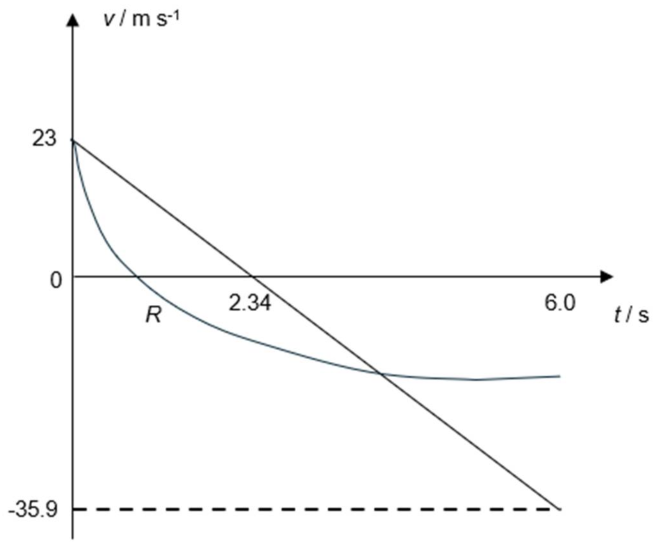
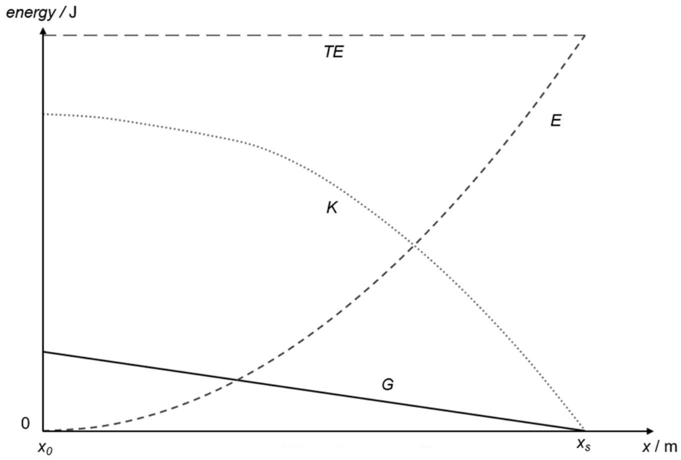
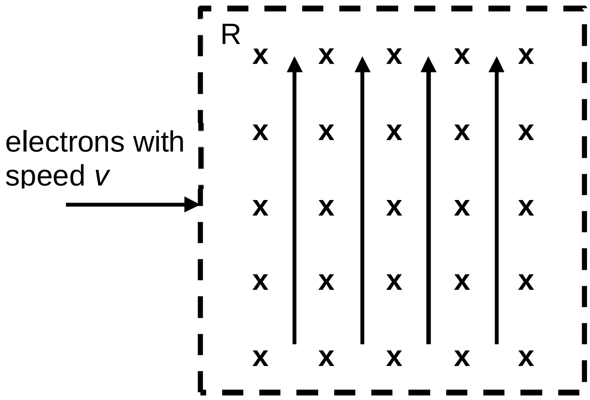
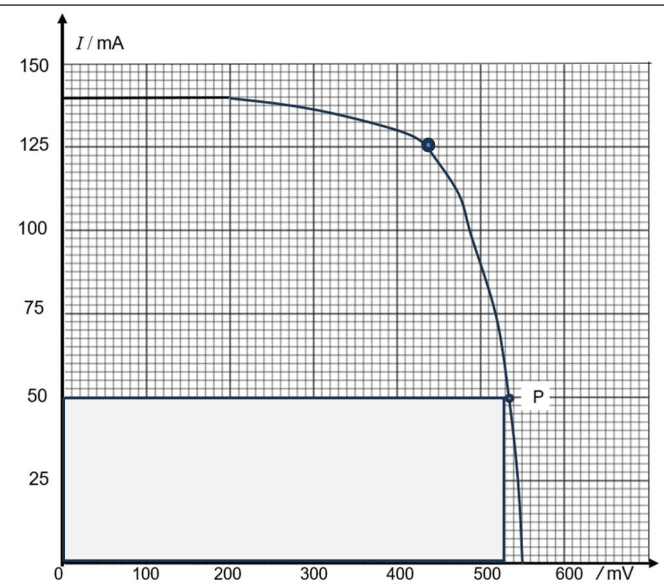
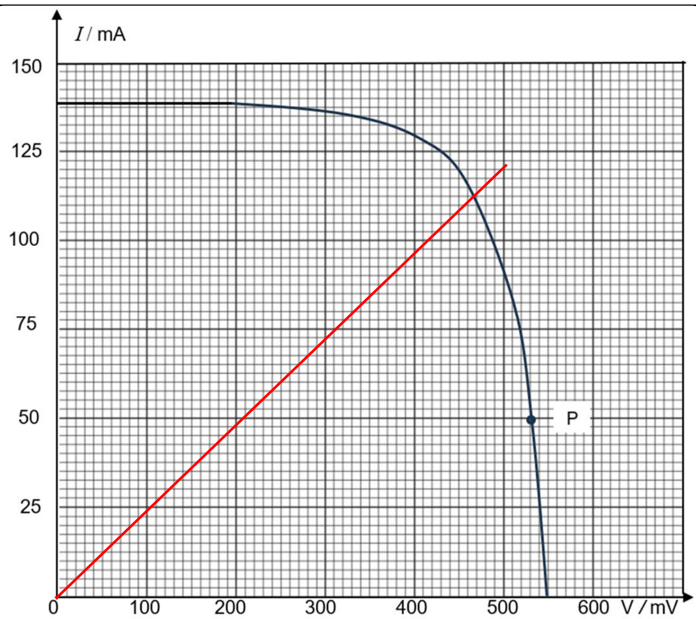
Qn	Suggested Answer
1	
(a)	*Precision* is defined as a measure of how close the experimental values are to each other.
	Accuracy is defined as a measure of how close the experimental values are to the true value of the physical quantity.
(b)	$g = \frac{4\pi^2 L}{T^2} = \frac{4\pi^2\left(50.0\times10^{-2}\right)}{1.42^2} = 9.78933 \text{ m s}^{-2}$
	$\pm\frac{\Delta g}{g} = \pm\left(\frac{\Delta L}{L} + 2\frac{\Delta T}{T}\right)$ $\pm\Delta g = \pm\left(\frac{0.2}{50.0} + \frac{0.02}{1.42}\right)\times 9.78933 = \pm 0.17704$
	$= \pm\ 0.2 \text{ m s}^{-2}$ (1 s.f.) $g = 9.8 \pm 0.2 \text{ m s}^{-2}$
(c)	There is error due to human reaction time. Taking a large number of oscillations will reduce the fractional/percentage uncertainty of the measurement of time. The absolute uncertainty is the same but taking more oscillations reduces the effect in the calculation of *T*. ($\Delta T = \Delta t\ /\ n$ where $\Delta t = \pm\ 0.2 - 0.4$ s (human reaction time) and *n* is the number of oscillations.)
2	
(a)(i)	Taking upwards as positive, $v^2 = u^2 + 2as$ $0^2 = u^2 + 2(-9.81)(27)$
	$u = 23.02$ $= 23 \text{ m s}^{-1}$ (2 s.f.) (shown)
	

