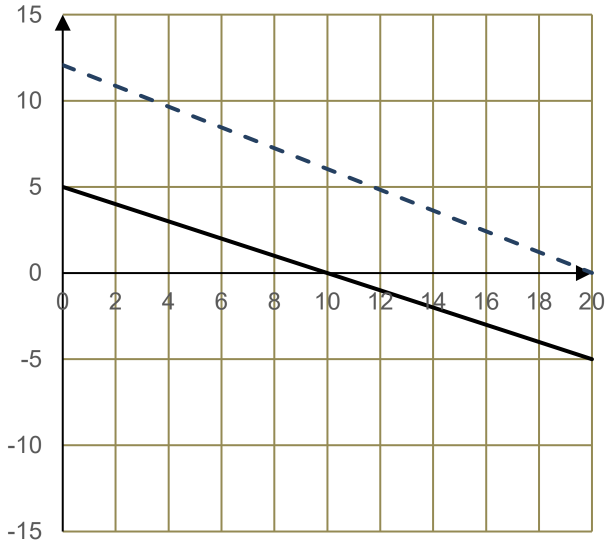
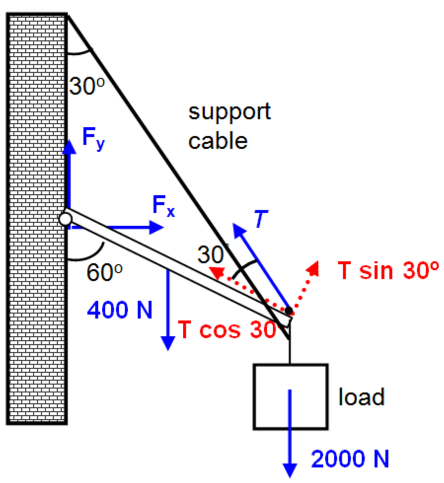
RVHS JC2 H2 Physics Preliminary Examinations Paper 3 Mark Scheme

Questions			Answers	Marks
1	**(a)**		Repeated readings with error of **different magnitude** and **sign**. OR Repeated readings with **scatter of readings about a mean value**. By plotting a graph and drawing a line of best fit for the points/can be reduced by averaging	B1 B1
	(b)		Units of $\frac{kr^3(p_1-p_2)}{l}\sqrt{\frac{M}{RT}} = \frac{m^3 Pa}{m}\sqrt{\frac{kg\ mol^{-1}}{J\ K^{-1}\ mol^{-1}K}}$ $= kgms^{-2}\sqrt{\frac{kg\ s^2}{kgm^2}}$ $= kgs^{-1}$	
	(c)	**(i)**	Density = m/V m = density x V = density x π(D^2 /4) L = (8.96) x π(6.0^2 /4) L = 7093.46 g = 7.09346 kg Δm/m = 2ΔD/D + ΔL/L = (2(0.1)/(6.0) + (0.1/28.0) = 0.0369 Δm = m(2ΔD/D + ΔL/L) = (7093.46)(0.0369) = 0.262 kg 7.1 +/- 0.3 kg (Correct s.f.)	 M1 M1 A1 A1
		(ii)	Same measurements, but smaller absolute uncertainties, so percentage uncertainty is smaller	B1

Questions			Answers	Marks
2	**(a)**		apply equation of motion $v = u + at$ vertically, we get $-5 = +5 - 9.81t$ for substitution	 M1
			$t = 1.019$ s for intermediate value	 A1
	(b)		$\frac{20}{1.019} = 19.62$ m s^{-1}	B1
			Alternative, Using $v_y = u_0 + at$ and substituting $t = \frac{x}{v_x}$, we get $\boldsymbol{v_y} = u_0 - g\frac{1}{v_x}\boldsymbol{x}$. So gradient = $-\frac{1}{2} = -\frac{9.81}{v_x}$	

	(c)		$tan\ \theta = \dfrac{5.0}{19.62}$	M1
			$\theta = 14.3^o$	A1
	(d)		x-intercept at (20,0) (because at maximum height $v_y = 0$) y-intercept above 5 (because with θ< 45° to increase range , <u>θ needs to increase</u>, and v sinθ needs to increase.) Example:  Extra note As θ increase, and v_x =v cosθ decreases. So gradient increases.	B1
3	**(a)**		The moment of a force is equal to the <u>product of the force and the perpendicular distance</u> of the line of action of the force <u>from the pivot</u>. It is the turning effect of a force.	B1
	(b)	**(i)**		

