WJEC EDUQAS A-LEVEL PHYSICS · COMPONENT 3

PHYSICS



EXAM QUESTION PACK

3.10 ELECTROMAGNETIC INDUCTION

SCORE	PERCENTAGE
/47	%

STEMUP

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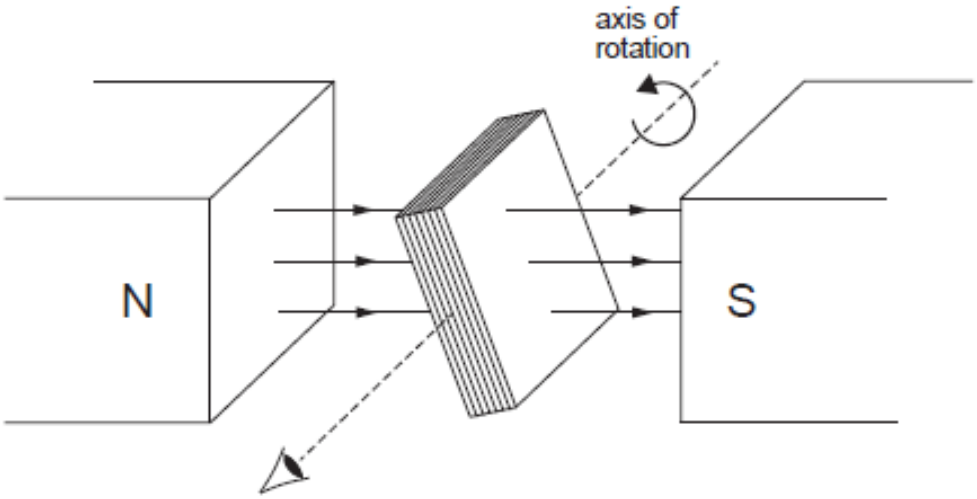
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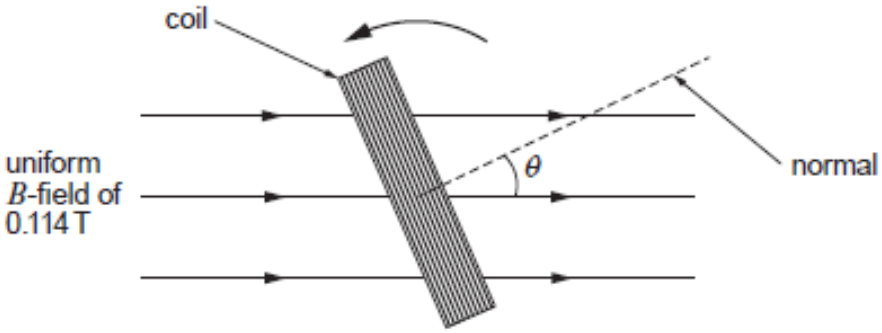
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#1

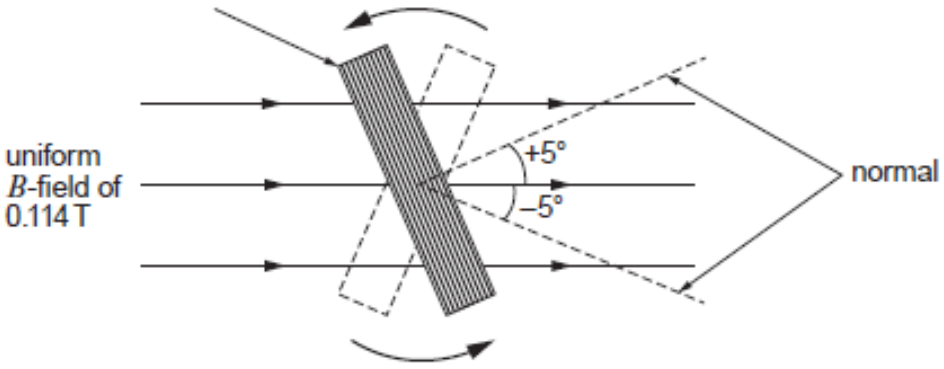
10. A rectangular coil rotates at a constant angular velocity within a uniform magnetic field of 0.114 T. The coil has 270 turns and cross-sectional area 420 cm^2. The diagram below is a simplified 3D diagram of the coil.



This second diagram is a 2D representation of the coil looking along the axis of rotation.



The flux **linkage** of the coil for the angles $\theta = -5°$ and $\theta = +5°$ is 1.29 Wb turn in each case.



