A Level AQA Physics
17 Magnetic fields – answers

OXFORD Revise

Question	Answers	Extra information	Mark	AO Spec reference
01.1	Reading will increase because the magnet will experience a downwards force/an equal and opposite force from the current (according to Newton's third law)		1 1	3.4.1.5 AO2
01.2	Max 3 from: • Use a variable resistor to change the current and an ammeter to measure • Record the change in mass on the balance • Record the length of wire in the magnetic field – measure using 15 cm ruler/callipers Accuracy: • Wire must be clamped securely so that it cannot move • Wire should be perpendicular to field • Tare the balance before the experiment begins Safety: • Wire may become hot – take readings quickly and turn off between each reading	Full marks only if safety/accuracy point included	max 3	3.7.5.1 AO2 AO1
01.3	Evidence of large triangle – or clear data points taken from graph e.g., $\frac{2.0 - 0.6}{5.4 - 2.6} = 0.5 \pm 0.1\,\text{g A}^{-1}$ or $5.0 \pm 0.1 \times 10^{-4}\,\text{kg A}^{-1}$ kg A^{-1}	Allow either 1 mark for correct units	1 1 1	MS3.4 AO2
01.4	Use of $F = BIl$ or $F = mg$ $mg = BIl$ $m = \frac{Bl}{g} \times I$ gradient $= \frac{Bl}{g}$ $B = \text{gradient} \times \frac{g}{l} = (5.0 \pm 0.1 \times 10^{-4}) \times \frac{9.81}{0.05} = 0.098\,\text{T}$	possible follow through from value of gradient in 1.3	1 1 1	3.7.5.1 MS3.3 AO3

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02.1	$\Delta W = \Delta VQ = eV$ since e is charge on proton if this happens n times energy gained is neV		1	3.7.3.3 AO2
02.2	**B** field is into the page/perpendicular and into		1	3.7.5.1 AO1
02.3	Spiral path shown – exiting the cyclotron at some point		1	3.7.5.2 AO2
02.4	Electric fields: • No acceleration • No electric field inside a conductor Magnetic fields: • Acceleration since changing direction so velocity changing • There is a force perpendicular to direction of motion/centripetal force provided by the magnetic field		 1 1 1 1	3.7.3.2 AO2 3.7.5.2 3.6.1.1
02.5	$F = \frac{mv^2}{r}$ or $F = Bqv$ $\frac{mv^2}{r} = Bqv$ $\frac{mv}{r} = Bq$ $v = \frac{2\pi r}{T}$ and $T = \frac{1}{f}$ so $v = 2\pi rf$ $\frac{m \times 2\pi rf}{r} = Bq$ $m2\pi f = Bq$ $f = \frac{Bq}{2\pi m}$	Rearranging and cancelling must be clear in method 1 mark for each of: • Equating centripetal force with Bqv • Applying $f = \frac{1}{T}$ OR $f = \frac{2\pi}{\omega}$ • Applying $v = \frac{2\pi r}{T}$ OR $2\pi rf$ OR $v = r\omega$ • Clear algebraic working	1 1 1 1	3.6.1.1 3.7.5.2 AO2

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02.6	Cyclotron frequency will decrease as the acceleration will be less ($a = \frac{F}{m}$) so velocity and hence period will increase		1 1	3.5.1.4 AO3
03.1	Electric field provides force to the right Force due to E field = qE Magnetic field provides force to the left Force due to B field = Bqv When forces are equal the ion can enter/ion undeflected $qE = Bqv$ $v = \frac{E}{B}$		1 1 1 1	3.7.3.2 3.7.5.2 AO3
03.2	$v = \frac{E}{B}$ $E = vB = 0.1 \times 4.2 \times 10^5$ $E = \frac{V}{d}$ $d = \frac{V}{E} = \frac{400}{0.1 \times 4.2 \times 10^5}$ $d = 0.0095\ \text{m}\ (0.01\ \text{m})$		1 1	3.7.3.2 AO2
03.3	$F = \frac{mv^2}{r}$ or $F = Bqv$ $\frac{mv^2}{r} = Bqv$ $\frac{mv}{r} = Bq$ $r = \frac{mv}{Bq}$		1 1	3.6.1.1 3.7.5.2 AO2

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03.4	$r = \frac{mv}{Bq}$ $\Delta r = \frac{(43.9 - 39.9) \times 1.661 \times 10^{-27}\,\text{kg} \times 4.2 \times 10^{5}}{1.1 \times 1.6 \times 10^{-19}}$ $\Delta r = 0.016\,\text{m}$		1 1	3.8.1.6 3.7.5.2 AO2
04.1	Max 2 from: • The search coil is detecting induced e.m.f. in the coils • There must be a changing magnetic flux linkage • a.c. current in large coil means a changing magnetic field • Mention of Faraday's law		1 1	3.7.5.4 AO2
04.2	Angle between search coil and magnetic field: • Protractor/protractor card fixed to surface • Sensible method of reducing parallax errors, e.g. use of clamp to hold protractor beneath search coil/ruler and set square arrangement E.m.f. induced from the oscilloscope screen: • Choose suitable scale to maximise trace • Peak-to-peak reading divided by 2 • Multiply number of divisions by volts per div scale		1 1 1 1	PS4.1 AO3
04.3	Graph of e.m.f. versus cos θ with suitable line of best fit Axes labelled with units Suitable scales chosen (data should be at least half graph paper)	If e.m.f. versus θ plotted lose one mark	1 1 1	3.7.5.3 3.7.5.4 AO3
04.4	Need to determine intercept to check relationship – gradient = $\frac{155 - 128}{0.97 - 0.79} = 150 \pm 4$ Intercept: $y = mx + c$ $155 - (150 \times 0.97) = c$ $c = 9.5$	If θ graph drawn allow one mark for stating it is cosine graph	1 1	MS3.3 MS3.4 AO2