			Take moments about the hinge, $(400)(\frac{L}{2}\sin 60) + 2000(L\sin 60) = T\sin 30(L)$ $T = 3810$ N	B1 C1 A1

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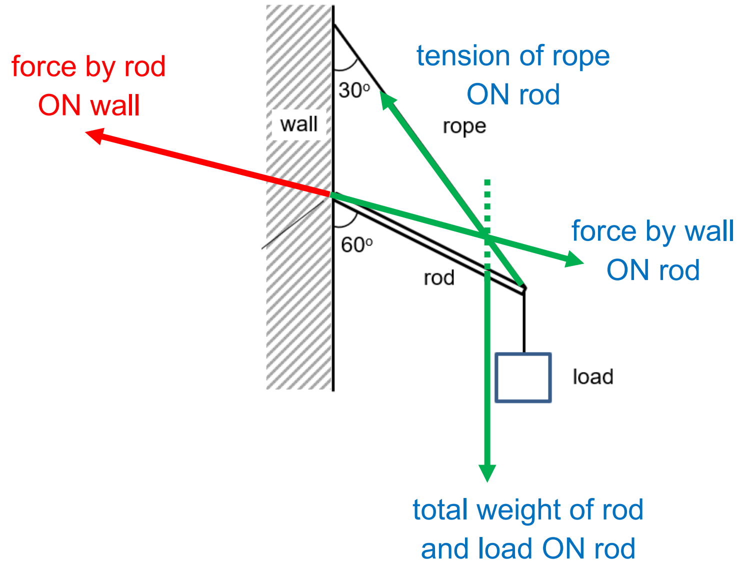
<tr><td></td><td></td><td>(ii)</td><td>
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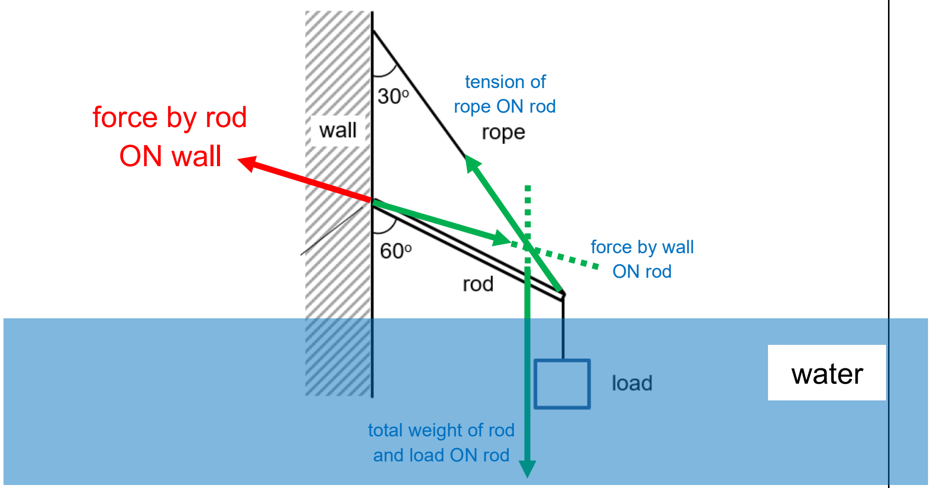
<tr><td></td><td>(c)</td><td></td><td>

<u>The direction of all forces remain unchange since the load remains submerged in water at the same location.</u>

The <u>upthrust acting on the load will reduce the tension in the rope.</u> Since the horizontal component of the tension reduces, the force by wall on rod also reduces. This will result in a <u>lower value of force by rod on wall.</u></td><td>B1 (direction)

B1 (magnitude)</td></tr>
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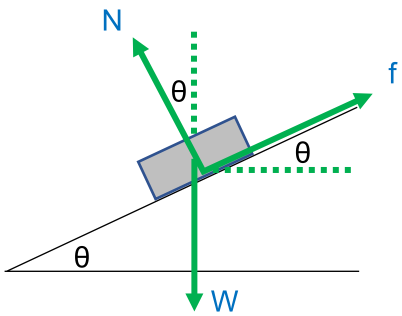
Questions	Answers	Marks

