

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) $r_\alpha = (4 \times 1.66 \times 10^{-27} \times 1.5 \times 10^6) / (1.2 \times 10^{-3} \times 2 \times 1.6 \times 10^{-19})$
 $= 25.9 \text{ m}$ A2
- (ii) $r_\beta = 25.9 \times 3.64 \times 10^3 = 7.13 \times 10^3 \text{ m}$ 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) $\frac{1}{2}\pi$ 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
 $F = 0.075 \text{ N}$ 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
 $B = 7.0 \times 10^{-2} \text{ T} = 70 \text{ mT}$ A0 [2]
- (d) (i) (induced) e.m.f. is proportional to / equal to rate of change of
 (magnetic) flux (linkage) M1
 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
 $= 0.0123 \text{ Wb turns}$
 induced e.m.f = $0.0123 / 0.14$ C1
 $= 88 \text{ mV}$ A1 [3]
 (Note: This is a simplified treatment. A full treatment would involve the
 averaging of $B \cos\theta$ leading to a $\sqrt{2}$ factor)

Q6.

- 6 (a) unit of magnetic flux density / magnetic field strength (uniform) field normal to wire carrying current of 1 A giving force (per unit length) of 1 N m^{-1} B1
M1
A1 [3]
- (b) (i) force on magnet / balance is downwards (so by Newton's third law) force on wire is upwards pole P is a north pole B1
M1
A1 [3]
- (ii) $F = BIL$ and $F = mg$ (g missing, then 0/3 in (ii))
 $2.3 \times 10^{-3} \times 9.8 = B \times 2.6 \times 4.4 \times 10^{-2}$ ($g = 10$, loses this mark)
 $B = 0.20 \text{ T}$ C1
C1
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)
constant field in coil / flux (linkage) of coil does not change A1
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) $Eq = Bqv$
 $v = (12 \times 10^3) / (930 \times 10^{-6})$
 $= 1.3 \times 10^7 \text{ m s}^{-1}$ C1
 C1
 A1 [3]

(ii) $Bqv = mv^2 / r$
 $q/m = (1.3 \times 10^7) / (7.9 \times 10^{-2} \times 930 \times 10^{-6})$
 $= 1.8 \times 10^{11} \text{ C kg}^{-1}$ C1
 C1
 A1 [3]

Q10.

6 (a) (i) straight line with positive gradient through origin M1
 A1 [2]

(ii) maximum force shown at $\theta = 90^\circ$
 zero force shown at $\theta = 0^\circ$
 reasonable curve with F about $\frac{1}{2}$ max at 30° M1
 M1
 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
2. speed of magnet varies so varying rate of change of flux
3. magnet changes direction of motion (so current changes direction) | B1
B1
B1 | [1]
[1]
[1] |
| | (b) period = 0.75s
frequency = 1.33Hz | 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 (<i>minimum of 3 circles</i>)
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) <i>either</i> reference to Newton's third law
<i>or</i> 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
current/wire normal to magnetic field
(for flux density 1 T,) force per unit length is 1 N m^{-1} M1
M1
A1 [3]
- (b) (i) (originally) downward force on magnet (due to current)
by Newton's third law (allow "N3")
upward force on wire B1
M1
A1 [3]
- (ii) $F = BIL$
 $2.4 \times 10^{-3} \times 9.8 = B \times 5.6 \times 6.4 \times 10^{-2}$
 $B = 0.066 \text{ T}$ (need 2 SF)
(g missing scores 0/2, but g = 10 leading to 0.067 T scores 1/2) C1
A1 [2]
- (c) new reading is $2.4\sqrt{2} \text{ g}$
either changes between +3.4 g and -3.4 g
or total change is 6.8 g C1
A1 [2]

Q15.

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

Q16.

