CAMBRIDGE INTERNATIONAL AS & A LEVEL PHYSICS · 9702

PHYSICS



MARK SCHEME

20 MAGNETIC FIELDS

SCORE	PERCENTAGE
/	%

STEMUP

These questions belong to CIE, not to us.

The examination questions, mark schemes and examiner comments in this pack were written and published by Cambridge International (CIE). They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with CIE and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. CIE has not endorsed, approved or been involved in the production of it. CIE and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

CIE publishes its past papers, mark schemes and examiner reports. Always check the current syllabus at cambridgeinternational.org before you revise.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

292. 9702_w16_MS_43 Q: 8

strong <u>uniform</u> magnetic field	B1	
nuclei precess/rotate about field (direction)	(1)	
radio-frequency pulse (applied)	B1	
R.F. or pulse is at Larmor frequency/frequency of precession	(1)	
causes resonance/excitation (of nuclei)/nuclei absorb energy	B1	
on relaxation/de-excitation, nuclei emit r.f./pulse	B1	
(emitted) r.f./pulse detected and processed	(1)	
non-uniform magnetic field	B1	
allows position of nuclei to be located	B1	
allows for location of detection to be changed/different slices to be studied	(1)	
any two of the points marked (1)	B2	[8]

293. 9702_m21_MS_42 Q: 9

	Answer	Marks
(a)	(magnetic) flux density × area × number of turns	**M1**
	area is perpendicular to (magnetic) field	**A1**
(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**
(c)(i)	light damping	**B1**

	Answer	Marks
(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

294. 9702_s21_MS_41 Q: 10

	Answer	Marks
(a)	direction of (induced) e.m.f.	M1
	is such as to oppose the change causing it	A1
(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)
(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

295. 9702_s21_MS_42 Q: 9

	Answer	Marks
(a)	(particle is) stationary/not moving	B1
	(particle is) moving parallel to the (magnetic) field	B1
(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
(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

296. 9702_s21_MS_43 Q: 10

	Answer	Marks
(a)	direction of (induced) e.m.f.	M1
	is such as to oppose the change causing it	A1
(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)
(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

297. 9702_m20_MS_42 Q: 3

	Answer	Marks
(a)(i)	**0.050** m	A1
(a)(ii)	$\omega = v_o / x_o$	C1
	$T = 2\pi / \omega$ $0.42 = (2\pi \times 0.050) / T$	C1
	T = **0.75** s	A1
(a)(iii)	one point labelled P where ellipse crosses displacement axis marked	A1
(b)(i)	(induced) e.m.f. proportional to rate	M1
	of change of (magnetic) flux (linkage)	A1
(b)(ii)	(there is) current in the circuit	B1
	either	
	current causes thermal energy (dissipated) in resistor	B1
	thermal energy comes from energy of magnet	B1
	or	
	current causes magnetic field around coil	(B1)
	two fields cause an opposing force on magnet	(B1)

298. 9702_s20_MS_41 Q: 9

	Answer	Marks
(a)(i)	e.m.f. $= (\Delta)BAN/t$	C1
	$= 45 \times 10^{-3} \times \pi \times (1.8 \times 10^{-2})^2 \times 350 / 0.20 = 0.080$ V	A1
(a)(ii)	0 to 0.2 s: straight horizontal line at 0.080 V or –0.080 V	B1
	0.2 s to 0.4 s: zero	B1
	0.4 s to 0.8 s: straight horizontal line at 0.040 V or –0.040 V	B1
	opposite polarity to 0 to 0.2 s line	B1
(b)	either disc cuts flux lines (of the magnet) **or** there is a changing flux in the disc	B1
	(by Faraday's law) e.m.f. is induced in the disc	B1
	e.m.f. causes (eddy) currents in the disc	B1
	current in the magnetic field (of the magnet) causes force on disc	B1

299. 9702_s20_MS_43 Q: 9

	Answer	Marks
(a)(i)	e.m.f. $= (\Delta)BAN/t$	C1
	$= 45 \times 10^{-3} \times \pi \times (1.8 \times 10^{-2})^2 \times 350 / 0.20 = 0.080$ V	A1
(a)(ii)	0 to 0.2 s: straight horizontal line at 0.080 V or –0.080 V	B1
	0.2 s to 0.4 s: zero	B1
	0.4 s to 0.8 s: straight horizontal line at 0.040 V or –0.040 V	B1
	opposite polarity to 0 to 0.2 s line	B1
(b)	either disc cuts flux lines (of the magnet) **or** there is a changing flux in the disc	B1
	(by Faraday's law) e.m.f. is induced in the disc	B1
	e.m.f. causes (eddy) currents in the disc	B1
	current in the magnetic field (of the magnet) causes force on disc	B1

300. 9702_m19_MS_42 Q: 10

	Answer	Marks
(a)	single straight line along full length of solenoid	B1
	at least two more parallel lines along full length of solenoid	B1
	correct direction – right to left	B1
(b)	(induced) e.m.f. proportional / equal to rate	M1
	of change of (magnetic) flux (linkage)	A1
(c)	increasing current causes increasing flux	B1
	increasing flux induces e.m.f. in coil	B1
	(induced) e.m.f. opposes growth of current	B1

301. 9702_s19_MS_41 Q: 8

	Answer	Marks
(a)(i)	region where a force is exerted on: a magnetic pole **or** a moving charge **or** a current-carrying wire	**B1**
(a)(ii)	arrow on axis of solenoid pointing downwards labelled P	**B1**
(b)(i)	direction of induced e.m.f./current	**M1**
	(tends to) oppose the change causing it	**A1**
(b)(ii)	magnetic field in solenoid is increasing	**B1**
	field in coil in opposite direction to oppose increase	**B1**
	arrow inside or just above small coil pointing in opposite direction to P	**B1**
(c)	e.m.f. $= N\Delta\phi / \Delta t$	**C1**
	$= (75 \times 1.4 \times 10^{-3} \times 2 \times 7.0 \times 10^{-4}) / 0.12$	**C1**
	$= 1.2 \times 10^{-3}$ V	**A1**

302. 9702_s19_MS_43 Q: 8

	Answer	Marks
(a)(i)	region where a force is exerted on: a magnetic pole **or** a moving charge **or** a current-carrying wire	**B1**
(a)(ii)	arrow on axis of solenoid pointing downwards labelled P	**B1**
(b)(i)	direction of induced e.m.f./current	**M1**
	(tends to) oppose the change causing it	**A1**
(b)(ii)	magnetic field in solenoid is increasing	**B1**
	field in coil in opposite direction to oppose increase	**B1**
	arrow inside or just above small coil pointing in opposite direction to P	**B1**
(c)	e.m.f. $= N\Delta\phi / \Delta t$	**C1**
	$= (75 \times 1.4 \times 10^{-3} \times 2 \times 7.0 \times 10^{-4}) / 0.12$	**C1**
	$= 1.2 \times 10^{-3}$ V	**A1**

303. 9702_m18_MS_42 Q: 10

	Answer	Marks
(a)(i)	*either* product of flux density and area	**M1**
	direction of flux normal to area	**A1**
	or flux density × area × $\sin\theta$	**(M1)**
	where θ is angle between direction of flux and area	**(A1)**
(a)(ii)	(induced) e.m.f. proportional to rate	**M1**
	of change of (magnetic) flux linkage	**A1**
(b)	e.m.f. $= \Delta(\phi N) / \Delta t$ $= (6.8 \times 10^{-6} \times 2 \times 3.5 \times 96) / (2.4 \times 10^{-3})$	**C1**
	$=$ **1.9** V	**A1**

	Answer	Marks
(c)	alternating	C1
	with same frequency as supply	A1

304. 9702_s18_MS_41 Q: 10

	Answer	Marks
(a)	induced e.m.f. proportional to rate	M1
	of change of (magnetic) flux (linkage) **or** of cutting (magnetic) flux	A1
(b)	current in coil produces flux	B1
	(by Faraday's law) changing flux induces e.m.f. in ring	B1
	current in ring causes field (around ring)	B1
	(by Lenz's law) field around ring opposes field around coil	B1

305. 9702_s18_MS_42 Q: 9

	Answer	Marks
(a)	(magnetic) flux density × area	B1
	magnetic flux density normal to area **or** reference to cross-sectional area **or** × sin (angle between *B* and *A*)	B1
	× number of turns on coil	B1
(b)	e.m.f. = BAN/t **or** e.m.f = rate of change of flux linkage	C1
	= $(7.5 \times 10^{-3} \times \pi \times \{1.2 \times 10^{-2}\}^2 \times 160) / 0.15$ = 3.6×10^{-3} V	A1
(c)	sketch: zero for 0–0.10 s, 0.25–0.35 s, and 0.425–0.55 s, and non-zero outside these ranges	B1
	two horizontal steps, with zero voltage either side	B1
	with same polarity	B1
	correct values (1st step 3.6 mV and 2nd step 7.2 mV)	B1

306. 9702_s18_MS_43 Q: 10

	Answer	Marks
(a)	induced e.m.f. proportional to rate	M1
	of change of (magnetic) flux (linkage) **or** of cutting (magnetic) flux	A1
(b)	current in coil produces flux	B1
	(by Faraday's law) changing flux induces e.m.f. in ring	B1
	current in ring causes field (around ring)	B1
	(by Lenz's law) field around ring opposes field around coil	B1

