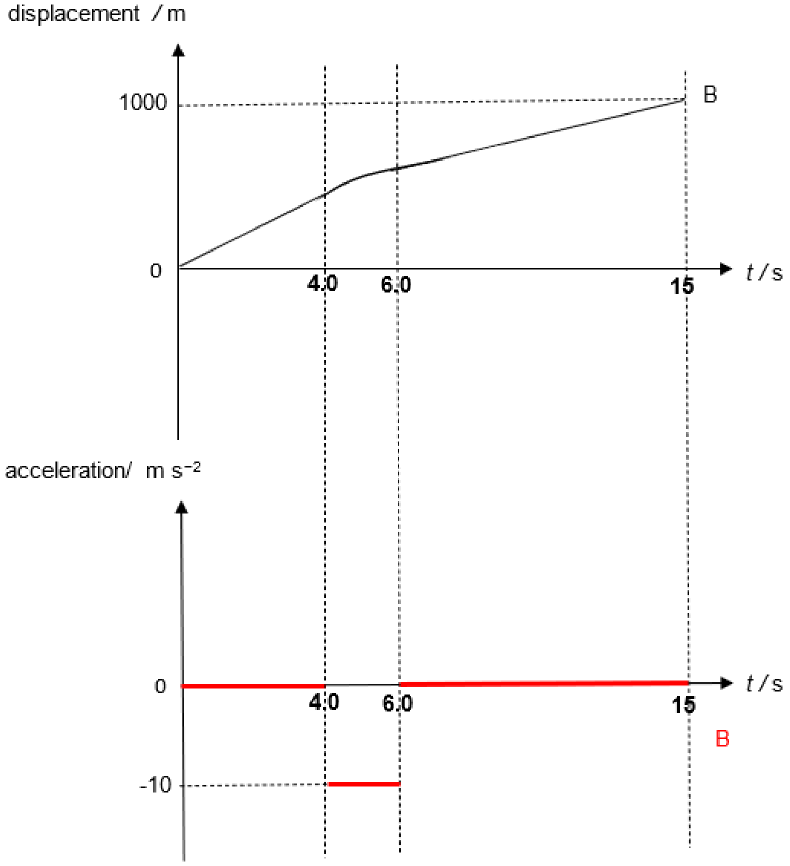
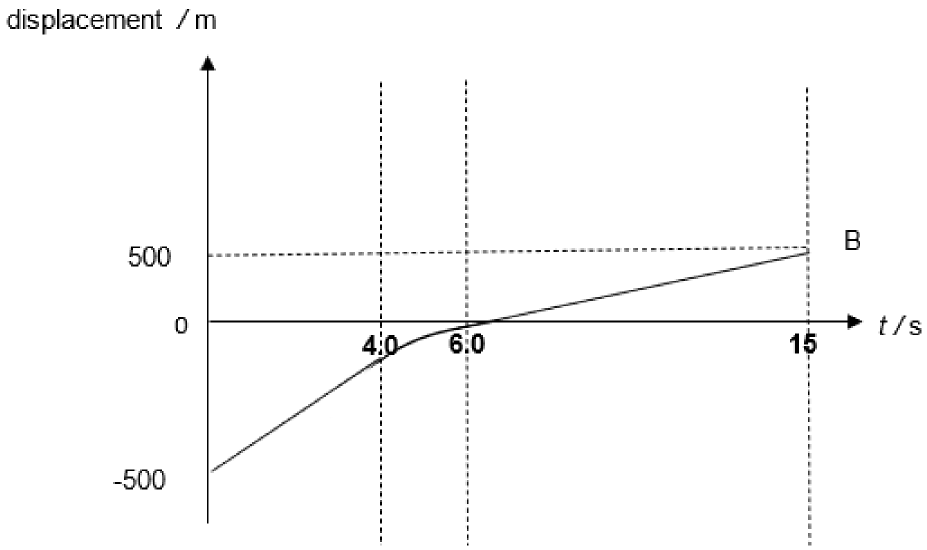
Paper 2 – Structured

