EUNOIA JUNIOR COLLEGE
JC2 June Common Test 2020
General Certificate of Education Advanced Level
Higher 1

PHYSICS 8867

MARK SCHEME

June/July 2020

Paper 1
Longer Structured Questions

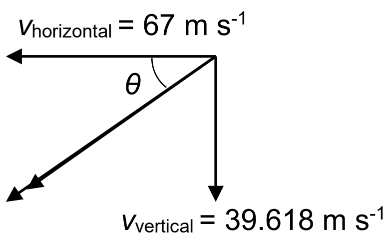
Qns	Answer	Marks

1(a)

Consider vertical motion, taking downwards as positive

$$v^2 = u^2 + 2as$$
$$v_{\text{vertical}} = \sqrt{2as} = \sqrt{2(9.81)(80)}$$
$$\left[= 40 \text{ m s}^{-1} \quad (39.618 \text{ m s}^{-1}) \right]$$

C1 (vertical velocity value)



$$\tan\theta = \frac{v_{\text{vertical}}}{v_{\text{horizontal}}}$$
$$\theta = \tan^{-1}\left(\frac{v_{\text{vertical}}}{v_{\text{horizontal}}}\right) = 30.6°$$

direction:
30.6° below the horizontal to the left OR
69.4° from the normal/vertical to the left

A1 (direction)

speed:

$$v^2 = v_{\text{horizontal}}^2 + v_{\text{vertical}}^2$$
$$v = \sqrt{v_{\text{horizontal}}^2 + v_{\text{vertical}}^2} = \sqrt{67^2 + 2(9.81)(80)} = 77.8 \text{ m s}^{-1}$$

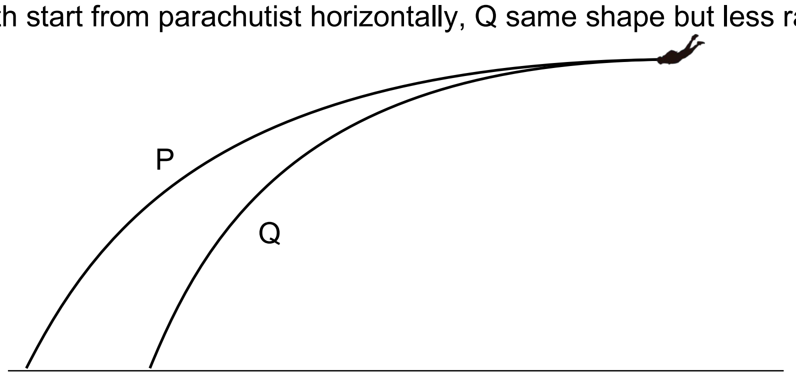
A1

(accept method by PCE)

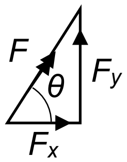
1(b)

both start from parachutist horizontally, Q same shape but less range:

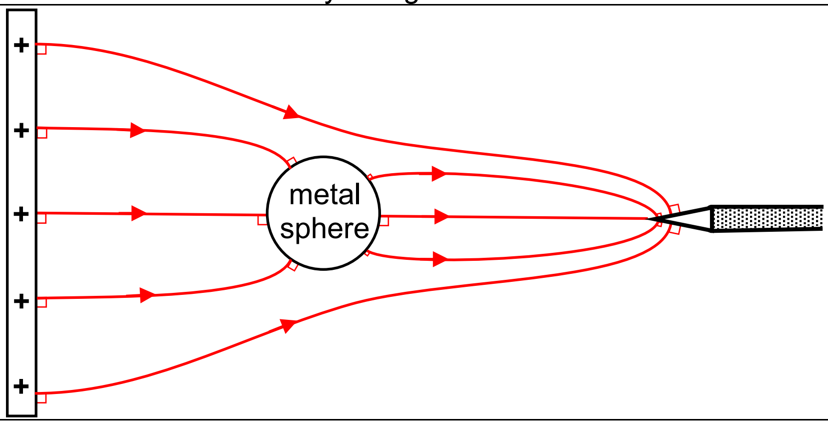
A1



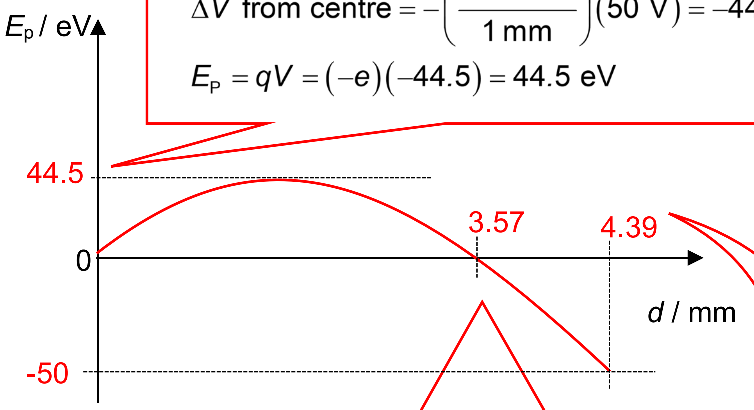
Qns	Answer	Marks
1(c)(i)	air resistive force is equal and opposite to weight of parachutist [accept if free body diagram is clear, labelled and correct] [0 if velocity appears as a vector on free body diagram]	A1 (magnitude and direction
1(c)(ii)	$\left.\begin{array}{l}\text{loss in GPE is w.d. against force due to air resistance} \\ \text{converted into heat} \\ \text{KE remains same}\end{array}\right\}$	B1
1(c)(iii)	By N2L, $F = \dfrac{dp}{dt}$ $F_{\text{avg}} \approx \dfrac{\Delta p}{\Delta t} = \dfrac{p_{\text{final}} - p_{\text{initial}}}{\Delta t}\left(= \dfrac{0 - 574}{\Delta t}\right)\left(\text{ or } a = 28 \text{ m s}^{-2}\right)$ $= \dfrac{m\left(v_{\text{final}} - v_{\text{initial}}\right)}{\Delta t}$ $\left\|F_{\text{avg}}\right\| = \left\|\dfrac{(82)(0-7)}{0.25}\right\|$ $= 2296 \text{ N} \quad (\text{accept } 2300 \text{ N})$	C1 (terminal momentum) A1
2(a)	resultant force in any direction is zero resultant moment about any point is zero	B1 B1
2(b)(i)	(by Principle of Moments) $\left.\begin{array}{l}\text{take moment about hinge} \\ \text{sum of clockwise moments = sum of anticlockwise moments}\end{array}\right\}$ $T_{\text{A}}(15) = (700 \sin 40°)(5)$ $T_{\text{A}} = \dfrac{(700 \sin 40°)(5)}{15} = 150 \text{ N (shown)}$	M1 M1 A0

Qns	Answer	Marks
2(b)(ii)	system is in equilibrium so resultant force in any direction is zero horizontally: $(700 \sin 40°) = T_A + F_x$ $F_x = (700 \cos 40°) - T_A$ $= (700 \cos 40°) - 150$ $[= 300 \text{ N to the right}]$ vertically: $(700 \cos 40°) + W = F_y$ $F_y = (700 \cos 40°) + 2000$ $[= 2536 \text{ N vertically upwards}]$  $F^2 = F_x^2 + F_y^2$ $\lvert F \rvert = \sqrt{F_x^2 + F_y^2}$ $= 2550 \text{ N}$ $\tan\theta = \dfrac{F_y}{F_x}$ $\theta = \tan^{-1}\left(\dfrac{F_y}{F_x}\right)$ $= 83.3°$ to the horizontal	**C1** (300N, right) or (2536N, up) **A1** (2550 N) **A1** (83.3°)
2(c)	Let T be new tension along half the wire $2T \sin 1.5° = 10$ $T = \dfrac{10}{2\sin 1.5°}$ $= 191 \text{ N}$	**C1** (eqn) **A1**