307. 9702_w18_MS_41 Q: 9

	Answer	Marks
(a)	(induced) e.m.f. proportional/equal to rate	M1
	of change of (magnetic) flux (linkage)	A1
(b)(i)	induced e.m.f. $= (\Delta B)AN/\Delta t$ $= (2 \times 0.19 \times 1.5 \times 10^{-4} \times 120) / 0.13$	C1
	$= 0.053\,V$	A1
(b)(ii)	reading on voltmeter connected to coil C / V: 0 0.053 0 (*all three values required*)	A1
	reading on voltmeter connected to Hall probe / V: zero in middle column	B1
	final column correct sign (negative)	B1
	final column correct magnitude (0.20)	B1

308. 9702_w18_MS_42 Q: 9

	Answer	Marks
(a)	$0 \rightarrow t_1$ horizontal straight line at non-zero value of V_H **and** $t_3 \rightarrow t_4$ horizontal straight line at different non-zero V_H	B1
	$t_1 \rightarrow t_3$ straight diagonal line with negative gradient **and** graph line starts at (0, V_0) and ends at (t_4, $-2V_0$)	B1
(b)	$E = 0$ for $0 \rightarrow t_1$ **and** $t_3 \rightarrow t_4$	B1
	E is non-zero at all points between $t_1 \rightarrow t_3$	M1
	E has constant magnitude between $t_1 \rightarrow t_3$	A1

309. 9702_w18_MS_43 Q: 9

	Answer	Marks
(a)	(induced) e.m.f. proportional/equal to rate	M1
	of change of (magnetic) flux (linkage)	A1
(b)(i)	induced e.m.f. $= (\Delta B)AN/\Delta t$ $= (2 \times 0.19 \times 1.5 \times 10^{-4} \times 120) / 0.13$	C1
	$= 0.053\,V$	A1
(b)(ii)	reading on voltmeter connected to coil C / V: 0 0.053 0 (*all three values required*)	A1
	reading on voltmeter connected to Hall probe / V: zero in middle column	B1
	final column correct sign (negative)	B1
	final column correct magnitude (0.20)	B1

310. 9702_s17_MS_42 Q: 3

	Answer	Marks
(a)(i)	e.g. period = 6 / 2.5	C1
	frequency = 0.42 Hz	A1
(a)(ii)	energy $= ½ m \times 4\pi^2 f^2 y_0^2$	C1
	$= ½ \times 0.25 \times 4\pi^2 \times 0.42^2 \times (1.5 \times 10^{-2})^2$	C1
	$= 2.0 \times 10^{-4}$ J	A1
(b)(i)	(induced) e.m.f. proportional to rate of	M1
	change of magnetic flux (linkage) **or** cutting of magnetic flux	A1
(b)(ii)	coil cuts flux/field (of moving magnet) inducing e.m.f. in coil	B1
	(induced) current in resistor causes heating (effect)	M1
	thermal energy/heat derived from energy of oscillations (of magnet)	A1

311. 9702_w17_MS_41 Q: 5

	Answer	Marks
(a)(i)	force proportional to product of charges and inversely proportional to square of separation	A1
(a)(ii)	curve starting at (R, F_C)	B1
	passing through ($2R$, $0.25F_C$)	B1
	passing through ($4R$, $0.06F_C$)	B1
(b)	graph: $E = 0$ when current constant (0 to t_1, t_2 to t_3, t_4 to t_5)	B1
	stepped from t_1 to t_2 and t_3 to t_4	B1
	(steps) in opposite directions	B1
	later one larger in magnitude	B1

312. 9702_w17_MS_43 Q: 5

	Answer	Marks
(a)(i)	force proportional to product of charges and inversely proportional to square of separation	A1
(a)(ii)	curve starting at (R, F_C)	B1
	passing through ($2R$, $0.25F_C$)	B1
	passing through ($4R$, $0.06F_C$)	B1
(b)	graph: $E = 0$ when current constant (0 to t_1, t_2 to t_3, t_4 to t_5)	B1
	stepped from t_1 to t_2 and t_3 to t_4	B1
	(steps) in opposite directions	B1
	later one larger in magnitude	B1

313. 9702_m16_MS_42 Q: 10

(a) (i) change in flux linkage $= 40 \times (5.0 - 3.0) \times 10^{-6}$
$= 8(.0) \times 10^{-5}$ Wb — A1 [1]

(ii) time taken $= 8.0 \times 10^{-5} / 5.0 \times 10^{-4}$
$= 0.16$ (s) — C1
speed $= 3.0 \times 10^{-2} / 0.16$
$= 0.19$ (0.188) m s^{-1} — A1

or

$E = (\Delta\Phi / \Delta x) \times$ speed
speed $= 5.0 \times 10^{-4} / (8.0 \times 10^{-5} / 3.0 \times 10^{-2})$ — (C1)
$= 0.19$ (0.188) m s^{-1} — (A1) [2]

(b) a constant non-zero value of E from 0 to 3 cm and
a different constant non-zero value of E from 3 to 6 cm — M1
E from 3–6 cm has the opposite sign to and larger value than E from 0–3 cm — A1 [2]

314. 9702_w16_MS_41 Q: 9

(a) (induced) e.m.f. proportional to rate
of change of (magnetic) flux (linkage) — M1 A1 [2]

(b) flux linkage $= BAN$

$= \pi \times 10^{-3} \times 2.8 \times \pi \times (1.6 \times 10^{-2})^2 \times 85 = 6.0 \times 10^{-4}$ Wb — B1 [1]

(c) e.m.f. $= \Delta N\Phi / \Delta t$

$= (6.0 \times 10^{-4} \times 2) / 0.30$ — C1

$= 4.0$ mV — A1 [2]

(d) sketch: $E = 0$ for $t = 0 \rightarrow 0.3$ s, 0.6 s $\rightarrow$ 1.0 s, 1.6 s $\rightarrow$ 2.0 s — B1

$E = 4$ mV for $t = 0.3$ s $\rightarrow$ 0.6 s (either polarity) — B1

$E = 2$ mV for $t = 1.0$ s $\rightarrow$ 1.6 s — B1

with opposite polarity — B1 [4]

STEMUP.CO.UK

315. 9702_w16_MS_43 Q: 9

(a) (induced) e.m.f. proportional to rate M1
of change of (magnetic) flux (linkage) A1 [2]

(b) flux linkage $= BAN$

$= \pi \times 10^{-3} \times 2.8 \times \pi \times (1.6 \times 10^{-2})^2 \times 85 = 6.0 \times 10^{-4}$ Wb B1 [1]

(c) e.m.f. $= \Delta N\Phi / \Delta t$

$= (6.0 \times 10^{-4} \times 2) / 0.30$ C1

$= 4.0\,\text{mV}$ A1 [2]

(d) sketch: $E = 0$ for $t = 0 \rightarrow 0.3\,\text{s}$, $0.6\,\text{s} \rightarrow 1.0\,\text{s}$, $1.6\,\text{s} \rightarrow 2.0\,\text{s}$ B1

$E = 4$ mV for $t = 0.3\,\text{s} \rightarrow 0.6\,\text{s}$ (either polarity) B1

$E = 2$ mV for $t = 1.0\,\text{s} \rightarrow 1.6\,\text{s}$ B1

with opposite polarity B1 [4]

316. 9702_s21_MS_42 Q: 10

	Answer	Marks
(a)	the steady current **or** the direct current	**M1**
	that produces the same heating effect (as the alternating current)	**A1**
(b)(i)	peak current = 2.6 A **and** r.m.s. current = 1.8 A	**A1**
(b)(ii)	peak current = 2.0 A **and** r.m.s. current = 2.0 A	**A1**
(c)(i)	$k = 2\pi f$	**C1**
	$= 2\pi \times 50$ $= 310\,\text{rad s}^{-1}$	**A1**
(c)(ii)	power $= V_{RMS}^2 / R$ **or** power $= V_0^2 / 2R$	**C1**
	$R = (240 / \sqrt{2})^2 / 3200$ **or** $R = 240^2 / (2 \times 3200)$ $R = 9.0\,\Omega$	**A1**

250. 9702_w16_MS_43 Q: 6

(a) reference to input (voltage) and output (voltage) B1
there is no time delay between change in input and change in output B1 [2]

or

reference to rate at which output voltage changes (B1)
infinite rate of change (of output voltage) (B1)

(b) (i) $2.00 / 3.00 = 1.50 / R$ C1

or

$V_+ = (3.00 \times 4.5) / (2.00 + 3.00) = 2.7$
$2.7 = 4.5 \times R / (R + 1.50)$ (C1)

resistance = $2.25\,\text{k}\Omega$ A1 [2]

(ii) **1.** correct symbol for LED M1
two LEDs connected with opposite polarities between V_{OUT} and earth A1 [2]

2. below 24 °C, $R_T > 1.5\,\text{k}\Omega$ or resistance of thermistor increases/high B1

$V_- < V_+$ or V_- decreases/low (must not contradict initial statement) M1

V_{OUT} is positive/+5 (V) and LED labelled as 'pointing' from V_{OUT} to earth A1 [3]

251. 9702_w21_MS_41 Q: 8

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

252. 9702_w21_MS_43 Q: 8

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

STEMUP.CO.UK

253. 9702_s20_MS_41 Q: 8

	Answer	Marks
(a)	magnetic field normal to current	B1
	newton per ampere	B1
	newton per metre	B1
(b)(i)	current in wire QL gives rise to a force **or** wire QL is perpendicular to the magnetic field	B1
	force on wire QL is vertical	B1
	force does not act through the pivot	B1
(b)(ii)	forces act through the same line **or** forces are horizontal	B1
	forces are equal (in magnitude) and opposite (in direction)	B1
(c)(i)	change $= mg \times (\Delta)L$	C1
	$= 1.3 \times 10^{-4} \times 9.81 \times 2.6 \times 10^{-2} = 3.3 \times 10^{-5}$ N m^{-1}	A1
(c)(ii)	change $= B \times (\Delta)I \times L \times x$	C1
	$3.3 \times 10^{-5} = B \times 1.2 \times 0.85 \times 10^{-2} \times 5.6 \times 10^{-2}$	C1
	$B = 0.058$ T	A1

