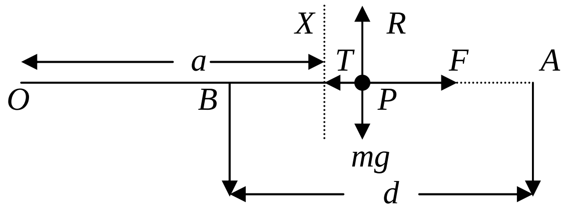
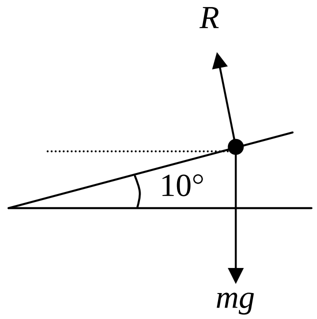
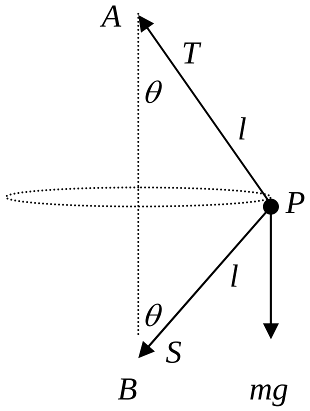
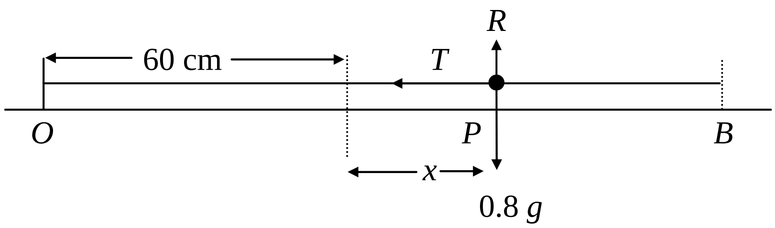
Question Number	Scheme	Marks
1.	 $R = mg$	B1
	$F = \mu R = \mu mg$	B1
	Attempt to relate Fd to EPE	M1
	$\frac{2}{3}\ mg\ d = \dfrac{4mg(\frac{a}{2})^2}{2a}$	M1 A1 ft
	Final answer: $d = \frac{3}{4}a$	A1 (6)
		(6 marks)
2.	 ($\updownarrow$) $R\cos 10° = mg$	M1 A1
	($\leftrightarrow$) $R\sin 10° = \dfrac{mv^2}{r}$	M1 A1ft
	Solving for r: $r = \left[\dfrac{18^2}{g\tan 10^\circ}\right]$	M1
	$r = 190$ (m) [Accept 187, 188]	A1 (6)
		(6 marks)
3. (*a*)	$\frac{1}{10}x(4 - 3x) = 0.2\,a$	M1 A1
	$\frac{1}{10}x(4 - 3x) = 0.2v\dfrac{dv}{dx}$ or $\frac{1}{10}x(4 - 3x) = 0.2\dfrac{d(\frac{1}{2}v^2)}{dx}$	M1
	Integrating : $v^2 = 2x^2 - x^3$ (+ C) or equivalent	M1 A1
	Substituting $x = 6$, $v = 0$ to find candidate's C	M1
	$v^2 = 2x^2 - x^3 + 144$	A1 (7)
(*b*)	Substituting $x = 0$ and finding v; $v = 12$ (m s^{-1})	M1; A1 ft (2)
		(9 marks)

(ft = follow through mark)

Question Number	Scheme	Marks
4. (*a*)		
	(↕) $(T - S)\cos\theta = mg$	M1 A1
	(↔) $(T + S)\sin\theta = mr\omega^2$	M1 A1 ft
	$= m(l\sin\theta)\omega^2$	A1
	Finding T in terms of l, m, ω^2 and g	M1
	$T = \frac{1}{6}m(3l\omega^2 + 4g)$ (*)	A1 (7)
(*b*)	$S = \frac{1}{6}m(3l\omega^2 - 4g)$ any correct form	M1 A1 (2)
(*c*)	Setting $S \geq 0$; $\omega^2 \geq \dfrac{4g}{3l}$ (*) (no wrong working seen)	M1 A1 (2)
		(11 marks)
5. (*a*)	 $\lambda = 12$ N $OB = 85$ cm	
	Hooke's Law: $T = \dfrac{12x}{0.6}$ [= 20x]	M1
	Equation of motion: $(-)T = 0.8\ddot{x}$	M1
	$-\dfrac{12x}{0.6} = 0.8\ddot{x}$ $\ddot{x} = -25x$	A1
	Finding ω from derived equation of form $\ddot{x} = -\omega^2 x$	M1
	Period = $\dfrac{2\pi}{\omega} = \dfrac{2\pi}{5}$ (*) no incorrect working seen	A1 (5)
(*b*)	Substituting (candidate's) ω and a in $\omega^2 a$; $= 25 \times 0.25 = 6.25$ (m s^{-2})	M1; A1 (2)
	(or finding $T_{max} = 0.8a \Rightarrow a = 5/0.8 = 6.25$)	
(*c*)	Complete method for x; $x = 0.25\cos 10°$ (–0.2098)	M1 A1
	Using $v^2 = \omega^2(a^2 - x^2) \Rightarrow v = (\pm)5\sqrt{[(0.25)^2 - (0.25\cos 10°)]}$	M1 A1 ft
	$v = (\pm)\ 0.68$ (m s^{-1})	A1 (5)
(*d*)	Direction $\overrightarrow{OB}$ or equivalent	B1 (1)
		(13 marks)

