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) <u>e.m.f.</u> is proportional to / equal to <u>rate of change</u> 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	M1	
			rate of change of (magnetic) flux (linkage) / rate of flux cutting	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	C1	
			frequency = 1.33 Hz	A1	[2]
	(c)		graph: smooth correctly shaped curve with peak at f_0	M1	
			A never zero	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)*	M1	
			separation increasing with distance from wire	A1	
			correct direction	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	M1	
			so forces are equal	A1	[2]
	(c)		force <u>always</u> towards wire A/<u>always</u> in same direction	B1	
			varies from zero (to a maximum value) (1)		
			variation is sinusoidal / $\sin^2$ (1)		
			(at) twice frequency of current (1)		
			(any two, one each)	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 $N m^{-1}$	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 $N m^{-1}$	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* $B = F/IL\sin 2$..........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 $= 2.52 \times 10^{-4}$ 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 <u>centripetal force</u> = mv^2/r	1	
			$mv^2/r = Bqv$ <u>hence</u> $q/m = v/rB$ *(some algebra essential)*	1	[2]
		(ii)	q/m = $(8.2 \times 10^6)/(23 \times 10^{-2} \times 0.74)$	1	
			= 4.82×10^7 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)	$½mv^2 = qV$ ......(or some verbal explanation)	B1	
		$½ \times 9.11 \times 10^{-31} \times v^2 = 1.6 \times 10^{-19} \times 1.2 \times 10^4$	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)	B1	
		(allow 'induced voltage, induced p.d.)		
		flux is cust as the disc moves	M1	
		hence inducing an e.m.f	A0	[2]
	(ii)	field in disc is not uniform/rate of cutting not same/speed of disc not same (over whole disc)	B1	
		so different e.m.f.'s in different parts of disc	M1	
		lead to eddy currents	A0	[2]
(b)		eddy currents dissipate thermal energy in disc	B1	
		energy derived from oscillation of disc	B1	
		energy of disc depends on amplitude of oscillations	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	B1	
		a force is experienced by	M1	
		current-carrying conductor / moving charge / permanent magnet	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
$= 4.0 \times 10^{-5}$ T C1
force per unit length $= BI$
$= 4.0 \times 10^{-5} \times 7.0$ C1
$= 2.8 \times 10^{-4}$ 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 equal and opposite 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 into plane of paper	B1	[2]

Q35.

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

Q36.

6	(a) (i)	particle must be moving with component of velocity normal to magnetic field	M1 A1	[2]
	(ii)	$F = Bqv \sin \theta$ q, v and θ explained	M1 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 <u>electric</u> field *either* $F_E = qE$ (*no need to explain symbols*) *or* electric field gives rise to force (on an electron)	M1 A1	[2]

Q37.

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

Q38.

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

Q39.

5 (a) *either* $\phi = BA \sin\theta$	M1	
where A is the area (through which flux passes)		
θ is the angle between B and (plane of) A	A1	
or		
$\phi = BA$	(M1)	
where A is area normal to B	(A1)	[2]
(b) graph: V_H constant and non zero between the poles and zero outside	M1	
sharp increase/decrease at ends of magnet	A1	[2]
(c) (i) (induced) e.m.f. proportional to	M1	
rate of change of (magnetic) flux (linkage)	A1	[2]
(ii) short pulse on entering and on leaving region between poles	M1	
pulses approximately the same shape but opposite polarities	A1	
e.m.f. zero between poles and outside	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	M1	
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	A1	[2]
(c) (i) (induced) e.m.f. proportional to rate	M1	
of change of (magnetic) flux (linkage)	A1	[2]
(*allow rate of cutting of flux*)		
(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	B1	
	force is (always) normal to direction of motion		
	this force provides the centripetal force	A1	[3]
(b)	$mv^2 / r = Bqv$	M1	
	hence $q / m = v / Br$	A0	[1]
(c) (i)	$q / m = (2.0 \times 10^7) / (2.5 \times 10^{-3} \times 4.5 \times 10^{-2})$	C1	
	$= 1.8 \times 10^{11}$ C kg^{-1}	A1	[2]
(ii)	sketch: curved path, constant radius, in direction towards bottom of page	M1	
	tangent to curved path on entering and on leaving the field	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)	(Φ =) $BA \sin\theta$	A1	[1]
(b) (i)	plane of frame is always parallel to B_V / flux linkage always zero	B1	[1]
(ii)	$\Delta\Phi = 1.8 \times 10^{-5} \times 52 \times 10^{-2} \times 95 \times 10^{-2}$	C1	
	$= 8.9 \times 10^{-6}$ Wb	A1	[2]
(c) (i)	(induced) e.m.f. proportional to rate of	M1	
	change of (magnetic) flux (linkage)	A1	[2]
	(*allow rate of cutting of flux*)		
(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 so not circular	B1 A0	[1]
(b) (i)	direction of force due to magnetic field opposite to that due to electric field magnetic field into plane of page	B1 B1	[2]
(ii)	force due to magnetic field = force due to electric field $Bqv = qE$ $B = E / v$ $= (2.8 \times 10^4) / (4.7 \times 10^5)$ $= 6.0 \times 10^{-2}$ T	B1 C1 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 V_H then non-zero constant V_H returns to zero when current switched off	B1 B1 B1	[3]
(b) (i)	(induced) e.m.f. proportional to rate of change of (magnetic) flux (linkage)	M1 A1	[2]
(ii)	pulse as current is being switched on zero e.m.f. when current in coil pulse in opposite direction when switching off	B1 B1 B1	[3]

Q45.

5 (a)	only curve with decreasing gradient acceptable value near $x = 0$ and does not reach zero (*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)	M1 A1	[2]
(b)	graph: from 0 to $2T$, two cycles of a sinusoidal wave all peaks above 3.5 mV peaks at 4.95/5.0 mV (*allow 4.8 mV to 5.2 mV*)	M1 C1 A1	[3]
(c)	e.m.f. induced in coil when magnetic field/flux is changing/cutting *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 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*)	

(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]