Qns	Answer	Marks
1(a)(i)	Precision is determined by the range in the values. Range of Set A = 1.55 – 1.43 = 0.12 cm Range of Set B = 1.58 – 1.42 = 0.16 cm Range of Set C = 1.56 – 1.45 = 0.11 cm Therefore, Set C is more precise as the range of values are smaller than the other two sets.	**M1 for all correct values** **A1**
1(a)(ii)	Accuracy is determined by the closeness of the measured value to the true value. Average values for Set A = $\frac{1.52+1.49+1.43+1.52+1.55}{5}=1.502$ = 1.50 Average values for Set B = $\frac{1.42+1.45+1.43+1.51+1.58}{5}=1.478$ = 1.48 Average values for Set C = $\frac{1.45+1.56+1.47+1.53+1.46}{5}=1.494$ = 1.49 Therefore, Set A is more accurate as the average values are closer to the true value of the diameter.	**M1 for all correct values** **A1**

Qns	Answer	Marks
1(b)(i)		B1 B1
	Alternative *s-t* graph	
		
	For *s-t* graph: 1m – for correct sketch of graph for car B and correct displacement value Also, gradient of the line for first 4.0s must be greater than the gradient of the line for the last 9.0s	
	For a-*t* graph: 1m – for correct sketch of graph for car B and correct acceleration value	

Qns	Answer	Marks
1(b)(ii)	Minimum distance occurs when both cars have the same speed (v = 60 m s^{-1}).	B1
	Distance covered by Car A during the 6.0 s = $\left[\frac{1}{2}\times(25+60)\times 6.0\right]$ = 255 m Distance covered by Car B during the 6.0 s : $(80\times 4.0)+\left[\frac{1}{2}\times(80+60)\times 2.0\right]$ = 460 m	C1 for both correct answer
	Minimum distance = (500 + 255) - 460 = 295 m	A1

Qns	Answer	Marks
2(a)	<u>No resultant force</u> (in any direction) <u>No resultant moment</u> (about any point)	B1 B1
2(b)	Let the length of the rod be L. Take moment about the wall hinge. Sum of clockwise moment = Sum of anticlockwise moment $80\left(\frac{1}{2}L\sin 60^o\right)=T\left(L\sin 50^o\right)$ T = 45.2 N Let the vertical force at hinge be R_y. Let the horizontal force at hinge be R_x. No resultant force in vertical direction: $R_y + T\cos(180^o - 60^o - 50^o) = W$ $R_y + (45.2)\cos 70^o = 80$ $R_y = 64.5$ N No resultant force in horizotal direction: $R_x = T\sin(180^o - 60^o - 50^o)$ $R_x = (45.2)\sin 70^o$ $R_x = 42.5$ N Force by hinge on rod $R=\sqrt{R_x{}^2+R_y{}^2}$ $R=\sqrt{42.5^2+64.5^2}$ = 77.2 N Let θ be the angle of R from the wall $\tan\theta=\frac{R_x}{R_y}$ $\tan\theta=\frac{42.5}{64.5}$ $\theta = 33.4^o$ from wall	M1 A1 C1 A1 A1