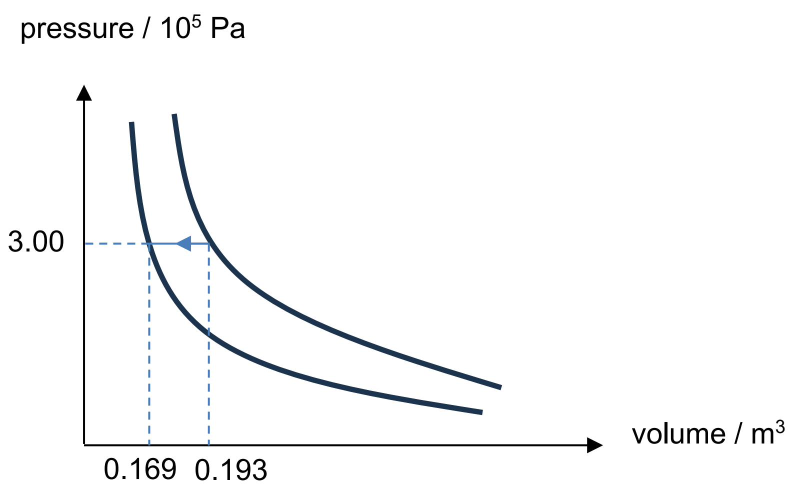
4	**(a)**		kinetic energy was converted to gravitational potential energy and work done against frictional force.	B1
	(b)		$\frac{1}{2}mv^2 = mg\Delta h + work\ done\ against\ friction$	M1
			$\Delta h = 150 \sin 0.57^o = 1.492\ \mathrm{m}$	C1
			$work\ done\ against\ friction = \frac{10^2}{2}m - 9.81 \times 1.492m = 35.36m$	M1
			proportion of energy lost due to friction $= \frac{35.36}{10^2/2} = 0.71$	A1

5	**(a)**		Since the mass is not moving in a straight line, there must be a net force acting on the mass according to Newton's first law. Although the speed remains the same, its direction changes. Since, the change in velocity acts towards the centre of circular motion, the acceleration as well as the net force also acts towards the centre of circular motion according to Newton's second law.	B1 B1
	(b)		 $N\cos\theta + f\sin\theta - W = 0$ $N\cos 40 + 61\sin 40 - 8.0(9.81) = 0$ $N = 51.26\text{ N}$ $N = 51\text{N}$	M1 A1
	(c)		$f\ cos\ \theta - N\ sin\ \theta = mr\omega^2$ $61\ cos\ 40 - 51\ sin\ 40 = (8.0)(12)\left(\frac{2\pi}{T}\right)^2$ $13.9465 = (8.0)(12)\left(\frac{2\pi}{T}\right)^2$ $T = 16.5\ s$	C1 A1
6	**(a)**		A field of force (around a mass) is a region of space that can be mapped with lines of gravitational force (or with lines of gravitational potential) (Answer must be contextualised to "gravitational force" for the first point.) Gravitational field strength at a point is defined as the gravitational force per unit mass acting on a small mass placed at that point.	B1 B1
	(b)		Gravitational force provides the centripetal force for circular motion to take place. By Newton's 2nd Law, F = ma $GMm/r^2 = mr\omega^2$ $GM/r^3 = (2\pi/T)^2$ $T^2 = 4\pi^2\ r^3/\ GM$	B1 B1 B1
	(c)		$T_G = 7.16$, $\lg T_G = 0.85$ From graph, $\lg (r_G) = 9.05$, $r_G = 1.12 \times 10^9$ m~ 1×10^9 m (estimate)	M1 A1
	(d)		$T_T = (16.2 / 24)$ days, $\lg T_T = -0.17$	B1

			From graph, lg (r_G) = 8.35, r_G = 2.24 x 10^8 m r_G calculated is the distance of the Thebe to the centre of Jupiter. We can only decide on the accuracy of the statement if the radius of Jupiter is known.	B1
	(e)	**(i)**	W = m.ΔV = m.(Φ final – Φ initial) = 53.2(– 42.5 – (– 47.6)) =271.32 MJ = 271.32×10^6 J ~ 2.7(1)×10^8 J	M1 A1
		(ii)	$\Phi = -GM/r$ $\Phi.r = constant$ 42.5(9.38) = 398.65 ~ 400 47.6(8.38) = 398.89 ~ 400 54.1(7.38) = 399.26 ~ 400 Need to show constant value, to 1 s.f., for all 3 orbits (shown)	M1
7	**(a)**		When there is no current through the 12 V battery, the potential difference across the 12 V battery and the light bulbs must be equal to 12 V. If the p.d. across each light bulb is 12 V, the current through each bulb is 12/3.0 = 4.0 A Current through resistor R = 4.0 + 4.0 = 8.0 A p.d. across R = 14.0 – 12.0 = 2.0 V resistance of R = 2.0 / 8.0 = 0.25 Ω	B1 C1 A0
	(b)		Since the potential difference across R_1 remains at 12 V, same amount of current will flow through R_1 and no current will flow through R_2. Hence, the current through the 14 V generator and resistor R will reduce to 4.0 A Since the p.d. across R remains the same at 2.0 V, the value of R should be adjusted to a lower value (new R = 2.0 / 4.0 = 0.50 Ω)	B1 B1 B1
	(c)		There will be emf across the lamps even if either the generator or the battery is defective. The power from the generator can be used to charge the car's battery when the light bulbs are removed. The light bulbs will light up longer since energy is delivered from both generator and battery.	B1 B1
8	**(a)**	**(i)**	P = 236, Q = 92 R = 143	B1 B1
		(ii)	E = (Δm) c2 = [(235.1 + 1.009) – (148.0 + 84.9 + 3 x1.009)] u c2 = (0.182) (1.66 x 10–27) (3.00 x 108)2 = 2.719 x 10–11 J for only one uranium nucleus	M1 A1
	(b)	**(i)**	It is **<u>not</u>** triggered or affected by external conditions (temperature, pressure, et cetera)	B1