254. 9702_s20_MS_43 Q: 8

	Answer	Marks
(a)	magnetic field normal to current	B1
	newton per ampere	B1
	newton per metre	B1
(b)(i)	current in wire QL gives rise to a force **or** wire QL is perpendicular to the magnetic field	B1
	force on wire QL is vertical	B1
	force does not act through the pivot	B1
(b)(ii)	forces act through the same line **or** forces are horizontal	B1
	forces are equal (in magnitude) and opposite (in direction)	B1
(c)(i)	change $= mg \times (\Delta)L$	C1
	$= 1.3 \times 10^{-4} \times 9.81 \times 2.6 \times 10^{-2} = 3.3 \times 10^{-5}$ N m^{-1}	A1
(c)(ii)	change $= B \times (\Delta)I \times L \times x$	C1
	$3.3 \times 10^{-5} = B \times 1.2 \times 0.85 \times 10^{-2} \times 5.6 \times 10^{-2}$	C1
	$B = 0.058$ T	A1

255. 9702_s18_MS_41 Q: 9

	Answer	Marks
(a)	using Fleming's left-hand rule force on wire is upwards	B1
	by Newton's third law, force on magnet is downwards	B1
(b)(i)	$F = BIL$	C1
	$= 3.7 \times 10^{-3} \times 5.1 \times 8.5 \times 10^{-2}$ $= 1.6 \times 10^{-3}$ N	A1
(b)(ii)	$F = 1.6 \times 10^{-3}$ N	A1
(c)	sketch: sinusoidal wave with two cycles	B1
	amplitude 2.3×10^{-3} N	B1
	period 0.05 s	B1

256. 9702_s18_MS_43 Q: 9

	Answer	Marks
(a)	using Fleming's left-hand rule force on wire is upwards	B1
	by Newton's third law, force on magnet is downwards	B1
(b)(i)	$F = BIL$	C1
	$= 3.7 \times 10^{-3} \times 5.1 \times 8.5 \times 10^{-2}$ $= 1.6 \times 10^{-3}$ N	A1
(b)(ii)	$F = 1.6 \times 10^{-3}$ N	A1
(c)	sketch: sinusoidal wave with two cycles	B1
	amplitude 2.3×10^{-3} N	B1
	period 0.05 s	B1

257. 9702_w18_MS_42 Q: 8

	Answer	Marks
(a)	force per unit current	B1
	force per unit length (of wire)	B1
	current normal to (magnetic) field	B1
(b)(i)	forces (on PQ and RS) are horizontal	B1
	(hence they create) no moment about the pivot	B1
	or	
	forces (on PQ and RS) are equal and opposite	(B1)
	(hence there is) no net force (on the two sections)	(B1)
(b)(ii)	realisation of the need to apply moments	C1
	$BILx = mgy$ $B \times 2.7 \times 1.2 \times 10^{-2} \times 7.5 = 45 \times 10^{-6} \times 9.81 \times 8.8$	C1
	$B = 1.6 \times 10^{-2}$ T	A1

258. 9702_w16_MS_42 Q: 9

(a) (by Newton's third law) force on wire is up(wards) M1
by (Fleming's) left-hand rule/right-hand slap rule to give current A1
in direction left to right shown on diagram A1 [3]

(b) force ∝ current *or* $F = BIL$ *or* $B\ (= 0.080/6.0L) = 1/75L$ C1

maximum current $= 2.5 \times \sqrt{2}$ C1
$= 3.54\,\text{A}$

maximum force in one direction $= (3.54/6.0) \times 0.080$ C1
$= 0.047\,\text{N}$

difference $(= 2 \times 0.047) = 0.094\,\text{N}$
or
force varies from 0.047 N upwards to 0.047 N downwards A1 [4]

259. 9702_s21_MS_41 Q: 9

	Answer	Marks
(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**
(b)(i)	face PSWV shaded	**B1**
(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**
(c)(i)	number density of charge carriers	**B1**
(c)(ii)	PV **or** QT **or** SW	**B1**
(d)	(for semiconductor,) n is (much) smaller so V_H (much) larger	**B1**

260. 9702_s21_MS_42 Q: 8

	Answer	Marks
(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**
(b)	change in potential energy = change in kinetic energy **or** $qV = ½mv^2$	**B1**
	$v = \sqrt{(2qV / m)}$	**A1**
(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**
(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**
(c)(iii)	(for α-particle,) q / m is (much) smaller	**B1**
	r would be <u>much</u> larger	**B1**

261. 9702_s21_MS_43 Q: 9

	Answer	Marks
(a)	region where there is a force exerted on	**M1**
	a current-carrying conductor **or** a <u>moving</u> charge **or** a magnetic material/magnetic pole	**A1**
(b)(i)	face PSWV shaded	**B1**
(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**
(c)(i)	number density of charge carriers	**B1**
(c)(ii)	PV **or** QT **or** SW	**B1**
(d)	(for semiconductor,) n is (much) smaller so V_H (much) larger	**B1**

262. 9702_m20_MS_42 Q: 8

	Answer	Marks
(a)	a region where a magnet / magnetic material / moving charge / current carrying conductor experiences a force	**B1**
(b)	$B = F / Il$ e.g. = $9 \times 10^{-3} / (5.0 \times 0.045)$	**C1**
	= **0.040** T	**A1**
(c)(i)	force is (always) perpendicular to the velocity / direction of motion	**B1**
	magnetic force provides the centripetal force *or* force perpendicular to motion causes circular motion	**B1**
	magnitude of force (due to the magnetic field) is constant *or* no work done by force *or* the force does not change the speed	**B1**
(c)(ii)	Applying the list rule, any 2 from: accelerating p.d. radius of path / radius of semicircle magnetic flux density	**B2**

263. 9702_s20_MS_42 Q: 9

	Answer	Marks
(a)(i)	force is downwards/down the page **or** current is (right) to left	**B1**
	by left-hand rule, field is into plane of paper	**B1**
(a)(ii)	magnetic force provides the centripetal force	**C1**
	$Bqv = mv^2 / r$	**C1**
	$v = Bqr / m$ $= (8.0 \times 10^{-4} \times 1.60 \times 10^{-19} \times 6.4 \times 10^{-2}) / (9.11 \times 10^{-31})$ $= 9.0 \times 10^{6}$ m s^{-1}	**A1**
9(b)(i)	arrow showing field direction down the page	**B1**
(b)(ii)	$Bqv = Eq$ **or** $v = E / B$	**C1**
	$E = 9.0 \times 10^{6} \times 8.0 \times 10^{-4}$ $= 7.2 \times 10^{3}$ N C^{-1}	**A1**
(c)	straight line/undeviated	**B1**
	condition for no deflection depends only on v **or** condition for no deflection does not depend on m or q	**B1**

264. 9702_s19_MS_42 Q: 8

	Answer	Marks
(a)(i)	$v_N = 3.4 \times 10^7 \times \sin 30°$ $= 1.7 \times 10^7\ \text{m s}^{-1}$	A1
(a)(ii)	$mv^2 / r = Bqv$ **or** $r = mv / Bq$	C1
	$r = (9.11 \times 10^{-31} \times 1.7 \times 10^7) / (3.2 \times 10^{-3} \times 1.60 \times 10^{-19})$	C1
	$= 0.030\ \text{m}$	A1
(b)	zero	B1
(c)	helix/coil	B1

265. 9702_w19_MS_42 Q: 8

	Answer	Marks
(a)	magnitude: (force =) Bqv	B1
	direction: P→Q **or** E→F **or** S→R **or** H→G	B1
(b)(i)	EHSP and FGRQ	B1
(b)(ii)	PE **or** QF **or** RG **or** SH	B1
(c)(i)	*any one correct starting point from:* • (mass of 1 atom =) $27 \times 1.66 \times 10^{-27}$ • (amount of substance per unit volume =) 2.7 / 27 • 27 g (of substance) contains 6.02×10^{23} atoms • (2.7 g mass contains) 0.1 mol • (1 cm^3 volume contains) 0.1 mol • (1 m^3 volume contains) 10^5 mol	C1
	$n = (2.7 \times 10^3) / (27 \times 1.66 \times 10^{-27}) = 6.0 \times 10^{28}$ **or** $n = (2.7 / 27) \times 10^6 \times 6.02 \times 10^{23} = 6.0 \times 10^{28}$	A1
(c)(ii)	$V_H = (0.15 \times 4.6) / (6.0 \times 10^{28} \times 0.090 \times 10^{-3} \times 1.60 \times 10^{-19})$	C1
	$= 8.0 \times 10^{-7}\ \text{V}$	A1

266. 9702_m18_MS_42 Q: 9

	Answer	Marks
(a)(i)	PSYV and QRXW	B1
(a)(ii)	electron moving in magnetic field deflected towards face QRXW	M1
	so face PSYV is more positive	A1
(b)(i)	PV *or* SY *or* RX *or* QW	B1
(b)(ii)	number of charge carriers per unit volume	B1
(b)(iii)	negative and positive charge (carriers) would deflect in opposite directions	M1
	so no change in polarity	A1

