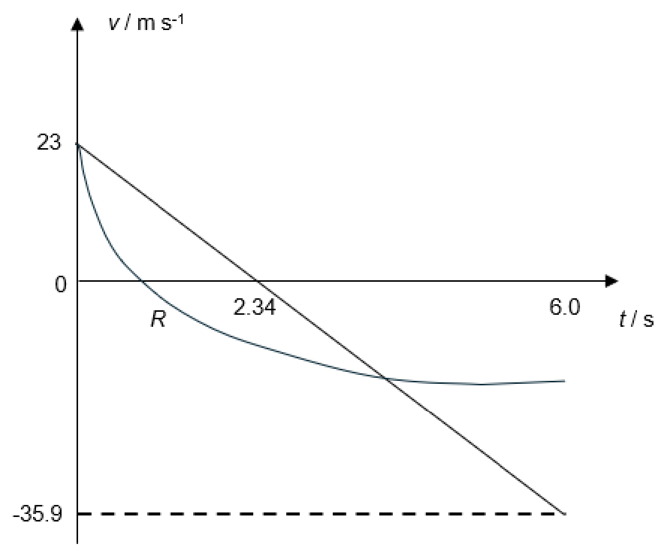
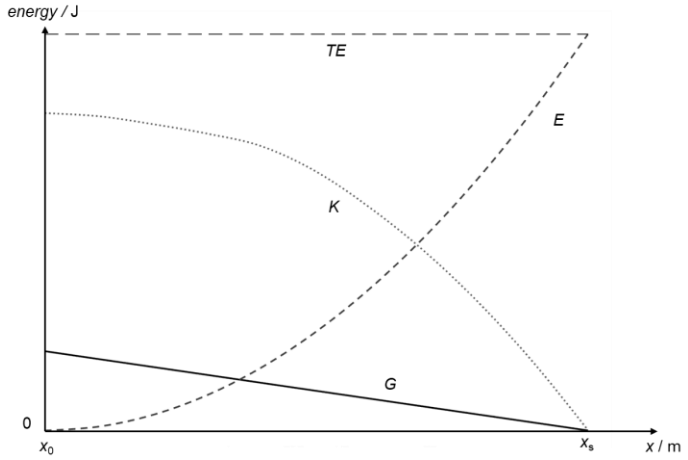
Qn	Suggested Answer
1	
(a)	*Precision* is defined as a measure of how close the experimental values are to each other.
	Accuracy is defined as a measure of how close the experimental values are to the true value of the physical quantity.
(b)	$g=\dfrac{4\pi^2L}{T^2}=\dfrac{4\pi^2\left(50.0\times10^{-2}\right)}{1.42^2}=9.78933$ m s^{-2}
	$\pm\dfrac{\Delta g}{g}=\pm\left(\dfrac{\Delta L}{L}+2\dfrac{\Delta T}{T}\right)$ $\pm\Delta g=\pm\left(\dfrac{0.2}{50.0}+\dfrac{0.02}{1.42}\right)\times9.78933=\pm0.17704$
	= ± 0.2 m s^{-2} (1 s.f.) g = 9.8 ± 0.2 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 Δt = ± 0.2 – 0.4 s (human reaction time) and *n* is the number of oscillations.)
2	
(a)(i)	Taking upwards as positive, $v^2=u^2+2as$ $0^2=u^2+2(-9.81)(27)$
	$u=23.02$ $=23$ 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)	*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 $= \frac{1}{2}mv^2$ $= \frac{GMm}{2r}$
(b)(ii)	Total energy $=$ Kinetic energy $+$ Gravitational potential energy $= \frac{GMm}{2r} + (-\frac{GMm}{r})$
	$= -\frac{GMm}{2r}$
(c)(i)	Period of rotation of satellite, T = 24.6 x 3 = 73.8 hours
	Gravitational force of Mars on satellite provides the centripetal force. $\frac{GMm}{r^2} = mr(\frac{2\pi}{T})^2$ $r^3 = \frac{(6.67\times10^{-11})(6.39\times10^{23})(73.8\times60\times60)^2}{4\pi^2}$
	$r = 4.24\times10^7\,\text{m}$ (3 s.f.)
(c)(ii)	Work done $= -\frac{GMm}{2(2r)} - (-\frac{GMm}{2r})$ $= \frac{1}{2}(\frac{GMm}{2r})$ $= \frac{(6.67\times10^{-11})(6.39\times10^{23})(470)}{4(4.24\times10^7)}$
	$= 118$ MJ (3 s.f.)
(d)	Total energy will be reduced. This means that the radius of circular orbit will gradually decrease.
	Decreasing circular orbit means that the kinetic energy increases and thus the speed of the satellite would increase.

