

Question			Answer	Marks	Guidance
1			Any <u>one</u> from: • Mass obtained using a balance / scales • Weight / load obtained using a newtonmeter / spring balance • Distance / height obtained using a ruler / metre stick / measuring tape Time obtained using a clock / (stop)watch / timer or light-gate <u>and</u> timer or light-gate <u>and</u> data-logger (output power =) 'mass $\times$ g $\times$ distance'/time or 'weight $\times$ distance/time' or 'weight $\times$ speed' input power = output power/0.15	B1 B1 B1 B1	 The term clock / (stop)watch / timer /data-logger must be spelled correctly to gain this mark Allow symbols, e.g mgh/t, Wh/t and Wv
			Total	4	

Question			Expected Answers	Marks	Additional Guidance
2	a		Measurements: height (of wall) time (of fall) Instruments: ruler / tape (measure) stopwatch / timer / clock / video $g = \frac{2s}{t^2}$ / $g = 2 \times$ gradient of $s-t^2$ graph Note: Allow full credit if candidate has used alternative approaches using $v^2 = u^2 + 2as$ or $v = u + at$. Any <u>two</u> from: g is an estimate because - air resistance / drag ignored - parallax problems with 'landing time' - starting / stopping the clock	B1 B1 B1 B1 B1 B1×2	Must use tick or cross on Scoris to show if the mark is awarded Allow: 'distance (of fall)' instead of 'height'  The 4th B1 can only be scored if <i>stopwatch</i> / <i>timer</i> / <i>clock</i> / <i>video</i> (camera) is spelled correctly Allow: Use of 'a' instead of 'g' Note: a must be the subject Allow: 'wind resistance'/'resistive force' for first bullet point Allow: 'reaction time' but not 'human error' for the third bullet point
	b	i	Radio (waves) / microwaves	B1	
		ii	Time taken for the signal to travel from satellite to car is determined / 'delay' time for signal is determined distance = $c \times$ (delay) time	M1 A1	Allow: speed of light / $3.0 \times 10^8 \text{ m s}^{-1}$ instead of c Note: Distance must be the subject for the second B1 mark

Question			Expected Answers	Marks	Additional Guidance
		iii	Mention of circles / spheres / shells	B1	Note: This mark can be scored if a diagram shows circles / arcs (no label required)
			The position of the car is where the circles intersect / trilateration mentioned	B1	Note: This mark can be scored on a diagram if it shows intersecting circles / arcs and the intersection point is marked 'car'
			Total	12	

Question	Answer	Marks	Guidance
3	Diagram showing - Oil in (insulated) container - Electrical heater <u>fully immersed in oil</u> <u>Thermometer / Temperature sensor</u> Electrical circuit - Ammeter in series , voltmeter in parallel with heater / joulemeter in parallel with heater - Power supply /+ & - signs marked on wires Measurements - Measure mass of oil /use known mass of oil, - Measure change in temperature / initial and final temperatures - Measure current, pd and (fixed) time / energy Calculation Input Energy = $E = Pt = VIt$ and $c = \frac{E}{m\Delta\theta}$ Uncertainties Any two together with minimising action. - Heat losses (make $\Delta\theta$ uncertain) - minimise by using initial θ below and final θ <u>same amount</u> above, room temperature - Temperature varies throughout oil - minimise by stirring before taking temperature readings - Some energy is required to raise temperature of the container / heater (etc) - allow by including in calculation. - Temperature will continue to rise after heater is turned off – find max temperature.	B1 B1 B1 B1 2 x B1	Not: oven or hotplate Allow: 'Fully immersed' seen in the body of text  Thermometer /Temperature sensor must be spelled correctly on diagram All elements should be shown to score these diagram marks. Ignore appropriate additional items Connections to heater should be clear. Must have all elements. Allow: Use of symbols Allow: Take energy reading from joulemeter Not: use given power rating of heater Input energy must be consistent with equipment used. c must be the subject of the equation and temperature rise ($\Delta\theta$ or $\theta_2 - \theta_1$) must be clear. Allow: Draw graph of temperature against time $c = VI / [\text{gradient} \times \text{mass}]$ These points may be scored in the description of method. No credit for other uncertainties including heat lost to surroundings
	Total	6	

