CAMBRIDGE INTERNATIONAL A LEVEL • PHYSICS 9702

Topical Questions

Unit 20: Magnetic Fields and Electromagnetic Induction

Past Papers 2021 – 2025

MARK SCHEME 32 Questions

Prepared by

Waseem Ahmad

A Level Physics Teacher

Author of ***Practical Mastery: Cambridge 9702 Paper 3***

www.examspath.com

Question 1 — Mark Scheme

9702/41 Cambridge International AS & A Level – Mark Scheme **PUBLISHED** October/November 2021

Question	Answer	Marks
8(a)	newton per ampere per metre	**M1**
	where current/wire is perpendicular to magnetic field	**A1**
8(b)(i)	$F = BIL\sin\theta$	**C1**
	$B = 1.0 / (5.0 \times 0.060 \times \sin 50°)$ $= 4.4$ mT	**A1**
8(b)(ii)	(from Fleming's left-hand rule) force on wire is upwards, so reading decreases	**B1**
8(b)(iii)	frame will rotate (so that PQ becomes perpendicular to the field)	**B1**

Question 2 — Mark Scheme

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Question	Answer	Marks
8(a)(i)	arrow from Q pointing downwards, labelled B	**B1**
8(a)(ii)	arrow from Q pointing towards P, labelled F	**B1**
8(b)(i)	force is proportional to product of both currents (I and $2I$) **or** Newton's third law	**B1**
	forces are equal	**B1**
8(b)(ii)	opposite	**B1**

Question 3 — Mark Scheme

Question	Answer	Marks
10(a)(i)	to increase the magnetic flux linkage (between the coils)	**B1**
10(a)(ii)	to reduce energy losses	**B1**
	by reducing induced currents	**B1**
10(b)(i)	maximum V_{OUT} = 12 000 × (625 / 25 000) = 300 V	**A1**
10(b)(ii)	r.m.s. current = 300 / (640 × √2) = 0.33 A	**A1**
10(b)(iii)	sketch: sinusoidal shape in positive half of the graph, sitting with 'minima' resting on the time-axis (at P = 0)	**B1**
	each 'cycle' shown repeating every 20 ms	**B1**
	maximum P shown as 140 W	**B1**
10(c)	power curve is symmetrical about the midpoint (on the power axis)	**B1**
	mean power is half the peak power	**B1**

Question 4 — Mark Scheme

Question	Answer	Marks
8(a)	newton per ampere per metre	M1
	where current/wire is perpendicular to magnetic field	A1
8(b)(i)	$F = BIL\sin\theta$	C1
	$B = 1.0 / (5.0 \times 0.060 \times \sin 50°)$ $= 4.4$ mT	A1
8(b)(ii)	(from Fleming's left-hand rule) force on wire is upwards, so reading decreases	B1
8(b)(iii)	frame will rotate (so that PQ becomes perpendicular to the field)	B1

Question 5 — Mark Scheme

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Question	Answer	Marks
9(a)	region where there is a force exerted on	**M1**
	a current-carrying conductor **or** a moving charge **or** a magnetic material/magnetic pole	**A1**
9(b)(i)	face PSWV shaded	**B1**
9(b)(ii)	accumulating electrons cause an electric field (between the faces)	**B1**
	force due to electric field opposes force due to magnetic field	**B1**
	accumulation stops when magnetic force equals electric force	**B1**
9(c)(i)	number density of charge carriers	**B1**
9(c)(ii)	PV **or** QT **or** SW	**B1**
9(d)	(for semiconductor,) n is (much) smaller so V_H (much) larger	**B1**

Question 6 — Mark Scheme

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Question	Answer	Marks
10(a)	direction of (induced) e.m.f.	**M1**
	is such as to oppose the change causing it	**A1**
10(b)	ring cuts (magnetic) flux and causes induced e.m.f. in ring	**B1**
	(induced) e.m.f. causes (eddy/induced) currents (in ring)	**B1**
	currents (in ring) cause magnetic field (around ring)	**M1**
	two fields interact to cause resistive/opposing force	**A1**
	or	
	current (in ring) is in a magnetic field	**(M1)**
	which causes resistive force	**(A1)**
	or	
	currents (in ring) dissipate thermal energy	**(M1)**
	(thermal) energy comes from energy of oscillations	**(A1)**
10(c)	current cannot pass all the way around the ring	**B1**
	(induced) currents smaller	**B1**
	smaller resistive force (so more oscillations) **or** smaller rate of dissipation of energy (so more oscillations)	**B1**

