

<b>1</b>	$v^2 = 2 \times 9.8 \times 10$ $v = 14 \text{ m s}^{-1}$ $\text{speed} = \sqrt{7^2 + 14^2}$ $15.7 \text{ or } 7\sqrt{5} \text{ m s}^{-1}$ $\tan^{-1}(14/7) \text{ or } \tan^{-1}(7/14)$ $63.4^\circ$ to the horizontal	M1 A1 M1 A1 M1 A1	Using $v^2 = u^2 + 2as$ with $u = 0$  Method to find speed using their “v”  Method to find angle using their “v” $26.6^\circ$ to vertical
<b>6</b>			<b>6</b>
<b>2 (i)</b>	$(6\sin \Pi/2) \div (\Pi/2)$ 3.82	M1 A1	Use of correct formula <b>2 AG</b>
<b>(ii)</b>	$8\bar{d} = 3(6-3.82) + 5 \times 9.82$ $\text{or } 8x = \pm\{3(-3.82) + 5 \times 3.82\}$ $\bar{d} = 6.95 \text{ or } 6.96 \text{ or } x = \pm 0.955$ $\tan \theta = 0.96/6$ $\theta = 9^\circ$	M1 A1 A1 M1 A1	Method to find centre of mass   Attempt to find the required angle
<b>7</b>			<b>7</b>
<b>3 (i)</b>	$D = 128\,000/80 (= 1600)$ $k(80)^2 = 128\,000/80$  $k = \frac{1}{4}$ $R = 900 \text{ N}$	B1 M1 A1 A1 B1	Driving force = resistance   FT on their k ( $R = 3600k$ )
<b>(ii)</b>	$D = 128\,000 / 60 (= 2133\frac{1}{3})$ $2000 \times 9.8 \times \sin 2^\circ$ $6400/3 - 900 - 2000 \times 9.8 \times \sin 2^\circ = 2000a$ $a = 0.275 \text{ m s}^{-2}$	B1 B1 M1 A1	4 terms required
<b>9</b>			<b>9</b>
<b>4 (i)</b>	$4T \cos 20^\circ = 5 \times g \times 2.5$  $T = 32.6 \text{ N}$	M1 A1 A1	Using moments; allow sin/cos mix Allow with omission of g
<b>(ii)</b>	$X = T \sin 20^\circ$ $X = 11.1$ FT $Y + T \cos 20^\circ = 5 \times g$ $\text{or } 2.5Y = 1.5 \times T \cos 20^\circ \text{ or } 4Y = 1.5 \times 5g$ $Y = 18.4$ FT  $R = \sqrt{X^2 + Y^2} \text{ or } \tan^{-1}(Y/X)$ $\text{or } \tan^{-1}(X/Y)$  $R = 21.5 \text{ N}$ $\theta = 58.8^\circ$ above the horizontal	M1 A1 M1 A1 M1 A1 A1	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>			<b>10</b>

5 (i)	$T\cos 45^\circ + R\sin 45^\circ = mg$ $T\sin 45^\circ - R\cos 45^\circ = m\sin 45^\circ \omega^2$ $2T = \sqrt{2}mg + ml\omega^2$ $T = m/2(\sqrt{2}g + l\omega^2)$	*M1 A1 *M1 A1 Dep*M1 A1 6	3 terms  3 terms; $a = r \omega^2$  Method to eliminate R <b>AG</b> www
5 (ii)	$R = 0$ $2R = \sqrt{2}mg - ml\omega^2$ or $T\cos 45^\circ = mg$ or $T = ml\omega^2$ Solve to find $\omega$  $\omega = 4.16 \text{ rad s}^{-1}$	B1 B1   M1  A1 4	may be implied      <b>10</b>
6 (i)	$2mu = 2mv + 3mv$  $v = 2/5 u$	M1 A1 A1 3	Conservation of momentum  Must be $v =$
6 (ii)	$e = (3v - v) / u$ $e = 4/5$	M1 A1 2	Using restitution <b>AG</b>
6 (iii)	Initial K.E. $= 9mv^2 / 2 = 18mu^2 / 25$ Final K.E. $= 9mv^2 / 8 = 9mu^2 / 50$ $\frac{1}{2} m (V)^2 = \text{Final K.E.}$ $V = 3u / 5$	B1 FT B1 FT M1 A1 4	FT on their $v$ from (i) FT on their $v$ from (i)  <b>AG</b>
6 (iv)	$4mu / 5 - 3mu / 5 = 2mx + my$ $u / 5 = 2x + y$ $e = 4/5 = (y - x) / u$ $4u = 5y - 5x$ solving 2 relevant equations $x = -u/5$ $y = 3u/5$ $y = 3u/5$ away from wall (x) + towards wall (y)	M1 A1 FT M1 FT A1 M1 A1 A1 A1 8	Conservation of momentum FT on their $v$ from (i); aef Using restitution FT on their $v$ from (i); aef  both <b>17</b>



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