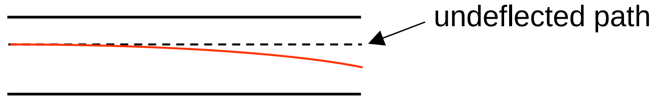
Qns	Answer	Marks
3a	Let speed of X before hitting Y be v_i Gain in KE = Loss in GPE $\frac{1}{2}mv_i^2 = mgh_i$ $v_i = \sqrt{2gh_i} = \sqrt{2\times 9.81\times 1.50\sin 40°}$ $v_i = 4.35 \text{ m s}^{-1}$	**B0** **M0** **A1**
3bi	Let speed of X after hitting Y be v_f Loss in KE = Gain in GPE $\frac{1}{2}mv_f^2 = mgh_f$ $v_f = \sqrt{2gh_f} = \sqrt{2\times 9.81\times 0.80\sin 40°}$ $v_f = 3.18 \text{ m s}^{-1}$ **EITHER** Since collision is elastic, Relative speed of approach = relative speed of separation $v_i = v_y - v_f$ 4.35 = v_y - (- 3.18) v_y = 1.17 m s^{-1} **OR** By conservation of linear momentum, $m_X u_X = m_X v_X + m_Y v_Y$ $30(4.35 + 3.18) = m_Y v_Y \quad \cdots(1)$ By conservation of energy Loss in KE of X = Gain in KE of Y $\frac{1}{2}m_X u_X^2 - \frac{1}{2}m_X v_X^2 = \frac{1}{2}m_Y v_Y^2$ $30(4.35^2 - 3.18^2) = m_Y v_Y^2 \quad \cdots(2)$ Taking (2) ÷ (1) $v_Y = 1.17 \text{ m s}^{-1}$	**M1** **M1** **A1** (either eqn correctly written) **M1** **A1**

Qns	Answer	Marks
3bii	Gain in KE of Y = Loss in GPE of X $\frac{1}{2}m_Y v_y^{\ 2} = m_X g\Delta h$ $m_Y = \frac{2m_X g\Delta h}{v_y^{\ 2}}$ $m_Y = \frac{2(0.030)(9.81)\sin 40°(1.50-0.80))}{1.17^2}$ $m_Y = 0.192$ kg $m_Y = 190$ g **OR** From (b)(i) Using the law of conservation of momentum in (1) and energy in (2) $30^2(4.35+3.18)^2 = m_Y^{\ 2}v_Y^{\ 2} \qquad \cdots(1)^2$ $30(4.35^2-3.18^2) = m_Y v_Y^{\ 2} \qquad \cdots(2)$ Taking $(1)^2 \div (2)$ $m_Y = 193$ g = 190 g (2 s.f.)	B1 M1 A0 B1 M1 A0
3ci	The collision is inelastic because the <u>relative speed of approach</u> is non-zero but the <u>relative speed of separation is zero</u>, which means that they are <u>not equal</u>.	A1
3cii	By conservation of linear momentum, $m_X v_i = (m_X + m_Y)v'$ $v' = \frac{m_X v_i}{m_X + m_Y}$ $v' = \frac{(0.030)(4.35)}{0.030+0.190}$ $v' = 0.5932$ m s^{-1} $v' = 0.59$ m s^{-1}	M1 A0

Qns	Answer	Marks
3ciii	Loss in KE = Gain in GPE + work done against friction $\frac{1}{2}(m_X + m_Y)(v')^2 = (m_X + m_Y)gd\sin 50° + fd$ $\frac{1}{2}(m_X + m_Y)(v')^2 = ((m_X + m_Y)g\sin 50° + f)d$ $d = \frac{\frac{1}{2}(0.030+0.190)(0.59^2)}{(0.030+0.190)\times 9.81\times\sin 50°+2.2}$ $d = 0.0099$ m OR Resultant force along the slope = friction + component of weight $ma = 2.2 + mg\sin 50°$ $a = \frac{2.2}{0.220} + (9.81)\sin 50°$ $a = 17.51\ \mathrm{m\ s^{-2}}$ where a is directed downslope. Using $v^2 = u^2 + 2as$, where s is the distance travelled up the slope, d. $0 = (0.59)^2 - 2(17.51)d$ $d = 0.0099$ m	B1 M1 A1 (M1) (C1) (A1)