Question 7 — Mark Scheme

9702/42 Cambridge International AS & A Level – Mark Scheme May/June 2021
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Question	Answer	Marks
8(a)	• force per unit length • force per unit current • length/current perpendicular to field *1 mark for any two points, 2 marks for all three points*	**B2**
8(b)	change in potential energy = change in kinetic energy **or** $qV = ½mv^2$	**B1**
	$v = \sqrt{(2qV / m)}$	**A1**
8(c)(i)	magnetic force = centripetal force **or** $Bqv = mv^2 / r$	**M1**
	clear substitution of expression for v and correct algebra leading to $q / m = 2V / B^2r^2$	**A1**
8(c)(ii)	$q / m = (2 \times 230) / [(0.38 \times 10^{-3})^2 \times 0.14^2]$	**C1**
	$= 1.6 \times 10^{11}$ C kg^{-1}	**A1**
8(c)(iii)	(for α-particle,) q / m is (much) smaller	**B1**
	r would be <u>much</u> larger	**B1**

Question 8 — Mark Scheme

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Question	Answer	Marks
9(a)	(particle is) stationary/not moving	B1
	(particle is) moving parallel to the (magnetic) field	B1
9(b)	magnetic field around each coil is circular **or** each coil is normal to magnetic field due to adjacent coils	B1
	current in coil interacts with (magnetic) field to exert force (on coil)	B1
	force is normal to both coil and magnetic field **or** force parallel to axis (of coil)	B1
	forces between coils are attractive so spring contracts	B1
9(c)	(oscillating) coils cut magnetic flux **or** as separation of coils changes, magnetic flux changes	B1
	cutting flux causes induced e.m.f. in coils	B1
	changing (induced) e.m.f. causes changing current (in coil)	B1

Question 9 — Mark Scheme

Question	Answer	Marks
8(a)(i)	at least one anticlockwise arrow and no clockwise arrows	**B1**
8(a)(ii)	(force is to the) left	**B1**
8(a)(iii)	force is the same	**B1**
	Newton's third law (of motion) *or* force depends on the product of the two currents	**B1**

Question 10 — Mark Scheme

Question	Answer	Marks
9(a)	(magnetic) flux density × area × number of turns	M1
	area is perpendicular to (magnetic) field	A1
9(b)	use of $t = 1.2$ s	C1
	$\varepsilon = \frac{\Delta BAN}{\Delta t}$ $= \frac{0.250 \times \pi \times 0.030^2 \times 540}{1.2}$	C1
	$= 0.32V$	A1
9(c)(i)	light damping	B1

Question	Answer	Marks
9(c)(ii)	sheet cuts (magnetic) flux and causes induced emf	B1
	(induced) emf causes (eddy) currents (in sheet)	B1
	either currents (in sheet) cause resistive force or currents (in sheet) dissipate energy	B1
	smaller currents in Y or larger currents in X, so dashed line is X	B1

Question 11 — Mark Scheme

Question	Answer	Marks
6(a)	less in smaller solenoid	**B1**
6(b)	greater in smaller solenoid	**B1**
6(c)(i)	direction of (induced) e.m.f.	**M1**
	such as to (produce effects that) oppose the change that caused it	**A1**
6(c)(ii)	change of flux (linkage) in smaller solenoid induces e.m.f. in smaller solenoid	**B1**
	(induced) current in smaller solenoid causes field around it	**B1**
	the two fields (interact to) create an attractive force	**B1**