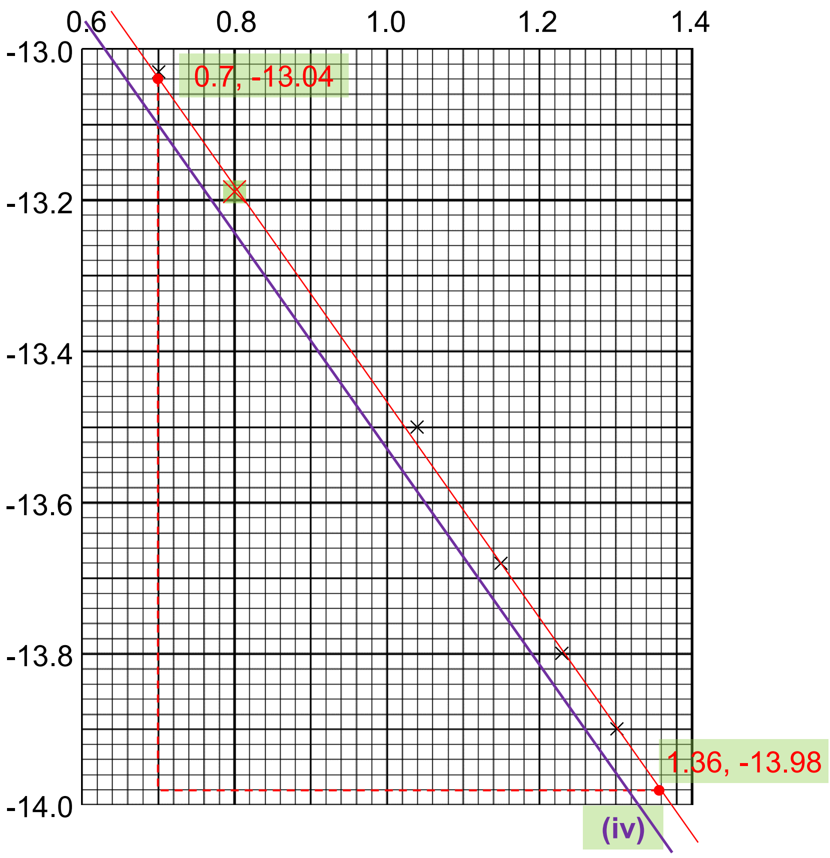
Qns	Answer	Marks
3(a)(i)	same direction as Earth's rotation about its own axis so satellite begins launch with some speed in correct direction satellite already has some kinetic energy so less fuel needed to raise the gravitational potential energy	**M1** **A1** (energy)
3(a)(ii)	gravitational force provides centripetal force $\frac{GMm}{r^2} = mr\omega^2$ $GM = r^3\omega^2$ $r = \sqrt[3]{\frac{GM}{\omega^2}} = \sqrt[3]{\frac{GM}{\left(\frac{2\pi}{T}\right)^2}}$ $= \sqrt[3]{\frac{(6.67\times10^{-11})(6.0\times10^{24})}{\left(\frac{2\pi}{24\times60\times60}\right)^2}}$ $\left[= 4.23\times10^7 \text{ m} \quad (4.2298\times10^7 \text{ m})\right]$ $h = r - R_E = r - 6400\times10^3$ $= 3.59\times10^7 \text{ m}$	**M1** **C1** (*r* value) **A0**
3(b)(i)	$E_{total} = E_K + E_P$ $= \frac{1}{2}mv^2 + \left(-\frac{GMm}{r}\right) = \frac{1}{2}r\left(\frac{mv^2}{r}\right) + \left(-\frac{GMm}{r}\right)$ $= \frac{1}{2}r\left(\frac{GMm}{r^2}\right) + \left(-\frac{GMm}{r}\right) = \left(\frac{GMm}{2r}\right) + \left(-\frac{GMm}{r}\right)$ $= -\frac{GMm}{2r}$	**M1** *(KE)* **A1** *(Summation)*
3(b)(ii)	$-\frac{GMm}{2r}$ $= -\frac{(6.67\times10^{-11})(6.0\times10^{24})(1000)}{2(4.2298\times10^2)}$ $= -4.73\times10^9 \text{ J}$	 **A1**
3(b)(iii)	w.d. against drag so total energy decreases GPE decrease so satellite lowers in height KE increase so linear speed increase satellite spirals towards Earth with increasing speed *Note: see topical compilation (gravitational field) page 13 to understand how the change in radius affects the various energies*	**B1** **M1** **A1**
4(a)	magnetic force on particle is always normal to direction of motion so path is arc of a circle in magnetic field after leaving field, Newton's first law, no net force on particle so path is straight line after leaving field	**B1** **B1**