(a) Show clearly how this value for the flux linkage is obtained. [2]

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(b) Explain why the induced emf is zero when $\theta = 0$. [1]

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(c) The flux **linkage** of the coil for the angles $\theta = 85°$ and $\theta = 95°$ are 0.11 Wb turn and −0.11 Wb turn respectively. The coil rotates 10° in a time of 5.8 ms. Calculate the mean induced emf when rotating between $\theta = 85°$ and $\theta = 95°$. [2]

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Question taken from Eduqas examination paper 842103, June 2019

#2

10. A silver ring on a light rod swings as a pendulum with damped simple harmonic motion. The damping is caused by a stationary magnet as shown in the diagram.



(a) Explain why the motion of the pendulum is damped. [4]

(b) Explain what, if anything, would happen to the motion of the pendulum if the bar magnet were reversed. [2]

(c) The resistivity of silver is $1.59 \times 10^{-8}\,\Omega m$, the radius of the silver ring is 2.5 cm and the cross-sectional area of the silver wire of the ring is $2.4 \times 10^{-5}\,m^2$. Show clearly that the resistance of the silver ring is approximately $0.1 \times 10^{-3}\,\Omega$. [2]

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(d) The maximum current induced in the silver ring is 5.5 A. Calculate the maximum rate at which the magnetic flux density inside the ring changes. [3]

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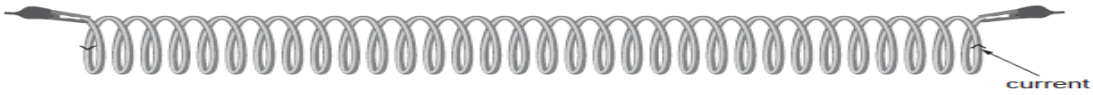
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Question taken from Eduqas examination paper 842103, June 2018

#3

(a) (i) A long solenoid has 12 000 turns per metre and carries a current of 3.8 A. Calculate the magnetic flux density at its centre. [1]

(ii) **Sketch the magnetic field lines** due to this long solenoid. [2]



(iii) State how the strength of the magnetic field produced by **this solenoid** can be increased greatly without increasing the current or changing the dimensions of the solenoid. [1]

(b) Maria carries out an experiment inside an extremely large magnetic field of uniform density 1.76 T. She uses a copper wire and deforms it from shape 1 to shape 2 in a time of 42 ms.

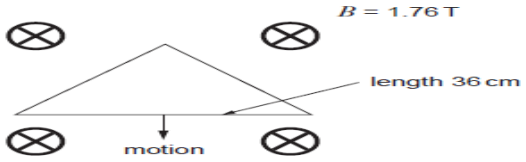


(i) Explain why a large current flows in the copper wire during this deformation. [3]

(ii) Explain how you can deduce that this current flows anticlockwise. [2]

(iii) Calculate the mean current flowing in the copper wire given that its resistance is $6.75 \times 10^{-3}\,\Omega$. [3]

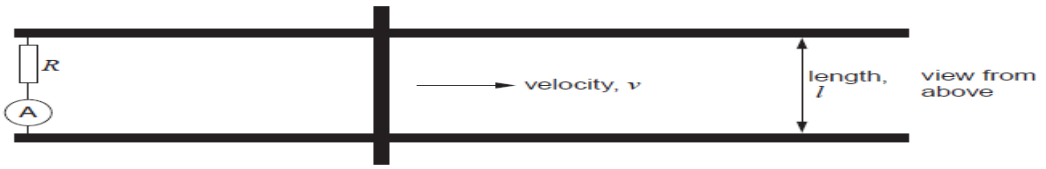
(iv) Halfway through the deformation of the copper wire it is in the position shown below. Maria claims that in this position, a "motor effect" force of approximately 200 N will act upwards on the length of copper wire shown. Determine whether or not Maria is correct. [3]



Question taken from Eduqas examination paper 842103, November 2020

#4

An experiment is carried out on a flat, horizontal railway track to measure the vertical component of the Earth's magnetic field, B. A metal conductor is placed across the railway tracks and moved quickly in the direction shown.



(a) (i) Explain why a current is detected by the ammeter. [2]

(ii) Explain why the current is independent of the horizontal component of the Earth's magnetic field. [1]

(b) Use Faraday's law to derive the expression for the current: [3]

$$I = \frac{Bl}{R} v$$

(c) The results obtained are tabulated.