Question 12 — Mark Scheme

Question	Answer	Marks
6(a)	product of (magnetic) flux density and area	**M1**
	where area is perpendicular to the (magnetic) field	**A1**
6(b)(i)	$N\Phi = BAN$	**C1**
	$= 400 \times 10^{-3} \times 0.12^2 \times 8$	**C1**
	= 0.046 Wb	**A1**
6(b)(ii)	(line is a) straight line	**B1**
6(b)(iii)	(induced) e.m.f. = rate of change of flux linkage	**C1**
	e.m.f. $= N\Phi / t$ $= 0.046 / 0.60$ = 0.077 V	**A1**
6(c)	(induced e.m.f. causes) current flow (in the coil)	**B1**
	either	
	current (in magnetic field) causes forces to act on the coil	**B1**
	(opposite sides of) coil forced inwards	**B1**
	or	
	current causes dissipation of energy in the resistance of the coil	**(B1)**
	temperature of the coil rises	**(B1)**

Question 13 — Mark Scheme

Question	Answer	Marks
6(a)	there must be a current (in the wire)	**B1**
	(wire) must be at a non-zero angle to the magnetic field	**B1**
6(b)(i)	arrow from X pointing horizontally to the left	**B1**
	arrow from Y pointing diagonally upwards and to the left at about 45°	**B1**
	arrow from Z pointing horizontally to the right	**B1**
6(b)(ii)	(flux densities at W and X are approximately) equal	**B1**
	(flux density at) Y greater than (flux density at) Z	**B1**
6(c)	current in wire creates magnetic field around wire	**B1**
	(each) wire sits in the magnetic field created by the other	**B1**
	(for each wire,) current / wire is perpendicular to magnetic field (due to other wire), (so) experiences a (magnetic) force	**B1**

Question 14 — Mark Scheme

Question	Answer	Marks
7(a)	induced e.m.f. is (directly) proportional to rate	**M1**
	of change of (magnetic) flux (linkage)	**A1**
7(b)	V_2 stepped, all at non-zero values, between t = 0 and t = 0.40 s	**B1**
	V_2 shown with same non-zero magnitude up to t = 0.15 s and after t = 0.25 s but with a different magnitude between these times	**B1**
	V_2 shown with a magnitude between t = 0.15 s and t = 0.25 s that is three times the magnitude before t = 0.15 s and after t = 0.25 s	**B1**
	V_2 shown with same sign up to t = 0.15 s and after t = 0.25 s, and opposite sign in between	**B1**
7(c)(i)	changing current in coil causes changing (magnetic) field **or** changing (magnetic) flux causes induced e.m.f. in ring	**B1**
	induced e.m.f. in ring causes current in ring	**B1**
	(magnetic) field due to (induced) current in ring interacts with (coil's) field to cause upwards force (on ring) **or** (induced) current in ring perpendicular to (coil's magnetic) field causes upwards force (on ring)	**B1**
7(c)(ii)	both magnetic fields reverse direction so ring still jumps up **or** current (in ring) and (coil's) field both reverse so ring still jumps up	**B1**

Question 15 — Mark Scheme

Question	Answer	Marks
6(a)(i)	PQRS and WXYZ	**B1**
6(a)(ii)	force on charge carriers is perpendicular to both (magnetic) field and current	**B1**
	as charge carriers are deflected to one side, an electric field is set up	**B1**
	(steady V_H when) electric and magnetic forces on charge carriers are equal (and opposite)	**B1**
6(b)(i)	n: number density of charge carriers	**B1**
	t: distance PW (or SZ or QX or RY)	**B1**
	q: charge on each charge carrier	**B1**
6(b)(ii)	V_H inversely proportional to t	**B1**
	(so t needs to be small for) V_H to be large enough to measure	**B1**

Question 16 — Mark Scheme

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Question	Answer	Marks
7(a)	force per unit current	**M1**
	force per unit length	**M1**
	current / wire is perpendicular to (magnetic) field (lines)	**A1**
7(b)(i)	current (in coil) is perpendicular to magnetic field (so force on wire)	**B1**
	force (on wire) is perpendicular to current and field (so is vertical) **or** current and field are both horizontal (so force is vertical)	**B1**
7(b)(ii)	$NBIL = mg$	**C1**
	$B = (2.16 \times 10^{-3} \times 9.81) / (40 \times 3.94 \times 0.0300)$	**C1**
	$= 4.48 \times 10^{-3}$ T	**A1**
7(b)(iii)	(magnetic) forces (on balance and newton meter) are (equal and) opposite	**B1**
	reading $= 0.563 - (2.16 \times 10^{-3} \times 9.81)$ $= 0.542$ N	**A1**

