Marking Scheme

#1

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
				Marks available					
2	*(a)*	(i)	$\omega = \frac{\text{angle swept out}}{\text{time taken}}$ [or in words] Or angle [accept: number of radians] swept out per unit time [or per second]	1			1		
		(ii)	Clear use of $\omega = \frac{v}{r}$ or equivalent (1) Convincing algebra (1)	1	1		2	1	
	(b)	(i)	Substitution into: $F = m\frac{v^2}{r}$ or equivalent either before or after rearrangement (1) v = 1.35 km s^{-1} (1)	1	1		2	1	
		(ii)	$\frac{GMm}{r^2} = \frac{mv^2}{r}$ or equivalent with M and m correctly identified (1) m cancels so speed of moon of twice the mass would be the same as that of Deimos. [Must be supported by argument even if argument not clear enough to give first mark.] (1) or in words, e.g. Equivalence of gravitational and inertial mass however expressed, [e.g. the force would be double and the mass is doubled] (1) Hence speed the same (1) or Another identical moon next to the existing one will orbit at the same speed (1), so the composite moon [of double the mass] will orbit at that speed (1).		2		2		
			Question 2 total	**3**	**4**	**0**	**7**	**2**	**0**

#2

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
				Marks available					
	(a)	(i)	[lantern moment] 0.9 × 9.81 × 0.8 [= 7.06] [N m] or by implication (1) [bar moment] 1.8 × 9.81 × 0.55 [= 9.70] [N m] or by implication (1) Total = 17 N m **UNIT** (1) accept 16.8 and 16.7 Give 1 mark if g omitted and answer given as 1.7 with or without any unit.	1 1	1		3	3	
		(ii)	[Anticlockwise] torque due to wire = T × 1.1 m × sin 35° or by implic (1) T = 27 [N] **ecf on (a)(i)** (1)			2	2	2	
		(iii)	Tension must increase (1) Convincing brief explanation e.g. reducing angle decreases [perpendicular] distance **or** reduces component of tension perpendicular to bar (vertical component **or** tension must increase to compensate **or** so that [total] clockwise moment is still balanced (1) **Accept** numerical demonstration using a specific angle smaller than 35° for both marks (First mark for demonstration, second for conclusion)			2	2		
	(b)		1.4 [m s^{-1}]		1		1		
			Question total	**2**	**2**	**4**	**8**	**5**	**0**

#3

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
				Marks available					
9	(a)		Conversion $4.32 \times 10^6 \times 1.6 \times 10^{-19}$ i.e. 6.912×10^{-13} [J] (1) Rearrangement for v i.e. $v = \sqrt{\frac{2E}{m}}$ (1) Answer = 1.44×10^7 m s^{-1} (1)		3		3	2	
	(b)		24 total energy 'kicks' (or 2 per revolution) (1) 4.32 MeV divided by 24 (=180 000) (1) Also need to divide by 2e, Answer = 90 000 V (1) (2 marks for 180 kV, 1 mark for 360 kV, 2.16 MV →1 mark)		3		3	2	
	(c)		Equating: $m\omega^2 r = Bqv$ (1) or $\omega = \frac{Bq}{m}$ Rearrangement: $f = \frac{Bq}{2\pi m}$ (1) By implication can give 2 marks for this Answer = 3.6 MHz (ecf on part (b) i.e. using 1e instead of 2e 1.8 MHz) (1)		3		3	2	
			Question 9 total	0	9	0	9	6	0

