1 A coin, of mass 0.01 kg, is placed on a horizontal turntable. The coin is at a distance of 50 cm from the centre of the turntable. The coefficient of friction between the coin and the turntable is 0.4. The turntable rotates about its centre, so that the coin follows a circular path at a constant speed, without slipping.

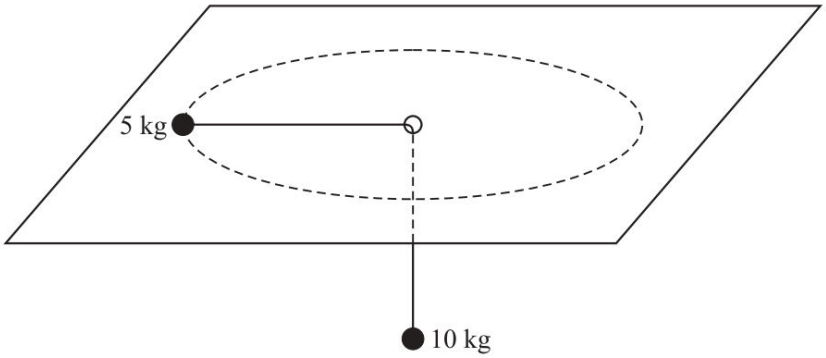
(a) Calculate the maximum magnitude of the friction force acting on the coin. *(2 marks)*

(b) Find the maximum angular speed of the turntable in revolutions per minute. *(4 marks)*

(c) The angular speed of the turntable is halved. What happens to the magnitude of the friction force acting on the coin? *(1 mark)*

Question Number and part	Solution	Marks	Total Marks	Comments
1(a)	$F = 0.4 \times 9.8 \times 0.01 = 0.0392\,\text{N}$	M1 A1	2	Use of $F = \mu R$
(b)	$0.0392 = 0.01 \times 0.5\omega^2$	M1		Use of $F = mr\omega^2$
	$\omega = \sqrt{\dfrac{0.0392}{0.005}} = 2.8\,\text{rad s}^{-1}$	A1		
	$= \dfrac{2.8 \times 60}{2\pi} = 26.7\,\text{rpm}$	A1 A1	4	Correct conversion factor
(c)	It would be reduced by a factor of 4	B1	1	
	Total		**7**	

2 Two particles are connected by a light, inextensible string. One particle, which has mass 5 kg, follows a circular path of radius 70 cm, on a smooth horizontal table. The string passes through a hole in the table and a second particle, of mass 10 kg, hangs in equilibrium on the other end of the string as shown in the diagram.



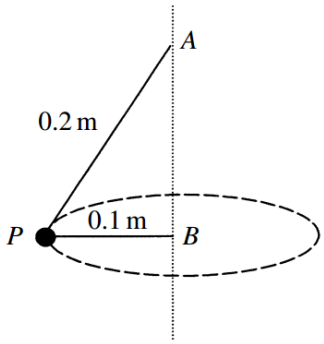
(a) By considering the 10 kg particle, calculate the tension in the string. *(2 marks)*

(b) Find the speed of the particle on the table. *(4 marks)*

(c) The string breaks. Describe what happens to the particle on the table. *(2 marks)*

2 (a)	$T = 10 \times 9.8 = 98$ N	M1 A1	 2	Use of $T = mg$ Correct T (Allow $g = 10$)
(b)	$\frac{5v^2}{0.7} = 98$	M1 A1		Use of $\frac{mv^2}{r}$ or $mr\omega^2$ in Newton's second law (2 terms) Correct equation
	$v = 3.70\,\text{m s}^{-1}$	M1 A1	 4	Finding v Correct v Allow 3.7
(c)	Straight line along a tangent to the circle	B1 B1	 2	For tangent For constant speed or straight line
	Total		**8**	

6 A particle, P, of mass 2 kg, is attached to two strings of lengths 0.2 metres and 0.1 metres. The strings are fixed to the particle and to the points A and B respectively. The point A is directly above the point B. The particle describes a horizontal circle, centre B and radius 0.1 metres, at a speed of $4\,\text{m}\,\text{s}^{-1}$. The particle and strings are shown in the diagram.