Q4	Expected Answers	Marks	Additional guidance
(a)(i)	Force/acceleration is proportional to displacement (from equilibrium position) (Resultant force) force/acceleration is (always) towards equilibrium position (WTTE, e.g. allow fixed point).	B1 B1	Allow force/acceleration is in opposite direction to the displacement. Allow $\text{acc} \propto x$, provided x is identified as the displacement for 1 st mark. 2 nd mark only scored if –ve sign used and explained.
(a)(ii)	True; False False; False	B2	-1 for each error stop at zero Assume ✓ means true and X means false Do not credit blank spaces
(b)	Measurements: angle measured <u>with protractor</u> stated or shown on the diagram <u>stop-watch/ms timer/data-logger</u> to measure time stated or shown on the diagram Conclusion: compare periods for different angles stated/implied OR plot period against angle major difficulty: angle of swing decreases during the timing of the swing solution: e.g. measure time for $\frac{1}{4}$, $\frac{1}{2}$ or 1 swing accurately (using electronic timer/datalogger) OR use data logger with motion sensor to record many swings and analyse how the period changes over time OR video the motion with onscreen timer and analyse	B1 B1 B1 M1 A1	Allow ruler used to measure initial and subsequent displacement/amplitude if explained. Allow table of results with correct column headings i.e. at least angle and period Do not allow 'time is short so measure nT and divide by n to reduce (%) error'.(WTTE)
	Total	9	

Question			Expected Answers	Marks	Additional guidance
	(c)	(i)	mass = $235 \times 1.7 \times 10^{-27}$ (= 3.995×10^{-25} kg) volume = $\frac{4}{3}\pi \times (8.8 \times 10^{-15})^3$ (= 2.855×10^{-42} m³) density = mass/volume density = 1.4×10^{17} (kg m⁻³)	C1 C1 A1	Allow: 1.66×10^{-27} kg for mass of nucleon Allow: 10^{17} (kg m⁻³) for this estimation question Note: Omitting 235 gives 6.0×10^{14} (kg m⁻³), allow 2 mark Allow: 1 mark if 92 or 143 is used to determine the mass of the nucleus; this gives a density value of 5.5×10^{16} (kg m⁻³) and 8.5×10^{16} (kg m⁻³) respectively
		(ii)	The nucleons / neutrons and protons are packed together with little or no empty space (AW)	B1	
			Total	14	

Question			Answer	Marks	Guidance
4	(a)		Obtain a set of readings for: mass m , time period AND calculate frequency using $f \equiv \underline{1/T}$. Plot graphs of f against $1/m$ AND f against $1/\sqrt{m}$ The graph which is a straight line through the origin provides the correct relationship Reference to one method of improving reliability eg counting more than 5 oscillations to find T or f taking repeat measurements of T or f (and average values) time oscillations from equilibrium position	B1 B1 B1 B1	Not number of oscillations in a set time Allow: product method using two or more points (B1) Select the relation which gives a constant product (B1) Allow: plot $\ln f$ against $\ln m$ (B1) gradient= -1 then $f \propto 1/m$ or gradient= -0.5 then $f \propto 1/\sqrt{m}$ (B1)
	(b)	(i)	$v_{\max} = 2\pi f A = 2\pi \left(\frac{1}{1.2}\right) \times 36 \times 10^{-3}$ $v_{\max} = \frac{3\pi}{50} \quad (= 0.188)$ $KE_{\max} = \frac{1}{2} \times 0.4 \times \left(\frac{3\pi}{50}\right)^2$ $KE_{\max} = 7.1 \times 10^{-3} \quad (\text{J})$	C1 C1 A1	Note: mark is for substitution
		(ii)	$a_{\max} = (2\pi f)^2 A = \left[2\pi \left(\frac{1}{1.2}\right)\right]^2 \times 36 \times 10^{-3}$ $a_{\max} = 0.99 \quad (\text{ms}^{-2})$	C1 A1	Note: mark is for correct substitution

Question			Answer	Marks	Guidance
	(c)		Reference to : kinetic energy (of masses and spring), gravitational potential energy (of mass and spring), elastic (potential) energy / strain energy of spring KE: <u>zero</u> (at lowest point), increasing to max at equilibrium point, decreasing to <u>zero</u> (at highest point) GPE: increases (as masses rise from lowest to highest point) (clearly worded ora)(AW) strain / elastic energy: decreases (as masses rise from lowest to highest point) (clearly worded ora) (AW)	B1 B1 B1 B1	Note: mark to be awarded only if all 3 forms are quoted  Note: potential must be spelled correctly throughout to score this mark
			Total	13	