#4

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
				Marks available					
(a)			$\frac{\text{final velocity - initial velocity}}{\text{time [taken to change]}}$ or equivalent [1]	1			1		
(b)	(i)		[Distance gone per second] = $2\pi \times 0.25$ [m] $\times$ 5.2×10^6 [s^{-1}] [1] = 8.2×10^6 [m s^{-1}] [1]	1	1		2	2	
	(ii)		acc = $\frac{(8.0\times10^6)^2}{0.25}$ [m s^{-2}] **or** $\frac{(8.17\times10^6)^2}{0.25}$ [m s^{-2}] [1] = 2.6 (or 2.7) $\times$ 10^{14} m s^{-2} **unit mark** [1] South or towards circle centre. Accept downwards. [1]	1 1	1		3	1	
	(iii)		Time for half revolution = $\frac{1}{2} \times \frac{1}{5.2 \times 10^6}$ s [= 9.62 $\times$ 10^{-8} s] [1] Final velocity – initial velocity = 1.63×10^7 [m s^{-1}] [South] [1] Mean acc = 1.7 $\times$ 10^{14} [m s^{-2}] **South** [Accept South for Δv] [1]		3		3	2	
(c)			Adam is wrong because acc's (or force) *direction* keeps changing [1] Brian is right because final vel – initial vel = 0 or equiv [1]			2	2		
			Question total	4	5	2	11	5	0

#5

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
				Marks available					
(a)	(i)		Units of a, v, r given as m s^{-2}, m s^{-1}, m (1) Convincing algebra **must see** m^2 s^{-2} (1)	1	1		2	1	
	(ii)		[According to equation] a becomes smaller **or** zero (1) [Sensible because] body's path [almost] straight **or** equivalent (1)			2	2		
(b)	(i)		$v = \frac{2\pi \times 200}{52}$ [= 24.2 m s^{-1}] or ω = 0.121 [rad s^{-1}](1) $F_{centrip}$ = 1 150 × ($\frac{2\pi \times 200}{52}$)^2 ÷ 200 [N] or equivalent or by implic(1) $F_{centrip}$ = 3 360 [N] **or** 3 400 [N] **Accept** 3 358 [N] or 3 300 [N] (1)		3		3	3	
	(ii)	I	$F_{centrip} = F \sin\theta$ **or** 3 360 (or 3 000) = 5 500 sin θ **or** equiv **or** by implic **ecf** on $F_{centrip}$ (1) θ = 37.6°(or 38°) (1)		2		2	2	
		II	Forward component of F must balance D (**or** must be equal and opposite to D) **or** since car is travelling at constant speed (1) $D = F\cos\theta$ or equiv **ecf on** θ (1) D = 4 360 [N] (1)	1	1 1		3	2	
			Question total	2	8	2	12	8	0

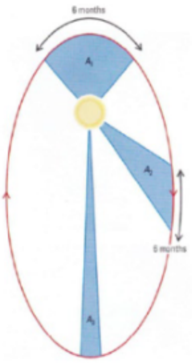
#6

Question				Marking details	AO1	AO2	AO3	Total	Maths	Prac
4	(a)	(i)	I	Use of $\omega = 2\pi f$ even if f is still in revs per minute or by impl [1] ω = 0.859 [rad s^{-1}] [1]	1	1		2	1	
			II	Use of $v = r\omega$ [= 3.26 m s^{-1}] or equiv or by impl. [1] Time = 3.06 [s] [1] ecf	1	1		2	1	
			III	Use of $a = \frac{v^2}{r}$ or $a = r\omega^2$ or by implication [1] a = 2.80 [m s^{-2}] [1] ecf	1	1		2	1	
		(ii)	I	Correct substitutions in $mg = T\cos\theta$ (or after transposition) or by implication [1] 2.76 [N] [1] [2.55 N indicates error of principle]		2		2	1	
			II	[Horizontal component of] tension provides centripetal force [1] $T\sin 16°$ evaluated [0.761 N ecf on T] or used in calculation [1] Conclusion clearly based on calculation e.g. Either $\frac{2.76 \sin 16°}{0.270} = 2.82$ [m s^{-2}] or 2.80 ecf from (a)(i)III × 0.270 kg = 0.756 [N] and agreement noted ecf [1]			3	3	2	
	(b)			Example defined e.g. bends in roads or rail lines, spin-drier... [1] One factor affecting centripetal acceleration considered in context e.g. bends in roads or tracks must not be too sharp, or spin speed must be high enough... [1] Another factor considered e.g. vehicle speed warnings, drum size limited or more intricate measures e.g. banking of tracks [1]			3	3		
				Question 4 total	**3**	**5**	**6**	**14**	**6**	**0**

