Mark Scheme for June 2010
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All Examiners are instructed that alternative correct answers and unexpected approaches in candidates’ scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the Report on the Examination.

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Any enquiries about publications should be addressed to:

OCR Publications
PO Box 5050
Annesley
NOTTINGHAM
NG15 0DL

Telephone:    0870 770 6622
Facsimile:    01223 552610
E-mail:       publications@ocr.org.uk
| 1 | \(v^2 = 2 \times 9.8 \times 10\)  
\(v = 14\) m s\(^{-1}\)  
speed = \(\sqrt{(7^2 + 14^2)}\)  
15.7 or 7√5 m s\(^{-1}\)  
tan\(^{-1}\)(14/7) or tan\(^{-1}\)(7/14)  
63.4° to the horizontal | M1  
A1  
M1  
A1  
M1  
A1  
6 | 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 |
|---|---|---|---|
| 2 (i) | \((6\sin \pi/2) \div (\pi/2)\)  
3.82 | M1  
A1  
2 | Use of correct formula AG |
| (ii) | \(8d = 3(6-3.82) + 5\times 9.82\)  
or \(8x = \pm \{3(-3.82) + 5\times 3.82\}\)  
d = 6.95 or 6.96 or \(x = \pm 0.955\)  
tan\(0° = 0.96/6\)  
\(0° = 9°\) | M1  
A1  
A1  
M1  
A1  
5 | Method to find centre of mass  
Attempt to find the required angle  
7 |
| 3 (i) | \(D = 128\) 000/80 (= 1600)  
\(k(80)^2 = 128\) 000/80  
k = \(1/4\)  
\(R = 900\) N | B1  
M1  
A1  
A1  
B1  
5 | Driving force = resistance  
FT on their \(k\) (\(R = 3600k\)) |
| (ii) | \(D = 128\) 000 / 60 (= 2133½)  
2000 x 9.8 x sin2°  
6400/3-900-2000 x 9.8 x sin2° = 2000a  
a = 0.275 m s\(^{-2}\) | B1  
B1  
M1  
A1  
4 | 4 terms required  
9 |
| 4 (i) | \(4T\cos20° = 5 \times g \times 2.5\)  
\(T = 32.6\) N | M1  
A1  
A1  
3 | Using moments; allow sin/cos mix  
Allow with omission of g |
| (ii) | \(X = T\sin20°\)  
\(X = 11.1\)  
\(Y + T\cos20° = 5 \times g\)  
or 2.5\(Y = 1.5 \times T\cos20\) or 4\(Y = 1.5 \times 5g\)  
\(Y = 18.4\)  
\(R = \sqrt{(X^2 + Y^2)}\) or tan\(^{-1}\)(Y/X)  
or tan\(^{-1}\)(X/Y)  
\(R = 21.5\) N  
\(0° = 58.8°\) above the horizontal | M1  
A1  
M1  
A1  
M1  
A1  
A1  
7 | allow sin/cos mix  
FT their \(T\)  
FT their \(T\), but not from omission of \(g\)  
\(X ≠ 0, Y ≠ 0\)  
or 31.2° to left of vertical  
10 |
<table>
<thead>
<tr>
<th></th>
<th>5 (i)</th>
<th>6 (i)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tcos45° + Rsin45° = mg</strong></td>
<td><strong>2mu = 2mv + 3mv</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Tsin45° - Rcos45° = mlsin45°ω²</strong></td>
<td><strong>v = 2/5 u</strong></td>
<td></td>
</tr>
<tr>
<td>2T = √2mg + mlo²</td>
<td>e = (3v – v) / u</td>
<td></td>
</tr>
<tr>
<td>T = m/2(√2g + lo²)</td>
<td>e = 4/5</td>
<td></td>
</tr>
<tr>
<td>3 terms</td>
<td><strong>Conservation of momentum</strong></td>
<td></td>
</tr>
<tr>
<td>3 terms; a = r ω²</td>
<td>Must be v =</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>(ii)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>R = 0</td>
<td><strong>Using restitution</strong></td>
<td></td>
</tr>
<tr>
<td>2R = √2mg - mlo²</td>
<td>AG</td>
<td></td>
</tr>
<tr>
<td>or Tcos45° = mg</td>
<td>AG</td>
<td></td>
</tr>
<tr>
<td>or T = mlo²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solve to find ω</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ω = 4.16 rad s⁻¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th></th>
<th>(iii)</th>
<th>(iv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial K.E. = 9mv² / 2 = 18mu² /25</td>
<td>4mu / 5 – 3mu /5 = 2mx + my</td>
<td></td>
</tr>
<tr>
<td>Final K.E. = 9mv² / 8 = 9mu² /50</td>
<td>u / 5 = 2x + y</td>
<td></td>
</tr>
<tr>
<td>½m (V)² = Final K.E.</td>
<td>e = 4/5 = (v – x) / u</td>
<td></td>
</tr>
<tr>
<td>V = 3 u /5</td>
<td>4u = 5y – 5x</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>AG</td>
<td></td>
</tr>
<tr>
<td>FT on their v from (i)</td>
<td>solving 2 relevant equations</td>
<td></td>
</tr>
<tr>
<td>FT on their v from (i)</td>
<td>x = -u/5 y = 3u/5</td>
<td></td>
</tr>
<tr>
<td>AG</td>
<td>y = 3u/5</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>both</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 7 (i) | \[ R = 0.2 \times 9.8 \times \cos 30^\circ = (1.70) \]  
\[ F = 0.1 \times 9.8 \times \cos 30^\circ = (0.849) \]  
\[ \frac{1}{2} \times 0.2 \times 11^2 - \frac{1}{2} \times 0.2 \times v^2 = \]  
\[ 0.2 \times 9.8 \times 5 \sin 30^\circ + 5 \times 0.849 \]  
\[ v = 5.44 \text{ m s}^{-1} \]  
| B1 | FT on their R, but not R =0.2g 
| B1 | Use of conservation of energy 
| FT | A1 
| A1 | A1 
| A1 | A1  
| Or | \[ F + 0.2g \sin 30^\circ = \pm 0.2a \]  
\[ a = \pm 9.1 \]  
\[ v^2 = 11^2 + 2 \times a \times 5 \]  
\[ v = 5.44 \text{ m s}^{-1} \]  
| M1 | Use of N2L, 3 terms 
| A1 | Complete method to find v 

