Mark Scheme for June 2010
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Any enquiries about publications should be addressed to:

OCR Publications
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Annesley
NOTTINGHAM
NG15 0DL

Telephone: 0870 770 6622
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### Question 1

\[ v^2 = 2 \times 9.8 \times 10 \]
\[ v = 14 \text{ m s}^{-1} \]

**Method to find speed using their “v”**

\[ v^2 = u^2 + 2as \]
(\( u = 0 \))

**Method to find angle using their “v”**

\[ 15.7 \text{ or } 7 \sqrt{5} \text{ m s}^{-1} \]
\[ \tan^{-1}(14/7) \text{ or } \tan^{-1}(7/14) \]

63.4° to the horizontal

**Use of correct formula**

3.82

### Question 2

1. **Use of correct formula**

\[ \frac{(6\sin \frac{\pi}{2})}{(\frac{\pi}{2})} \]

3.82

2. **Method to find centre of mass**

\[ 8d = 3(6-3.82) + 5x9.82 \]

or \[ 8x = \pm \{3(-3.82) + 5x3.82\} \]

\[ d = 6.95 \text{ or } 6.96 \text{ or } x = \pm/0.955 \]

\[ \tan \theta = 0.96/6 \]

\[ \theta = 9^\circ \]

### Question 3

1. **Driving force = resistance**

\[ D = 128 \times 1000 = 1600 \]

\[ k(80)^2 = 128 \times 1000 \]

\[ k = \frac{1}{4} \]

\[ R = 900 \text{ N} \]

**FT on their k (R = 3600k)**

2. **4 terms required**

\[ D = 128 \times 1000 / 60 = 2133\frac{1}{3} \]

\[ 2000 \times 9.8 \times \sin 2^\circ \]

\[ 6400 \times 3-900-2000 \times 9.8 \times \sin 2^\circ = 2000a \]

\[ a = 0.275 \text{ m s}^{-2} \]

### Question 4

1. **Using moments; allow sin/cos mix**

\[ 4T\cos 20^\circ = 5 \times g \times 2.5 \]

\[ T = 32.6 \text{ N} \]

**Allow with omission of g**

2. **allow sin/cos mix**

\[ X = T\sin 20^\circ \]

\[ X = 11.1 \text{ FT} \]

\[ Y + T\cos 20^\circ = 5 \times g \]

or \[ 2.5Y = 1.5 \times T\cos 20\text{ or } 4Y = 1.5 \times 5g \]

\[ Y = 18.4 \text{ FT} \]

\[ R = \sqrt{(X^2 + Y^2)} \text{ or } \tan^{-1}(Y/X) \]

or \[ \tan^{-1}(X/Y) \]

\[ R = 21.5 \text{ N} \]

\[ \theta = 58.8^\circ \text{ above the horizontal} \]

**or 31.2° to left of vertical**

10
<p>| | | | | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>5 (i)</strong></td>
<td>( T\cos45° + R\sin45° = mg )</td>
<td>*M1 A1</td>
<td>3 terms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( T\sin45° - R\cos45° = m\ell\sin45°\omega^2 )</td>
<td>*M1 A1</td>
<td>3 terms; ( a = r \omega^2 )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 2T = \sqrt{2mg + m\ell\omega^2} )</td>
<td>Dep*M1 A1</td>
<td>Method to eliminate ( R )</td>
<td>AG www</td>
</tr>
<tr>
<td></td>
<td>( T = m/2(\sqrt{2g + \ell\omega^2}) )</td>
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<tr>
<td><strong>5 (ii)</strong></td>
<td>( R = 0 )</td>
<td>B1</td>
<td>may be implied</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 2R = \sqrt{2mg - m\ell\omega^2} )</td>
<td>B1</td>
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<tr>
<td></td>
<td>or ( T\cos45° = mg )</td>
<td>M1</td>
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<tr>
<td></td>
<td>or ( T = m\ell\omega^2 )</td>
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<td></td>
<td>Solve to find ( \omega )</td>
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<tr>
<td></td>
<td>( \omega = 4.16 \text{ rad s}^{-1} )</td>
<td>A1 4</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td><strong>6 (i)</strong></td>
<td>( 2mu = 2mv + 3mv )</td>
<td>M1 A1 A1</td>
<td>Conservation of momentum</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( v = 2/5u )</td>
<td></td>
<td>Must be ( v = )</td>
<td></td>
</tr>
<tr>
<td><strong>6 (ii)</strong></td>
<td>( e = (3v - v) / u )</td>
<td>M1 A1</td>
<td>Using restitution</td>
<td>AG</td>
</tr>
<tr>
<td></td>
<td>( e = 4/5 )</td>
<td></td>
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</tr>
<tr>
<td><strong>6 (iii)</strong></td>
<td>Initial K.E. = ( 9mv^2 / 2 = 18mu^2 / 25 )</td>
<td>B1 FT B1 FT</td>
<td>FT on their ( v ) from (i)</td>
<td>FT on their ( v ) from (i)</td>
</tr>
<tr>
<td></td>
<td>Final K.E. = ( 9mv^2 / 8 = 9mu^2 / 50 )</td>
<td>B1 FT M1 A1</td>
<td></td>
<td>AG</td>
</tr>
<tr>
<td></td>
<td>( \frac{1}{2}m(V)^2 = \text{Final K.E.} )</td>
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<td></td>
<td>( V = 3\ u / 5 )</td>
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<tr>
<td><strong>6 (iv)</strong></td>
<td>( 4mu / 5 - 3mu / 5 = 2mx + my )</td>
<td>M1 A1 FT M1 FT</td>
<td>Conservation of momentum</td>
<td>FT on their ( v ) from (i); aef</td>
</tr>
<tr>
<td></td>
<td>( u / 5 = 2x + y )</td>
<td>A1 FT</td>
<td>Using restitution</td>
<td>FT on their ( v ) from (i); aef</td>
</tr>
<tr>
<td></td>
<td>( e = 4/5 = (v - x) / u )</td>
<td>M1 FT</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 4u = 5y - 5x )</td>
<td>A1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>solving 2 relevant equations</td>
<td>M1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>( x = -u/5 ) ( y = 3u/5 )</td>
<td>A1 A1</td>
<td></td>
<td>both</td>
</tr>
<tr>
<td></td>
<td>( y = 3u/5 )</td>
<td>A1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>away from wall ( (x) ) + towards wall ( (y) )</td>
<td>A1 8</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>
7 (i) \[ R = 0.2 \times 9.8 \times \cos 30^\circ = 1.70 \] 
\[ F = 0.1 \times 9.8 \times \cos 30^\circ = 0.849 \] 
\[ \frac{1}{2} \times 0.2 \times 11^2 - \frac{1}{2} \times 0.2 \times 0.2 \times v^2 = 0.2 \times 9.8 \times 5 \sin 30^\circ + 5 \times 0.849 \]
\[ v = 5.44 \text{ m s}^{-1} \]

