12. Motion in a Circle

12.2 Centripetal acceleration

Paper 4

Marking Scheme

Q1.

(b)(ii)	arrow, labelled A, pointing in NW direction	**B1**
(c)(ii)	$a = v^2 / r$ **or** $a = r\omega^2$	**C1**
	$a = 0.68^2 / (0.093 - 0.012)$ **or** $(0.093 - 0.012) \times 8.4^2$ $= 5.7\ \text{m s}^{-2}$	**A1**

Q2.

(a)(ii)	$a = r\omega^2$ **or** $a = v^2 / r$	**C1**
	$a = 0.85 \times 140^2$ **or** $120^2 / 0.85$ $= 1.7 \times 10^4\ \text{m s}^{-2}$	**A1**

Q3.

(a)	horizontal force on sphere causes centripetal acceleration	**B1**
	weight of sphere is (now) equal to vertical component of tension **or** horizontal and vertical components (of force) (now) combine to give greater tension (in spring)	**B1**
	greater tension in spring so greater extension of spring	**B1**
(b)(i)	$r = 10.8 \times \sin 27° = 4.9\ \text{cm}$	**A1**
(b)(ii)	$T \cos \theta = mg$ **or** $T \cos \theta = W$ **and** $W = mg$	**C1**
	$T \cos 27° = 0.29 \times 9.81$ leading to $T = 3.2\ \text{N}$	**A1**
(b)(iii)	$\Delta T = 3.2 - (0.29 \times 9.81)$	**C1**
	$k = \Delta T / \Delta x$ $= [3.2 - (0.29 \times 9.81)] / [10.8 - 8.5]$ $= 0.15\ \text{N cm}^{-1}$	**A1**
(c)(i)	centripetal acceleration $= (T \sin \theta) / m$ $= (3.2 \times \sin 27°) / 0.29$	**C1**
	$= 5.0\ \text{m s}^{-2}$	**A1**
(c)(ii)	$a = r\omega^2$ **and** $\omega = 2\pi / T$ **or** $a = v^2 / r$ **and** $v = 2\pi r / T$	**C1**
	$T = 2\pi \times \sqrt{(0.049 / 5.0)}$ $= 0.62\ \text{s}$	**A1**

Q4.

(c)(iii)	$a = r\omega^2$	**C1**
	$= 0.18 \times (1.745 \times 10^{-3})^2$ $= 5.5 \times 10^{-7}\ \text{m s}^{-2}$	**A1**
(d)	centripetal acceleration is negligible compared with acceleration of free fall **or** numerical comparison establishing answer to **(c)(iii)** $\ll 9.81$	**B1**
	resultant force is negligible compared with weight (of modelling clay) (so variation is negligible) **or** force exerted by minute hand (approximately) equal (and opposite) to weight of modelling clay	**B1**

Q5.

(b)(i)	(electric) force is perpendicular to velocity (of particles)	**B1**
	force (perpendicular to velocity) causes centripetal acceleration **or** force does not change the speed of the particles **or** force has constant magnitude	**B1**
(b)(iii)	$F = mr\omega^2$ **and** $\omega = 2\pi / T$ **or** $F = mv^2 / r$ **and** $v = 2\pi r / T$	**C1**
	$F = 4\pi^2 mr / T^2$ $T = \sqrt{[4\pi^2 \times 9.11 \times 10^{-31} \times 1.59 \times 10^{-10} / (2.28 \times 10^{-9})]}$	**C1**
	$= 1.58 \times 10^{-15}$ s	**A1**

Q6.

(c)(i)	$T = 24$ hours	**C1**
	$a = r\omega^2$ **and** $\omega = 2\pi / T$ **or** $a = v^2 / r$ **and** $v = 2\pi r / T$ **or** $a = 4\pi^2 r / T^2$	**C1**
	$a = (4\pi^2 \times 6.4 \times 10^6) / (24 \times 60 \times 60)^2$ $= 0.034$ m s^{-2}	**A1**
(c)(ii)	identification of the two forces acting on the object as gravitational force and (normal) contact force	**M1**
	gravitational force and normal contact force are in opposite directions, and their resultant causes the (centripetal) acceleration	**A1**

Q7.

(b)(ii)	$a = r\omega^2$ **and** $\omega = 2\pi / T$ **or** $a = v^2 / r$ **and** $v = 2\pi r / T$	**C1**
	$a = 3.39 \times 10^6 \times (2\pi / (24.6 \times 3600))^2$ $= 0.0171$ m s^{-2}	**A1**

Q8.

(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**

Q9.

(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**

Q10.

(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**

Q11.

(b)(i)	velocity changes/direction of motion changes/there is an acceleration/there is a resultant force so not in equilibrium	**B1**