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	Conclusion: this does prove the relationship as this is a straight line through the origin but there must be a systematic error OR This does not prove the relationship as there is not a straight line through the origin	Allow either conclusion with justification, i.e., what they are looking for	1	
05.1	Area = $\pi r^2 = \pi \times 0.9 \times 10^{-2}$ $\phi = BA = 5.0 \times 10^{-3} \times (\pi \times 0.9 \times 10^{-2})^2$ $\phi = 1.3 \times 10^{-6}$ Wb or webers		1 1 1	3.7.5.3 AO2
05.2	$\phi = BA\cos\theta = 5.0 \times 10^{-3} \times (\pi \times 0.9 \times 10^{-2})^2 \cos 40$ $\phi = 9.7 \times 10^{-7}$ (Wb)		1	3.7.5.3 AO2
05.3	$\varepsilon = N\frac{\Delta\phi}{\Delta t}$ $\varepsilon = 5000 \times \frac{1.3 \times 10^{-6} - 9.7 \times 10^{-7}}{0.2}$ $\varepsilon = 0.0083$ V	e.c.f. from **05.2** ignore minus sign	1 1	3.7.5.4 AO2
05.4	A large e.m.f. would be induced in the coil (larger than in **05.3**) Rapid change in magnetic flux linkage $\varepsilon = N\frac{\Delta\phi}{\Delta t}$		1 1	3.7.5.4 AO3
06.1	$F = Bqv$ Electrons move to the right/towards Y/away from X Fleming's left hand rule	2^{nd} mark for direction and explanation	1 1	3.7.5.2 AO1
06.2	On **Figure 8** left-hand side marked as positive and right-hand side marked as negative	Allow an answer consistent with their answer to **06.1**, i.e., if they think electrons move to left allow reverse labels	1	3.7.3.2 AO1

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06.3	Force due to magnetic field = force due to electric field $Bqv = Eq$ Since uniform field $E = \frac{V}{d}$ $Bqv = \frac{Bq}{d}$ $Bvd = V$		1 1 1	3.7.5.2 3.7.3.2 AO2
06.4	$V_H = Bvd$ and $v = \frac{I}{nAe}$ $V_H = \frac{BdI}{nAe}$ $V_H = \frac{BdI}{ndte} = \frac{BI}{nte}$		1 1	3.7.5.2 AO3
06.5	$V_H = \frac{BI}{nte}$ all other values constant $V_H \propto \frac{1}{n}$ So V_H greater, easier to detect magnetic flux density.		1 1	3.7.5.2 AO3
07.1	micrometer/digital calliper measuring several places along length and finding mean		1 1	Ate PS4.1 AO1
07.2	$\rho = \frac{M}{V}$ $M = \rho \times V = 2700 \times 15\times10^{-3} \times 50\times10^{-3} \times 0.02\times10^{-3}$ $M = 4.05\times10^{-5}$ kg		1 1	3.4.2.1 AO2
07.3	use of $F = BIl$ or $W = mg$ $I = \frac{mg}{Bl} = \frac{4.05 \times 10^{-5}\,\text{kg} \times 9.81}{0.03 \times 0.05}$ $I = 0.26$ A		1 1	3.7.5.1 AO2

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07.4	Diagram showing field perpendicular to current Direction and current such that foil feels upwards force		1 1	3.7.5.1 AO1
08.1	Crosses drawn on the diagram – uniformly placed – at least 4		1	3.7.5.2 AO1
08.2	Ion feels a resultant force perpendicular to direction of motion Provides centripetal force		1 1	3.6.1.1 AO1
08.3	$F = \frac{mv^2}{r}$ or $F = Bqv$ $\frac{mv^2}{r} = Bqv$ $\frac{mv}{r} = Bq$ $r = \frac{mv}{Bq}$		1 1	3.6.1.1 3.7.5.2 AO2
08.4	Circle starting at P but then with a greater radius arriving at a point further to the right than R		1	3.7.5.2 AO2
08.5	$\frac{r_1}{m_1} = \frac{r_2}{m_2}$ $r_2 - r_1 = 0.2\text{ mm}$ $r_2 - r_2\frac{m_1}{m_2} = 0.2$ $r_2(1 - \frac{m_1}{m_2}) = 0.2$ $r_2(1 - \frac{10.012937\text{ u}}{11.009305\text{ u}}) = 0.2$ $r_2 = 2.2\text{ m}$ $d = 2 \times 2.2 = 4.4\text{ m}$	Award for appreciation r proportional to m	1 1 1 1	3.7.5.2 AO3

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Skills box answers

Question	Answer
1	Draw a graph using the data. Note that the mass is given in grams and needs to be converted to kg. The gradient of the graph is 4.0×10^{-4} kg A^{-1}. This gives a magnetic field of 0.08 T.
2	The variable resistor is used to limit the current through the wire and to prevent it overheating.
3	The force will be reduced because $F = BIL \sin\theta$ and now θ is less than 90°