G484 The Newtonian World

Question			Expected Answers	Marks	Additional guidance
1	a	i	Force is proportional to the rate of change of **momentum** *(QWC This mark can only be scored if momentum is spelled correctly)*	B1	Allow “equal” instead of proportional, allow “change in momentum over time” (WTTE) Do not allow F = ma or in words
		ii	When one body exerts a force on another the other body exerts an equal (in magnitude) and opposite (in direction) force on the first body (WTTE)	B1	Must refer to two bodies. Do not allow a bare “Action and reaction are equal and opposite”.
	b	i	*area*: number of squares correctly counted: 20 - 24 (500 – 600) = **2.2** Ns {allow 2.0 to 2.4}	C1 A1	First mark for correct number of squares Second mark for correct conversion to Ns If 2 Δs assumed, area = 1.68 Ns and scores 1 mark 1680 scores 0 (2 errors) but 2200 scores 1 mark
		ii	**Impulse** QWC must be spelled correctly	B1	No not allow change of momentum.
		iii	recall of Impulse = change in momentum OR I = mv OR mv –mu (mv = 2.2 hence v = 2.2/0.046) v = **47.8** ms^{-1} (hence about 50) (2.0 gives 43.5, 2.1 45.7, 2.3 50, 2.4 52.2)	C1 A1	Allow ‘Area = mv’ Allow ecf from cand’s value for (b)(i): e.g. mv = 1.68 v = 36.5 ms^{-1} and scores 2 marks mv = 2200 v = 47800 ms^{-1} also scores 2marks! (ecf)
		iv	initial horizontal velocity = 50cos42 = (37.2 ms^{-1}) initial vertical velocity = 50sin42 = (33.5 ms^{-1}) time taken to reach maximum height = 33.5/9.8 (= 3.41 s) total time to reach ground = 2x 3.41 = 6.82 s hence distance = 50cos42xtotal time = 37.2x6.82 = **253** m any valid assumption: eg no air resistance / horizontal velocity is constant/ acceleration due to gravity is 9.8 (or 10) ms^{-2} / ball follows a parabolic or symmetrical path (WTTE).	C1 C1 C1 A1 B1	Allow 1 mark for correct identification of cosine and sine components of v, without substitution. Allow ecf for cand’s value of v throughout e.g if 47.8 is used for v, distance = **232** m and this scores four marks. if 47800 is used distance = 2.32 x 10^8 m! Also allow “only the gravitational force is acting” “no friction” “only gravity”
			Total	**12**	

Question			Expected Answers	Marks	Additional guidance
2	a	i	($v = 2\pi r/t$) $t = 2\pi 60/0.26 =$ **1450** s	B1	Correct answer is 1449.96 hence allow 1.4×10^3 Do not allow a bare 1.5×10^3
		ii	(ii) correct substitution into $F = mv^2/r$: eg $F = (9.7\times10^3 \times 0.26^2)/60$ F = **10.9** N	C1 A1	 Allow 11 N
	b	i	THREE correct arrows at A, B and C **all** pointing towards the centre (judged by eye)	B1	Ignore starting point of arrow
		ii	1. Greatest reaction force is at **C** because it supports weight of sock AND provides the required upward resultant (centripetal) force (WTTE) 2. Least at **A** because sock's weight provides part of the required downward resultant (centripetal) force (WTTE)	**M1** A1 B1	This is a mandatory M mark. The second mark cannot be gained unless this is scored. Any indication that candidates think that the centripetal force is a **third** force loses this second and possibly the next mark. They must make correct reference to the resultant force that provides the required centripetal force/acceleration. Allow answers using the equation $F = mv^2/r$ such as $N_c - mg$ (at C) = centripetal force OR mv^2/r OR $mg + N_A$ (at A) = centripetal force OR mv^2/r
			Total	**7**	

Question			Expected Answers	Marks	Additional guidance
3	a		arrows (at least one) indicating direction is **towards** the planet. All lines looking as though they would meet at the centre judged by eye	B1 B1	 At least 4 drawn and care taken Some of the lines must be outside the planet.
	b	i	($mg = GMm/r^2$ and hence) $\mathbf{M = gr^2/G}$ correct substitution $M = 24.9 \times (7.14 \times 10^7)^2/6.67\times10^{-11}$ $= \mathbf{1.9 \times 10^{27}}$ Kg (i.e about $\mathbf{2\times10^{27}}$)	C1 **M1** A1	Equation needs to be rearranged as shown for C1 mark
		ii	correct substitution into $V=(4/3)\pi r^3 = (4/3)\pi(7.14\times10^7)^3$ {= 1.52×10^{24} m^3} density = mass/volume = $1.9 \times10^{27}/1.52 \times 10^{24}$ = **1250** kg m^{-3}	C1 A1	If m= 2×10^{27} kg is used d = 1312 scores 2 marks
			Total	**7**	