267. 9702_s18_MS_42 Q: 8

	Answer	Marks
(a)	electric and magnetic fields at right-angles to one another *(may be shown on a clearly labelled diagram)*	B1
	particle enters fields (with velocity) normal to the (two) fields *(may be shown on a clearly labelled diagram)*	B1
	no deviation for particles with selected velocity	B1
(b)	magnetic force equals/is the centripetal force	C1
	$Bqv = mv^2/r$	C1
	$M = Bqr/v$ $= (94 \times 10^{-3} \times 1.6 \times 10^{-19} \times 0.075) / (3.4 \times 10^4)$	M1
	division by 1.66×10^{-27} shown, to give $m = 20$ u	A1
(c)	sketch: semicircle clear (in same direction)	B1
	with larger radius	B1

268. 9702_w18_MS_41 Q: 8

	Answer	Marks
(a)	region where there is a force	M1
	experienced by a current-carrying conductor/moving charge/(permanent) magnet	A1
(b)(i)	single path, deflection in 'upward' direction	B1
	acceptable circular arc in whole field	B1
	no 'kinks' at start or end of curvature, and straight outside region of field	B1
(b)(ii)	force (on particle) is normal to velocity/direction of motion/direction of speed	B1
(c)	magnetic force provides/is the centripetal force	B1
	$Bqv = mv^2/r$ **or** $r = mv/Bq$	C1
	(if q is doubled), new speed = $2v$	A1

269. 9702_w18_MS_43 Q: 8

	Answer	Marks
(a)	region where there is a force	M1
	experienced by a current-carrying conductor/moving charge/(permanent) magnet	A1
(b)(i)	single path, deflection in 'upward' direction	B1
	acceptable circular arc in whole field	B1
	no 'kinks' at start or end of curvature, and straight outside region of field	B1
(b)(ii)	force (on particle) is normal to velocity/direction of motion/direction of speed	B1
(c)	magnetic force provides/is the centripetal force	B1
	$Bqv = mv^2/r$ **or** $r = mv/Bq$	C1
	(if q is doubled), new speed = $2v$	A1

270. 9702_m17_MS_42 Q: 8

	Answer	Marks
(a)	region (of space) where there is a force	M1
	produced by / on a magnet / magnetic pole / moving charge / current-carrying conductor	A1
(b)(i)	out of (the plane of) the paper / page	B1
(b)(ii)	the force on the particle is (always) perpendicular to the velocity / perpendicular to the direction of travel / towards the centre of path	B1
	no work is done by the force on the particle / there is no acceleration in the direction of the velocity / the acceleration is (always) perpendicular to the velocity	B1
(b)(iii)	$F = Bqv$ or $F = mv^2/r$	C1
	$mv^2/(d/2) = Bqv$ so $d = 2mv/Bq$	A1
(b)(iv)	time = distance / speed $T_{(F)} = \pi d/2v$	C1
	$T_{(F)} = (\pi/2v) \times (2mv/Bq)$ $T_{(F)} = \pi m/Bq$ and so $T_{(F)}$ independent of v	A1

271. 9702_s17_MS_41 Q: 7

	Answer	Marks
(a)	(magnetic) force (always) normal to velocity/direction of motion	M1
	(magnitude of magnetic) force constant **or** speed is constant/kinetic energy is constant	M1
	so provides the centripetal force	A1
(b)	increase in KE = loss in PE **or** $\frac{1}{2}mv^2 = qV$	M1
	$p = mv$ with algebra leading to $p = \sqrt{(2mqV)}$	A1
(c)	$Bqv = mv^2/r$ $mv = Bqr$ **or** $p = Bqr$	C1
	$(2 \times 9.11 \times 10^{-31} \times 1.60 \times 10^{-19} \times 120)^{1/2} = B \times 1.60 \times 10^{-19} \times 0.074$	C1
	$B = 5.0 \times 10^{-4}$ T	A1
(d)	greater momentum	M1
	($p = Bqr$ and) so r increased	A1

272. 9702_s17_MS_42 Q: 9

	Answer	Marks
(a)(i)	Hall voltage depends on thickness of slice	C1
	thinner slice, larger Hall voltage	A1
(a)(ii)	Hall voltage depends on current in slice	B1
(b)	sinusoidal wave, one cycle	B1
	at $\theta = 0$ and at $\theta = 360°$, $V_H = V_{MAX}$	B1
	at $\theta = 180°$, $V_H = -V_{MAX}$	B1

273. 9702_s17_MS_43 Q: 7

	Answer	Marks
(a)	(magnetic) force (always) normal to velocity/direction of motion	M1
	(magnitude of magnetic) force constant **or** speed is constant/kinetic energy is constant	M1
	so provides the centripetal force	A1
(b)	increase in KE = loss in PE **or** $\frac{1}{2}mv^2 = qV$	M1
	$p = mv$ with algebra leading to $p = \sqrt{(2mqV)}$	A1
(c)	$Bqv = mv^2 / r$ $mv = Bqr$ **or** $p = Bqr$	C1
	$(2 \times 9.11 \times 10^{-31} \times 1.60 \times 10^{-19} \times 120)^{1/2} = B \times 1.60 \times 10^{-19} \times 0.074$	C1
	$B = 5.0 \times 10^{-4}$ T	A1
(d)	greater momentum	M1
	($p = Bqr$ and) so r increased	A1

274. 9702_w17_MS_41 Q: 8

	Answer	Marks
(a)	DERQ and CFSP	B1
(b)(i)	force (on charge) due to magnetic field = force due to electric field **or** $Bqv = Eq$ **or** $v = E/B$	B1
	$E = V_H/d$	B1
	$V_H = Bvd$	B1
(b)(ii)	use of $I = nAqv$ **and** $A = dt$	M1
	algebra clear leading to $V_H = BI/ntq$	A1
(c)	(in metal,) n is very large	M1
	(therefore) V_H is small	A1

275. 9702_w17_MS_42 Q: 8

	Answer	Marks
(a)(i)	DERQ and CFSP	B1
(a)(ii)	charge carriers moving normal to (magnetic) field	B1
	charge carriers experience a force normal to I (and B)	B1
	charge build-up sets up electric field across the slice **or** build-up of charges results in a p.d. across the slice	B1
	charge stops building up/V_H becomes constant when $F_B = F_E$	B1
(b)	V_H inversely proportional to n/number density of charge carriers	B1
	number density of charge carriers (n) lower in semiconductors so V_H larger for semiconductor slice	B1
	or	
	V_H proportional to v/drift velocity	(B1)
	(for same current) drift velocity (v) higher in semiconductors so V_H larger for semiconductor slice	(B1)

276. 9702_w17_MS_42 Q: 9

	Answer	Marks
(a)	region (of space)	B1
	where an object/particle experiences a force	B1
(b)	electric and magnetic fields normal to each other	B1
	velocity of particle normal to both fields	B1
	forces (on particle) due to fields are in opposite directions	B1
	forces are equal for particles with a particular speed/for a selected speed/for speed given by $v = E(q)/B(q)$	B1
(c)(i)	path labelled Q shown undeviated	B1
(c)(ii)	reasonable curve in field and no 'kink' on entering, labelled V	B1
	deviated 'upwards'	B1

277. 9702_w17_MS_43 Q: 8

	Answer	Marks
(a)	DERQ and CFSP	B1
(b)(i)	force (on charge) due to magnetic field = force due to electric field **or** $Bqv = Eq$ **or** $v = E/B$	B1
	$E = V_H/d$	B1
	$V_H = Bvd$	B1
(b)(ii)	use of $I = nAqv$ **and** $A = dt$	M1
	algebra clear leading to $V_H = BI/ntq$	A1
(c)	(in metal,) n is very large	M1
	(therefore) V_H is small	A1

278. 9702_w16_MS_41 Q: 7

(a) region (of space) where a force is experienced by a particle B1 [1]

(b) (i) gravitational B1

(ii) gravitational and electric B1

(iii) gravitational, electric and magnetic B1 [3]

(c) (i) force (always) normal to direction of motion M1

(magnitude of) force constant
or
speed is constant/kinetic energy is constant M1

magnetic force provides/is the centripetal force A1 [3]

(ii) $mv^2/r = Bqv$ B1

momentum or p or $mv = Bqr$ B1 [2]

279. 9702_w16_MS_43 Q: 7

(a)	region (of space) where a force is experienced by a particle		B1	[1]
(b)	**(i)** gravitational		B1	
	(ii) gravitational and electric		B1	
	(iii) gravitational, electric and magnetic		B1	[3]
(c)	**(i)** force (always) normal to direction of motion		M1	
	(magnitude of) force constant *or* speed is constant/kinetic energy is constant		M1	
	magnetic force provides/is the centripetal force		A1	[3]
	(ii) $mv^2 / r = Bqv$		B1	
	momentum or p or $mv = Bqr$		B1	[2]

280. 9702_w21_MS_42 Q: 8

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

281. 9702_w19_MS_41 Q: 8

	Answer	Marks
(a)	concentric circles (around the wire)	**M1**
	at least 3 circles shown, all with increasing separation	**A1**
	direction anticlockwise	**B1**
(b)(i)	$B = (4\pi \times 10^{-7} \times 6.2) / (2\pi \times 3.1 \times 10^{-2})$	**C1**
	$= 4.0 \times 10^{-5}$ T	**A1**
(b)(ii)	$F = BIL$ **or** $F / L = BI$	**C1**
	$F / L = 4.0 \times 10^{-5} \times 8.5$ $= 3.4 \times 10^{-4}$ N m^{-1}	**A1**
(c)	correct application of Newton's 3rd law to the forces **or** F / L is proportional to the product of the two currents	**M1**
	so same magnitude	**A1**