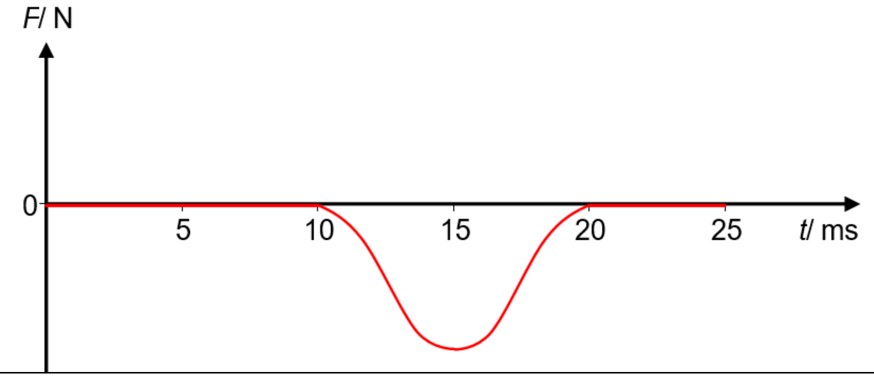
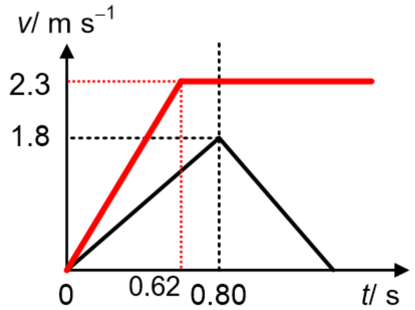
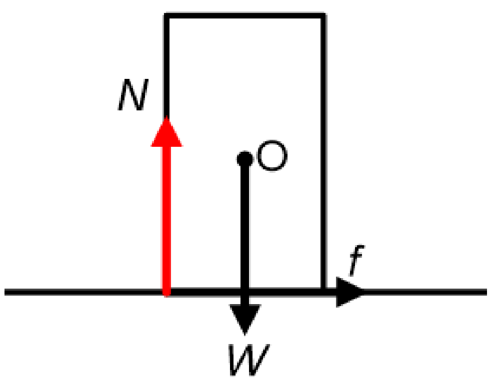
Qns	Answer	Marks
4(b)(i)	momentum/speed decreasing so the radius of circular motion ($r = mv / Bq$) is becoming smaller	**B1** **B1**
4(b)(ii)1.	Spirals are in opposite directions so oppositely charged	**B1**
4(b)(ii)2.	equal initial radius so equal initial speeds	**B1**
4(c)	$F = BILsin\theta$ F = 0.4 x 6 x 0.14sin60° F = 0.29 N	**C1** **A1**
5(a)	region of space in which a force acts on a stationary charge	**B1**
5(b)	 	**B1** arrow directions **B1** normal to surfaces **B1** symmetry above and below sphere
5(c)(i)	as electron moves right towards -50V plate, kinetic energy decreases as electric potential energy increases at closest distance of approach from -50 V plate, kinetic energy is minimum while electric potential energy is maximum as electron moves left towards + 50 V plate, kinetic energy increases as electric potential energy decreases	**B1** **B1** **B1**

5(c)(ii)	E field strength is uniform between charged parallel plates so acceleration a is constant $F = qE = m_e a_{\text{horizontal}}$ $a_{\text{horizontal}} = \frac{q}{m_e}E = \frac{q}{m_e}\frac{\Delta V}{\Delta x}$ $= \left(\frac{1.6\times10^{-19}}{9.11\times10^{-31}}\right)\left(\frac{50-(-50)}{2.0\times10^{-3}}\right) = 8.7816\times10^{15}\ \text{m s}^{-2}$ at closest distance, $v_{\text{horizontal}} = 0$ $v^2 = u^2 + 2as = (v\ \sin45°)^2 + 2a_{\text{horizontal}}x_{\text{fr centre}}$ $x = 1.0\times10^{-3} - x_{\text{fr centre}} = 1.0\times10^{-3} - \left\lvert\frac{(v\ \sin45°)^2}{2a_{\text{horizontal}}}\right\rvert$ $= 1.0\times10^{-3} - \left\lvert\frac{\left((5.6\times10^6)\ \sin(45°)\right)^2}{2\left(\frac{1.6\times10^{-19}}{9.11\times10^{-31}}\right)\left(\frac{50-(-50)}{2.0\times10^{-3}}\right)}\right\rvert$ $= 1.1\times10^{-4}\ \text{m}$ **OR** By conserving energy, consider change in potential from centre of plates, loss in KE = gain in EPE $\frac{1}{2}m(v\ \sin\theta)^2 = q\Delta V_{\text{closest}}$ $\Delta V_{\text{closest}} = \frac{m(v\ \sin\theta)^2}{2q}$ $\left(= \frac{(9.11\times10^{-31})\left((5.6\times10^6)\ \sin(45°)\right)^2}{2(1.6\times10^{-19})} = 44.64\right)$ E field strength is uniform between charged parallel plates: $E = \frac{\Delta V}{\Delta x} = \frac{50-(-50)}{2.0\times10^{-3}} = \frac{\Delta V_{\text{closest}}}{x_{\text{fr centre}}}$ $x_{\text{fr centre}} = \frac{\Delta V_{\text{closest}}(2.0\times10^{-3})}{100}$ $= \frac{m(v\ \sin\theta)^2}{2q}\left(\frac{(2.0\times10^{-3})}{100}\right)$ $= \left(\frac{(9.11\times10^{-31})\left((5.6\times10^6)\ \sin(45°)\right)^2}{2(1.6\times10^{-19})}\right)\left(\frac{(2.0\times10^{-3})}{100}\right)$ $= 8.928\times10^{-4}\ \text{m}$ $x = (1.0\times10^{-3}) - x_{\text{fr centre}}$ $= 1.1\times10^{-4}\ \text{m}$	**M0** (kinematics) **C1** (accel value) **C1** (substitute into $0^2 = u^2 + 2as$) **A1** (need units) **M0** (PCE) **C1** (ΔV value) **C1** (x from centre) **A1** (need units)