- 5 (a) (uniform magnetic) flux normal to long (straight) wire carrying a current of 1 A
(creates) force per unit length of 1 N m⁻¹ M1
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
 $= 2.8 \times 10^{-5} \text{ T}$ A1 [2]
- (iii) $F = BIL (\sin \theta)$ C1
 $= 2.8 \times 10^{-5} \times 9.3 \times 1$
 $F/L = 2.6 \times 10^{-4} \text{ N m}^{-1}$ 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 \propto 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
 $r = 0.39 \text{ m}$ A1 [4]
- (c) (i) arrow pointing up page B1
(ii) $Bqv = Eq$ C1
 $E = 0.12 \times 4.5 \times 10^6$
 $= 5.4 \times 10^5 \text{ V m}^{-1}$ A1 [3]
- (d) gravitational force $\ll F_B$ 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) $x_0 = 1.5 \text{ mV}$... (allow ± 0.1)..... C1
 $\omega = 2\pi / T = 2\pi / (3 \times 10^{-3})$ C1
 $= 2090 \text{ rad s}^{-1}$ 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
 $= 9.18 \times 10^{-5} \text{ Wb}$ A1 [2]
- (ii)1 $\Delta\phi = 9.18 \times 10^{-5} \text{ Wb}$ A1
- (ii)2 $e = (N\Delta\phi)/\Delta t$
 $= (9.18 \times 10^{-5})/0.20$ C1
 $= 4.59 \times 10^{-4} \text{ V}$ 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
 $= 50 \times 10^{-3} \times 0.4 \times 10^{-4} \times 150 = 3.0 \times 10^{-4} \text{ Wb}$ 1 [3]
- (allow $49 \text{ mT} \rightarrow 2.94 \times 10^{-4} \text{ Wb}$ or $51 \text{ mT} \rightarrow 3.06 \times 10^{-4} \text{ Wb}$)
- (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 = $8.0 \times 10^{-3} \times 0.4 \times 10^{-4} \times 150$ 1
 $= 4.8 \times 10^{-5} \text{ Wb}$ 1
 change = $2.52 \times 10^{-4} \text{ Wb}$ 1 [2]
- (ii) e.m.f. = $(2.52 \times 10^{-4})/0.30$ 1
 $= 8.4 \times 10^{-4} \text{ V}$ 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 $q/m = v/r B$ (some algebra essential) 1 [2]
- (ii) $q/m = (8.2 \times 10^6)/(23 \times 10^{-2} \times 0.74)$ 1
 $= 4.82 \times 10^7 \text{ C kg}^{-1}$ 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
 $v = 6.49 \times 10^7 \text{ m s}^{-1}$ 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) $Bl \sin \theta$ 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) $B = 2 \times 10^{-7} / 0.75 \times 10^{-2} (= 2.67 \times 10^{-5} \text{ T})$ C1
 force = $0.26 \times 10^{-3} \times 9.81 (= 2.55 \times 10^{-3} \text{ N})$ 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
 $I = 18 \text{ A}$ 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) (i) concentric circles ...*(at least three lines)*M1
with increasing separationA1
correct direction clearB1 [3]
- (b) (i) correct position to left of wireB1 [1]
- (ii) $B = (4\pi \times 10^{-7} \times 1.7) / (2\pi \times 1.9 \times 10^{-2})$ C1
 $= 1.8 \times 10^{-5} \text{ T}$ A1 [2]
- (c) distance \propto currentC1
current $= (2.8 / 1.9) \times 1.7$
 $= 2.5 \text{ A}$ A1 [2]
- [Total: 8]

Q28.

- 5 (a) (i) concentric circles, anticlockwise*(minimum 3 circles)*M1
separation of lines increases with distance from wireA1 [2]
- (ii) direction from Y towards XA1 [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
 $= 4.0 \times 10^{-5} \text{ T}$ C1
force per unit length $= BI$
 $= 4.0 \times 10^{-5} \times 7.0$ C1
 $= 2.8 \times 10^{-4} \text{ N}$ A1 [4]
- (ii) *either* force depends on product of the currents in the two wiresM1
so equalA1
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 toM1
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 fieldM1
opposes (changing) field produced in primaryM1
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
 $= 0.454 \text{ T}$ 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
 $B = 0.499 \text{ T}$ A1 [2]

Q31.