282. 9702_w19_MS_43 Q: 8

	Answer	Marks
(a)	concentric circles (around the wire)	M1
	at least 3 circles shown, all with increasing separation	A1
	direction anticlockwise	B1
(b)(i)	$B = (4\pi \times 10^{-7} \times 6.2) / (2\pi \times 3.1 \times 10^{-2})$	C1
	$= 4.0 \times 10^{-5}$ T	A1
(b)(ii)	$F = BIL$ **or** $F / L = BI$	C1
	$F / L = 4.0 \times 10^{-5} \times 8.5$ $= 3.4 \times 10^{-4}$ N m^{-1}	A1
(c)	correct application of Newton's 3rd law to the forces **or** F / L is proportional to the product of the two currents	M1
	so same magnitude	A1

283. 9702_m21_MS_42 Q: 8

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

	Answer	Marks
(b)(i)	frequency of radio waves is equal to natural frequency of protons	B1
	resonance of protons occurs / protons absorb energy	B1
(b)(ii)	in between pulses / when pulse stops	B1
	Any 1 from: • protons de-excite • protons emit r.f. pulses • emitted (r.f.) pulse (from proton) detected	B1

284. 9702_s19_MS_41 Q: 9

	Answer	Marks
(a)	nuclei precess	B1
	precession is about direction of magnetic field	B1
	frequency of precession depends on field strength **or** frequency of precession is in radio-frequency range	B1
(b)	Any two points from: • frequency (of precession) depends on position • to locate position of (spinning) nuclei • to change region where nuclei are detected	B2

285. 9702_s19_MS_43 Q: 9

	Answer	Marks
(a)	nuclei precess	B1
	precession is about direction of magnetic field	B1
	frequency of precession depends on field strength **or** frequency of precession is in radio-frequency range	B1
(b)	Any two points from: • frequency (of precession) depends on position • to locate position of (spinning) nuclei • to change region where nuclei are detected	B2

286. 9702_w19_MS_41 Q: 9

	Answer	Marks
(a)	nuclei precess	B1
	precession is about (direction of magnetic) field **or** frequency of precession is in radio-frequency range	B1
(b)	• frequency (of precession) depends on field strength • to locate/find position of (spinning) nuclei • to change region where nuclei are detected *any two points, one mark each*	B2

287. 9702_w19_MS_43 Q: 9

	Answer	Marks
(a)	nuclei precess	B1
	precession is about (direction of magnetic) field **or** frequency of precession is in radio-frequency range	B1
(b)	• frequency (of precession) depends on field strength • to locate/find position of (spinning) nuclei • to change region where nuclei are detected *any two points, one mark each*	B2

288. 9702_s17_MS_41 Q: 8

	Answer	Marks
	strong (uniform) magnetic field	B1
	* nuclei precess/rotate about field (direction)	
	radio frequency pulse/RF pulse (applied)	B1
	* RF or pulse is at Larmor frequency / frequency of precession	
	causes resonance / excitation (of nuclei)/nuclei to absorb energy	B1
	on relaxation/de-excitation, nuclei emit RF/pulse	B1
	* (emitted) RF/pulse detected and processed	
	non-uniform field (superposed on uniform field)	B1
	allows positions of (resonating) nuclei to be determined	B1
	* allows for position of detection to be changed/different slices to be studied	
	*max. 2 of additional detail points marked **	B2

289. 9702_s17_MS_43 Q: 8

	Answer	Marks
	strong (uniform) magnetic field	**B1**
	* nuclei precess/rotate about field (direction)	
	radio frequency pulse/RF pulse (applied)	**B1**
	* RF or pulse is at Larmor frequency / frequency of precession	
	causes resonance / excitation (of nuclei)/nuclei to absorb energy	**B1**
	on relaxation/de-excitation, nuclei emit RF/pulse	**B1**
	* (emitted) RF/pulse detected and processed	
	non-uniform field (superposed on uniform field)	**B1**
	allows positions of (resonating) nuclei to be determined	**B1**
	* allows for position of detection to be changed/different slices to be studied	
	*max. 2 of additional detail points marked**	**B2**

290. 9702_w16_MS_41 Q: 8

strong uniform magnetic field B1

nuclei precess/rotate about field (direction) (1)

radio-frequency pulse (applied) B1

R.F. or pulse is at Larmor frequency/frequency of precession (1)

causes resonance/excitation (of nuclei)/nuclei absorb energy B1

on relaxation/de-excitation, nuclei emit r.f./pulse B1

(emitted) r.f./pulse detected and processed (1)

non-uniform magnetic field B1

allows position of nuclei to be located B1

allows for location of detection to be changed/different slices to be studied (1)

any two of the points marked (1) B2 [8]

291. 9702_w16_MS_42 Q: 10

nuclei emitting r.f. (pulse) B1

Larmor frequency/r.f. frequency emitted/detected depends on magnitude of magnetic field B1

nuclei can be located (within a slice) B1

changing field enables position of detection (slice) to be changed B1 [4]

STEMUP.CO.UK

292. 9702_w16_MS_43 Q: 8

strong <u>uniform</u> magnetic field	B1	
nuclei precess/rotate about field (direction)	(1)	
radio-frequency pulse (applied)	B1	
R.F. or pulse is at Larmor frequency/frequency of precession	(1)	
causes resonance/excitation (of nuclei)/nuclei absorb energy	B1	
on relaxation/de-excitation, nuclei emit r.f./pulse	B1	
(emitted) r.f./pulse detected and processed	(1)	
non-uniform magnetic field	B1	
allows position of nuclei to be located	B1	
allows for location of detection to be changed/different slices to be studied	(1)	
any two of the points marked (1)	B2	[8]

293. 9702_m21_MS_42 Q: 9

	Answer	Marks
(a)	(magnetic) flux density × area × number of turns	**M1**
	area is perpendicular to (magnetic) field	**A1**
(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**
(c)(i)	light damping	**B1**

Q1.

5	(a)		centripetal force = mv^2/r B1	
			magnetic force $F = Bqv$ B1	
			(hence) $mv^2/r = Bqv$ B1	
			$r = mv/Bq$ A0	[3]
	(b)		$r_\alpha/r_\beta = (m_\alpha/m_\beta) \times (q_\beta/q_\alpha)$ C1	
			$= (4 \times 1.66 \times 10^{-27})/(9.11 \times 10^{-31} \times 2)$	
			$= 3.64 \times 10^3$ A2	[3]
	(c)	(i)	$r_\alpha = (4 \times 1.66 \times 10^{-27} \times 1.5 \times 10^6)/(1.2 \times 10^{-3} \times 2 \times 1.6 \times 10^{-19})$	
			$= 25.9$ m A2	
		(ii)	$r_\beta = 25.9 \times 3.64 \times 10^3 = 7.13 \times 10^{-3}$ m A1	[3]
	(d)	(i)	deflected upwards B1	
			but close to original direction B1	
		(ii)	opposite direction to α-particle and 'through side' B1	[3]

Q2.

6	(a)	(i)	flux/field in core must be changing	M1	
			so that an e.m.f./current is induced in the secondary	A1	[2]
		(ii)	power = VI	M1	
			output power is constant so if V_S increases, I_S decreases	A1	[2]
	(b)	(i)	same shape and phase as I_P graph	B1	[1]
		(ii)	same frequency	M1	
			correct phase w.r.t. Fig. 6.3	A1	[2]
		(iii)	½π rad or 90°	B1	[1]

Q3.

6	(a)	(i)	arrow B in correct direction (down the page)	B1	
		(ii)	arrow F in correct direction (towards Y)	B1	[2]
	(b)	(i)	When two bodies interact, force on one body is equal but opposite in direction to force on the other body.	B1	[1]
		(ii)	direction opposite to that in (a)(ii)	B1	[1]
	(c)		suggested reasonable values of I and d	B1	
			mention of expression $F = BIL$	B1	
			force between wires is small	M1	
			compared to weight of wire	A1	[4]

Q4.

8 (a) arrow labelled E pointing down the page — B1 [1]

(b) (i) $Bqv = qE$ — M1
forces are independent of mass and charge 'cancels' — M1
so no deviation — A1 [3]

(ii) magnetic force > electric force — M1
so deflects — M1
'downwards' — A1 [3]

Q5.

6 (a) parallel (to the field) — B1 [1]

(b) (i) torque $= F \times d$
$2.1 \times 10^{-3} = F \times 2.8 \times 10^{-2}$ — C1
$F = 0.075$ N — A1 [2]
(use of 4.5 cm scores no marks)

(ii) zero — A1 [1]

(c) $F = BILN(\sin\theta)$ — C1
$0.075 = B \times 0.170 \times 4.5 \times 10^{-2} \times 140$ — M1
$B = 7.0 \times 10^{-2}$ T $= 70$ mT — A0 [2]

(d) (i) (induced) e.m.f. is proportional to / equal to rate of change of — M1
(magnetic) flux (linkage) — A1 [2]

(ii) change in flux linkage $= BAN$
$= 0.070 \times 4.5 \times 10^{-2} \times 2.8 \times 10^{-2} \times 140$ — C1
$= 0.0123$ Wb turns
induced e.m.f $= 0.0123 / 0.14$ — C1
$= 88$ mV — A1 [3]
(Note: This is a simplified treatment. A full treatment would involve the averaging of B cosθ leading to a $\sqrt{2}$ factor)

Q6.

