Paper 1 Mark scheme

Question number	Acceptable answers	Additional guidance	Mark
1	D		**1**
2	A		**1**
3	D		**1**
4	D		**1**
5	B		**1**
6	C		**1**
7	D		**1**
8	D		**1**
9	C		**1**
10	A		**1**

(Total for Multiple Choice Questions = 10 marks)

Question number	Acceptable answers	Additional guidance	Mark
11	An explanation that makes reference to: • Most alpha particles pass through undeflected **(1) OR** some deflected through a small angle **(1)** • A very small number are deflected through an angle greater than 900 **(1)** • This suggests that the alpha particles are deflected by a charged nucleus that has a very small diameter compared to that of the atom rather than the charge being distributed throughout the atom **(1)** • and that most of the mass of the atom is concentrated in the nucleus rather than distributed throughout the atom **(1)**		**4**

(Total for Question 11 = 4 marks)

Question number	Acceptable answers	Additional guidance	Mark
12 (a)	• Recognises that weight acts at midpoint of diving board 1.8 (m) from X **(1)** • Use of moment = perpendicular force x distance **(1)** • Total clockwise moment = 3150 Nm **(1)** • Recognises that clockwise moment = anticlockwise moment **(1)** • *F*=3500 N **(1)**	Example of calculation: Total clockwise moment = (680x3.6)+(390x1.8) = 3150 Nm *F* = 3150/0.9 = 3500 N	**5**
12 (b)	• The forces are different types **(1)** • The forces act on the same object **(1)**		**2**

(Total for Question 12 = 7 marks)

Question number	Acceptable answers	Additional guidance	Mark
13 (a)	• The number of charge carriers increases with temperature **(1)** • So this lowers the resistance (despite the increase in lattice vibrations) **(1)**	Accept number of electrons.	**2**
13 (b)	• R_T = 0.7 – 0.8 kΩ [read from graph] **(1)** • Use of $V=IR$ (with 3.5 V and R_T) to find I **and** $V=IR$ (with V = 5.5 V) to find R **(1)** • R=1100 – 1300 Ω **(1)**	Accept use of $Vo = Vs\left(\frac{R_1}{R_1 + R_2}\right)$ Or $V_{out}/(V_s - V_{out}) \times R_T = R$ Example of calculation: $I = \frac{3.5}{750} = 0.0047$ A $R = \frac{5.5}{0.0047} = 1170\ \Omega$	**3**

(Total for Question 13 = 5 marks)

Question number	Acceptable answers	Additional guidance	Mark
14 (a)	**Either** • Calculate acceleration **(1)** • Use of $F = ma$ **(1)** • F = 38 N **(1)** **OR** • Calculate change in momentum **(1)** • Use of $F = \frac{\Delta mv}{\Delta t}$ **(1)** • F = 38 N **(1)**	Example of calculation: $F = \frac{0.06\ x\ 25}{0.04} = 37.5$ N	**3**
14 (b)	• Use of $s = ut + \frac{1}{2}at^2$ **(1)** • Use of $s = \frac{1}{2}at^2$ with vertical components to find t **(1)** • Use of $s = ut$ with horizontal components to find s **(1)** • Subtract 12 from their answer for horizontal distance **(1)** • Distance from net = 6 m **(1)** • Makes conclusion whether the ball is within the required range of the net **(1)**	Answer consistent with calculated value. Example of calculation: $t = \sqrt{\frac{2 \times 2.5}{9.81}}$ = 0.714 s $s = 25 \times 0.714 = 17.85$ m Distance from net = 17.85 – 12 = 5.9 m	**6**

(Total for Question 14 = 9 marks)

<table>
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<tr>
<td>15 (a)*</td>
<td>
This question assesses a student’s ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