			It is impossible to predict ***which*** nucleus will decay at a particular instant or ***when*** a particular nucleus will decay	B1
		(ii)	$${}^{90}_{38}Sr \rightarrow {}^{90}_{39}Y + {}^{0}_{-1}\beta$$ Both correct yittrium and beta numbers	B1
		(iii)	$N = N_0 e^{-\lambda t}$ where $\lambda = \frac{ln2}{t_{1/2}}$ (equations provided in data sheet) $$= (2.36 \times 10^{13})e^{-\left(\frac{ln2}{28}\right)(112)}$$ $$= (2.36 \times 10^{13})(0.0625)$$ $$= 1.48 \times 10^{12}$$ Alternative Half life is 28 years so 112 years is 4 half lives Number present after this time is 1/16 of original Number present = $2.36 \text{x} 10^{13}/16 = 1.47(5) \text{ x } 10^{12}$	M0 M1 A1

Questions			Answers	Marks
9	(a)		Using $Q = mc\Delta\theta$, we get $1.79 \times 10^4 = m \times 5190 \times (50.0 - 10.0)$, giving $m = 0.08622$ kg	M1
			number of moles = $\frac{86.22 \text{ g}}{4 \text{ g mol}^{-1}} = 21.56 \text{ mol}$	M1
			number of atoms = $21.56 \times 6.02 \times 10^{23} = 1.298 \times 10^{25} = 1.30 \times 10^{25}$	A1
	(b)	(i)	gas that obeys $pV = nRT$	B1
			p: pressure of the gas V: volume of the gas n: number of moles of the gas T: thermodynamic temperature of the gas or temperature in Kelvin	B1
		(ii)	for ideal gas, internal energy consists only of kinetic energies of gas molecules.	B1
			$\Delta u = n\left[\frac{3}{2}R(T_f - T_i)\right] = 21.56 \times \frac{3}{2} \times 8.31 \times -40 = -10749 = -1.07 \times 10^4 \text{ J}$ allow $\Delta u = \frac{3}{2}n(p_f V_f - p_i V_i)$ if the volumes of the gas were found. If candidates obtain $\Delta u = 1.07 \times 10^4$ J , award maximum of 1 mark even though first B1 may not be awarded.	B1
		(iii)	Since $\langle E_k \rangle = \frac{1}{2}mv_{rms}^2 = \frac{3}{2}kT$, $v_{rms} \propto \sqrt{T}$	B1
			$$\frac{\sqrt{10 + 273.15} - \sqrt{50 + 273.15}}{\sqrt{50 + 273.15}} \times 100\% = -6.39\%$$	B1

	(c)	**(i)**	<u>increase</u> in internal energy of the system is equals to the sum of thermal energy <u>supplied into</u> the system and work done <u>on</u> the system. B1: for directions of change (underlined)	B2
		(ii)	$\Delta u = q + w$ gives $w = -1.07 \times 10^4 - (-1.79 \times 10^4) = 0.72 \times 10^4$ J	B1
			so work done by the gas is -7.2×10^3 J	B1
		(iii)	for changes at constant volume, *w* = 0, so	B1
			$q = \Delta u = -1.07 \times 10^4$ J	B1
	(d)	**(i)**	Using $V = \frac{nRT}{p}$ gives $V_i = \frac{21.56 \times 8.31 \times (50+273.15)}{300\ 000} = 0.193$ m^3 $V_f = \frac{21.56 \times 8.31 \times (10+273.15)}{300\ 000} = 0.169$ m^3	B1
				B1
		(ii)	• (positive) work is done on gas when process occurs at constant pressure, however • no work done on gas when volume is constant	B1
			• So for Δu to be equal <u>more</u> thermal energy must be released by gas when the process occurs at constant pressure than at constant volume	B1

