

<p><b>1</b></p>	$v^2 = 2 \times 9.8 \times 10$ $v = 14 \text{ m s}^{-1}$ speed = $\sqrt{7^2 + 14^2}$ 15.7 or $7\sqrt{5} \text{ m s}^{-1}$ $\tan^{-1}(14/7)$ or $\tan^{-1}(7/14)$ 63.4° to the horizontal	M1 A1 M1 A1 M1 A1 <b>6</b>	Using $v^2 = u^2 + 2as$ with $u = 0$  Method to find speed using their “v”  Method to find angle using their “v” 26.6° to vertical <b>6</b>
<p><b>2 (i)</b></p>	$(6\sin \Pi/2) \div (\Pi/2)$ 3.82	M1 A1 <b>2</b>	Use of correct formula <b>AG</b>
	<p><b>(ii)</b></p> $8\bar{d} = 3(6-3.82) + 5 \times 9.82$ or $8x = \pm\{3(-3.82) + 5 \times 3.82\}$ $\bar{d} = 6.95$ or $6.96$ or $x = \pm 0.955$ $\tan\theta = 0.96/6$ $\theta = 9^\circ$	M1 A1 A1 M1 A1 <b>5</b>	Method to find centre of mass  Attempt to find the required angle <b>7</b>
<p><b>3 (i)</b></p>	$D = 128\,000/80 (= 1600)$ $k(80)^2 = 128\,000/80$  $k = 1/4$ $R = 900 \text{ N}$	B1 M1 A1 A1 B1 <b>5</b>	Driving force = resistance  FT on their k ( $R = 3600k$ )
<p><b>(ii)</b></p>	$D = 128\,000 / 60 (= 2133\frac{1}{3})$ $2000 \times 9.8 \times \sin 2^\circ$ $6400/3 - 900 - 2000 \times 9.8 \times \sin 2^\circ = 2000a$ $a = 0.275 \text{ m s}^{-2}$	B1 B1 M1 A1 <b>4</b>	4 terms required <b>9</b>
<p><b>4 (i)</b></p>	$4T\cos 20^\circ = 5 \times g \times 2.5$  $T = 32.6 \text{ N}$	M1 A1 A1 <b>3</b>	Using moments; allow sin/cos mix Allow with omission of g
	<p><b>(ii)</b></p> $X = T\sin 20^\circ$ $X = 11.1$ FT $Y + T\cos 20^\circ = 5 \times g$ or $2.5Y = 1.5 \times T\cos 20$ or $4Y = 1.5 \times 5g$ $Y = 18.4$ FT  $R = \sqrt{X^2 + Y^2}$ or $\tan^{-1}(Y/X)$ or $\tan^{-1}(X/Y)$  $R = 21.5 \text{ N}$ $\theta = 58.8^\circ$ above the horizontal	M1 A1 M1 A1 M1 A1 A1 <b>7</b>	allow sin/cos mix FT their T  FT their T, but not from omission of g $X \neq 0, Y \neq 0$  or $31.2^\circ$ to left of vertical <b>10</b>

<p><b>5 (i)</b></p>	$T\cos 45^\circ + R\sin 45^\circ = mg$ $T\sin 45^\circ - R\cos 45^\circ = m\sin 45^\circ \omega^2$ $2T = \sqrt{2}mg + ml\omega^2$ $T = m/2(\sqrt{2}g + l\omega^2)$	<p>*M1 A1 *M1 A1 Dep*M1 A1 <b>6</b></p>	<p>3 terms 3 terms; <math>a = r \omega^2</math> Method to eliminate R <b>AG</b> www</p>
<p><b>(ii)</b></p>	$R = 0$ $2R = \sqrt{2}mg - ml\omega^2$ <p>or <math>T\cos 45^\circ = mg</math> or <math>T = ml\omega^2</math> Solve to find <math>\omega</math></p> $\omega = 4.16 \text{ rad s}^{-1}$	<p>B1 B1  M1  A1 <b>4</b></p>	<p>may be implied     <b>10</b></p>

<p><b>6 (i)</b></p>	$2mu = 2mv + 3mv$ $v = 2/5 u$	<p>M1 A1 A1 <b>3</b></p>	<p>Conservation of momentum Must be <math>v =</math></p>
<p><b>(ii)</b></p>	$e = (3v - v) / u$ $e = 4/5$	<p>M1 A1 <b>2</b></p>	<p>Using restitution <b>AG</b></p>
<p><b>(iii)</b></p>	$\text{Initial K.E.} = 9mv^2 / 2 = 18mu^2 / 25$ $\text{Final K.E.} = 9mv^2 / 8 = 9mu^2 / 50$ $\frac{1}{2} m (V)^2 = \text{Final K.E.}$ $V = 3 u / 5$	<p>B1 FT B1 FT M1 A1 <b>4</b></p>	<p>FT on their v from (i) FT on their v from (i)  <b>AG</b></p>
<p><b>(iv)</b></p>	$4mu / 5 - 3mu / 5 = 2mx + my$ $u / 5 = 2x + y$ $e = 4/5 = (y - x) / u$ $4u = 5y - 5x$ <p>solving 2 relevant equations</p> $x = -u/5 \quad y = 3u/5$ $y = 3u/5$ <p>away from wall (x) + towards wall (y)</p>	<p>M1 A1 FT M1 FT A1 M1 A1 A1 A1 <b>8</b></p>	<p>Conservation of momentum FT on their v from (i); aef Using restitution FT on their v from (i); aef  both <b>17</b></p>