Qns	Answer	Marks
5(c)(iii)	The change in EPE is due to changing KE affected by acceleration horizontally. V at centre line is 0V ΔV from centre $= -\left(\dfrac{1\text{ mm} - x}{1\text{ mm}}\right)(50\text{ V}) = -44.5\text{ V}$ $E_P = qV = (-e)(-44.5) = 44.5\text{ eV}$  $s = ut + \dfrac{1}{2}at^2,\ a = 8.7816\times10^{15}\text{ m s}^{-2}$ when $s = 0$, $t = \dfrac{2v\sin45°}{a}$ $d = v_{\text{vertical}}t = (v\cos45°)\left(\dfrac{2v\sin45°}{a}\right) = \dfrac{v^2}{a}$ $= 3.57\times10^{-3}\text{ m}$ $s = ut + \dfrac{1}{2}at^2,\ a = 8.7816\times10^{15}\text{ m s}^{-2}$ when $s = -1.0$ mm, $-1.0\times10^{-3} = (v\sin45°)t + \dfrac{1}{2}at^2$ $t = 1.1075\times10^{-9}\text{ s}$ $d = v_{\text{vertical}}t = \left((5.6\times10^{6})\cos45°\right)(1.1075\times10^{-9})$ $= 4.39\times10^{-3}\text{ m}$	**B1** (parabola) **B1** (y labels) **B1** (x = 3.57) **B1** (x = 4.39)
6(a)(i)	$\left.\begin{aligned}&W = F_E = QE\\&W = Q\dfrac{\Delta V}{d}\ \text{ OR }\ Q\dfrac{V_+ - V_-}{d}\end{aligned}\right\}$ droplet is in equilibrium so vector sum of downward acting weight and upward electric force is zero	**B1** **B1**

Qns	Answer	Marks
6(a)(ii)	upthrust due to air negligible compared to gravitational force/weight because density of air negligible to density of oil at same temperature	**B1**
6(b)	<table><tr><td>ΔV</td><td>T</td><td>W / 10^{-14} N</td><td>Q / 10^{-19} C</td><td>N</td></tr><tr><td>770</td><td>11.2</td><td>2.9</td><td>1.66</td><td>1</td></tr><tr><td>230</td><td>10.0</td><td>3.4</td><td>6.53</td><td>4</td></tr><tr><td>1030</td><td>9.4</td><td>**3.7**</td><td>**1.59**</td><td>**1**</td></tr><tr><td>470</td><td>7.6</td><td>**5.2**</td><td>**4.89**</td><td>**3**</td></tr><tr><td>820</td><td>6.9</td><td>5.9</td><td>3.18</td><td>2</td></tr><tr><td>395</td><td>6.2</td><td>7.0</td><td>7.83</td><td>5</td></tr></table>	**B1** (both W's) **B1** (both Q's) **B2** (each N)
6(c)	$\langle e \rangle = \dfrac{\sum Q}{\sum N}$ $= \dfrac{(1.66 + 6.53 + 1.59 + 4.89 + 3.18 + 7.83) \times 10^{-19}}{1 + 4 + 1 + 3 + 2 + 5}$ $= 1.61 \times 10^{-19}$ C $\left(\text{accept } 1.605 \times 10^{-19} \text{ C} \right)$	**M1** (substitution) **A1**
6(d)(i)	$T = 8, \; W = 4.8 \times 10^{-14}$ $\lg \left(4.8 \times 10^{-14} \right) = -13.319$ (do not accept -13.3 because numbers before d.p. insignificant)	**A1**