Question 17 — Mark Scheme

Question	Answer	Marks
8(a)	direction of induced e.m.f.	**M1**
	such as to (produce effects that) oppose the change that caused it	**A1**
8(b)(i)	X = 0.85 A	**A1**
	Y = 2π / 0.040	**C1**
	= 160 rad s^{-1}	**A1**
8(b)(ii)	two cycles of a sinusoidal curve with a period of 0.040 s	**B1**
	correct phase (i.e. V_2 max / min at t = 0, 0.02, 0.04, 0.06 and 0.08 s, and V_2 zero at t = 0.01, 0.03, 0.05, 0.07 s)	**B1**
	maximum / minimum V_2 shown (consistently) at ± 6.5 V	**B1**
8(b)(iii)	(magnitude of) V_2 is proportional to rate of change of (magnetic) flux	**B1**
	• V_2 is proportional to gradient of I_1–t curve • V_2 has maximum magnitude when I_1–t curve is steepest • V_2 is zero when I_1–t curve is horizontal / a maximum or minimum • V_2 changes sign when sign of gradient of I_1–t curve changes *Any two points, 1 mark each*	**B2**

Question 18 — Mark Scheme

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Question	Answer	Marks
6(a)	it is zero when (plane of) probe is parallel to the (magnetic) field (lines)	**B1**
	it is maximum when (plane of) probe is perpendicular to (magnetic) field (lines)	**B1**
6(b)(i)	number density of charge carriers	**B1**
6(b)(ii)	smaller value of n so greater Hall voltage / V_H	**B1**
6(c)	(36 mV corresponds to) 48 mT	**C1**
	use of 1.4 s or (8.6 – 7.2) s	**C1**
	$E = \Delta BAN / \Delta t$	**C1**
	$= \frac{48 \times 10^{-3} \times 0.018^2 \times \pi \times 780}{1.4}$ $= 0.027\,\text{V}$	**A1**

Question 19 — Mark Scheme

Question	Answer	Marks
6(a)	a region where a force acts on	**M1**
	a current-carrying conductor **or** a moving charge **or** a magnetic material / magnetic pole	**A1**
6(b)	concentric circles around the wire	**B1**
	spacing between circles increases with distance from wire	**B1**
	arrows showing direction of field is clockwise	**B1**
6(c)(i)	$F = BIL$	**C1**
	force per unit length $= BI$ $= 2.6 \times 10^{-3} \times 5.0$ $= 0.013\ \text{N m}^{-1}$	**A1**
6(c)(ii)	to the right	**B1**
6(c)(iii)	force (per unit length) has the same magnitude due to Newton's 3rd law	**B1**
	$0.013 = 1.5 \times 10^{-3} \times I$ current = 8.7 A	**A1**

Question 20 — Mark Scheme

Question	Answer	Marks
6(a)(i)	product of (magnetic) flux density and area	**M1**
	area perpendicular to the (magnetic) field	**A1**
6(a)(ii)	flux $= B \times \pi r^2$ $= 0.17 \times \pi \times 0.36^2$	**C1**
	$= 6.9 \times 10^{-2}$ Wb	**A1**
6(b)	time for one revolution = 1 / 25 s	**C1**
	e.m.f. = rate of cutting flux **or** $\Delta\Phi / \Delta t$	**C1**
	$= 0.069 \times 25$ $= 1.7$ V	**A1**
6(c)	current (in disc) is perpendicular to magnetic field **or** current causes force to act on disc	**B1**
	force opposes rotation of disc	**B1**
	left-hand rule indicates current is from rim to axle	**B1**