**FT on their R, but not R = 0.2g**

**Use of conservation of energy**

Or

\[ F + 0.2g \sin 30^\circ = \pm 0.2a \]
\[ a = \pm 9.1 \]
\[ v^2 = 11^2 + 2 \times a \times 5 \]
\[ v = 5.44 \text{ m s}^{-1} \]

6 **AG**

(ii) \[ t = 5 \cos 30^\circ / 5.44 \cos 30^\circ \]
\[ t = 0.919 \text{ s} \]
\[ u = 5.44 \sin 30^\circ = 2.72 \]
\[ s = 2.72 \times 0.919 - 4.9 \times 0.919^2 \]
\[ s = -1.6 \text{ (or better)} \]

Ht drop to \( C = 5 \sin 30^\circ = 2.5 \text{ m} \)

Ball does not hit the roof

**time to lateral position over \( C \)**

Or

\[ y = x \tan \theta - gx^2 \sec^2 \theta / 2V^2 \]

**all 3 correct**

first substitute values

5 \[ V = 5.44 \quad 0 = 30^\circ \quad x = 5 \cos 30^\circ \]

marks of (ii) \[ y = 2.5 - 9.8x253/4x4/3 / (2 \times 5.44^2) \]
\[ y = -1.6 \text{ (or better)} \]

OR (ii) \[ u = 5.44 \sin 30^\circ = 2.72 \]
\[ -2.5 = 5.44 \sin 30^\circ t - 4.9t^2 \]
\[ t = 1.04 \]
\[ x = 5.44 \cos 30^\circ \times 1.04 = 4.9 \text{ (or better)} \]

Horizontal distance from \( B \) to \( C \) = \[ 5 \cos 30^\circ = 4.3 \text{ (or better)} \]

Ball does not hit the roof

**time to position level with \( AC \)**

OR (ii) \[ y = x \tan \theta - gx^2 \sec^2 \theta / 2V^2 \]

substitute values

\[ -2.5 = 0.577x - 0.221x^2 \]

Attempt to solve quadratic for \( x \)
\[ x = 4.9 \text{ (or better)} \]

Horizontal distance from \( B \) to \( C \) = \[ 5 \cos 30^\circ = 4.3 \text{ (or better)} \]

Ball does not hit the roof

**aef**

OR (ii) \[ u = 5.44 \sin 30^\circ = 2.72 \]
\[ -2.5 = 5.44 \sin 30^\circ t - 4.9t^2 \]
\[ t = 1.0 \text{ (or better)} \]
\[ T = 5 \cos 30^\circ / 5.44 \cos 30^\circ \]
\[ T = 0.92 \text{ (or better)} \]

Ball does not hit the roof

**aef**

**time to position level with \( AC \)**

**time to lateral position over \( C \)**
<table>
<thead>
<tr>
<th>OR (ii)</th>
<th>Attempt at equation of trajectory</th>
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<td>Solving their quadratic and linear</td>
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<td>equations to get at least $x$ or $y$</td>
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<td>$x = 5.2$ (or better) or $y = -3.0$ (or better)</td>
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<td>Horizontal distance from B to C =</td>
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<td></td>
<td>$5\cos30 = 4.3$ (or better)</td>
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<td>Or Ht drop to $C = 5\sin30^\circ = 2.5$</td>
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### Mark Scheme

- **M1**
- **A1**
- **B1**

**Equation of BC**

**Must be the one needed for comparison**

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<td>equations</td>
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<tr>
<td></td>
<td>$x = 5.2$ (or better) and $y = -3.0$ (or better)</td>
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<tr>
<td></td>
<td>Distance = 6.0 (or better)</td>
</tr>
<tr>
<td></td>
<td>Ball does not hit the roof</td>
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</tbody>
</table>

### Mark Scheme

- **M1**
- **A1**
- **B1**

**Distance from B to point of intersection**
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14 – 19 Qualifications (General)
Telephone: 01223 553998
Facsimile: 01223 552627
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