A Level AQA Physics

18 Electromagnetic induction – answers

Question	Answers	Extra information	Mark	AO Spec reference
01.1	Current flowing clockwise – use of Fleming's right hand rule	Allow anticlockwise of field lines pointing in wrong direction	1	3.7.5.4 AO2
01.2	Change in magnetic flux linkage as the conductor moves through the magnetic field e.m.f. induced = $\frac{N\Delta\phi}{\Delta t}$/(Faraday's law)		1 1	3.7.5.4 AO2
01.3	e.m.f. induced = $\frac{N\Delta\phi}{\Delta t} = \frac{NB\Delta A}{\Delta t}$ and $N = 1$ Area mapped out in time $t = lvt$ $\varepsilon = \frac{Blvt}{t} = Blv$		1 1	3.7.5.4 AO3
01.4	$\varepsilon = Blv$ $B = \frac{\varepsilon}{lv} = \frac{45\times10^{-3}}{0.05\times15}$ $B = 0.06$ $B = 0.06$ T or teslas		1 1 1	3.7.5.4 AO2 AO1
02.1	The product of the magnetic flux and the area swept out by the conductor where B is normal to A Units: weber (weber turns)	Allow equation if terms defined	1 1	3.7.5.3 AO1
02.2	Coil shown vertical, horizontal, vertical, horizontal, vertical		1	3.7.5.4 AO2
02.3	Sine curve Positive sine curve		1 1	3.7.5.4 AO2
02.4	$\omega = 2\pi f = 2\pi \times 50$ $\varepsilon = BAN\omega \sin\omega t = BAN\omega$ $B = \frac{\varepsilon}{AN\omega} = \frac{0.45}{1.2\times10^{-3}\times20\times2\pi\times50}$ $B = 0.06$ T		1 1 1	3.7.5.4 AO2

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03.1	Max 3 marks from: • ac current in wire produces changing/alternating magnetic flux • this induces a changing magnetic field in the iron core/iron core becomes magnetised • the changing magnetic flux linkage in the coils induces e.m.f./Faraday's law applied		max 3	3.7.5.4 AO3
03.2	E.m.f. induced is proportional to the rate of change of flux linkage/ $\varepsilon = \frac{N\Delta\phi}{\Delta t}$ (Faraday's law) Larger current means larger B OR greater change in magnetic flux linkage per second		1 1	3.7.5.4 AO2
03.3	Cable to lamp contains more than one wire / live and neutral Current in opposite directions so magnetic fields cancel out		1 1	3.7.5 AO3
03.4	Resolution refers to the smallest difference/change in the current it can give, in this case 0.1 mA Accuracy is how close to true value so, if reading 100 A, the actual value could be 98 or 102		1 1	3.1.2 AO2
03.5	Detects the Earth's magnetic field/zeroing it allows magnetic flux due to current only to be detected Flux density depends on angle between clamp and the Earth's magnetic field		1 1	3.7.5 AO3
04.1	Max 3 marks from: • Adjust the time-base so that a complete wave can be seen on the screen • Move the wave left or right so that the start of a cycle is on a grid line • Adjust the y-amplification until the peak-to-peak of the wave is at a maximum • Move the wave up or down so that one of the peaks is on a line		max 3	3.7.5.5 AO2
04.2	$T = 6\,\text{cm} \times 0.2\times10^{-3} = 1.2\times10^{-3}\,\text{s}$ $f = \frac{1}{T} = 830\,\text{Hz}$		1 1	3.7.5.5 AO1

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OXFORD Revise

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04.3	Peak-to-peak = 6 squares Peak voltage = 3 × 0.5 = 1.5 V $V_{\text{rms}} = \frac{V_0}{\sqrt{2}} = \frac{1.5}{\sqrt{2}} = 1.1\text{ V}$		1 1 1	3.7.5.5 AO1 AO2
04.4	$P = \frac{V^2 rms}{R} = \frac{1.1^2}{20} = 0.061\text{ W}$ (0.056 W using unrounded values)		1	3.5.1.4 AO2
05.1	Use of $s = ut + \frac{1}{2}at^2$ and u=0 $t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2 \times 0.32}{9.81}} = 0.26\text{ s}$		1 1	3.4.1.3 AO2
05.2	The falling magnet causes a changing flux in the copper pipe/conductor/changing flux linkage This induces an e.m.f. in the copper pipe The e.m.f. is induced so that the current flows in a way to oppose the change that caused it		1 1 1	3.5.7.4 AO2
05.3	Weight causes the magnet to accelerate downwards The downward movement induces the force that slows it down As it slows, the magnetic force decreases The forces acting on the magnet must be balanced/zero resultant force/weight = magnetic force		1 1 1 1	3.4.1.5 AO3
05.4	Max 4 marks from: • the ac current produces a changing/alternating magnetic field/magnetic flux • this magnetises the iron clamp stand • induces an alternating/changing e.m.f. in the aluminium disc • the current flows so magnetic field opposes the change that caused it • repels the changing magnetic field of the coil so it hovers		max 4	3.7.5.4 AO3
05.5	The magnetic flux linkage would not change/magnetic flux is constant/need changing magnetic flux linkage to induce e.m.f. in the disc		1	3.7.5.4 AO2