(ft = follow through mark; (*) indicates final line is given on the paper)

Question Number	Scheme	Marks
6. (*a*)	Energy: $\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = mga(1 - \cos\theta)$	M1 A1 A1
	Radial: $(\pm R) + mg\cos\theta = \dfrac{mv^2}{a}$	M1 A1
	Eliminating v and finding $\cos\theta =$, $\dfrac{u^2 + 2ga}{3ga}$	M1, A1 (7)
(*b*)	Energy (C and ground): $\frac{1}{2}m\left(\dfrac{9ag}{2}\right) - \frac{1}{2}mv^2 = mga(1 = \cos\theta)$	M1 A1
	Eliminating v: $\frac{1}{2}m\left(\dfrac{9ag}{2}\right) - \frac{1}{2}mag\cos\theta = mga(1 + \cos\theta)$	M1 A1
	$\cos\theta = \frac{5}{6}$	M1 A1 ft
	$\theta = 34°$	A1 (7)
		(14 marks)
Alt (*b*)	Or energy (A and ground): $\frac{1}{2}m\left(\dfrac{9ag}{2}\right) - \frac{1}{2}mu^2 = 2mga$	M1 A1
	$u^2 = \frac{1}{2}ga$	M1 A1
	Using with (*a*) to find $\cos\theta = \frac{5}{6}$; $\theta = 34°$	M1 A1; A1 (7)
Alt	Projectile approach: $V_x = v\cos\theta$; $V_y^2 = (v\sin\theta)^2 + 2ga(1 + \cos\theta)$ $\left(\dfrac{9ag}{2}\right) = V_x^2 + V_y^2 \Rightarrow \left(\dfrac{9ag}{2}\right) - v^2 = 2ga(1 + \cos\theta)$ – M1 A1, then scheme	

(ft = follow through mark)

Question Number	Scheme	Marks
7. (*a*)	$V = \pi \int y^2 \;\mathrm{d}x = \tfrac{1}{4}\pi \int (x-2)^4 \mathrm{d}x$	M1
	$\int (x-2)^4 \mathrm{d}x = \tfrac{1}{5}(x-2)^5$	M1 A1
	$V = \dfrac{8\pi}{5}$	A1 (4)
(*b*)	Using $\pi \int xy^2 \;\mathrm{d}x = \tfrac{1}{4}\pi \int x(x-2)^4 \mathrm{d}x$	M1
	Correct strategy to integrate [e.g. substitution, expand, by parts]	M1
	[e.g. $\tfrac{1}{4}\pi \int (u-2)^4 \mathrm{d}u$; $\tfrac{1}{4}\pi \int (x^5 - 8x^4 + 24x^3 - 32x^2 + 16x)\,\mathrm{d}x$]	
	$= \tfrac{1}{4}\pi\left[\dfrac{2u^5}{5} + \dfrac{u^6}{6}\right]$ or $\tfrac{1}{4}\pi\left[\dfrac{x^6}{6} - \dfrac{8x^5}{5} + 6x^4 - \dfrac{32x^3}{3} + 8x^2\right]$	M1 A1
	$= \dfrac{8\pi}{15}$ limits need to be used correctly	A1 (7)
	$V_c\,(\rho)\,\bar{x} = \pi(\rho)\int xy^2 \;\mathrm{d}x$ seen anywhere	M1
	$\bar{x} = \tfrac{1}{3}$ cm (*) no incorrect working seen	A1
(*c*)	Moments about *B*: $8A = 10W - 2W(\tfrac{1}{3})$	M1 A1 A1
	$A = \dfrac{59W}{12}$ $(4.9W)$	M1 A1 (5)
		(16 marks)

(ft = follow through mark; (*) indicates final line is given on the paper)