Question 21 — Mark Scheme

Question	Answer	Marks
6(a)	• force per unit length • force per unit current • length / current perpendicular to field *1 mark for any two points, 2 marks for all three points*	**B2**
6(b)(i)	into the page	**B1**
6(b)(ii)	$F = Bqv$	**C1**
	$= 4.8 \times 10^{-3} \times 1.6 \times 10^{-19} \times 1.7 \times 10^{7} = 1.3 \times 10^{-14}$ N	**A1**
6(b)(iii)	arrow at point X pointing down the page	**B1**
6(b)(iv)	$F = mv^2 / r$	**C1**
	$1.3 \times 10^{-14} = (9.11 \times 10^{-31}) \times (1.7 \times 10^{7})^2 / r$	**C1**
	($r = 0.020$ m) $d = 2r$ $d = 0.040$ m	**A1**
6(c)	path shows upwards deflection such that the curvature is always anticlockwise within the field	**B1**
	circular path with larger radius	**B1**
	line enters field at X and leaves field at distance $2d$ vertically from X	**B1**

Question 22 — Mark Scheme

Question	Answer	Marks
7(a)(i)	$V_H = BI / ntq$ $= (4.0 \times 10^{-6} \times 5.4) / (1.5 \times 10^{16} \times 1.8 \times 10^{-3} \times 1.60 \times 10^{-19}) = 5.0$ V	A1
7(a)(ii)	sketch: straight diagonal line from (0, 0) to $t = 0.020$ s **and** straight diagonal line between two non-zero V_H values of same sign from $t = 0.040$ to 0.050 s	B1
	horizontal straight line at $V_H = 5.0$ V from $t = 0.020$ to 0.040 s	B1
	horizontal straight line at $V_H = 2.5$ V from $t = 0.050$ to 0.080 s	B1
7(b)(i)	e.m.f. = rate of change of (magnetic) flux (linkage)	C1
	$E = NA\,\Delta B / \Delta t$ **or** $E = NA \times$ gradient (at $t = 0.010$ s)	C1
	$E = 3000 \times 3.4 \times 10^{-4} \times (4.0 \times 10^{-6}) / (0.020) = 2.0 \times 10^{-4}$ V	A1
7(b)(ii)	sketch: line showing non-zero E from $t = 0$ to $t = 0.020$ s and from $t = 0.040$ s to $t = 0.050$ s, and $E = 0$ at all other times	B1
	'top hats' showing constant non-zero E from $t = 0$ to $t = 0.020$ s and from $t = 0.040$ s to $t = 0.050$ s	B1
	magnitude of E shown as 2.0×10^{-4} V in both non-zero sections	B1
	sign of E in the $t = 0$ to $t = 0.020$ s region opposite to the sign of E in the $t = 0.040$ s to $t = 0.050$ s region	B1

Question 23 — Mark Scheme

Question	Answer	Marks
5(a)	*any 2 points from*: • (angular) displacement • velocity • momentum • (centripetal) acceleration • (resultant) force	**B2**
5(b)(i)	$Bqv = mv^2 / r$	**M1**
	$v = 2\pi r / T$	**M1**
	completion of algebra leading to $B = 2\pi m / qT$	**A1**
5(b)(ii)	$B = (2\pi \times 4 \times 1.66 \times 10^{-27}) / (2 \times 1.60 \times 10^{-19} \times 2.5 \times 10^{-6})$	**C1**
	$= 0.052$ T	**A1**
5(b)(iii)	**either** the same because T is independent of r **or** the same because B, q and m are unchanged **or** the same because both radius and speed have doubled	**B1**
5(b)(iv)	$qE = Bqv$	**C1**
	$E = Bv = 0.052 \times 1.1 \times 10^6$ $= 5.7 \times 10^4$ N C^{-1}	**A1**

Question 24 — Mark Scheme

Question	Answer	Marks
6(a)(i)	non-zero horizontal straight line from X to Y	**B1**
6(a)(ii)	constant flux density (inside coil)	**B1**
	either (magnetic) flux linkage proportional to flux density **or** $\Phi = BAN$ and B, A and N are all constant	**B1**
6(a)(iii)	$\Phi = BAN$	**C1**
	$= 0.080 \times 0.71 \times 10^{-4} \times 64$ $= 3.6 \times 10^{-4}$ Wb	**A1**
6(a)(iv)	*sketch showing*: E is zero from time 0 to time t and non-zero after time t	**B1**
	E has constant non-zero magnitude between time t and time $4t$	**B1**
	E has non-zero value of one sign between time t and time $2t$, and non-zero value of the opposite sign between time $2t$ and time $4t$	**B1**
6(b)	current in spring creates a magnetic field around the spring	**B1**
	either (magnetic) fields around adjacent turns interact to cause a force to be exerted (between the turns) **or** current in one turn interacts with (magnetic) field due to adjacent turns to cause force to be exerted (between the turns)	**B1**
	(magnetic force) is attractive so distance (between turns) decreases	**B1**