<table>
<tr><td>Number of indicative marking points seen in answer</td><td>Number of marks awarded for indicative marking points</td></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5–4</td><td>3</td></tr>
<tr><td>3–2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
</td>
<td>
Guidance on how the mark scheme should be applied:
The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points which is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).
If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).
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<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
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Question number	Acceptable answers	Additional guidance	Mark
15 (a)* (continued)	**Indicative content** • At terminal velocity the forces on the drop are balanced **OR** weight = drag • The p.d. creates an electrostatic force acting upwards on the drop • The electrostatic force increases as p.d. increases • The net upward force causes the drop to have a negative acceleration • As speed decreases the drag decreases • The drop remains stationary when the forces are balanced **OR** until the drop remains stationary when weight = electrostatic force		**6**
15 (b)	• Equate the electric force and the gravitational force **(1)** • Use of E=V/d to obtain $q = mgd/V$ **(1)**	$qE = mg$ $q(V/d) = mg$ $q = mgd/V$	**2**
15 (c)	An explanation that makes reference to: • Electrostatic/upward force (on drop) would be greater than the weight/downward force **(1)** • So drop would <u>accelerate</u> upwards **(1)**	Indication of which force is greater, unbalanced is insufficient.	**2**

(Total for Question 15 = 10 marks)

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<tr><td>16 (a)*</td><td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

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Question number	Acceptable answers	Additional guidance	Mark
16 (a)* (continued)	**Indicative content** • The supply creates a changing magnetic field in the iron core • Rate of change of flux in toothbrush coil is equal to rate of change of flux in charger coil (for an ideal transformer) • The changing flux linkage in the coil of the toothbrush induces an e.m.f. according to Faraday's law • E = – N dφ/dt so to step down the e.m.f. there must be fewer turns in the toothbrush coil • The e.m.f. in the toothbrush coil must be larger than the toothbrush battery • Diode is included so battery is not discharged by the alternating e.m.f.	Allow provides dc to charge battery or similar.	**6**
16 (b)(i)	R= 47.4 Ω **(1)**	Example of calculation: R = 2.7 V/0.057 A = 47.4 Ω	**1**
16 (b)(ii)	• Use of $\mathcal{E}=V+Ir$ **or** correct attempt to find r **(1)** • r = 57.9 Ω or find ratio $\frac{R}{r}$ **(1)** • Makes conclusion by comparing r and R, recognising maximum power supplied when $\frac{R}{r} = 1$ **(1)**	Answer consistent with calculated value. Example of calculation: $r = \frac{(6.0\ V - 2.7\ V)}{0.057\ A} - 50 = 57.9\ \Omega$	**3**

(Total for Question 16 = 10 marks)

Question number	Acceptable answers	Additional guidance	Mark
17 (a)	• Use of: $R = \frac{\rho L}{A}$ **(1)** • $\frac{R_B}{R_A} = 0.5$ [accept 2:4 **or** 1:2 **or** 1/2] **(1)**	Example of calculation: $\frac{R_B}{R_A} = \frac{L_2 d_1^2}{L_1 d_2^2}$ $\frac{R_B}{R_A} = \frac{2Ld^2}{L(2d)^2} = \frac{2}{4} = 0.5$	**2**
17 (b)	• Correct transfer of data for gradient **(1)** • Large triangle used **(1)** • $\rho = 1.1 \times 10^{-4}$ Ωm **(1)** Conclusion: • 1.1×10^{-4} Ωm is greater than 3 x 10^{-5} Ωm, so resistivity increases when clay is added **(1)**	Answer to be consistent with calculated value. Example of calculation: Gradient = $\rho L = 16.5 \times 10^{-6}$ Ωm^2 $\rho = 16.5 \times 10^{-6}$ Ωm^2/0.15 m = 1.1×10^{-4} Ωm	**4**
17 (c)	An explanation that makes reference to: • A rise in temperature causes the amplitude of the vibrating ions to increase **(1)** • This causes the number of collisions per second between the ions and the moving electrons to increase **(1)** • So the rate of flow of electrons decreases (causing the resistance of the metal to increase) **(1)**	Allow reduce mean free path or drift velocity of electrons. Accept current decreases	**3**

(Total for Question 17 = 9 marks)

