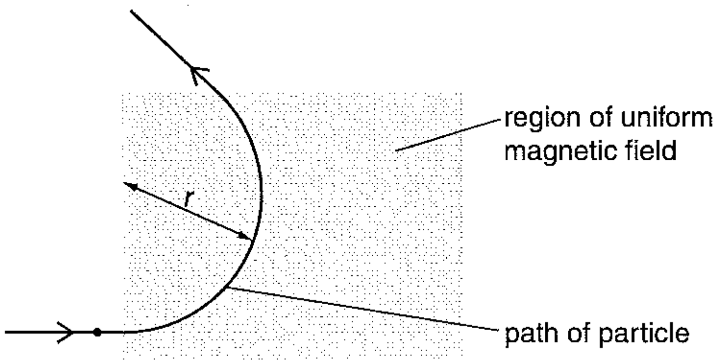

Fig. 2.2

The direction of the field is perpendicular to the plane of the paper. The magnetic field has flux density B. The particle has mass m, charge Q and speed v. The particle travels in a circular arc of radius r in the magnetic field.

(i) Derive an equation for the radius r in terms of B, m, Q and v.

[2]

(ii) A thin aluminium plate is now placed in the magnetic field. Fig. 2.3 shows the path of an unknown charged particle.

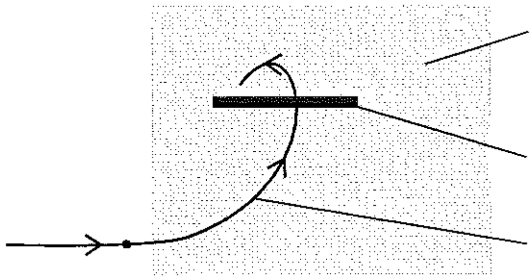

Fig. 2.3

The particle loses some of its kinetic energy as it travels through the plate. The initial radius of the path of the particle before it enters the plate is 4.8 cm. After leaving the plate the final radius of the path of the particle is 1.2 cm.

Calculate the ratio

$$\frac{\text{initial kinetic energy of particle}}{\text{final kinetic energy of particle}}.$$

ratio = ... **[2]**

Question			Answer	Marks	Guidance
2	(a)	(i)	(weight = BIL) $6.8\times10^{-5} = 0.070\times I\times 0.01$ (Any subject) I = 0.097 (A)	C1 A1	
		(ii)	The force on the cables will keep changing direction	B1	
	(b)	(i)	$BQv = mv^2/r$ $r = \dfrac{mv}{BQ}$	M1 A1	**Allow** *e*, *q* instead of Q **Note**: *r* must be the subject of this equation
		(ii)	($p = mv = BQr$, KE = ½ p^2/m) KE $\propto r^2$ ratio = $\dfrac{4.8^2}{1.2^2}$ ratio = 16	C1 A1	**Allow** full credit for correct alternative approaches **Allow** 16 : 1
			Total	**7**	