

G484 The Newtonian World

Question	Expected Answers	Marks	Additional guidance
1 a i	Force is proportional to the <u>rate of change</u> of <u>momentum</u> (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 <u>equal</u> (in magnitude) and <u>opposite</u> (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 Δ s 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 $v = 2.2/0.046$) $v = \mathbf{47.8}$ 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 = $50\cos 42 = (37.2 \text{ ms}^{-1})$ initial vertical velocity = $50\sin 42 = (33.5 \text{ ms}^{-1})$ time taken to reach maximum height = $33.5/9.8 (= 3.41 \text{ s})$ total time to reach ground = $2 \times 3.41 = 6.82 \text{ s}$ hence distance = $50\cos 42 \times \text{total time} = 37.2 \times 6.82 = \mathbf{253}$ 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 <u>four</u> marks. if 47800 is used distance = 2.32×10^8 m! Also allow “only the gravitational force is acting” “no friction” “only gravity”
	Total	12	

Question			Expected Answers	Marks	Additional guidance
2	a	i	$(v = 2\pi r/t) \quad t = 2\pi 60/0.26 = \mathbf{1450 \text{ s}}$	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 $F = (9.7 \times 10^3 \times 0.26^2)/60$ $F = \mathbf{10.9 \text{ N}}$	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	$(mg = GMm/r^2 \text{ and hence}) \quad \mathbf{M = gr^2/G}$ correct substitution $M = 24.9 \times (7.14 \times 10^7)^2 / 6.67 \times 10^{-11}$ $= \mathbf{1.9 \times 10^{27} \text{ Kg}}$ (i.e about 2×10^{27})	C1 M1 A1	Equation needs to be rearranged as shown for C1 mark
		ii	correct substitution into $V = (4/3)\pi r^3 = (4/3)\pi (7.14 \times 10^7)^3 \{= 1.52 \times 10^{24} \text{ m}^3\}$ density = mass/volume = $1.9 \times 10^{27} / 1.52 \times 10^{24} = \mathbf{1250 \text{ kg m}^{-3}}$	C1 A1	If $m = 2 \times 10^{27} \text{ kg}$ is used $d = 1312$ scores 2 marks
			Total	7	

Question			Expected Answers	Marks	Additional guidance
4	a		The resultant force is zero (WTTE)	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
			Forces are weight and force from the spring (allow tension)	B1	
	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	$x = a \cos 2\pi f t \Rightarrow 2\pi f = 7.85$ (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 $T = 0.8$ s and hence $f = 1.25$ Hz. This scores 0.
		iii	correct subst ⁿ in $V_{\max} = (2\pi f)A \Rightarrow V_{\max} = 2\pi \times 1.25 \times 0.012$ $V_{\max} = \mathbf{0.094} \text{ ms}^{-1}$	C1 A1	Many will forget to change 12 mm into 0.012m and have $v = 94 \text{ ms}^{-1}$ this scores 1 mark.
	c		roughly sinusoidal graph of <u>correct period</u> ie 0.8s <u>90° 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 $E = 0.08 \times 4180 \times 40$ ratio = $0.08 \times 4180 \times 40 / 5 \times 10^{-5} \times 2460 \times 40 = \mathbf{2.7(2) \times 10^3}$	C1 A1	Allow $80 \times 4180 / 0.05 \times 2460$ (13376/4.92) for this C1 mark. 1: 2700 does not score the second mark.
		ii	<i>Any valid advantage: eg</i> 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) (<i>solved by</i>) insulating beaker/use lid - false temp reading (<i>solved by</i>) stir the liquid - temp continues to rise after heater switched off measure highest value - thermal capacity of vessel (<i>solved by</i>) 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 <i>max 4</i>	If no reference to <u>rate</u> 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 $pV/T = \text{constant}$: OR $V/T = \text{constant}$ e.g. $1.2 \times 10^{-4} / 293 = V / 363$ $V = (363/293) \times 1.2 \times 10^{-4} = \mathbf{1.49 \times 10^{-4} \text{ m}^3}$.	C1 A1	Both temps must be in Kelvin. Allow $1.5 \times 10^{-4} \text{ m}^3$
	c		Use of $1/2 m \langle c^2 \rangle = 3/2 kT$ Correct substitution: $\sqrt{\langle c^2 \rangle} = \sqrt{(3kT/m)} = \sqrt{(3 \times 1.38 \times 10^{-23} \times 363 / 4.7 \times 10^{-26})}$ $\sqrt{\langle c^2 \rangle} = \mathbf{565 \text{ ms}^{-1}}$	C1 C1 A1	If 90°C is used $\sqrt{\langle c^2 \rangle} = 282 \text{ ms}^{-1}$ 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	