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<p><b>7 (i)</b></p> <p><b>Or</b> last 4 marks of (i)</p>	<p><math>R = 0.2 \times 9.8 \times \cos 30^\circ (= 1.70)</math>  <math>F = 0.1 \times 9.8 \times \cos 30^\circ (= 0.849)</math> FT</p> <p><math>\frac{1}{2} \times 0.2 \times 11^2 - \frac{1}{2} \times 0.2 v^2 =</math>  <math>0.2 \times 9.8 \times 5 \sin 30 + 5 \times 0.849</math>  <math>v = 5.44 \text{ m s}^{-1}</math></p> <p><math>F + 0.2g \sin 30 = \pm 0.2a</math>  <math>a = \pm 9.1</math>  <math>v^2 = 11^2 + 2 \times a \times 5</math>  <math>v = 5.44 \text{ m s}^{-1}</math></p>	<p>B1 B1 M1 A1 A1 A1 <b>6</b> M1 A1 M1 A1</p>	<p>FT on their R, but not <math>R = 0.2g</math> Use of conservation of energy</p> <p><b>AG</b></p> <p>Use of N2L, 3 terms</p> <p>Complete method to find v</p>
<p><b>(ii)</b></p> <p><b>Or</b> first 5 marks of (ii)</p>	<p><math>t = 5 \cos 30^\circ / 5.44 \cos 30^\circ</math>  <math>t = 0.919 \text{ s}</math>  <math>u = 5.44 \sin 30^\circ (= 2.72)</math>  <math>s = 2.72 \times 0.919 - 4.9 \times 0.919^2</math>  <math>s = -1.6</math> (or better)                      Ht drop to C = <math>5 \sin 30^\circ = 2.5 \text{ m}</math>                      Ball does not hit the roof</p> <p><math>y = x \tan \theta - gx^2 \sec^2 \theta / 2V^2</math>                      substitute values  <math>V = 5.44 \quad \theta = 30^\circ \quad x = 5 \cos 30^\circ</math>  <math>y = 2.5 - 9.8 \times 25 \times 3 / 4 \times 4 / 3 / (2 \times 5.44^2)</math>  <math>y = -1.6</math> (or better)</p>	<p>M1 A1 B1 M1 A1 B1 A1 <b>7</b> B1 M1 A1 A1 A1</p>	<p>time to lateral position over C</p> <p>Ht dropped</p> <p><b>13</b></p> <p>all 3 correct</p>
<p><b>OR (ii)</b></p>	<p><math>u = 5.44 \sin 30^\circ (= 2.72)</math>  <math>-2.5 = 5.44 \sin 30 t - 4.9 t^2</math></p> <p><math>t = 1.04</math>  <math>x = 5.44 \cos 30 \times 1.04 = 4.9</math> (or better)                      Horizontal distance from B to C =  <math>5 \cos 30 = 4.3</math> (or better)                      Ball does not hit the roof</p>	<p>B1 M1 A1 A1 A1 B1 A1 <b>7</b></p>	<p>aef time to position level with AC</p>
<p><b>OR (ii)</b></p>	<p><math>y = x \tan \theta - gx^2 \sec^2 \theta / 2V^2</math>                      substitute values  <math>-2.5 = 0.577x - 0.221x^2</math>                      Attempt to solve quadratic for x  <math>x = 4.9</math> (or better)                      Horizontal distance from B to C =  <math>5 \cos 30 = 4.3</math> (or better)                      Ball does not hit the roof</p>	<p>B1 M1 A1 M1 A1 B1 A1 <b>7</b></p>	<p>aef</p>
<p><b>OR (ii)</b></p>	<p><math>u = 5.44 \sin 30^\circ = 2.72</math>  <math>-2.5 = 5.44 \sin 30 t - 4.9 t^2</math></p> <p><math>t = 1.0</math> (or better)  <math>T = 5 \cos 30^\circ / 5.44 \cos 30^\circ</math>  <math>T = 0.92</math> (or better)                      Ball does not hit the roof</p>	<p>B1 M1 A1 A1 M1 A1 A1 <b>7</b></p>	<p>aef time to position level with AC time to lateral position over C</p>

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<p><b>OR (ii)</b></p>	<p>Attempt at equation of trajectory  <math>y = 0.577x - 0.221x^2</math>  <math>y = -0.577x</math>                      Solving their quadratic and linear equations to get at least x or y  <math>x = 5.2</math> (or better) or <math>y = -3.0</math> (or better)                      Horizontal distance from B to C =  <math>5\cos 30 = 4.3</math> (or better)                      Or Ht drop to C = <math>5\sin 30^\circ = 2.5</math>                      Ball does not hit the roof</p>	<p>M1                      A1                      B1                        M1                      A1                        B1                      A1 <b>7</b></p>	<p>Equation of BC                        Must be the one needed for comparison</p>
<p><b>OR (ii)</b></p>	<p>Attempt at equation of trajectory  <math>y = 0.577x - 0.221x^2</math>  <math>y = -0.577x</math>                      Solving their quadratic and linear equations  <math>x = 5.2</math> (or better) and <math>y = -3.0</math> (or better)                      Distance = 6.0 (or better)                        Ball does not hit the roof</p>	<p>M1                      A1                      B1                        M1                      A1                        B1                      A1 <b>7</b></p>	<p>Distance from B to point of intersection</p>