Question 25 — Mark Scheme

Question	Answer	Marks
7(a)	(induced) e.m.f. is (directly) proportional to rate	M1
	of change of (magnetic) flux (linkage)	A1
7(b)(i)	$\Phi = BA$	C1
	$= 7.2 \times 10^{-3} \times 3.2 \times 10^{-4}$ $= 2.3 \times 10^{-6}$ Wb	A1
7(b)(ii)	tangent drawn at steepest point on Fig. 7.2	C1
	evidence of multiplication by 340	C1
	maximum rate of change of flux = 0.82 Wb s^{-1}	A1
7(b)(iii)	$V_0 = 0.82$ V **or** V_0 given as identical numerical answer to the answer in **(b)(ii)**	A1
7(b)(iv)	sinusoidal curve of period 2.0 ms from $t = 0$ to $t = 6.0$ ms	B1
	all peaks at $+V_0$ and all troughs at $-V_0$	B1
	line showing $V = 0$ at (and only at) $t = 0$, 1.0, 2.0, 3.0, 4.0, 5.0 and 6.0 ms	B1
7(b)(v)	$A = 0.82$ V **or** A has same numerical value as answer in **(b)(iii)**, with unit V	A1
	$B = 2\pi / (2.0 \times 10^{-3})$	C1
	$= 3100$ rad s^{-1}	A1

Question 26 — Mark Scheme

Question	Answer	Marks
7(a)	• force per unit length • force per unit current • length / current perpendicular to field *1 mark for any two points, 2 marks for all three points*	**B2**
7(b)	concentric circles around the wire (at least two circles needed)	**B1**
	spacing between circles increases with distance from wire (at least four circles needed)	**B1**
	arrows showing direction of field is clockwise	**B1**
7(c)(i)	(each) wire sits in the (magnetic) field created by the other	**B1**
	current (in one wire) is perpendicular to (magnetic) field (due to other wire) so (magnetic) force acts (on wire)	**B1**
7(c)(ii)	arrow drawn, starting from X and pointing towards Y, labelled F	**B1**
7(c)(iii)	(forces have) equal magnitudes	**B1**
	(forces are in) opposite directions	**B1**
7(c)(iv)	no change (in the direction of the force) since both the current in X and the field due to Y have reversed	**B1**

Question 27 — Mark Scheme

Question	Answer	Marks
6(a)	$F_B = F_E$	B1
	either: $Bqu = qE$ and $E = V / d$ leading to $u = V / Bd$ *or*: $Bqu = qV / d$ leading to $u = V / Bd$	B1

Question	Answer	Marks
6(b)	$E_K = \frac{1}{2}mu^2$	C1
	$u = \sqrt{[(2 \times 4.1 \times 10^{-17}) / (3.2 \times 10^{-27})]}$ $= 1.6 \times 10^5 \text{ms}^{-1}$	C1
	$B = 980 / (3.6 \times 10^{-2} \times 1.6 \times 10^5)$ $= 0.17 \text{ T}$	A1
6(c)	expression is independent of mass and charge	A1
6(d)	*either*: electric force is downwards so magnetic force is upwards *or*: no resultant force so magnetic force is upwards	B1
	(positive ions so) current is from left to right	B1
	from (Fleming's) left-hand rule, magnetic field is into the page	B1
6(e)	curved path inside plates with consistent direction of curvature and with no discontinuity at entry or in curvature	B1
	direction of deflection is upwards	B1