Question			Expected Answers	Marks	Additional guidance
4	**a**		The resultant force is zero (WTTE) Forces are weight and force from the spring (allow tension)	B1 B1	For the first mark allow - sum of forces is zero, - upward force = downward force, - forces cancel each other BUT do not allow forces are balanced Allow force of gravity for weight
	b	**i**	acceleration is (directly) proportional to displacement and is directed in the opposite direction to the displacement. (WTTE)	M1 A1	allow a=-$(2\pi f)^2$ x, provided a and x are identified and –ve sign must be explained. Do not allow "acceleration is prop to negative displacement for second mark. Allow always towards the equilibrium position
		ii	x= acos2πft $\Rightarrow$ 2πf = 7.85 (expressed in any form) f = (7.85/2π) = 1.25 (1.249Hz)	**M1** A1	Do not allow use of Fig 4.2 to show T= 0.8s and hence f=1.25 Hz. This scores 0.
		iii	correct subst^n in $V_{max} = (2\pi f)A \Rightarrow V_{max} = 2\pi$x1.25x0.012 V_{max} = **0.094** ms^{-1}	C1 A1	Many will forget to change 12 mm into 0.012m and have v = 94 ms^{-1} this scores 1 mark.
	c		roughly **sinusoidal** graph of <u>correct period</u> ie **0.8s** <u>90^o out of phase</u> with displacement graph (i.e. starts at origin with -ve initial gradient) <u>maximum velocity</u> correctly shown as 0.094 {allow ecf from (iii)}	B1 B1 B1	
			Total	**11**	

Question			Expected Answers	Marks	Additional guidance
5	a	i	correct substitution in $E = mc\Delta\theta$: eg E = 0.08x4180x40 ratio = 0.08x4180x40/5 x 10^{-5} x2460x40 = **2.7(2) x 10^3**	C1 A1	Allow 80x4180/0.05x2460 (13376/4.92) for this C1 mark. 1: 2700 does not score the second mark.
		ii	*Any valid advantage: eg* car cooling systems <u>because</u> it absorbs large amounts of heat for a small rise in temp OR ideal fluid for central heating systems <u>because</u> it releases large amounts of heat for a small drop in temp. OR helps to maintain constant body temperature <u>since</u> body is mainly water which absorbs lots of heat for small temp rise	 B1 B1	 First mark for valid situation Second mark for correct explanation of <u>why</u> the high value of the shc is helpful.
	b		***labelled diagram (2 marks)*:** liquid in vessel with <u>electrical</u> heater (submerged) and thermometer ammeter connected in series between supply and heater AND voltmeter connected across heater. ***list of measurements (3 marks):*** mass of liquid, initial and final temperature/change of temp (of the liquid) I, V and t values OR energy meter readings OR power and time ***explanation (1 mark):*** $E = mc\Delta\theta$ rearranged to $c = E/m\Delta\theta$ ***uncertainties (2 marks) each stated with explanation of remedy**:* e.g. - heat losses (makes E or $\Delta\theta$ uncertain) *(solved by)* insulating beaker/use lid - false temp reading *(solved by)* stir the liquid - temp continues to rise after heater switched off measure highest value - thermal capacity of vessel (*solved by*) take this into account in calculation	 B1 B1 B1 B1 B1 B1 B1 B1 max 2	Allow use of joule meter if convincingly connected to heater and power supply i.e. 2 wires from power supply two wires to heater Allow such things as "find mass", "known mass", "10K temp rise", "time for 2 minutes" "known power", etc. Allow $ItV/m\Delta\theta$. Do not allow "repeat the experiment". Give credit for valid suggestions if mentioned anywhere in the description of the experiment.
			Total	**12**	

Question			Expected Answers	Marks	Additional guidance
6	**a**		(n) number of **moles** (T) **absolute** temperature OR thermodynamic temp OR temp measured in **Kelvin**	B1 B1	 Accept **K** for Kelvin
	b	**i**	(When gas is heated) molecules gain KE/move faster this would cause more collisions/sec (with the walls) collisions exert more force/greater change in momentum per collision For constant pressure fewer collisions/sec are required Constant pressure is achieved by the increase in volume OR with a bigger volume there are fewer collisions/sec	B1 B1 B1 B1 B1 *max 4*	If no reference to rate of collisions, max of 3 marks This must be explained fully but can be done with reference to $P = (1/3)\rho \langle c^2 \rangle$
		ii	correct substitution in pV/T = constant: OR V/T = constant e.g. 1.2×10^{-4} /**293** = V/**363** V= $(363/293) \times 1.2 \times 10^{-4}$ = **1.49×10^{-4}** m^3.	 C1 A1	 Both temps must be in Kelvin. Allow 1.5×10^{-4} m^3
	c		Use of $1/2 m\langle c^2 \rangle = 3/2\ kT$ Correct substitution: $\sqrt{\langle c^2 \rangle} = \sqrt{(3kT/m)} = \sqrt{(3 \times 1.38 \times 10^{-23} \times 363/4.7 \times 10^{-26})}$ $\sqrt{\langle c^2 \rangle}$ = **565** ms^{-1}	C1 C1 A1	If 90^0 C is used $\sqrt{\langle c^2 \rangle}$ = 282 ms^{-1} and scores 2 marks Allow 570 ms^{-1} If they do not square root, they get 319225 ms^{-1} and score 2 marks
			Total	**11**	