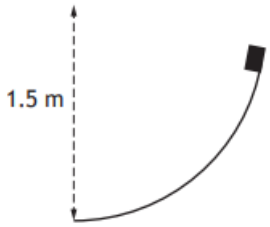
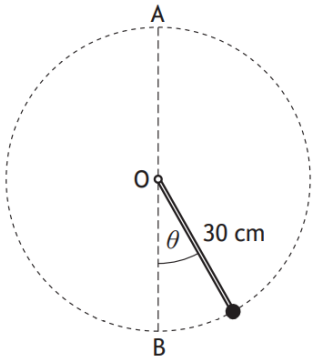
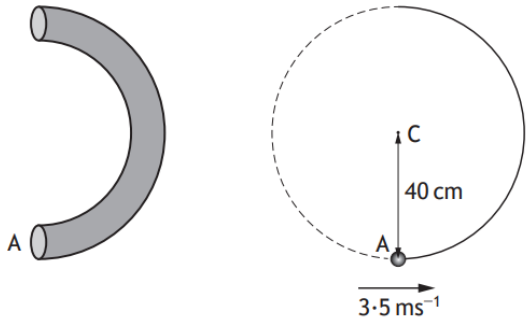
Y	Q	Work, Energy and Power
24	10	An object slides from rest down a smooth ramp which forms a circular arc of radius 1.5 metres.  The object travels a distance of 2.1 metres to reach the bottom of the ramp. Determine the speed of the object after travelling this distance. **4**
24	16	A motorised sledge of mass m kg is travelling along a rough horizontal track with instantaneous acceleration a m s^{-2}. The engine is working at a constant rate of P watts and the coefficient of friction is 0.1. (a) When the instantaneous velocity of the sledge is V m s^{-1}, show that $$P = mV(a + 0.1g)$$ **2** The sledge now ascends a slope of 30° to the horizontal with the same coefficient of friction. The engine now works at a rate of $3P$ watts. At a particular instant, both the instantaneous acceleration a m s^{-2} and the instantaneous velocity V m s^{-1} have the same values as they did when the sledge was travelling on the horizontal track. (b) Calculate the acceleration at this instant. **4**
23	11	A force $\mathbf{F} = 0.3\mathbf{i} + 0.5\mathbf{j}$ moves a body between two points on the $x\,y$ plane with coordinates (16, 4) and (12, 20). The force is given in newtons, and distances are given in metres. (a) Calculate the work done by the force $\mathbf{F}$. **2** (b) Hence find the component of the force in the direction of the displacement. **2**
23	15	A bullet of mass m kg is fired at a block of wood of mass M kg which hangs vertically and at rest at the end of a light inextensible string. The bullet enters the block horizontally while travelling at a speed of u m s^{-1}, and becomes embedded in the block. The block then swings until it reaches a height h metres above its original position. Show that $h = \frac{1}{2g}\left(\frac{mu}{M+m}\right)^2$. **5**

22	10	A particle of mass 0.1 kg is suspended from a fixed point O by a light inextensible rod of length 30 cm. The rod is rotating in a vertical circle with diameter AB and makes an angle θ with OB. The particle has a speed of 1.2 m s^{-1} at A.  (a) Use conservation of energy to find the speed of the particle at B. (b) Find the tension in the rod when the particle is at A and interpret your answer. (c) Find the size of the angle θ when the tension in the rod is zero.	2 3 5
22	14	A particle of mass 5 kg is initially at rest. It is projected horizontally from an origin, O, along the positive direction of the x-axis. The particle moves with variable acceleration given by $a = (15 + x - 2x^2)\,\text{m s}^{-2}$, $x \geq 0$ where x is measured in metres. (a) Calculate the displacement from O at which the particle reaches its maximum speed. (b) (i) Calculate the work done in reaching this maximum speed. (ii) Hence, or otherwise, calculate the maximum speed.	2 3 2
22	16	A particle of mass 0.1 kg is launched at an acute angle to the horizontal, from the origin, with a kinetic energy of 20 joules. It moves in a vertical x-y plane under the influence of gravity and there is no resistance to motion. (a) Find the speed of the particle when it is at a height of 10 metres. (b) Find the height of the particle when it has a velocity of $\begin{pmatrix} 4 \\ 5 \end{pmatrix}\text{m s}^{-1}$. (c) Determine the kinetic energy of the particle at its maximum height.	2 2 1
19	13	A body of mass m kilograms is projected with speed $V\,\text{m s}^{-1}$ up a rough plane inclined at an angle θ to the horizontal. The body comes to rest after travelling a distance of s metres up the slope. The coefficient of friction between the body and the slope is μ. (a) Show that $s = \dfrac{V^2}{2g(\mu\cos\theta + \sin\theta)}$. (b) Given that the work done against friction is equal to $\frac{1}{8}mV^2$ joules, find an expression for μ in terms of θ.	4 3

19	14	A vertical semicircle of radius 40 cm is formed from a length of smooth pipe as shown in the diagram. A ball is projected with a speed of $3{\cdot}5\,\text{m s}^{-1}$ from A, the bottom of the semicircle.  The centre of the circular path is the point C and the ball comes to instantaneous rest at a point P. (a) Find the size of angle PCA. **4** The ball is projected from A again with an initial speed of u metres per second. (b) Determine the restriction on u required for the ball to exit at the top of the pipe. **3** (c) Given that the ball acts as a particle, state another assumption that has been made about the ball in your solution. **1**	
17	9	A body of mass 20 kg is moving along a rough horizontal surface with speed $12\,\text{m s}^{-1}$. As it passes through a point P, a horizontal force $F=\left(249-50\sqrt{x}\right)$ newtons is applied, where x metres is the displacement of the body from P. Given that the coefficient of friction between the body and the surface is 0·25: (a) find the work done on the body in the first 10 metres of its motion from P **4** (b) find the speed of the body after travelling 10 metres from P. **2**	
16	3	A constant force $\mathbf{F}=(2\mathbf{i}+3\mathbf{j})$ N acts on a particle as it moves in a straight line from point A to point B with position vectors $(-3\mathbf{i}+\mathbf{j})$ metres and $(6\mathbf{i}+4\mathbf{j})$ metres respectively. Calculate the work done by the force. **3**	
16	7	An object of mass 9 kg starts from rest at an origin and moves in a straight line so that its acceleration in m s^{-2} is given as $a=4-\sqrt{t}$, where t is the time in seconds. Calculate its maximum speed and hence the increase in kinetic energy. **4**	
16 Sp	3	A cyclist climbs a hill of length 2·4 km and constant gradient 1:25 in 12 minutes. When cycling at a constant speed of $v\,\text{m s}^{-1}$, the external resistances to motion are $(10{\cdot}5+0{\cdot}4v^2)$ N. Given that the total mass of the cyclist and bike is 66 kg, calculate the power produced by the cyclist. **4**	
16 Sp	8	A stone of mass 0·25 kg moves along a smooth horizontal surface. It passes a fixed point O with a velocity of $3\mathbf{i}\,\text{m s}^{-1}$. When it is at a distance x metres from O, a force of magnitude $(2\sin x+5)\mathbf{i}$ N acts on it along the line of movement. (a) Calculate the work done by the force in moving the stone 3 metres beyond O. **2** (b) Find the speed of the stone at this point. **2**	