6 (a) unit of magnetic flux density / magnetic field strength B1
(uniform) field normal to wire carrying current of 1 A M1
giving force (per unit length) of 1 N m^{-1} A1 [3]

(b) (i) force on magnet / balance is downwards (so by Newton's third law) B1
force on wire is upwards M1
pole P is a north pole A1 [3]

(ii) $F = BIL$ and $F = mg$ *(g missing, then 0/3 in* ***(ii)****)* C1
$2.3 \times 10^{-3} \times 9.8 = B \times 2.6 \times 4.4 \times 10^{-2}$ *(g = 10, loses this mark)* C1
$B = 0.20$ T A1 [3]

(c) reading for maximum current = $2.3 \times \sqrt{2}$ C1
total variation = $2 \times 2.3 \times \sqrt{2}$
= 6.5 g A1 [2]

Q7.

7 coil in series with meter *(do not allow inclusion of a cell)* B1
push known pole into coil B1
observe current direction *(not reading)* B1
(induced) field / field from coil repels magnet B1
either states rule to determine direction of magnetic field in coil
or reversing magnet direction gives opposite deflection on meter B1
direction of induced current such as to oppose the change producing it B1 [6]

Q8.

5 (a) (i) V_H depends on angle between (plane of) probe and *B*-field B1
either V_H max when plane and *B*-field are normal to each other
or V_H zero when plane and *B*-field are parallel
or V_H depends on sine of angle between plane and *B*-field B1 [2]

(ii) 1 calculates $V_H r$ at least three times M1
to 1 s.f. constant so valid or approx constant so valid
or to 2 s.f., not constant so invalid A1 [2]

2 straight line passes through origin B1 [1]

(b) (i) e.m.f. induced is proportional / equal to M1
rate of change of (magnetic) flux (linkage) A1
constant field in coil / flux (linkage) of coil does not change B1 [3]

(ii) e.g. vary current (in wire) / switch current on or off / use a.c. current
rotate coil
move coil towards / away from wire (1 mark each, max 3) B3 [3]

Q9.

7	(a)	arrow pointing up the page	B1	[1]
	(b) (i)	$Eq = Bqv$	C1	
		$v = (12 \times 10^3) / (930 \times 10^{-6})$	C1	
		$= 1.3 \times 10^7$ m s^{-1}	A1	[3]
	(ii)	$Bqv = mv^2 / r$	C1	
		$q/m = (1.3 \times 10^7) / (7.9 \times 10^{-2} \times 930 \times 10^{-6})$	C1	
		$= 1.8 \times 10^{11}$ C kg^{-1}	A1	[3]

Q10.

6	(a) (i)	straight line with positive gradient	M1	
		through origin	A1	[2]
	(ii)	maximum force shown at $\theta = 90°$	M1	
		zero force shown at $\theta = 0°$	M1	
		reasonable curve with F about ½ max at 30°	A1	[3]
	(b) (i)	force on electron due to magnetic field	B1	
		force on electron normal to magnetic field and direction of electron	B1	[2]
	(ii)	quote / mention of (Fleming's) left hand rule	M1	
		electron moves towards QR	A1	[2]

Q11.

5	(a)	region (of space) where there is a force	M1	
		either on / produced by magnetic pole		
		or on / produced by current carrying conductor / moving charge	A1	[2]
	(b) (i)	force on particle is (always) normal to velocity / direction of travel	B1	
		speed of particle is constant	B1	[2]
	(ii)	magnetic force provides the centripetal force	B1	
		$mv^2 / r = Bqv$	M1	
		$r = mv / Bq$	A0	[2]
	(c) (i)	direction from 'bottom to top' of diagram	B1	[1]
	(ii)	radius proportional to momentum	C1	
		ratio = 5.7 / 7.4		
		= 0.77	A1	[2]
		*(answer must be consistent with direction given in **(c)(i)**)*		

Q12.

5	(a) (i)	(induced) e.m.f. proportional to rate of change of (magnetic) flux (linkage) / rate of flux cutting	M1 A1		[2]
	(ii)	**1.** moving magnet causes change of flux linkage	B1		[1]
		2. speed of magnet varies so varying rate of change of flux	B1		[1]
		3. magnet changes direction of motion (so current changes direction)	B1		[1]
	(b)	period = 0.75 s frequency = 1.33 Hz	C1 A1		[2]
	(c)	graph: smooth correctly shaped curve with peak at f_0 *A* never zero	M1 A1		[2]
	(d) (i)	resonance	B1		[1]
	(ii)	e.g. quartz crystal for timing / production of ultrasound	A1		[1]

Q13.

7	(a)	sketch: concentric circles *(minimum of 3 circles)* separation increasing with distance from wire correct direction	M1 A1 B1		[3]
	(b) (i)	arrow direction from wire B towards wire A	B1		[1]
	(ii)	*either* reference to Newton's third law *or* force on each wire proportional to product of the two currents so forces are equal	M1 A1		[2]
	(c)	force <u>always</u> towards wire A/<u>always</u> in same direction varies from zero (to a maximum value) (1) variation is sinusoidal / $\sin^2$ (1) (at) twice frequency of current (1) *(any two, one each)*	B1 B2		[3]

Q14.

5	(a)	(long) straight conductor carrying current of 1 A	M1	
		current/wire normal to magnetic field	M1	
		(for flux density 1 T,) force per unit length is 1 Nm^{-1}	A1	[3]
	(b) (i)	(originally) downward force on magnet (due to current)	B1	
		by Newton's third law (allow "N3")	M1	
		upward force on wire	A1	[3]
	(ii)	$F = BIL$		
		$2.4 \times 10^{-3} \times 9.8 = B \times 5.6 \times 6.4 \times 10^{-2}$	C1	
		$B = 0.066$ T *(need 2 SF)*	A1	[2]
		(*g missing scores 0/2, but g = 10 leading to 0.067T scores 1/2*)		
	(c)	new reading is $2.4\sqrt{2}$ g	C1	
		either changes between +3.4 g and –3.4 g		
		or total change is 6.8 g	A1	[2]

Q15.

5	(a)	(uniform magnetic) flux normal to long (straight) wire carrying a current of 1 A	M1	
		(creates) force per unit length of 1 Nm^{-1}	A1	[2]
	(b) (i)	flux density $= 4\pi \times 10^{-7} \times 1.5 \times 10^{3} \times 3.5$	C1	
		$= 6.6 \times 10^{-3}$ T	A1	[2]
	(ii)	flux linkage $= 6.6 \times 10^{-3} \times 28 \times 10^{-4} \times 160$	C1	
		$= 3.0 \times 10^{-3}$ Wb	A1	[2]
	(c) (i)	(induced) e.m.f. proportional to rate of	M1	
		change of (magnetic) flux (linkage)	A1	[2]
	(ii)	e.m.f. $= (2 \times 3.0 \times 10^{-3}) / 0.80$	C1	
		$= 7.4 \times 10^{-3}$ V	A1	[2]

Q16.

5 (a) (uniform magnetic) flux normal to long (straight) wire carrying a current of 1 A M1
(creates) force per unit length of 1 N m^{-1} A1 [2]

(b) (i) sketch: concentric circles M1
increasing separation *(must show more than 3 circles)* A1
correct direction (anticlockwise, looking down) B1 [3]

(ii) $B = (4\pi \times 10^{-7} \times 6.3) / (2\pi \times 4.5 \times 10^{-2})$ C1
$= 2.8 \times 10^{-5}$ T A1 [2]

(iii) $F = BIL (\sin\theta)$ C1
$= 2.8 \times 10^{-5} \times 9.3 \times 1$
$F/L = 2.6 \times 10^{-4}$ N m^{-1} A1 [2]

(c) force per unit length depends on product $I_X I_Y$ / by Newton's third law / action and reaction are equal and opposite M1
so same for both A1 [2]

Q17.

6 (a) e.g. E-field, force independent of speed, B-field, force ∝ speed … B2
E-field, force along field direction, B-field, force normal etc … B2 [4]

(b) (i) out of plane of paper (not 'upwards') B1
(ii) $mv^2 / r = Bqv$ C1
$r = (1.67 \times 10^{-27} \times 4.5 \times 10^6) / (0.12 \times 1.6 \times 10^{-19})$ C1
$r = 0.39$ m A1 [4]

(c) (i) arrow pointing up page B1
(ii) $Bqv = Eq$ C1
$E = 0.12 \times 4.5 \times 10^6$
$= 5.4 \times 10^5$ V m^{-1} A1 [3]

(d) gravitational force $<< F_B$ or F_E B1 [1]

Q18.

7 (a) (i) the wire cuts magnetic field B1
e.m.f. induced when there is a change/cutting of flux B1
(ii) (Lenz) e.m.f. 'opposes' change causing it B1
as direction of movement changes, so does e.m.f. B1 [4]

(b) $x_0 = 1.5$ mV …(allow ±0.1) C1
$\omega = 2\pi / T = 2\pi / (3 \times 10^{-3})$ C1
$= 2090$ rad s^{-1} C1
$x = 1.5 \sin 2090t$ A1 [4]

Q19.