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05.6	Nothing happens/stays still Although there is changing magnetic flux linkage, there is not a complete conductor	Allow no induced current as not complete conductor	1	3.7.5.4 AO2
06.1	$f = \frac{1}{T} = \frac{1}{0.02} = 50\text{ Hz}$		1	3.7.5.5 AO1
06.2	$N\phi = BAN$ $A = \frac{N\phi}{BN} = \frac{3\times10^{-2}}{330 \times 0.06} = 1.52\times10^{-3}\text{ m}^2$		1 1	7.7.5.4 AO3
06.3	$\varepsilon = BAN\omega \sin \omega t = BAN\omega$ $= BAN 2\pi f$ $= 0.06 \times 1.5\times10^{-3} \times 330 \times 2\pi \times 50$ $= 9.4\text{ V}$	Could also use tangent to the graph at 0.01 s	1 1 1	7.7.5.4 AO2
06.4	$V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{9.3}{\sqrt{2}} = 6.6\text{ V}$ $P = \frac{V_{rms}^2}{R} = \frac{6.6^2}{75} = 0.59\text{ W}$	Allow 1 mark for calculation of max power transfer	1 1	3.7.5.4 3.7.5.5 3.5.1.4 AO2
07.1	$\frac{N_s}{N_p} = \frac{V_s}{V_p}$ $\frac{N_s}{N_p} = \frac{400\,000}{25\,000} = 16$		1	3.7.5.6 AO1
07.2	Use of $P = I^2R$ or $I = \frac{P}{V} = \frac{1500\times10^6}{400\,000} = 3750\text{ A}$ $P = 3750^2 \times 30 = 4.2 \times 10^8\text{ W}$		1 1	3.5.1.4 3.7.5.6 AO2
07.3	$\text{Efficiency} = \frac{\text{useful output power}}{\text{input power}}$ $\text{Efficiency} = \frac{1500\times10^6 - 4.2\times10^8}{1500\times10^6} = 0.72$ or 72%	Possible e.c.f. from **07.2**	1 1	3.4.1.7 AO1

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07.4	Any three from: • Stepping up voltage steps down current/current decreased by factor of 16 • Power loss in cable due to heating effect of current/I^2R/reducing current reduces heating losses • Power loss = $\frac{V^2}{R}$ but V is the potential difference across the transmission cables, not 400 000 V OR p.d. = IR so larger current results in more p.d. between the ends of the cables • current is the same throughout the cable and power station	Students may also calculate pd across wire at different transmission volts – the larger the current the greater this is	1 1 1	3.7.5.6 AO3
08.1	Max 3 marks from: • a.c. current in the primary coil produces a changing/alternating magnetic flux • there is (an equal) changing magnetic flux in the secondary coil • rate of changing magnetic flux linkage in the secondary coil induces an e.m.f. in the secondary coil/Faraday's law/$\varepsilon = \frac{N\Delta\phi}{\Delta t}$ • the e.m.f. depends on the ratio of primary to secondary coils		max 3	3.7.5.4 AO2
08.2	At resonance max energy transfer occurs For second mark any sensible suggestion, e.g. • vehicles need much higher power transfer • greater distance between coils • no iron core to link coils		1 1	3.6.1.4 AO3

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08.3	**How used:** Primary coils could be placed in the middle of a charging lane, vehicles pass over them charging continuously **Advantages**: • increases range of car • many cars charged simultaneously **Disadvantages** • battery never fully charged • difficulty of positioning car over coils for max energy transfer/not efficient • cost of setting up system	Allow any sensible suggestions 1 mark for how used and max of 3 marks for advantages and disadvantages combined Full marks must include something from each heading	1 max 3	3.7.5.6 AO3

Skills box answers

Question	Answer
1	Plot a graph of $\cos\theta$ against e.m.f. Points are (1, 30), (0.98, 29.4), (0.94, 28.4), (0.87, 26.1), (0.77, 23.8), (0.64, 19), (0.5, 14.9), (0.34, 10.4), (0.17, 4.9).
2	When the plane of the search coil is perpendicular to the field lines of the solenoid ($\theta = 0°$) the induced e.m.f. is at its maximum. As the angle increases, the coil cuts fewer field lines and the signal on the oscilloscope drops to near zero.
3	Flux linkage = $BAN\cos\theta = 4.0 \times 10^{-6}\,\text{T} \times \pi\,(6\times10^{-3})^2 \times 25 \times 1 = 1.1\times10^{-8}\,\text{Wb}$ Plot a graph of $\cos\theta$ against e.m.f. Points are (1, 30), (0.98, 29.4), (0.94, 28.4), (0.87, 26.1), (0.77, 23.8), (0.64, 19), (0.5, 14.9), (0.34, 10.4), (0.17, 4.9).