Qns	Answer	Marks
4a	Electric force per unit positive charge on a small stationary test charge at that point.	B1
4bi	Considering the distance between the nearest two equipotential lines around point A (4V and 0V) d = 3.5 cm $E = \Delta V/d = (4–0)/(3.5\times10^{-2})$ $F = eE = 1.6 \times 10^{-19} \times (4–0)/(3.5\times10^{-2})$ $= 1.8 \times 10^{-17}$ N	M1 A1
4bii	From point B to C, $\Delta V = –6 –4 = –10$V Change in $E_P = e\Delta V = –1.6 \times 10^{-19}$ (–10) $= 1.6 \times 10^{-18}$ J (Gain) By Principle of Conservation of Energy, Loss in Kinetic energy = Gain in Electric Potential Energy $\frac{1}{2}$ mu^2 – $\frac{1}{2}$ mv^2 = 9.6×10^{-19} $\frac{1}{2}(9.11 \times 10^{-31})(5.3 \times 10^{6})^2 – \frac{1}{2}(9.11 \times 10^{-31})v^2 = 1.6 \times 10^{-18}$ $v = 5.0 \times 10^{6}$ m s^{-1}	C1 C1 A1
c	The change in potential from P to Q can be determined by estimating the area under the graph, 1 square : (0.5×10^{3}) V m^{-1} $\times 10^{-2}$ m = 5 V 18 squares : 18 × 5 = 90 V Change in potential energy = $1.6 \times 10^{-19} \times 90 = 1.44 \times 10^{-7}$ J	C1 C1 A1

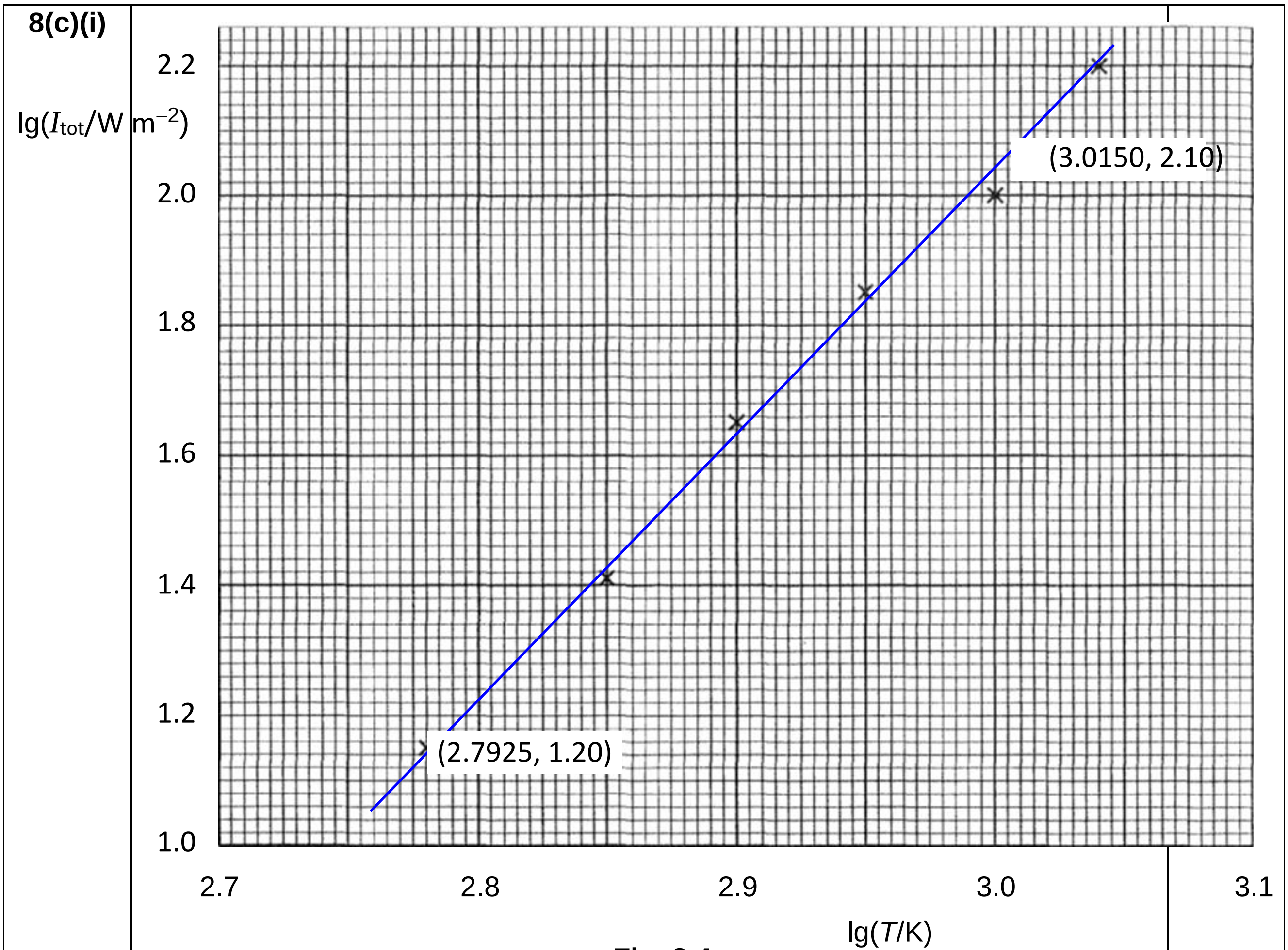
Qns	Answer	Marks
5(a)	$R_{diode} = \dfrac{V}{I} = \dfrac{0.56}{6.0 \times 10^{-3}} = 93\ \Omega$	A1
5(b)	$E = V_{diode} + V_{R3}$ $1.2 = 0.56 + (6.0 \times 10^{-3})R_3$ $R_3 = 110\ \Omega$	C1 A1
5(c)	$I = \dfrac{E}{R_1 + R_2}$ $= \dfrac{1.2}{50 + 200}$ $= 4.8 \times 10^{-3}$ A	C1 A1
5(d)	$I_{total} = 6.0 \times 10^{-3} + 4.8 \times 10^{-3} = 1.1 \times 10^{-2}$ A $P = I_{total}E = (1.1 \times 10^{-2})(1.2)$ $P = 1.3 \times 10^{-2}$ W	C1 A1
5(e)	$\dfrac{x}{1.0} = \dfrac{50}{250}$ $x = 0.20$ m	C1 A1

