Question		Answer	Marks	AO	Guidance	
12	(a)	$0=(39\sin\theta)^2+2(-10)h$	M1	3.3	Using $v^2=u^2+2as$ with $v = 0$, $a = \pm10$ or ±9.8 or $\pm g$, and $u=39\sin\theta$ or $u=39\cos\theta$. Accept any other complete method (using correct suvat equations) to find the maximum height e.g. $0=39\sin\theta-10t$ **and** with t then substituted into $s=(39\sin\theta)t+0.5(-10)t^2$	**Condone $g = 9.8$ for full marks in (a) and (b)**
		$0=\left(39\times\frac{5}{13}\right)^2+2(-10)h$	A1	1.1	A correct equation with the correct value of sin substituted **or** for $0=(39\sin(22.6...))^2+2(-10)h$	Allow using g (and not replaced with 10 or 9.8) for this **A** mark
		Max. height = 20 + h = 31.25 (m)	A1	2.2a	**www** • accept awrt 31.2 (using 22.6… as the angle and g = 10) • accept awrt 31.5 (coming from exact value of sin or 22.6… and g = 9.8) • condone 31.3 (**3** sf)	
			[3]			

Question		Answer	Marks	AO	Guidance	
12	**(b)**	$-20 = (39\sin\theta)T + \frac{1}{2}(-10)T^2$	**M1**	**3.3**	Applying $s = ut + \frac{1}{2}at^2$ with $s = \pm 20$, $a = \pm 10$ or ± 9.8 or $\pm g$ and $u = 39\sin\theta$ **or** $u = 39\cos\theta$	**Condone g = 9.8 for full marks in (a) and (b)** Accept any other complete method to find T
		$-20 = \left(39 \times \frac{5}{13}\right)T + \frac{1}{2}(-10)T^2$	**A1**	**1.1**	With correct value of sine or sin(22.6) Allow $-20 = \left(39 \times \frac{5}{13}\right)T + \frac{1}{2}(-9.8)T^2$	Allow using g (and not replaced with 10 or 9.8) for this **A** mark
		$T = 4$ **only**	**A1**	**1.1**	**BC** • accept awrt 4.07 (using g = 9.8 and exact value of sine) • accept awrt 4.06 (using g = 9.8 and 22.6…) • a value of 4(.00…) coming from 3.998… (using g = 10 and 22.6… for sine)	Condone $t = 4$
			[3]			

Question		Answer	Marks	AO	Guidance	
12	(c)	Examples of possible limitations • The ball will have dimensions/volume • The spin/rotational forces of the ball • A 1sf approx. to g was used • Other weather conditions (ignore wind and air resistance) • The ball is not a particle • g is modelled as a (universal) constant	**B1**	**3.5b**	Allow any correct limitation **B0** if referring to • Air resistance and/or wind (only) • The ground is unlikely to be horizontal (only) • The mass or weight or shape of P (only) • The angle/heights/speeds may not be as quoted (only) • Modelling the problem as 3D rather than in 2D (only) If multiple limitations given, and any are incorrect, then **B0**	
			[1]			

Question		Answer	Marks	AO	Guidance	
12	(d)	$a = 3kt^2 + 12t + \frac{3}{2}$	M1	3.4	Differentiate given v (at least two terms correct)	
		$BC = \left(39 \times \frac{12}{13}\right)'T'\ (=144)$	M1*	3.1b	Applying $s = ut$ horizontally to find distance BC with correct value of cos (or cos(22.6…)) and their value of T from **(b)**	Allow $g = 9.8$ which **if** correct leads to 146.34…
		$s = \frac{1}{4}kt^4 + 2t^3 + \frac{3}{4}t^2\ (+c)$	M1*	2.1	Integrate given v (at least two terms correct)	
		$\frac{1}{4}k(4)^4 + 2(4)^3 + \frac{3}{4}(4)^2 = 144$	M1dep*	3.4	Puts their integrated expression for s, with t = their T from **(b)**, equal to their distance for BC to form an equation in k only – **dependent on the two previous M marks only**	Must not include a $+c$ unless dealt with as part of a definite integral. However, if a $+c$ is included then subsequently ignored/set equal to zero without justification then give **bod** for this and any subsequent **A** marks (if earned)
		$k = \frac{1}{16}$	A1	1.1	Correct exact value for k (oe e.g. 0.0625)	**Final two marks can only be awarded if $g = 10$ used**
		$a = 52.5\ (\text{m s}^{-2})$	A1	2.2a	oe	
			[6]			