CAMBRIDGE INTERNATIONAL AS & A LEVEL PHYSICS · 9702

PHYSICS



MARK SCHEME

12 MOTION IN A CIRCLE

SCORE	PERCENTAGE
/	%

STEMUP

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Answers

1. 9702_w21_MS_41 Q: 1

	Answer	Marks
(a)	constant speed **or** constant magnitude of velocity	**B1**
	acceleration (always) perpendicular to velocity	**B1**
(b)(i)	$F = mv^2 / r$ **or** $v = r\omega$ **and** $F = mr\omega^2$	**C1**
	$F = 790 \times 94^2 / 318$ $= 22000$ N	**A1**
(b)(ii)	centripetal acceleration: same	**B1**
	maximum speed: greater	**B1**
	time taken for one lap of the track: greater	**B1**

2. 9702_w21_MS_42 Q: 1

	Answer	Marks
(a)	acceleration perpendicular to velocity	**B1**
(b)(i)	decreases	**B1**
(b)(ii)	(acceleration of) 9.8 m s^{-2} is caused by weight of car **or** centripetal force must be greater than weight of car	**B1**
	(acceleration > 9.8 m s^{-2}) requires contact force from track **or** (centripetal force > weight) requires contact force from track	**B1**
(c)	$\frac{1}{2}mv_Y^2 = \frac{1}{2}mv_X^2 - mgh$	**C1**
	$a = v^2 / r$	**C1**
	$v_Y^2 = 3.8^2 - 2 \times 9.81 \times 0.62$ so $v_Y = 1.5$ m s^{-1} $a = 1.5^2 / 0.31 = 7.3$ m s^{-2} (which is less than 9.8 m s^{-2}) so no	**A1**
	or	
	$v_Y = \sqrt{(9.81 \times 0.31)} = 1.74$ m s^{-1} so $v_X^2 = 1.74^2 + 2 \times 9.81 \times 0.62$ $v_X = 3.9$ m s^{-1} (which is greater than 3.8 m s^{-1}) so no	**(A1)**
(d)	acceleration is independent of mass so makes no difference **or** mass cancels in the equation so makes no difference	**B1**

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3. 9702_w21_MS_43 Q: 1

	Answer	Marks
(a)	constant speed **or** constant magnitude of velocity	**B1**
	acceleration (always) perpendicular to velocity	**B1**
(b)(i)	$F = mv^2 / r$ **or** $v = r\omega$ **and** $F = mr\omega^2$	**C1**
	$F = 790 \times 94^2 / 318$ $= 22\,000$ N	**A1**
(b)(ii)	centripetal acceleration: same	**B1**
	maximum speed: greater	**B1**
	time taken for one lap of the track: greater	**B1**

4. 9702_s20_MS_41 Q: 1

	Answer	Marks
(a)	force acting between two masses **or** force on mass due to another mass **or** force on mass in a gravitational field	**B1**
(b)	arc length = $r\theta$ $d = 1.5 \times 10^{17} \times 1.2 \times 10^{-5} = 1.8 \times 10^{12}$ m	**A1**
(c)(i)	$\omega = 2\pi / T$	**C1**
	$= 2\pi / (44.2 \times 365 \times 24 \times 3600)$ $= 4.5 \times 10^{-9}$ rad s^{-1}	**A1**
(c)(ii)	gravitational forces are equal **or** centripetal force about P is the same	**C1**
	$M_1 x\omega^2 = M_2(d - x)\omega^2$ so $M_1 / M_2 = (d - x) / x$	**A1**
(c)(iii)	$x = 0.4d$	**C1**
	$6.67 \times 10^{-11} \times M_1 = (1.0 - 0.4) \times (1.8 \times 10^{12})^3 \times (4.5 \times 10^{-9})^2$	**C1**
	$M_1 = 1.1 \times 10^{30}$ kg	**A1**

Q1.

1	(a)	(i)	angle (subtended) at centre of circle	B1	
			by an arc equal in length to the radius (of the circle)	B1	[2]
		(ii)	angle swept out per unit time / rate of change of angle	M1	
			by the string	A1	[2]
	(b)		friction provides / equals the centripetal force	B1	
			$0.72\,W = md\omega^2$	C1	
			$0.72\,mg = m \times 0.35\omega^2$		
			$\omega = 4.49$ (rad s^{-1})	C1	
			$n = (\omega/2\pi) \times 60$	B1	
			$= 43$ min^{-1} (allow 42)	A1	[5]
	(c)		*either* centripetal force increases as r increases		
			or centripetal force larger at edge	M1	
			so flies off at edge first	A1	[2]
			($F = mr\omega^2$ so edge first – treat as special case and allow one mark)		

Q2.

4	(a)	(i)	$(\theta =)\ \omega t$ *(allow any subject if all terms given)*	B1	[1]
		(ii)	(SQ =) $r \sin\omega t$ *(allow any subject if all terms given)*	B1	[1]
	(b)		this is the solution of the equation $a = -\omega^2 x$	M1	
			$a = -\omega^2 x$ is the (defining) equation of s.h.m.	A1	[2]
	(c)	(i)	$f = \omega / 2\pi$	C1	
			$= 4.7 / 2\pi$		
			$= 0.75$ Hz	A1	[2]
		(ii)	$v = r\omega$ (r must be identified)	C1	
			$= 4.7 \times 12$		
			$= 56$ cm s^{-1}	A1	[2]

Q3.

1	(a)		angle (subtended) at centre 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	
			$\omega = 7.6$ rad s^{-1}	A1	[4]

Q4.

1 (a) θ (rad) $= 2\pi \times (10.3/360)$ 1
$= 0.180$ rad (n.b. 3 sig. fig.) 1 **[2]**

(b) (i) $\tan\theta = 0.182$ (n.b. 3 sig. fig.) 1

(ii) percentage error $= (0.002/0.180) \times 100$ 1

$= 1.1$ (%) 1 **[3]**

(allow 0.002/0.182 and allow 1→ 4 sig. fig.)

Q5.

1 (a) (i) angle subtended at centre of circle B1
arc equal in length to the radius ..... B1 [2]

(ii) arc = $r\theta$ and for one revolution, arc = $2\pi r$ M1
so, $\theta = 2\pi r/r = 2\pi$ ..... A0 [1]

(b) (i) *either* weight provides/equals the centripetal force
or acceleration of free fall is centripetal acceleration B1
$9.8 = 0.13 \times \omega^2$ M1
$\omega = 8.7$ rad s^{-1} ..... A0 [2]

(ii) force in cord = weight + centripetal force (*can be an equation*) C1
force in cord = $(L - 13) \times 5/1.8$ *or* force constant = $5.0/1.8$ C1
$(L - 13) \times 5/1.8 = 5.0 + 5/9.8 \times L \times 10^{-2} \times 8.7^2$ C1
$L = 17.2$ cm ..... A1 [4]
(*constant centripetal force of 5.0 N gives L = 16.6 cm allow 2/4*)

Q6.

7 (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 $= 3.8 \times 10^5 \times 9.7 \times 10^{-6}$
$= 3.7$ km A1 [2]

(ii) Mars is (much) further from Earth / away (*answer must be comparative*) B1
angle (at telescope is much) smaller B1 [2]

Q7.

2	(a)	(i)	$F = R\cos\theta$	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]