- 5 (a) magnetic flux = BA C1
 $= 89 \times 10^{-3} \times 5.0 \times 10^{-2} \times 2.4 \times 10^{-2}$ A1 [2]
 $= 1.07 \times 10^{-4} \text{ Wb}$
- (b) (i) e.m.f. = $\Delta\phi / \Delta t$ C1
(for $\Delta\phi = 1.07 \times 10^{-4} \text{ Wb}$), $\Delta t = 2.4 \times 10^{-2} / 1.8 = 1.33 \times 10^{-2} \text{ s}$ C1
e.m.f. = $(1.07 \times 10^{-4}) / (1.33 \times 10^{-2})$ A1 [3]
 $= 8.0 \times 10^{-3} \text{ V}$
- (ii) current = $8.0 \times 10^{-3} / 0.12$ M1
 $\approx 70 \text{ mA}$ A0 [1]
- (c) force on wire = BIL C1
 $= 89 \times 10^{-3} \times 70 \times 10^{-3} \times 5.0 \times 10^{-2}$ M1
 $\approx 3 \times 10^{-4} \text{ (N)}$ A1 [3]
suitable comment e.g. this force is too / very small (to be felt)

Q32.

- 7 (a) force due to E -field is equal and opposite to force due to B -field
 $Eq = Bqv$
 $v = E/B$ B1
B1
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 Nm^{-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) $mv^2/r = Bqv$ M1
 $r = mv/Bq$ 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 initial 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) $F = Bqv \sin \theta$ 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
to oppose the change causing it M1
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'*)
caused by eddy currents M1
(allow 1 mark for 'reduce eddy currents') A1 [2]
- (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 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 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 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 of change of (magnetic) flux (linkage) M1
(allow rate of cutting of flux) 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
- (b) $mv^2 / r = Bqv$
hence $q / m = v / Br$
- (c) (i) $q / m = (2.0 \times 10^7) / (2.5 \times 10^{-3} \times 4.5 \times 10^{-2})$
 $= 1.8 \times 10^{11} \text{ C kg}^{-1}$
- (ii) sketch: curved path, constant radius, in direction towards bottom of page
tangent to curved path on entering and on leaving the field

B1
A1 [3]
M1
A0 [1]
C1
A1 [2]
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
- (ii) $(\Phi =) BA \sin \theta$
- (b) (i) plane of frame is always parallel to B_v /flux linkage always zero
- (ii) $\Delta \Phi = 1.8 \times 10^{-5} \times 52 \times 10^{-2} \times 95 \times 10^{-2}$
 $= 8.9 \times 10^{-6} \text{ Wb}$
- (c) (i) (induced) e.m.f. proportional to rate of change of (magnetic) flux (linkage)
(allow rate of cutting of flux)
- (ii) e.m.f. $= (8.9 \times 10^{-6}) / 0.30$
 $= 3.0 \times 10^{-5} \text{ V}$
- (iii) This question part was removed from the assessment. All candidates were awarded 1 mark.

B1 [1]
A1 [1]
B1 [1]
C1
A1 [2]
M1
A1 [2]
A1 [1]
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 B1
 $Bqv = qE$
 $B = E/v$ C1
 $= (2.8 \times 10^4) / (4.7 \times 10^5)$
 $= 6.0 \times 10^{-2} \text{ T}$ 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
 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
 of change of (magnetic) flux (linkage) M1
 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 2T, 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)

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- (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
 $= 6.61 \times 10^{-26} \text{ kg}$ C1
 $= (6.61 \times 10^{-26}) / (1.66 \times 10^{-27}) \text{ u}$
 $= 40 \text{ u}$ 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
 $= 2.6 \times 10^{-3} \times 5.4 \times 4.7 \times 10^{-2} \times \sin 34^\circ$
 $= 3.69 \times 10^{-4} \text{ N}$ A1 [2]
 (allow 1 mark for use of $\cos 34^\circ$)
- (b) peak current $= 1.7 \times \sqrt{2}$ C1
 $= 2.4 \text{ A}$
- max. force $= 2.6 \times 10^{-3} \times 2.4 \times 4.7 \times 10^{-2} \times \sin 34^\circ$
 $= 1.64 \times 10^{-4} \text{ N}$ C1
- variation $= 2 \times 1.64 \times 10^{-4}$
 $= 3.3 \times 10^{-4} \text{ N}$ A1 [3]