(a)(ii)	Straight line with negative gradient.
	Initial velocity of 23 m s^{-1}. Max height at 2.34 s. Graph stops at 6.0 s with velocity of -35.9 m s^{-1}. $\frac{v-u}{t}=g$ $t_{\text{max height}}=\frac{v-u}{g}=\frac{0-(-23)}{9.81}=2.34\text{ s}$ At $t=$ 6.0 s $v=u+at=23-(9.81)(6.0)$ $=-35.9\text{ m s}^{-1}$
(a)(iii)	Steeper slope before v = 0. Gentler slope after v = 0.
	Gradient at v = 0 should be parallel to graph in **(a)(ii)**.
(b)	
	GPE linear with negative gradient.
	EPE parabolic shape starting from x_0.
	KE shape and correct KE value at x_0 and x_s (TE is constant).
3	
(a)	The resultant force acting on the object must be zero.
	The resultant torque about any axis is zero.
(b)	Taking moments about the hinge, $2T\left(\frac{3}{5}\right)(0.800)=W\left(\frac{1.3}{2}\right)$ $2(47.5)\left(\frac{3}{5}\right)(0.800)=W\left(\frac{1.3}{2}\right)$
	$W=70.2\text{ N}$ $m=\frac{70.2}{9.81}=7.2\text{ kg (2 s.f.)}$

