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 X 10^3 Do not allow a bare 1.5 x10^3
		ii	(ii) correct substitution into $F = mv^2/r$: eg F = $(9.7x10^3x0.26^2)/60$ 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) **$M = gr^2/G$** correct substitution M = $24.9x(7.14 \times 10^7)^2/6.67x10^{-11}$ = **1.9×10^{27}** Kg (i.e about **$2x10^{27}$**)	C1 **M1** A1	Equation needs to be rearranged as shown for C1 mark
		ii	correct substitution into $V=(4/3)\pi r^3 = (4/3)\pi(7.14x10^7)^3$ {= 1.52×10^{24} m^3} density = mass/volume = $1.9 x10^{27}/1.52 \times 10^{24}$ = **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= a$\cos 2\pi ft \Rightarrow 2\pi f = 7.85$ (expressed in any form) f = $(7.85/2\pi)$ = 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 correct period ie **0.8s** 90^o out of phase with displacement graph (i.e. starts at origin with -ve initial gradient) maximum velocity 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 because it absorbs large amounts of heat for a small rise in temp OR ideal fluid for central heating systems because it releases large amounts of heat for a small drop in temp. OR helps to maintain constant body temperature since 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 why the high value of the shc is helpful.
	b		***labelled diagram (2 marks)*:** liquid in vessel with electrical 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 $1/2m\langle c^2 \rangle = 3/2\ kT$ 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**	