| (ii) | \[ t = 5 \cos 30^\circ / 5.44 \cos 30^\circ \]  
\[ t = 0.919 \text{ s} \]  
\[ u = 5.44 \sin 30^\circ = (2.72) \]  
\[ s = 2.72 \times 0.919 - 4.9 \times 0.919^2 \]  
\[ s = -1.6 \text{ (or better)} \]  
| M1 | time to lateral position over C 
| A1 | Ht dropped 
| B1 | Ball does not hit the roof 
| M1 | all 3 correct 
| A1 | A1 

| Or (i) | \[ y = x \tan \theta - gx \sec^2 \theta / 2V^2 \]  
\[ 5 \text{ V} = 5.44 \]  
\[ 0 = 30^\circ \]  
\[ x = 5 \cos 30^\circ \]  
\[ y = 2.5 - 9.8 \times 25 \times \frac{3}{4} \times \frac{1}{3} / (2 \times 5.44^2) \]  
\[ y = -1.6 \text{ (or better)} \]  
| B1 | all 3 correct 
| M1 | Substitute values 
| A1 | A1 

| OR (ii) | \[ u = 5.44 \sin 30^\circ = (2.72) \]  
\[ -2.5 = 5.44 \sin 30^\circ t - 4.9t^2 \]  
\[ t = 1.04 \]  
\[ x = 5.44 \cos 30^\circ \times 1.04 = 4.9 \text{ (or better)} \]  
| B1 | time to position level with AC 
| M1 | Horizontal distance from B to C = 5 \cos 30^\circ = 4.3 \text{ (or better)} 
| A1 | Ball does not hit the roof 
| A1 | A1 

| OR (ii) | \[ y = x \tan \theta - gx \sec^2 \theta / 2V^2 \]  
\[ -2.5 = 0.577x - 0.221x^2 \]  
| B1 | Substitute values 
| M1 | Attempt to solve quadratic for x 
| A1 | x = 4.9 \text{ (or better)} 
| A1 | Horizontal distance from B to C = 5 \cos 30^\circ = 4.3 \text{ (or better)} 
| B1 | Ball does not hit the roof 
| A1 | A1 

| OR (ii) | \[ u = 5.44 \sin 30^\circ = 2.72 \]  
\[ -2.5 = 5.44 \sin 30^\circ t - 4.9t^2 \]  
| B1 | Substitute values 
| M1 | Attempt to solve quadratic for x 
| A1 | x = 4.9 \text{ (or better)} 
| A1 | Horizontal distance from B to C = 5 \cos 30^\circ = 4.3 \text{ (or better)} 
| B1 | Ball does not hit the roof 
| A1 | A1 

| Aef | Time to position level with AC 
| Time to lateral position over C 

| Ball does not hit the roof 

<p>| 13 | 7 |</p>
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<tr>
<th><strong>OR (ii)</strong></th>
<th>Attempt at equation of trajectory</th>
</tr>
</thead>
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<tr>
<td>$y = 0.577x - 0.221x^2$</td>
<td></td>
</tr>
<tr>
<td>$y = -0.577x$</td>
<td></td>
</tr>
<tr>
<td>Solving their quadratic and linear equations to get at least $x$ or $y$</td>
<td></td>
</tr>
<tr>
<td>$x = 5.2$ (or better) or $y = -3.0$ (or better)</td>
<td></td>
</tr>
<tr>
<td>Horizontal distance from B to C = $5 \cos 30 = 4.3$ (or better)</td>
<td></td>
</tr>
<tr>
<td>Or Ht drop to $C = 5 \sin 30^\circ = 2.5$</td>
<td></td>
</tr>
<tr>
<td>Ball does not hit the roof</td>
<td></td>
</tr>
<tr>
<td>$M1$</td>
<td>$A1$</td>
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**Equation of BC**

Must be the one needed for comparison

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<td>$y = 0.577x - 0.221x^2$</td>
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<td>Solving their quadratic and linear equations</td>
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<tr>
<td>$x = 5.2$ (or better) and $y = -3.0$ (or better)</td>
<td></td>
</tr>
<tr>
<td>Distance = $6.0$ (or better)</td>
<td></td>
</tr>
<tr>
<td>Ball does not hit the roof</td>
<td></td>
</tr>
<tr>
<td>$M1$</td>
<td>$A1$</td>
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Distance from B to point of intersection