(c)	The tension in the cables has a horizontal component, while the weight has only vertical component. For the canopy to be in equilibrium, there must be a horizontal component by the hinge away from the hinge.
	The sum of the vertical component of the tensions in both cables is less than the weight, hence the force by the hinge has a vertical upward component.
4	
(a)	The total final momentum of a system after a collision is equal to total initial momentum of the system before the collision
	provided no net external force acts on the system.
(b)(i)	Applying the principle of conservation of momentum, $(75.0\times10.0)-0=(75.0+55.0)v$ $v=5.7692$ $=5.77\text{ m s}^{-1}$ (to 3 s.f.) (shown)
(b)(ii)	The skaters exert forces on each other that have the same magnitude but opposite in direction. The magnitude of the force is given by F on moving skater $=\dfrac{75.0(5.77-10.0)}{0.100}$ $=-3172.5$ ≈-3170 N (3 s.f.) OR F on stationary skater $=\dfrac{55.0(5.77-0)}{0.100}$ $=3173.5$ ≈ 3170 N (3 s.f.)
	Since the force exerted by the skaters on each other is less than 4500 N, the skaters would not sustain any injury.
5	
(a)	The *volt* is defined as the potential difference between two points in a circuit where 1 J of electrical energy is converted to other forms of energy when 1 C of charge passes from one point to the other.
(b)(i)	When current in P is 0.15 A, the p.d. across P is 2.70 V. The p.d. across Q is also 2.70 V. From the I-V graph of Q, the current through Q is 0.0900 A.
	Total current in battery = current in P + current in Q = 0.15 + 0.0900 = 0.24 A
(b)(ii)	P.d. across R = 4.5 – 2.70 = 1.8 V
	Resistance of R = $\dfrac{1.8}{0.24}=7.5\ \Omega$

(b)(iii)	In the given circuit, Resistance of P = $\dfrac{2.70}{0.15} = 18\ \Omega$ Resistance of Q = $\dfrac{2.70}{0.0900} = 30.0\ \Omega$
	Since resistance $R = \dfrac{\rho L}{A}$, $L = \dfrac{RA}{\rho}$ Since $A \propto d^2$, $L \propto Rd^2$ $\because \rho = \text{constant}$
	$\dfrac{L_P}{L_Q} = \left(\dfrac{R_P}{R_Q}\right)\left(\dfrac{d_P}{d_Q}\right)^2$ $= \left(\dfrac{18}{30}\right)\left(\dfrac{2}{1}\right)^2$ $= 2.4$
6	
(a)	Force per unit length acting on a straight, current-carrying conductor,
	carrying unit current and placed at right angles to an external magnetic field.
(b)(i)	 Arrow directed upwards. Must be drawn with a ruler.
(b)(ii)	For an undeflected beam, electric force = magnetic force $qE = Bqv\sin\theta$ $E = Bv\sin 90°$ $= (3.0\times10^{-3})(3.3\times10^{7})$
	$= 9.9\times10^{4}$ N C^{-1} (2 s.f.)

(b)(iii)	Magnetic force provides centripetal force.
	$Bqv\sin\theta = \dfrac{mv^2}{r}$ $Bev\sin 90° = \dfrac{mv^2}{r}$ $\dfrac{e}{m} = \dfrac{v}{rB}$ $= \dfrac{3.3\times10^{7}}{(6.0\times10^{-2})(3.0\times10^{-3})}$
	$= 1.8\times10^{11}$ C kg^{-1} (2 s.f.)
7	
(a)(i)	From graph, current from solar cell = 136.25 mA
(a)(ii)	At a potential difference of 550 mV, no current flows from the solar cell through the load resistor.
	This implies there is no potential difference across the internal resistance of the cell. Hence, the terminal p.d. is equal to the e.m.f of the solar cell.
(a)(iii)	$V = E - Ir$ $300\times10^{-3} = 550\times10^{-3} - (136.25\times10^{-3})r$
	r = 1.83 Ω (3 s.f.)
(a)(iv)	Efficiency $= \dfrac{\text{Power dissipated in load resistor}}{\text{Power generated by solar cell}}$ $= \dfrac{IV}{IE}$ $= \dfrac{V}{E}$ $= \dfrac{300}{550}$
	= 54.5% (3 s.f.)
(b)(i)	
	Rectangular shape.
	Extends vertically and horizontally from point P.

(b)(ii)1.	Increases.
(b)(ii)2.	Decreases.
(b)(iii)	Q is at (430,125.00).
(c)(i)	
	Straight line passing through origin.
	Ratio of I/V is a reciprocal of 4.2 Ω.
(c)(ii)	Locate intersection of the two graphs in Fig. 7.3. (470, 112.50) $P = IV$ $= 470 \times 112.50 \times 10^{-6}$
	$= 0.0529$ W (3 s.f.)
8	
(a)	*Newton's law of gravitation* states that every point mass attracts every other point mass with a force that is directly proportional to the product of their masses
	and inversely proportional to the square of the distance between them.
(b)(i)	Gravitational force provides the centripetal force.
	$\frac{GMm}{r^2} = \frac{mv^2}{r}$ Kinetic energy $= \frac{1}{2}mv^2$ $= \frac{GMm}{2r}$
(c)(i)	The size of the satellite is much smaller than the separation between Mars and itself.