Velocity / $m\,s^{-1}$ $\pm 1\,m\,s^{-1}$	Current / μA $\pm 10\,\mu A$
20	40
40	80
60	110
80	150

(i) Without drawing a graph, explain whether or not the data are consistent with the equation: [4]

$$I = \frac{Bl}{R} v$$

(ii) Use the data in the table with the smallest percentage uncertainties to calculate the vertical component of the Earth's magnetic field, B, together with its **absolute uncertainty** (l =1.400 m, R = 43.0 Ω with negligible uncertainties). [6]

Question taken from Eduqas examination paper 842103, June 2017

Marking Scheme

#1

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
10	(a)		Flux linkage, $N\Phi = NBA\cos\theta$ [1] All values substituted correctly e.g. $270 \times 0.042 \times 0.114\cos 5°$ [1]	2			2	1	
	(b)		Change in flux is zero or flux is constant Accept no lines being cut		1		1		
	(c)		$\frac{0.22}{5.8}$ or similar seen [1] Correct answer = 37.9 [V] [1]		2		2	1	
			Question 10 total	**2**	**3**	**0**	**5**	**2**	**0**

#2

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
10	(a)		Flux changes in ring as it approaches [or recedes from] magnet (1) Emf induced (1) [or by implication by next marking point] Current induced (complete circuit) (1) [Motor effect force] opposes motion or energy lost or Lenz's law stated(1)		4		4		
	(b)		Nothing [or equiv](1) Always opposes motion (Lenz) / field in opposite direction / current in opposite [not: the force opposite] (1)		2		2		
	(c)		Length = $2\pi r$ used (1) [0.157 m] $R = \frac{1.59\times10^{-8}\times2\pi\times0.025}{2.4\times10^{-5}}$ seen (or 1.04×10^{-4} [Ω] seen) (1)	1	1		2	1	
	(d)		Ohm's law used (1) $\text{Emf} = \frac{BNA}{t}$ i.e. Faraday's used (1) [= 0.55 mV] [NB c.s.a of wire used → no credit and no ecf] Answer, $\frac{B}{t}$ = 0.29 T s^{-1} (or 0.28 depending on rounding)(1)	1	1 1		3	2	
			Question 10 total	**2**	**9**	**0**	**11**	**3**	**0**

#3

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)	Answer = 57.3 m[T]	1			1	1	
		(ii)	Shape correct (minimum 3 lines) (1) Direction correct (no contradicting arrows) (1)	2			2		
		(iii)	Iron core	1			1		
	(b)	(i)	Change in flux (1) Complete circuit **OR** low resistance (1) Large rate of change of flux **OR** large flux & small t (1)		3		3		
		(ii)	Use FRHR **OR** use FLHR on electrons **OR** RH grip (1) on bottom part **OR** in bottom part **OR** induced field opposes (1)	1	1		2		
		(iii)	Faraday's law used e.g. 2.18 V **OR** $\frac{BA}{t}$ seen (1) $I = \frac{V}{R}$ used (1) Answer = 323 [A] (1)	1 1	 1		3	2	
		(iv)	Use of $F = BIL$ **ecf** (1) Answer = 205 [N] (1) Opposes motion (1)			3	3	2	
			Question total	**7**	**5**	**3**	**15**	**5**	**0**

#4

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)	Emf is induced due to rate of change of flux (or cutting) **or** reference to [Fleming's] RH rule (1) **don't accept** RH grip rule Current can flow **or** circuit is complete (1)	1	1		2		
		(ii)	Vertical component is perpendicular to the area swept **or** other components are not cut **Accept** flux due to horizontal field is zero or motion is in plane / parallel to horizontal field **Don't accept** current in the field		1		1		
	(b)		Induced emf = $\frac{d}{dt}(BA)$ with or without N (accept $\frac{BA}{t}$) (1) $\frac{d}{dt}(A) = \frac{ldx}{dt}$ accept $\frac{A}{t} = \frac{lx}{t}$ or $\frac{A}{t} = lv$ (1) $I = \frac{V}{R}$ and reasonable algebra (1)	1	 1 1		 3	 3	
	(c)	(i)	Good method employed e.g. calculating 3× ratio $\frac{v}{I}$, calculating B 3 times, or I is proportional to v etc. (1) Correct calculations e.g. 0.5, 0.5, 0.55, 0.53 / I is roughly $2v$ (1) B, ℓ and R are constants or equivalent e.g. $\frac{Bl}{R}$ is constant (1) Ok within uncertainties (1)			4	4	3	4
		(ii)	80 m s^{-1} and 150 μA used **accept** mean points if 80 m s^{-1} and 150 μA used for uncertainty (1) Rearrangement $B = \frac{RI}{lv}$ (1) Answer = 57.6 μ[T] (1) 1% and 7% used (1.25% and 6.7% ok) **ecf** accept first principles (1) Percentages added (8%) **ecf** (1) B = (58 ± 5) μT **ecf** accept (57.6 ± 4.6) μT unit mark and with consistent sig figs allow a max of 2 sig figs for the uncertainty (1)		 1 1 1	1 1 1	6	6	6
			Question total	**2**	**7**	**7**	**16**	**12**	**10**