10	**(a)**	**(i)**	A wave in which **energy is carried from one point to another** by means of vibrations or oscillations within the wave. The displacements of the particles in the wave are along the direction of transfer of energy of the wave.	B1 B1
	(a)	**(ii)**	Particle Y experiences lowest/minimum pressure since its neighbouring particles move away from it simultaneously at that instant.	B1 B1
	(a)	**(iii)**	Distance of 2 wavelength between X and Z wavelength λ = 5.1 / 2 = 2.55 m Since v = f λ = 130 x 2.55 = 330 m s^{-1}	 M1 A1
	(a)	**(iv)**	phase angle $= (\frac{1.5\lambda}{\lambda})2\pi$ $= 9.43\ \text{rad}$ (accept π or 3π)	A1
	(b)	**(i)**	Intensity of wave at position of microphone = $P / 4\pi x^2$ = $0.82/[4\pi(4.8)^2]$ = 2.83×10^{-3} W m^{-2} Assume the area of the sphere receiving the waves is πr^2, Power picked up by microphone = $I \times A$ = $(2.83 \times 10^{-3}) \times [\pi(0.025)^2]$ = 5.56×10^{-6} W ~ 6×10^{-6} W.	 M1 C1 A1

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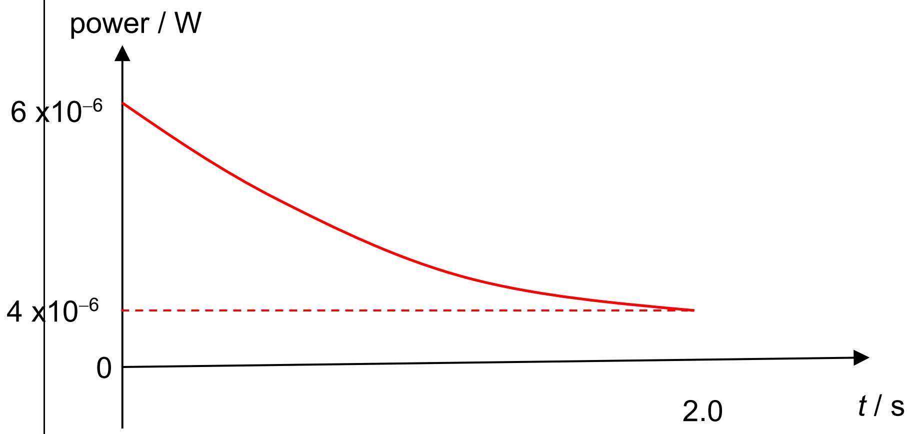

Since intensity is proportional to $1/r^2$, $I = k/r^2$

When $I = 2.83 \times 10^{-3}$ W m^{-2} and $r = 4.8$ m,
$k = (2.83 \times 10^{-3})(4.8^2) = 0.0652$

Since $I = P/A$ and $I = k/r^2$, and $r = 4.8 + vt$

$P/A = k/r^2 = k/(4.8 + vt)^2$
$P = kA/(4.8 + vt)^2$

Since $k = 0.0652$, $A = \pi(0.025)^2$, $v = 0.40$, $t = 2.0$,

$P = (0.0652)(\pi(0.025)^2)/(4.8 + (0.40 \times 2.0))^2$
$= 4.08 \times 10^{-6}$
$\sim 4 \times 10^{-6}$

1 mark for correct shape of graph
1 mark for labelling of points on the graph
1 mark for correct computation of power at t = 2 s.
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	(c)	(i)	path difference = 2 x 0.20m = 0.40 m	 A1
	(c)	(ii)	For next constructive interference to take place, path difference = nλ where n = 1. λ = 0.40m v = f λ 320 = f x 0.40 = 800 Hz	 C1 A1
	(c)	(iii)	The sound waves from path APB and AQB are channelled by the tube (contextualised response) meeting in the opposite directions. Since both waves are of equal amplitude, frequency and speed, they superpose and interfere to form a stationary wave.	B1 B1
	(c)	(iv)	A. Replace microphone with microwave detector connected to C.R.O.	B1
			B. Accept any other reasonable answers. Since frequency of microwave is higher, the wavelength will be shorter. The path difference will be smaller as well so the distances between adjacent nodes and antinodes of the signal will be smaller.	 B1