<table>
<tr><th>Question number</th><th>Acceptable answers</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>18 (a)</td><td>• Use of $F = BIl$ or use of $F=Bqv$ (1)
• Converts N to kg m s^{-2} (1)</td><td>Example
$B = \frac{F[\text{kg m } s^{-2}]}{I[\text{A}]\ l[\text{m}]}$
So units are kg A^{-1} s^{-2}</td><td>2</td></tr>
<tr><td>18 (b)</td><td>An explanation that makes reference to:
• The magnetic force on the electrons acts at right angles to the plane containing B and v (1)
• Hence the force is always towards the centre of the circle (1)
So providing a centripetal force on the electron or a centripetal acceleration that maintains circular motion (1)</td><td></td><td>3</td></tr>
<tr><td>18 (c)</td><td>• Calculates B x r (1)
• Calculate the percentage uncertainty (1)
• Suitable comment on difference from expectation (1)
• Weak conclusion because only three readings (1) OR no repeats (1) OR limited range (1)</td><td>Example of calculation:
%U = (0.06/5.01) x 100% = 1.2%
<table><tr><td>Radius /cm</td><td>Magnetic flux density/mT</td><td></td></tr><tr><td>8.0</td><td>0.63</td><td>5.04</td></tr><tr><td>9.5</td><td>0.52</td><td>4.94</td></tr><tr><td>11.0</td><td>0.46</td><td>5.06</td></tr></table></td><td>4</td></tr>
</table>

(Total for Question 18 = 9 marks)

Question number	Acceptable answers	Additional guidance	Mark
19 (a)	An explanation that makes reference to: • Electrons/charge transferred from negatively charged plate to positively charge plate through the resistor **(1)** • Hence the charge on capacitor decreases (exponentially) **(1)** • Until the charge on the capacitor equals 0/negligible **(1)**		**3**
19 (b)	**Either** • Use Q = 2.6 to read time constant from graph **(1) OR** draw tangent to curve at t = 0 and obtain time constant from intercept on x axis **(1)** • t = 17 – 18 (ms) **(1)** • Use of $T = RC$ with their T **(1)** • C = 0.019 - 0.021 mF **(1)** **OR** • Q_0 = 7 (mC) read from graph **(1)** • Any corresponding values of Q and t read from graph **(1)** • Use of $Q=Q_0 e^{-t/RC}$ with their values for Q_0, Q and t **(1)** • C = 0.0195 – 0.0196 mF **(1)** **OR** • Q_0 = 7 (mC) read from graph **(1)** • Q=3.5 (mC) when $T_{1/2}$ = 12.3 (ms) **(1)** • Use of $T_{1/2} = RC \ln 2$ **(1)** • C = 0.0195 – 0.0196 mF **(1)**	Example of calculation: T = 19 (ms) $C = 19 \times 10^{-3}/900 = 0.021$ mF	**4**

(Total for Question 19 = 7 marks)

Question number	Acceptable answers	Additional guidance	Mark
20 (a)(i)	• Recognise that for passenger to remain in their seat normal reaction $R \geq 0$ **(1)** **or** centripetal force >= weight **(1)** • Equate centripetal force and weight (for R=0) **(1)** • v = 9.1 m s^{-1} **(1)**	Example of calculation: $\frac{mv^2}{r} = mg$ $v = \sqrt{rg} = \sqrt{8.5\text{m} \times 9.81\text{ms}^{-2}} = 9.13\text{ms}^{-1}$	**3**
20 (a)(ii)	• Equate decrease in gravitational potential energy to increase in kinetic energy at top of loop **(1)** • Adds this to 17.0 **(1)** • Δh = 21.3 m **(1)**	Example of calculation: $mgh = \frac{1}{2}mv^2$ $h = \frac{v^2}{2g} = \frac{\left(9.13\text{ms}^{-1}\right)^2}{2 \times 9.81\text{ms}^{-2}} = 4.25\text{m}$ Δh = 17 + 4.3 = 21.3 m	**3**
20 (b)(i)	• Use of $a = \frac{v^2}{r}$ **(1)** • a = 6.1g **(1)**	Example of calculation: $a = \frac{v^2}{r} = \frac{\left(22.5\text{ms}^{-1}\right)^2}{8.5\text{m}} = 59.6\text{ms}^{-2}$ a = 59.6/9.8 = 6.1 g	**2**
20 (b)(ii)	An explanation that makes reference to: • Radius of curvature smallest at the top of the loop **(1) OR** radius larger at the bottom of the loop **(1)** • So acceleration at bottom is less for the same speed **(1)**		**2**

(Total for Question 20 = 10 marks)

PMT