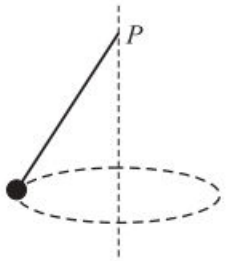
(a) Calculate the magnitude of the acceleration of the particle. *(2 marks)*

(b) Find the tension in the upper string. *(4 marks)*

(c) Find the tension in the lower string. *(5 marks)*

6(a)	$a = \frac{4^2}{0.1} = 160\ \text{ms}^{-2}$	M1 A1	2	Calculating the acceleration Correct acceleration
(b)	$\cos\theta = \frac{\sqrt{30}}{20} = \frac{\sqrt{3}}{2}$	B1		Identifying trig value
	$T_1\cos\theta = 2\times 9.8$	M1 A1		Resolving horizontally Correct equation
	$T_1 = \frac{2}{\sqrt{3}}\times 2\times 9.8 = 22.6\ \text{N}$	A1	4	Correct force
(c)	$\sin\theta = \frac{1}{2}$	B1		Identifying trig value
	$T_1\sin\theta + T_2 = 2\times 160$	M1 A1		Resolving horizontally Correct equation
	$T_2 = 320 - \frac{39.2}{\sqrt{3}}\times\frac{1}{2} = 309\ \text{N}$	m1 A1	5	Substituting and solving Correct force
	Total		**11**	

6 A particle, of mass m, is attached to one end of a light, inextensible string of length l. The other end of the string is fixed at P. The particle moves in a horizontal circle of radius r at a constant speed v, as shown below.



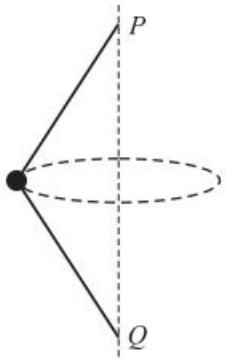
(a) Show that the tension in the string, T, is given by

$$T = \frac{mgl}{\sqrt{l^2 - r^2}}$$

(4 marks)

(b) Find v^2 in terms of r, g and l. *(5 marks)*

(c) A second light, inextensible string, of length l, is then attached to the particle and to Q, a fixed point directly below P, as shown in the diagram below. The particle moves in a horizontal circle of radius r at a constant speed V, with both strings taut.



Find the tension in the upper string in terms of m, g, l, r and V. *(6 marks)*

6(a)	$T\cos\theta = mg$	M1 A1		Resolves vertically
	$T\dfrac{\sqrt{l^2-r^2}}{l} = mg$	M1		Finds value for $\cos\theta$
	$T = \dfrac{mgl}{\sqrt{l^2-r^2}}$	A1	4	
(b)	$T\sin\theta = \dfrac{mv^2}{r}$	M1 A1		Resolves horizontally
	$\dfrac{mgl}{\sqrt{l^2-r^2}} \times \dfrac{r}{l} = \dfrac{mv^2}{r}$	M1		Finds value for $\sin\theta$
	$v^2 = \dfrac{gr^2}{\sqrt{l^2-r^2}}$	M1 A1	5	Solves for v
(c)	$T_1\sin\theta + T_2\sin\theta = \dfrac{mv^2}{r}$	M1 A1		Horizontal equation
	$T_1 + T_2 = \dfrac{mlv^2}{r^2}$			
	$T_1\cos\theta = T_2\cos\theta + mg$	M1 A1		Vertical equation
	$T_1 - T_2 = \dfrac{glm}{\sqrt{l^2-r^2}}$			
	$2T_1 = ml\left(\dfrac{v^2}{r^2} + \dfrac{g}{\sqrt{l^2-r^2}}\right)$	M1		Solves for T_1
	$T_1 = \dfrac{ml}{2}\left(\dfrac{v^2}{r^2} + \dfrac{g}{\sqrt{l^2-r^2}}\right)$	A1	6	
	Total		**15**	