5 (a) field producing force of 1.0 N m^{-1} on wire *OR* $B = F/IL\sin\theta$ M1
carrying current of 1.0 A normal to field *OR* symbols explained ... A1 [2]

(b) (i) $\phi = BA$
$= 1.8 \times 10^{-4} \times 0.60 \times 0.85$ C1
$= 9.18 \times 10^{-5}$ Wb ..... A1 [2]

(ii)1 $\Delta\phi = 9.18 \times 10^{-5}$ Wb A1

(ii)2 $e = (N\Delta\phi)/\Delta t$
$= (9.18 \times 10^{-5})/0.20$ C1
$= 4.59 \times 10^{-4}$ V ..... A1 [3]

(iii) there is an e.m.f. and a complete circuit
OR no resultant e.m.f. from other three sides
OR no e.m.f. in AB so yes ..... B1 [1]

Q20.

4 (a) (i) 50 mT 1

(ii) flux linkage = *BAN* 1
$= 50 \times 10^{-3} \times 0.4 \times 10^{-4} \times 150 = 3.0 \times 10^{-4}$ Wb 1 **[3]**

(allow 49 mT → 2.94 x 10^{-4} Wb or 51 mT → 3.06 x 10^{-4} Wb)

(b) e.m.f./induced voltage *(do not allow current)*
proportional/equal to 1
rate of change/cutting of flux (linkage) 1 **[2]**

(c) (i) new flux linkage $= 8.0 \times 10^{-3} \times 0.4 \times 10^{-4} \times 150$
$= 4.8 \times 10^{-5}$ Wb 1
change = 2.52×10^{-4} Wb 1 **[2]**

(ii) e.m.f. $= (2.52 \times 10^{-4})/0.30$ 1
$= 8.4 \times 10^{-4}$ V 1 **[2]**

(d) *either* for *a* small change in distance *x* 1
(change in) flux linkage decreases as distance increases 1
so speed must increase to keep rate of change constant 1 **[3]**
or (change in) flux linkage decreases as distance increases (1)
at constant speed, e.m.f/flux linkage decreases as x increases (1)
so increase speed to keep rate constant (1)

Q21.

5	(a)	into (plane of) paper/downwards	1		[1]
	(b) (i)	the centripetal force = mv^2/r	1		
		$mv^2/r = Bqv$ hence $q/m = v/rB$ *(some algebra essential)*	1		[2]
	(ii)	$q/m = (8.2 \times 10^6)/(23 \times 10^{-2} \times 0.74)$	1		
		$= 4.82 \times 10^7$ C kg^{-1}	1		[2]
	(c) (i)	mass = $(1.6 \times 10^{-19})/(4.82 \times 10^7 \times 1.66 \times 10^{-27})$	1		
		= 2u	1		[2]
	(ii)	proton + neutron	1		[1]

Q22.

5	(a)	$\frac{1}{2}mv^2 = qV$ .....(or some verbal explanation)	B1	
		$\frac{1}{2} \times 9.11 \times 10^{-31} \times v^2 = 1.6 \times 10^{-19} \times 1.2 \times 10^4$	B1	
		$v = 6.49 \times 10^7$ m s^{-1}	A0	[2]
	(b)(i)	*within field:* circular arc	B1	
		in 'downward' direction	B1	
		beyond field: straight, with no 'kink' on leaving field	B1	[3]
	(ii) 1.	v is smaller	M1	
		deflection is larger	A1	[2]
	2.	(magnetic) force is larger	M1	
		deflection is larger	A1	[2]

Q23.

6	(a)	(numerically equal to) force per unit length	M1	
		on straight conductor carrying unit current	A1	
		normal to the field	A1	[3]
	(b)	flux through coil = $BA \sin\theta$	B1	
		flux linkage = $BAN \sin\theta$	B1	[2]
	(c)(i)	(induced) e.m.f. proportional to	M1	
		rate of change of flux (linkage)	A1	[2]
	(ii)	graph: two square sections in correct positions, zero elsewhere	B1	
		pulses in opposite directions	B1	
		amplitude of second about twice amplitude of first	B1	[3]

Q24.

5	(a)	(i)	(induced) e.m.f proportional/equal to rate of change of flux (linkage) *(allow 'induced voltage, induced p.d.)* flux is cust as the disc moves hence inducing an e.m.f	B1 M1 A0	[2]
		(ii)	field in disc is not uniform/rate of cutting not same/speed of disc not same (over whole disc) so different e.m.f.'s in different parts of disc lead to eddy currents	B1 M1 A0	[2]
	(b)		eddy currents dissipate thermal energy in disc energy derived from oscillation of disc energy of disc depends on amplitude of oscillations	B1 B1 B1	[3]

Q25.

6 (a) (i) $BI \sin\theta$ ..... B1 [1]

(ii) (downwards) into (the plane of) the paper ..... B1 [1]

(b) (i) magnetic field (due to current) in one loop OR each loop acts as a coil B1
cuts/is normal to current in second loop OR produces magnetic field B1
causing force on second loop OR fields in same direction M1
either Newton's 3rd discussed
or vice versa clear gives rise to attraction OR so attracts ..... A1 [4]

(ii) $B = 2 \times 10^{-7} I / 0.75 \times 10^{-2}$ ($= 2.67 \times 10^{-5} I$) C1
force = $0.26 \times 10^{-3} \times 9.81$ ($= 2.55 \times 10^{-3}$ N) C1
$F = BIL$
$2.55 \times 10^{-3} = 2.67 \times 10^{-5} \times I^2 \times 2\pi \times 4.7 \times 10^{-2}$ C1
$I = 18$ A ..... A1 [4]

Q26.

8	(a)		region (of space) / area where a force is experienced by current-carrying conductor / moving charge / permanent magnet	B1 M1 A1	[3]
	(b)	(i)	electric	B1	[1]
		(ii)	gravitational	B1	[1]
		(iii)	magnetic	B1	[1]
		(iv)	magnetic	B1	[1]

Q27.

6 (a) concentric circles …(*at least three lines*) M1
with increasing separation A1
correct direction clear .....B1 [3]

(b) (i) correct position to left of wire .....B1 [1]

(ii) $B = (4\pi \times 10^{-7} \times 1.7) / (2\pi \times 1.9 \times 10^{-2})$ C1
$= 1.8 \times 10^{-5}$ T .....A1 [2]

(c) distance $\propto$ current C1
current = $(2.8 / 1.9) \times 1.7$
= 2.5 A .....A1 [2]

[Total: 8]

Q28.

5 (a) (i) concentric circles, anticlockwise ……(*minimum 3 circles*) M1
separation of lines increases with distance from wire .....A1 [2]

(ii) direction from Y towards X .....A1 [1]

(b) (i) flux density at wire Y = $(4\pi \times 10^{-7} \times 5.0) / (2\pi \times 2.5 \times 10^{-2})$ C1
= 4.0×10^{-5} T C1
force per unit length = BI
= $4.0 \times 10^{-5} \times 7.0$ C1
= 2.8×10^{-4} N .....A1 [4]

(ii) *either* force depends on product of the currents in the two wires M1
so equal A1
or (isolated system so) Newton's 3rd law applies .....(M1)
so equal .....(A1) [2]

[Total: 9]

Q29.

6 (a) (i) e.m.f. induced proportional / equal to M1
rate of change of (magnetic) flux (linkage) ..... A1 [2]

(ii) e.m.f. (induced) only when flux is changing / cut B1
direct current gives constant flux ..... B1 [2]

(b) (i) (induced) e.m.f. / current acts in such a direction to produce effects B1
to oppose the change causing it ..... B1 [2]

(ii) (induced) current in secondary produces magnetic field M1
opposes (changing) field produced in primary M1
so not in phase ..... A0 [2]

(c) (i) alternating means that voltage / current is easy to change ..... B1 [1]

(ii) high voltage means less power / energy loss (during transmission) ..... B1 [1]

[Total: 10]

Q30.

5 (a) field into (the plane of) the paper B1 [1]

(b) force due to magnetic field provides the centripetal force B1
$mv^2 / r = Bqv$ C1
$B = (20 \times 1.66 \times 10^{-27} \times 1.40 \times 10^5) / (1.6 \times 10^{-19} \times 6.4 \times 10^{-2})$ B1
$= 0.454\,T$ A0 [3]

(c) (i) semicircle with diameter greater than 12.8 cm B1 [1]

(ii) new flux density $= \frac{22}{20} \times 0.454$ C1
$B = 0.499\,T$ A1 [2]

Q31.

5 (a) magnetic flux $= BA$
$= 89 \times 10^{-3} \times 5.0 \times 10^{-2} \times 2.4 \times 10^{-2}$ C1
$= 1.07 \times 10^{-4}$ Wb A1 [2]

(b) (i) e.m.f. $= \Delta\phi / \Delta t$ C1
(for $\Delta\phi = 1.07 \times 10^{-4}$ Wb), $\Delta t = 2.4 \times 10^{-2} / 1.8 = 1.33 \times 10^{-2}$ s C1
e.m.f. $= (1.07 \times 10^{-4}) / (1.33 \times 10^{-2})$
$= 8.0 \times 10^{-3}$ V A1 [3]

(ii) current $= 8.0 \times 10^{-3} / 0.12$ M1
≈ 70 mA A0 [1]

(c) force on wire $= BIL$
$= 89 \times 10^{-3} \times 70 \times 10^{-3} \times 5.0 \times 10^{-2}$ C1
$\approx 3 \times 10^{-4}$ (N) M1
suitable comment e.g. this force is too / very small (to be felt) A1 [3]

Q32.

7	(a)	force due to *E*-field is <u>equal and opposite</u> to force due to *B*-field	B1	
		$Eq = Bqv$	B1	
		$v = E/B$	B1	[3]
	(b)	*either* charge and mass are not involved in the equation in **(a)**		
		or F_E and F_B are both doubled		
		or *E*, *B* and *v* do not change	M1	
		so no deviation	A1	[2]

Q33.