(c)(ii)	Period of rotation of satellite, $T = 24.6 \times 3$ $= 73.8$ hours
	Gravitational force of Mars on satellite provides the centripetal force. $\frac{GMm}{r^2} = mr(\frac{2\pi}{T})^2$ $r^3 = \frac{(6.67\times10^{-11})(6.39\times10^{23})(73.8\times60\times60)^2}{4\pi^2}$
	$r = 4.240\times10^7$ $= 4.24\times10^7$ m (3 s.f.)
(c)(iii)	Kinetic energy $= \frac{GMm}{2r}$ $= \frac{6.67\times10^{-11}\times6.39\times10^{23}\times470}{2(4.24\times10^7)}$ $= 2.36\times10^8$ J (3 s.f.)
(d)	Velocity is a vector quantity and has both magnitude and direction. Since the object in a circular path keeps changing direction despite a constant speed, it has a changing velocity.
	Since acceleration is the rate of change of velocity, the object has acceleration.
(e)(i)	By law of conservation of energy, Loss in kinetic energy of carriage = gain in gravitational potential energy of carriage
	$= mg(2R)$ $= 2mgR$
(e)(ii)	Resultant force of contact forces and weight provide centripetal forces at A and B. $N_A - mg = \frac{mv_A{}^2}{R}$ ....(1)
	$N_B + mg = \frac{mv_B{}^2}{R}$ ....(2)
	(1) – (2) $N_A - N_B - 2mg = \frac{mv_A^2 - mv_B^2}{R}$ From (e)(i), (3) Loss in Kinetic Energy $= \frac{1}{2}mv_A{}^2 - \frac{1}{2}mv_B{}^2$ $= mg(2R)$ $\frac{mv_A^2 - mv_B^2}{R} = 4mg$
	$N_A - N_B = 6\ mg$
(e)(iii)	Minimum N_A occurs when the carriage experiences $N_B = 0$ contact force at the top. This is because the contact force at B must be downwards.
	Thus, minimum $N_A = 6\ mg$.

(e)(iv)	At A, Sub $N_A = 6mg$ into $N_A - mg = \frac{mv^2}{R}$ $5mg = \frac{mv^2}{R}$ $v = \sqrt{5gR}$
	$= (5 \times 9.81 \times 20.0)^{1/2}$ $= 31.3 \text{ m s}^{-1}$ (3 s.f.)
9	
(a)	Random: Impossible to predict when a particular nucleus in a sample is going to decay.
	Spontaneous: The decay of a nucleus is not affected by by the presence of other nuclei, chemical reactions or physical conditions such as temperature and pressure.
(b)(i)	energy released $= \left[m_{Po} - \left(m_{Pb} + m_{He}\right)\right]c^2$
	$= \left[209.98264 - \left(205.97440 + 4.00260\right)\right]\left(1.66 \times 10^{-27}\right)\left(3.00 \times 10^{8}\right)^2$
	$= 8.43 \times 10^{-13}$ J
	$= 8.4 \times 10^{-13}$ J
(b)(ii)1.	By conservation of momentum, $p_i = p_f$ $0 = m_\alpha v_\alpha + \left(-m_{Pb} v_{Pb}\right)$ $\frac{\lvert p_\alpha \rvert}{\lvert p_{Pb} \rvert} = 1$
(b)(ii)2.	$KE = \frac{p^2}{2m}$ $\frac{KE_\alpha}{KE_{Pb}} = \frac{m_{Pb}}{m_\alpha} = \frac{206}{4}$
	$\frac{KE_\alpha}{KE_{Pb}} = 51.5$
(b)(iii)	$\frac{KE_\alpha}{\text{total energy}} = \frac{206}{206+4}$ $KE_\alpha = \left(\frac{206}{210}\right)\left(8.43 \times 10^{-13}\right)$
	$KE_\alpha = 8.3 \times 10^{-13}$ J (2 s.f.)
(b)(iv)	The recoiling nucleus (lead nucleus) will be at an excited state OR gamma radiation is released during decay.
(b)(v)	$\frac{A}{A_o} = \frac{15}{100}$ is between $\frac{1}{4}$ and $\frac{1}{8}$. This means the time taken is between 2 to 3 half-lives.
	Time taken is about 350 days.

(c)(i)	${}^{199}_{78}Pt \rightarrow {}^{199}_{79}Au + {}^{0}_{-1}e$ (+ anti-neutrino)
(c)(ii)	Half-life of platinum is much longer than that of gold.
	Formation of gold is slower than its decay, hence gold will be the nuclei of the smallest percentage.
(d)	Exposure to radiation my cause damage to living cells. OR May affect the ability of the cell to reproduce and/or survive. OR Radiation may result in the formation of free radicals. OR These free radicals will react and form harmful substances that damage cells.