Qns	Answer	Marks
6(a)(i)	The magnetic force is downwards (by FLHR, *B* points into the paper and current is to the left) in the region between the plates, hence the electric force must be upwards. Since the particles are negatively charged, the electric field must be downwards (opposite to the electric force). Hence, P is positive. (Plate Q is grounded, hence is at 0 V.)	**B1** **B1**
6(a)(ii)	To move undeflected, the net force must be zero. $F_E = F_B$ $qE = qvB$ $v = \dfrac{E}{B}$	**M1** **A0**
6(a)(iii)	 $v > \dfrac{E}{B} \Rightarrow qvB > qE$, or $F_B > F_E$. Since the magnetic force F_B points downwards, the particles will be deflected downwards. (Note that the path is not parabolic.)	**B1** **B1**
6(b)(i)	The magnetic force is always perpendicular to the velocity. Hence, it does no work on the particles. The kinetic energy, hence the speed, of the particle remain constant.	**B1** **B1**
6(b)(ii)	The magnetic force provides the centripetal force. $qvB = m\dfrac{v^2}{r} \Rightarrow \dfrac{q}{m} = \dfrac{v}{Br}$ With $v = \dfrac{E}{B}$, $\dfrac{q}{m} = \dfrac{E}{B^2 r}$	**M1** **M1** **A0**