(b)	(i)	(induced) e.m.f. is proportional to	M1	
		rate of change/cutting of (magnetic) flux (linkage)	A1	[2]
	(ii)	a current is induced in the coil	M1	
		as magnet moves in coil	A1	
		current in resistor gives rise to a heating effect	M1	
		thermal energy is derived from energy of oscillation of the magnet	A1	[4]

Q34.

5	(a)	(i) $Bqv(\sin\theta)$ or $Bqv(\cos\theta)$	B1	[1]
		(ii) qE	B1	[1]
	(b)	F_B must be opposite in direction to F_E	B1	
		so magnetic field <u>into</u> plane of paper	B1	[2]

Q35.

6	(a)	unit of magnetic flux density	B1	
		field normal to (straight) conductor carrying current of 1 A	M1	
		force per unit length is 1 Nm^{-1}	A1	[3]
	(b) (i)	force on particle always normal to direction of motion (and speed of particle is constant)	M1	
		magnetic force provides the centripetal force	A1	[2]
	(ii)	$mv^2/r = Bqv$	M1	
		$r = mv/Bq$	A0	[1]
	(c) (i)	the momentum/speed is becoming less	M1	
		so the radius is becoming smaller	A1	[2]
	(ii)	1. spirals are in opposite directions	M1	
		so oppositely charged	A1	[2]
		2. equal initial radii	M1	
		so equal (initial) speeds	A1	[2]

Q36.

6	(a) (i)	particle must be moving	M1	
		with component of velocity normal to magnetic field	A1	[2]
	(ii)	$F = Bqv \sin \theta$	M1	
		q, v and θ explained	A1	[2]
	(b) (i)	face BCGF shaded	A1	[1]
	(ii)	between face BCGF and face ADHE	A1	[1]
	(c)	potential difference gives rise to an electric field	M1	
		either $F_E = qE$ (*no need to explain symbols*)		
		or electric field gives rise to force (on an electron)	A1	[2]

Q37.

7	(a)	induced e.m.f./current produces effects/acts in such a direction/tends	M1	
		to oppose the change causing it	A1	[2]
	(b) (i)	1. to reduce flux losses/increase flux linkage/easily magnetised and demagnetised	B1	[1]
		2. to reduce energy/heat losses (*do not allow 'to prevent energy losses'*)	M1	
		caused by eddy currents	A1	[2]
		(*allow 1 mark for 'reduce eddy currents'*)		
	(ii)	alternating current/voltage	B1	
		gives rise to (changing) flux in core	B1	
		flux links the secondary coil	M1	
		(by Faraday's law) changing flux induces e.m.f. (in secondary coil)	A1	[4]

Q38.

4	(a)	force on proton is normal to velocity and field provides centripetal force (for circular motion)	M1 A1	[2]
	(b)	magnetic force = Bqv centripetal force = $mr\omega^2$ *or* mv^2/r $v = r\omega$ $Bqv = Bqr\omega = mr\omega^2$ $\omega = Bq/m$	B1 B1 B1 A1	[4]

Q39.

5	(a)	*either* $\phi = BA \sin\theta$ where A is the area (through which flux passes) θ is the angle between B and (plane of) A *or* $\phi = BA$ where A is area normal to B	M1 A1 (M1) (A1)	[2]
	(b)	graph: V_H constant and non zero between the poles and zero outside sharp increase/decrease at ends of magnet	M1 A1	[2]
	(c) (i)	(induced) e.m.f. proportional to rate of change of (magnetic) flux (linkage)	M1 A1	[2]
	(ii)	short pulse on entering and on leaving region between poles pulses approximately the same shape but opposite polarities e.m.f. zero between poles and outside	M1 A1 A1	[3]

Q40.

5	(a) (i)	field shown as right to left	B1	[1]
	(ii)	lines are more spaced out at ends	B1	[1]
	(b)	Hall voltage depends on angle *either* between field and plane of probe *or* maximum when field normal to plane of probe *or* zero when field parallel to plane of probe	M1 A1	[2]
	(c) (i)	(induced) e.m.f. proportional to rate of change of (magnetic) flux (linkage) (*allow rate of cutting of flux*)	M1 A1	[2]
	(ii)	e.g. move coil towards/away from solenoid rotate coil vary current in solenoid insert iron core into solenoid (*any three sensible suggestions, 1 each*)	 B3	[3]

Q41.

6	(a)	force due to magnetic field is constant force is (always) normal to direction of motion this force provides the centripetal force	B1 A1	[3]
	(b)	$mv^2 / r = Bqv$ hence $q / m = v / Br$	M1 A0	[1]
	(c) (i)	$q / m = (2.0 \times 10^7) / (2.5 \times 10^{-3} \times 4.5 \times 10^{-2})$ $= 1.8 \times 10^{11}$ C kg^{-1}	C1 A1	[2]
	(ii)	sketch: curved path, constant radius, in direction towards bottom of page tangent to curved path on entering and on leaving the field	M1 A1	[2]

Q42.

5	(a) (i)	region (of space) *either* where a moving charge (may) experience a force *or* around a magnet where another magnet experiences a force	B1	[1]
	(ii)	$(\Phi =) BA \sin\theta$	A1	[1]
	(b) (i)	plane of frame is always parallel to B_V / flux linkage always zero	B1	[1]
	(ii)	$\Delta\Phi = 1.8 \times 10^{-5} \times 52 \times 10^{-2} \times 95 \times 10^{-2}$ $= 8.9 \times 10^{-6}$ Wb	C1 A1	[2]
	(c) (i)	(induced) e.m.f. proportional to rate of change of (magnetic) flux (linkage) (*allow rate of cutting of flux*)	M1 A1	[2]
	(ii)	e.m.f. $= (8.9 \times 10^{-6}) / 0.30$ $= 3.0 \times 10^{-5}$ V	A1	[1]
	(iii)	This question part was removed from the assessment. All candidates were awarded 1 mark.	B1	[1]

Q43.

6 (a) *either* constant speed parallel to plate
or accelerated motion / force normal to plate / in direction field B1
so not circular A0 [1]

(b) (i) direction of force due to magnetic field opposite to that due to electric field B1
magnetic field into plane of page B1 [2]

(ii) force due to magnetic field = force due to electric field B1
$Bqv = qE$
$B = E / v$ C1
$= (2.8 \times 10^4) / (4.7 \times 10^5)$
$= 6.0 \times 10^{-2}$ T A1 [3]

(c) (i) no change / not deviated B1 [1]

(ii) deviated upwards B1 [1]

(iii) no change / not deviated B1 [1]

Q44.

7 (a) graph: V_H increases from zero when current switched on B1
V_H then non-zero constant B1
V_H returns to zero when current switched off B1 [3]

(b) (i) (induced) e.m.f. proportional to rate M1
of change of (magnetic) flux (linkage) A1 [2]

(ii) pulse as current is being switched on B1
zero e.m.f. when current in coil B1
pulse in opposite direction when switching off B1 [3]

Q45.

5 (a) only curve with decreasing gradient M1
acceptable value near $x = 0$ and does not reach zero A1 [2]

(*if graph line less than 4.0 cm do not allow A1 mark*)
(*no credit if graph line has positive and negative values of* V_H)

(b) graph: from 0 to 2*T*, two cycles of a sinusoidal wave M1
all peaks above 3.5 mV C1
peaks at 4.95 / 5.0 mV (*allow 4.8 mV to 5.2 mV*) A1 [3]

(c) e.m.f. induced in coil when magnetic field / flux is changing / cutting B1

either at each position, magnetic field does not vary
so no e.m.f. is induced in the coil / no reading on the millivoltmeter
or at each position, switch off current and take millivoltmeter reading
or at each position, rapidly remove coil from field and take meter reading B1 [2]

Q46.

6 (a) electric and magnetic fields normal to each other B1

either charged particle enters region normal to both fields
or correct B direction w.r.t. E for zero deflection B1
for no deflection, $v = E/B$ B1 [3]

(*no credit if magnetic field region clearly not overlapping with electric field region*)

© Cambridge International Examinations 2014

www.maxpapers.com

(b) (i) $m = Bqr/v$ C1
$= (640 \times 10^{-3} \times 1.6 \times 10^{-19} \times 6.2 \times 10^{-2})/(9.6 \times 10^{4})$ C1
$= 6.61 \times 10^{-26}$ kg C1
$= (6.61 \times 10^{-26})/(1.66 \times 10^{-27})$ u
$= 40$ u A1 [4]

(ii) $q/m \propto 1/r$ *or* m constant and $q \propto 1/r$ B1
q/m for A is twice that for B B1
ions in path A have (same mass but) twice the charge (of ions in path B) B1 [3]

Q47.

6 (a) $F = BIL\sin\theta$ C1
$= 2.6 \times 10^{-3} \times 5.4 \times 4.7 \times 10^{-2} \times \sin 34°$
$= 3.69 \times 10^{-4}$ N A1 [2]
(*allow 1 mark for use of cos 34°*)

(b) peak current $= 1.7 \times \sqrt{2}$ C1
$= 2.4$ A

max. force $= 2.6 \times 10^{-3} \times 2.4 \times 4.7 \times 10^{-2} \times \sin 34°$
$= 1.64 \times 10^{-4}$ N C1

variation $= 2 \times 1.64 \times 10^{-4}$
$= 3.3 \times 10^{-4}$ N A1 [3]