Motion in a Circle

Mark Scheme 1

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Motion in a circle
Sub Topic	
Paper Type	Theory
Booklet	Mark Scheme 1

Time Allowed: **60 minutes**

Score: **/50**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1	**(a)**	($F = R\cos\theta$	M1	
		$W = R\sin\theta$	M1	
		dividing, $W = F\tan\theta$	A0	[2]
		(max. 1 if derivation to final line not shown)		
	(ii)	<u>provides</u> the centripetal force	B1	[1]
	(b)	*either* $F = mv^2/r$ and $W = mg$		
		or $v^2 = rg/\tan\theta$	C1	
		$v^2 = (14 \times 10^{-2} \times 9.8)/\tan 28°$	C1	
		$= 2.58$		
		$v = 1.6\,\text{m s}^{-1}$	A1	[3]
2	**(a**	angle subtended at the centre of a circle	B1	
		by an arc equal in length to the radius	B1	[2]
	(b) (i)	arc = distance × angle	C1	
		diameter $= 3.8 \times 10^5 \times 9.7 \times 10^{-6}$		
		$= 3.7\,\text{km}$	A1	[2]
	(ii)	Mars is (much) further from Earth / away (*answer must be comparative)*	B1	
		angle (at telescope is much) smaller	B1	[2]
3	**(a**	gravitational force provides the centripetal force	B1	
		$GMm/r^2 = mr\omega^2$ (*must be in terms of* ω)	B	
		$r^3\omega^2 = GM$ <u>and</u> GM is a constant	B1	[3]
	(b) (i) 1.	for Phobos, $\omega = 2\pi/(7.65 \times 3600)$	C1	
		$= 2.28 \times 10^{-4}\,\text{rad s}^{-1}$		
		$(9.39 \times 10^6)^3 \times (2.28 \times 10^{-4})^2 = 6.67 \times 10^{-11} \times M$	C1	
		$M = 6.46 \times 10^{23}$ kg	A1	[3]
	2.	$(9.39 \times 10^6)^3 \times (2.28 \times 10^{-4})^2 = (1.99 \times 10^7)^3 \times \omega^2$	C1	
		$\omega = 7.30 \times 10^{-5}\,\text{rad s}^{-1}$	C1	
		$T = 2\pi/\omega = 2\pi/(7.30 \times 10^{-5})$		
		$= 8.6 \times 10^4$ s		
		$= 23.6$ hours	A1	[3]
	(ii)	*either* almost 'geostationary'		
		or satellite would take a long time to cross the sky	B1	[1]

4	**(a**	**(i)** rate of change of angle / angular displacement	M1	
		swept out by radius	A1	[2]
		(ii) $\omega \times T = 2\pi$	B1	[1]
	(b)	centripetal force is provided by the gravitational force	B1	
		either $mr(2\pi/T)^2 = GMm/r^2$ *or* $mr\omega^2 = GMm/r^2$	M1	
		$r^3 \times 4\pi^2 = GM \times T^2$	A1	
		$GM/4\pi^2$ is a constant (c)	A1	
		$T^2 = cr^3$	A0	[4]
	(c)	**(i)** *either* $T^2 = (45/1.08)^3 \times 0.615^2$ *or* $T^2 = 0.30 \times 45^3$	C1	
		T = 165 years	A1	[2]
		(ii) speed = $(2\pi \times 1.08 \times 10^8) / (0.615 \times 365 \times 24 \times 3600)$	C1	
		= 35 km s^{-1}	A1	[2]
5	**(a)**	angle (subtended) <u>at centre</u> of circle	B1	
		(by) arc equal in length to radius	B1	[2]
	(b)	**(i)** point S shown below C	B1	[1]
		(ii) (max) force / tension = weight + centripetal force	C1	
		centripetal force = $mr\omega^2$	C1	
		$15 = 3.0/9.8 \times 0.85 \times \omega^2$	C1	
		ω = 7.6 rad s^{-1}	A1	[4]

6	**(a)**	**(i)** $F = GMm / R^2$	B1	[1]
		(ii) $F = mR\omega^2$	B1	[1]
		(iii) reaction force = $GMm / R^2 - mR\omega^2$ (*allow e.c.f.*)	B1	[1]
	(b)	**(** *either* value of R in expression $R\omega^2$ varies		
		or $mR\omega^2$ no longer parallel to GMm / R^2 / normal to surface	B1	
		becomes smaller as object approaches a pole / is zero at pole	B1	[2]
		(ii) acceleration = $6.4 \times 10^6 \times (2\pi / \{8.6 \times 10^4\})^2$	C1	
		= 0.034 m s^{-2}	A1	[2]
		2. acceleration = 0	A1	[1]
	(c)	e.g. 'radius' of planet <u>varies</u>		
		density of planet <u>not constant</u>		
		planet spinning		
		nearby planets / stars		
		(*any sensible comments, 1 mark each, maximum 2)*	B2	[2]