Qns	Answer	Marks
7(a)	t = 1.2 s $E = \dfrac{d(N\phi)}{dt} = NA\dfrac{dB}{dt} = \dfrac{560 \times \pi \times 0.045^2 \times 0.250}{1.2}$ $= 0.74$ V or 0.742 V (accept 2 s.f. or 3 s.f.)	C1 A1
7(b)	Sheet <u>cuts</u> magnetic flux / experiences a <u>changing magnetic flux</u> (linkage) and causes <u>induced e.m.f.</u> in sheet (induced) e.m.f. causes (<u>induced eddy) currents</u> (in sheet) **Option 1:** Currents (in sheet is in a magnetic field which) <u>cause resistive force</u> **Option 2:** Currents (in sheet) <u>dissipate (thermal) energy</u>. (Thermal energy comes from energy of oscillations) **Option 3:** Currents (in sheet) produce a magnetic field around sheet which is in opposite direction to the external magnetic field and the <u>sheet is repelled</u> (current cannot pass all the way around the sheet / path of current is broken / not a complete/closed loop) **Option 1:** Smaller currents in Y OR smaller resistive force in Y **Option 2:** Larger currents in X OR larger resistive force in X, so **dashed line is X**	B1 B1 B1 B1

<table>
<tr><th>Qns</th><th>Answer</th><th>Marks</th></tr>
<tr><td>8(a)(i)</td><td>Label V between 400-700 nm on the horizontal axis.</td><td>B1</td></tr>
<tr><td>8(a)(ii)</td><td>Wavelengths corresponding to red light would have the greatest intensity within the spectrum of visible light.</td><td>B1</td></tr>
<tr><td>8(b)(i)</td><td>
<table>
<tr><th>T / K</th><th>λ_{max} / nm</th><th>$T \times \lambda_{max}$</th></tr>
<tr><td>600</td><td>4830</td><td>2898000</td></tr>
<tr><td>700</td><td>4140</td><td>2898000</td></tr>
<tr><td>800</td><td>3610</td><td>2888000</td></tr>
<tr><td>900</td><td>3210</td><td>2889000</td></tr>
<tr><td>1000</td><td>2900</td><td>2900000</td></tr>
<tr><td>1100</td><td>2630</td><td>2893000</td></tr>
</table>

Since the product $T \times \lambda_{max}$ for different temperatures are the same when rounded to 2 s.f., it is a constant.
$$\text{constant} = (T \times \lambda_{max})_{average} = 2.9 \times 10^6 \text{ K nm}$$
Note: Unit for constant is required in A level examination.</td><td>B1
B1
B1</td></tr>
<tr><td>8(b)(ii)</td><td>$T \times \lambda_{max} = 2.89 \times 10^6$
$\lambda_{max} = \dfrac{2.89 \times 10^6}{1200}$
$= 2.41 \times 10^3 \text{ nm} = 2.41 \times 10^{-6} \text{ m}$</td><td>M1
A1</td></tr>
</table>

8(c)(i)	 **Fig. 8.4**	
	$I_{tot} = cT^n$ $\lg I_{tot} = n \lg T + \lg c$ Hence, n is the gradient of the $\lg I_{tot}$ against $\lg T$ graph. $\text{gradient} = \dfrac{2.10 - 1.20}{3.0150 - 2.7925} = 4.045$ $n = 4.045$	**M1** **M1** **A1**
8(c)(ii)	$I_{tot} = cT^n$ $71 = c(900)^{4.045}$ $c = 7.97 \times 10^{-11}$ I_{tot} at 1200 K $= 7.97 \times 10^{-11} \times 1200^{4.045} = 227$ W m^{-2}	**M1** **M1** **A1**
8(d)	The curve should be similar to the curves for the other temperatures. It should start from the origin and peak at 2410 nm. It should be above the 1100 K curve (except intersecting at the origin). Graph has to be smooth. Note: Peak should be more pointed than that for 1100 K.	 **B1** **B1** **B1**

8(e)(i)	Either wavelength λ_{max} (wavelength at maximum intensity) or I_{tot} (total intensity) Determine the temperature using $T = \dfrac{\text{constant}}{\lambda_{max}}$ or $I_{tot} = cT^n$	**B1** **B1**
8(e)(ii)	advantage: No physical contact is needed to make the measurement. disadvantage: (any of the followings) The intensity varies smoothly with wavelength. It is difficult to measure λ_{max} to high precision. Low intensity with low temperature, difficult to measure. Presence of background radiation.	**B1** **B1**