Answers: Circular Motion

1.

(a)	Vertical arrows in opposite directions in correct positions	1	
	Labelled weight/mg and tension/T	1	**[2]**
(b)	Two forces, one vertical, the other along string, correctly labelled, ecf (a)	1	
	Resultant force/vector sum of the tension and weight/forces is a horizontal force/ (component of) tension provides horizontal force;	1	
	acting towards centre of rotation/axis	1	**[3]**
(c)	**(i)** $v = 2\pi rf$ or $2\pi r/T$	1	
	$=2\pi \times 0.05 \times 1.2 = 0.38$ (m s^{-1})	1	
	(ii) $F = mv^2/r$	1	
	$F = 0.02 \times 0.377^2 / 0.05$; $= 0.057$ (N) ecf	2	**[5]**
(d)	Moves in circle of larger diameter/ longer path	1	
	Larger centripetal force/acceleration is required at higher speed	1	
	Provided by larger horizontal component of tension/greater angle of string to axis	1	**[3]**

2. (You can skip this question now and come back after we study 'Gravitational Fields'.)

a	**i**	Arrows of equal length towards; and directed through centre of orbit	**2**
	ii	For circular orbit centripetal force required; force of attraction is along line joining stars which must therefore be diameter of circle/AW	**2**
b		F : force (of attraction) between M's/stars G : gravitational constant/AW M : mass of a star R : radius of orbit (of star system) *1 mark for 2 correct; 2 marks for all 4*	**2**
c	**i**	v = distance/time or circumference of circle/period = $2\pi R/T$;	**1**
	ii	$F = mv^2/r$ or Mv^2/R; so $F = 4\pi^2MR/T^2$	**2**
	iii	$F = GM^2/4R^2 = 4\pi^2MR/T^2$; suitable algebra to show $M = 16\pi^2 R^3/GT^2$	**2**
d		$M = 16 \times 9.87 \times (5 \times 10^{10})^3/6.67 \times 10^{-11} \times (8.64 \times 10^6)^2$ 1 giving $M = 4.0 \times 10^{30}$ (kg) *possible ecf from b(i)* 1	**2**

3.

a	**i**	vertical arrow through seat labelled weight/W/mg	**1**
		arrow upwards along chain labelled tension/T	**1**
	ii	resultant/unbalanced force/vector sum of tension and	**1**
		weight/(horizontal) component of tension; directed/acting towards centre of circle/rotation/axis/pillar	**1**
	iii	$F = mv^2/r$	**1**

b	**i**	$a = 3.528\ (m\ s^{-2})$ or $T \sin \theta = mv^2/r$ and/or $T \cos \theta = mg$ $\tan \theta = v^2/rg$ or $4.2^2/5 \times 9.8$; $= 0.36$ (giving $\theta = 19.8^o$) *max 4 marks*	**1** **1** **2**	
	ii	No change as mass cancels out in b(i)/angle is independent of mass	**1**	**5**

4.

a	i	arrows to show *R* (or *N*) vertically up and *mg* (or *W*) vertically down and along the same line (within ± 2 mm) ✓	**1**
a	ii	$mg - R = \frac{mv^2}{r}$ ∴ $R = mg - \frac{mv^2}{r}$ ✓ $\left[= m\left(g - \frac{v^2}{r}\right)\right]$	**1**
a	iii	**use of** $R = m\left(g - \frac{v^2}{r}\right)$ gives $R = 12\left(9.81 - \frac{11^2}{23}\right)$ ✓ = 55 (54.6) (N) ✓	**2**
b		*R* decreases (as *v* increases) ✓ because *mg* is unchanged but $\frac{mv^2}{r}$ is larger ✓ at higher speeds *R* becomes = 0 [**or** package is not in contact with the floor] ✓ supported by calculation eg when $v = 15\ m\ s^{-1}$, $R = 0.33$ N (or ≈ 0) ✓	**max 3**

5.

(a) Resultant force required

The direction of speed OR velocity is changing ✓

There is an acceleration/rate of change in momentum ✓ **2**

(b)(i) Angular speed

Use of an angle divided by a time ✓

7.3×10^{-5} rad s^{-1} OR 0.26 rad h^{-1} OR $4.2 \times 10^{-3\ o}$ s^{-1} OR 15^o h^{-1} ✓ **2**

(ii) Resultant force on student

Use of $F = mr\omega^2$ OR $v = r\omega$ with $F = \frac{mv^2}{r}$ ✓

2.0 N ✓ **2**

(iii) Scale reading

Evidence of contact force = mg – resultant force	✓	
Weight of girl = 588 (N) OR 589 (N) OR 60 × 9.81 (N)	✓	
Scale reading = 586 N OR 587 N [ecf their mg − their F]	✓	**3**

6.

(a) Radius of circular path

Correct use of $v = \frac{2\pi r}{T}$ (allow substitution of their T)	✓	
Radius = 70 – 80 m (74.48 m)	✓	**(2)**

(b) Resultant force

$F = \frac{mv^2}{r}$ [seen or used]	✓	
Force = 0.08 N (0.077 N) [Allow ecf of their radius.]	✓	
Towards the centre of the circular path / towards hub.	✓	**(3)**

(c) Forces on the man

(i)

Force P : Normal contact/reaction force / EM force / push of capsule or floor on man	✓	
Force Q : Pull of Earth on man / weight / gravitational pull	✓	**(2)**

(ii)

Resultant force (to centre)	✓	
(at A provided by) friction	✓	**(2)**

(iii)

at B resultant provided (by force Q being greater than P)	✓	**(1)**

7.

Explanation

There is a resultant (or net or unbalanced) force	✓	
Plus any 3 of following:-		
Direction of motion is changing	✓	
Velocity is changing	✓	
Velocity change implies acceleration	✓	
Force produces acceleration by $F = ma$ (or N2)	✓	
Force (or acceleration) is towards centre / there is a centripetal force (or acceleration) / no force (or acceleration) parallel to motion	✓	
No work done, so speed is constant	✓	**Max 3**
		4