5	
(a)(i)	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.
(a)(ii)	e.m.f. is the amount of non-electrical energy converted into electrical energy per unit charge passing through the terminals of the cell (source).
	p.d. is the amount of electrical energy converted to other forms of energy per unit charge passing 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 = $\frac{1.8}{0.24} = 7.5\ \Omega$
(b)(iii)	In the given circuit, Resistance of P = $\frac{2.70}{0.15} = 18\ \Omega$ Resistance of Q = $\frac{2.70}{0.0900} = 30.0\ \Omega$
	Since resistance $R = \frac{\rho L}{A}, \quad L = \frac{RA}{\rho}$ Since $A \propto d^2, \quad L \propto Rd^2 \quad \because \rho = \text{constant}$
	$\frac{L_P}{L_Q} = \left(\frac{R_P}{R_Q}\right)\left(\frac{d_P}{d_Q}\right)^2$ $= \left(\frac{18}{30}\right)\left(\frac{2}{1}\right)^2$ $= 2.4$
(b)(iv)	When Q stops conducting, effective resistance of the two lamps increases. By potential divider principle, the p.d. across lamp P increases. The current through P also increases as no current passes through Q.
	From the graph, as p.d. across P (or current in P) increases, its resistance increases.
6	
(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)	${}^{210}_{84}\text{Po} \rightarrow {}^{206}_{82}\text{Pb} + {}^{4}_{2}\text{He}$

(b)(ii)	$KE = \frac{p^2}{2m}$ Since magnitude of p is the same, $\frac{KE_\alpha}{KE_{Pb}} = \frac{m_{Pb}}{m_\alpha} = \frac{206}{4}$
	$\frac{KE_\alpha}{KE_{Pb}} = 51.5$
(b)(iii)	$A_o = \lambda N_o = \frac{\ln 2}{138 \times 24 \times (60)^2}\left(4.2 \times 10^{11}\right) = 2.44 \times 10^4$ Bq
	$A = A_o e^{-\left(\frac{\ln 2}{t_{1/2}}\right)t} = A_o e^{-\left(\frac{\ln 2}{138}\right)600}$
	$A = 1200$ Bq (2 s.f.)
(b)(iv)	The reading will be lower. Particles are emitted in all directions and only a proportion will be detected by the counter.
(c)(i)	By conservation of momentum, for a two particle system, the ratio of the speeds of the particles is fixed (inverse ratio of masses).
	By conservation of energy, energy released per decay is constant, the speed of the beta particle emitted should be constant. However, the range of KE suggest that there must be a third particle.
(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.
7	
(a)(i)	$P = \rho g h$ $= 1030 \times 9.81 \times 400$
	$= 4.04$ MPa (3 s.f.)
(a)(ii)	$\sigma = \frac{d_0 P}{2t}$ $t \geq \frac{d_0 P}{2\sigma} \geq \frac{6.30 \times 4.04 \times 10^6}{2 \times 550 \times 10^6}$
	$t \geq 0.0231$ m $= 2.4$ cm (round up to 2 s.f.) (shown)
(a)(iii)	The thickness of the hull is much smaller than the diameter/radius of the submarine.
(a)(iv)	$E = \frac{\sigma}{\frac{d_x}{d_0}}$ $d_x = \frac{\sigma d_0}{E} = \frac{550 \times 10^6 \times 6.30}{205 \times 10^9}$ $d_x = 16.9$ mm
	New diameter $= 6.30 - (16.9 \times 10^{-3}) = 6.28$ m (3 s.f.)

(a)(v)	A heavier submarine with a thicker hull has reduced manoeuvrability and slower speeds due to increased drag / requires higher power with a bigger engine. OR A thicker hull translates to a heavier submarine which requires a higher ballast capacity for buoyancy. This reduces room for crew and equipment. OR Building extremely thick hulls requires specialized materials and techniques, making them more expensive and time-consuming to manufacture.
(b)(i)	Sound waves are longitudinal waves OR The displacement of the water particles/ molecules of the medium is parallel to (or along) the direction of wave propagation
	The transfer of energy is via changing pressure (varying rarefactions and compressions).
(b)(ii)	$c = 1449.2 + 4.6T - 0.055T^2 + 0.00029T^3$ $+(1.34 - 0.010T)(S - 35) + 0.016D$ $c = 1449.2 + 4.6(28) - 0.055(28)^2 + 0.00029(28)^3$ $+(1.34 - 0.010(28))(\frac{33}{1000} - 35) + 0.016(400)$
	$c = 1500\text{ m s}^{-1}$ (2 s.f.)
(b)(iii)	Water is a less compressible medium / higher density medium as compared to air. OR Water molecules are at a closer proximity that enables faster transfer of vibrational energy between the molecules.
(b)(iv)	I at M $= \frac{P}{S_{\perp}} = \frac{P}{4\pi d^2}$
	P at M $= \frac{P}{4\pi d^2}S$ Reflected P at M $= \frac{P}{4\pi d^2}S$
	Reflected I from M (I_M) $= \frac{PS}{4\pi d^2}\frac{1}{\frac{4\pi d^2}{2}} = \frac{PS}{8\pi^2 d^4}$
	$d = \left[\frac{PS}{(I_M)8\pi^2}\right]^{\frac{1}{4}}$ (shown)
(c)(i)	$P = Fv = \frac{1}{2}C_d \rho v^2 A v$ $P = \frac{1}{2}(0.1)(1030)(\frac{37.0 \times 1000}{60 \times 60})^3(\frac{\pi(6.30)^2}{4})$
	$P = 1.74 \times 10^6$ W (3 s.f.)

(c)(ii)	The submarine includes irregular shaped features such as control tower, fins and anntennas that increases drag coefficient/area and hence increasing the power required. OR The flow of sea water over the submarine may turbulent, hence increasing the drag coefficient and the increasing power required. OR The hull of the submarine is not smooth ie covered by barnacles, hence increasing the drag coefficient and increasing the power required. OR The density of seawater is increased at other regions and hence more power is required. OR The efficiency of the engine is not 100%. Hence more power is required.