#7

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
				Marks available					
	(a)		Line drawn from Sun to planet..... (1) ......will sweep out equal areas reference to $A_1 = A_2 = A_3$ (1) ......in equal time intervals / 6 months (1)	3			3		
	(b)		$\frac{mv^2}{r} = \frac{GMm}{r^2}$ (1) $v = \frac{2\pi r}{T}$ (1) Substitution and clear algebra step shown (1) **Or:** $mr\omega^2 = \frac{GMm}{r^2}$ (1) $\omega = \frac{2\pi}{T}$ (1) Substitution and clear algebra step shown (1)	1 1	1		3	3	
	(c)	(i)	1.45 years = 4.573×10^7 [s] (1) Substitution into $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ i.e. $\frac{0.052}{486.14} = \frac{v}{3.0 \times 10^8}$ (1) $v = 3.209 \times 10^4$ [m s^{-1}] (1) $r = \frac{vT}{2\pi} = \frac{3.209 \times 10^4 \times 4.573 \times 10^7}{2\pi}$ $= 2.34 \times 10^{11}$ [m] (1) **Alternative** for 4.573×10^7 see $1.45 \times 86\,400 \times 365$	1	1 1 1		4	4	
		(ii)	Assumption CoM at/near centre of neutron star or M_1 much greater than M_2 (1) **Either**: $M = \frac{v^2 r}{G}$ (1) $M = \frac{(3.209 \times 10^4)^2 \times 2.34 \times 10^{11}}{6.67 \times 10^{-11}}$ (substitution) (1) **ecf** on v $M = 3.6 \times 10^{30}$ [kg] **and** valid conclusion (1)						
		(ii)	**Alternative:** $M = \frac{4\pi^2 r^3}{GT^2}$ (1) $M = \frac{4\pi^2 \times (2.34 \times 10^{11})^3}{6.67 \times 10^{-11} \times (4.573 \times 10^7)^2}$ (substitution) (1) **ecf** on T $M = 3.6 \times 10^{30}$ [kg] **and** valid conclusion (1)			4	4	4	
			Question total	**6**	**4**	**4**	**14**	**11**	**0**

#8

Question				Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
	(a)			Areas and time periods shown correctly or described [1] $A_1 = A_2$ $(= A_3)$ indicated [1]  6 months	2			2		
	(b)			$\frac{mv^2}{r} = \frac{GMm}{r^2}$ [1] $v = \frac{2\pi r}{T}$ [1] Substitution and clear algebra step shown [1] **Or** $mr\omega^2 = \frac{GMm}{r^2}$ [1] $\omega = \frac{2\pi}{T}$ [1] Substitution and clear algebra step shown [1]	1	1 1		3	2	
	(c)	(i)		$\omega = \frac{2\pi}{(7.7 \times 3\,600)}$ or $2.26(7) \times 10^{-4}$ rads^{-1} seen [1] $M = \frac{(2.27 \times 10^{-4})^2 \times (9.4 \times 10^6)^3}{6.67 \times 10^{-11}}$ substitution and re-arrangement [1] $M = 6.39[8] \times 10^{23}$ k[g] [1]		3		3	3	
		(ii)	I	Substitution into $V_g = -\frac{GM}{R}$ i.e. $V_g = -\frac{6.67 \times 10^{-11} \times 6.4 \times 10^{23}}{9.4 \times 10^6}$ [1] $V_g = -4.5(4) \times 10^6$ [J kg^{-1}] [1]	1	1		2	2	
			II	V_g at orbit of Deimos = $-\frac{6.67 \times 10^{-11} \times 6.4 \times 10^{23}}{2.35 \times 10^7}$ $= -1.8(2) \times 10^6$ J kg^{-1}[1] $\Delta V = -1.82 + 4.54 = 2.72$ M[J kg^{-1}] [1] Energy available per kg of fuel = $0.6 \times 4.4 = 2.64$ M[J kg^{-1}] [1] Scientists should not attempt manoeuvre [1] [**ecf** based on calculations]			4	4	3	
		(iii)		One of: • g is not constant [over the distance between orbits] • g decreases as height increases • work done per metre decreases as height increases • field is not uniform		1		1		
				Question total	**4**	**7**	**4**	**15**	**10**	**0**