Qns	Answer	Marks
6(d)(ii) (iii) (iv)	 $W = aT^b$ $\lg W = \lg a + b \lg T$ $\text{gradient} = \frac{\Delta y}{\Delta x} = \frac{-13.04-(-13.98)}{0.7-1.36}$ $= -1.42$ (accept [-1.5, -1.35]) $\rho \propto \frac{1}{a^2}$ *a* is lower so y-intercept is lower new sketch is parallel-to and lower than original	**B1** (plot, no ecf) **B1** (BFL) **B1** both set of read-off's to half sq **A1** (gradient within range) **B1** (0 if no **(iv)** label)
7(a)(i)	magnitude of the momentum of the cart before and after the collision is the same kinetic energy is constant	**B1** **B1**
7(a)(ii)	Change in momentum = 0.3 $F_{avg} = \frac{\Delta mv}{\Delta t}$ = 0.3 / 10 x 10^{-3} = 30 N	**C1** **A1**

Qns	Answer	Marks
7(a)(iii)		**B1** (Correct shape and time) **B1** (Negative)
7(a)(iv)	1. Time of contact will increase 2. Magnitude of maximum force will decrease	**B1** **B1**
7(b)(i)	Mass M hits the floor	**B1**
7(b)(ii)	The cart experiences a (constant) deceleration after t = 0.80 s	**B1**
7(b)(iii)	acceleration = 1.8 / 0.8 = 2.25 ms^{-2} Using $F_{net} = ma$ 9.81 (0.5) – f = (0.5 + 0.8) (2.25) f = 1.98 N	**C1** **C1** **A1**
7(b)(iv)	 Straight line through origin with a higher gradient and ends before 0.80 s with speed greater than 1.8 m s^{-1}. Horizontal line after hitting the floor (before 0.8 s)	 **B1** **B1**
7(c)(i)	If N passes through O, the block will topple as there will be a net anti-clock wise moment due to f.	**B1**
7(c)(ii) 1.	 N must be same length as W as both have the same magnutude	**B1**

Qns	Answer	Marks
7(c)(ii) 2.	Taking moments about O, $N\left(\frac{1.2}{2}\right)=f\left(\frac{2.5}{2}\right)$ $mg(0.60)=ma(1.25)$ (for $N=mg$ & $f=ma$) $a=\frac{(9.81)(0.60)}{1.25}$ $=4.71\text{ m s}^{-2}$	**C1** **C1** **A1**
8(a)(i)	Ohmic graph	**B1**
8(a)(ii)	Diode graph	**B1**
8(b)(i)	The p.d. between 2 points in a circuit is the energy converted per unit electric charge from electrical to non-electrical forms when charges moved between the 2 points.	**B1** **B1**
8(b)(ii)	Potential difference refers to energy conversion per unit charge from electrical to non-electrical forms. Emf refers to energy conversion per unit charge from non-electrical to electrical forms.	**B1**
8(c)(i)	$N = Q/e = It/e$ $= 2.3 \times (6 \times 60 \times 60)/1.60 \times 10^{-19}$ $= 3.11 \times 10^{23}$.	**C1** **A1**
8(c)(ii) 1.	$P=V^2/R$ $48=12^2/R$ $R=3.0\Omega$	**C1** **A1**
8(c)(ii) 2.	$A = \pi r^2 = \pi(9.1\times10^{-5})^2$ $R=\rho L/A$ $3.0 = (8.1\text{x}10\text{-}7)L/\ \pi(9.1\times10^{-5})^2$ L = 9.64 cm	**C1** **C1** **A1**
8(c)(ii) 3.	During operation, I^2R (joule) heating causes the filament to heat up. The increased lattice vibration increases the resistance of the filament.	**B1** **B1**
8(c)(ii) 4.	Effective resistance = (3/2) // (24/4) = 1.2 Ω Current = 12/(1.2+0.026) = 9.79 A Terminal p.d. = $E - Ir$ = 12 – (9.79)(0.026) = 11.75 V	**C1** **A1** **A1**
8(c)(ii) 5.	With the motor switched on, effective resistance of the circuit is lowered, leading to higher current from battery. With higher current, the potential difference across the internal resistance is larger, leaving less potential difference across the lamps.	**B1** **B1**