Question 28 — Mark Scheme

Question	Answer	Marks
7(a)	(induced) e.m.f. is (directly) proportional to rate	M1
	of change of (magnetic) flux (linkage)	A1
7(b)(i)	(uniform acceleration so) velocity is (directly) proportional to time	M1
	(Fig. 7.2 shows) e.m.f. is (directly) proportional to time so E is proportional to v.	A1

Question	Answer	Marks
7(b)(ii)	($v = at$ so) distance moved in time $\Delta t = at\Delta t$	C1
	$\Phi = BA$	C1
	$E = (\Delta\Phi / \Delta t) = B \times L \times (at\Delta t) / \Delta t = BLat$	A1
7(b)(iii)	$B = (0.30 \times 10^{-3}) / (0.45 \times 7.8 \times 2.0)$	C1
	$= 4.3 \times 10^{-5}$ T	A1

Question 29 — Mark Scheme

Question	Answer	Marks
7(a)	• force per unit length • force per unit current • length / current perpendicular to field *1 mark for any two points, 2 marks for all three points.*	**B2**
7(b)(i)	$F = BQv$	**B1**
7(b)(ii)	arrow at Y pointing vertically upwards	**B1**
7(b)(iii)	upwards deflection showing circular path	**B1**
7(c)(i)	electric field applied vertically downwards (may be shown on a labelled diagram)	**B1**
	electric force on particle in opposite direction to magnetic force (may be shown on a labelled diagram)	**B1**
	particle undeflected when magnitudes of electric and magnetic forces are equal	**B1**
7(c)(ii)	$EQ = BQv$	**B1**
	$v = E / B$	**A1**

Question 30 — Mark Scheme

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Question	Answer	Marks
6(a)(i)	$F = BIL$	C1
	force on QR = $5.2 \times 10^{-3} \times 1.2 \times 0.054 \times 190$	C1
	= 0.064 N	A1
6(a)(ii)	torque = force × perpendicular distance between forces	C1
	= $0.064 \times 0.025 \cos \theta = (1.6 \times 10^{-3}) \cos \theta$ N m	A1
6(a)(iii)	one complete cycle of a sinusoidal curve between 0 and 360°	B1
	τ axis labelled to show maximum and minimum torques at ± 1.6×10^{-3} N m	B1
	maximum at 0 and 360° and minimum at 180° (or vice versa), with torque shown as zero at 90° and 270°	B1
6(b)	(ferrous core) increases magnetic flux density	B1
	amplitude of torque increases	B1

Question 31 — Mark Scheme

Question	Answer	Marks
7(a)(i)	loss of energy (of oscillations)	**B1**
	due to resistive forces	**B1**
7(a)(ii)	amplitude (of oscillations) decreases gradually **or** oscillations continue (for several periods)	**B1**
7(a)(iii)	cutting of (magnetic) flux causes induced e.m.f. (in coil) **or** induced e.m.f. causes current (in resistor / circuit)	**B1**
	current causes dissipation of thermal energy in resistor **or** current in resistor causes dissipation of thermal energy	**B1**
	thermal energy comes from energy of oscillations	**B1**
7(b)	(for any given e.m.f.) current is lower so thermal energy dissipated at a lower rate **or** (for any given e.m.f.) current is lower so the resistive force is lower	**B1**
	oscillations are less damped **or** smaller decrease in amplitude of oscillations (in each period) **or** oscillations continue for longer	**B1**

Question 32 — Mark Scheme

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Question	Answer	Marks
7(a)	(induced) e.m.f. is (directly) proportional to rate	M1
	of change of (magnetic) flux (linkage)	A1
7(b)(i)	flux = e.m.f. × time	C1
	flux = 0.54 × 15 = 8.1 Wb	A1
7(b)(ii)	$\Phi = BA$	C1
	area = 8.1 / (38 × 10^{-6}) = 2.1 × 10^{5} m^2	A1
7(b)(iii)	area = speed × time × width	C1
	v = (2.1 × 10^{5}) / (15 × 68) = 210 m s^{-1}	A1
7(b)(iv)	opposing force (due to current in wings) must be backwards	B1
	from Fleming's left-hand rule, current (in wings) must be from Q to P	B1
	current is from – to + inside an e.m.f. source so P is at higher potential	B1

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