Mark Scheme for June 2010
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Mark schemes should be read in conjunction with the published question papers and the Report on the Examination.

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<table>
<thead>
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<th>Question</th>
<th>Description</th>
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| 1        | For included angle marked $\alpha$ or for $0.8(10.5 - 8.5\cos \alpha) = 4\cos \beta$ For opposite side marked 4/0.8 (or 4) or for $-- 0.8 \times 8.5 \sin \alpha = 4 \sin \beta$
|           | $8.4^2 + 6.8^2 - 2 \times 8.4 \times 6.8 \cos \alpha = 4^2$
|           | $\alpha = 28.1^\circ$ |
| 2(i)     | [100$a = 2aV_B$]
|           | Vertical component at B is 50 N
|           | Vertical component at C is 150 N |
| 2(ii)    | $100(0.5a) + (\sqrt{3} a)F = 150a$ or $100a + 100(1.5a) = 150a + (\sqrt{3} a)F$
|           | Frictional force is 57.7 N
|           | Direction is to the right |
| 3(i)     | $u = 4$
|           | $v = 2$ |
| 3(ii)    | $mu = ma + mb$ (or $u = b - a$)
|           | $u = b - a$ (or $mu = ma + mb$)
|           | $a = 0$ and $b = 4\text{ms}^{-1}$
|           | Speed of A is 2$m\text{s}^{-1}$ and direction at 90$^\circ$ to the wall
|           | Speed of B is 4$m\text{s}^{-1}$ and direction parallel to the wall |
| 4(i)     | $0.25 \frac{dv}{dt} = \frac{3}{50} - \frac{t^2}{2400}$ |
|           | $v = 12t/50 - \frac{t^3}{1800}$
|           | $v(12) = 1.92$ |
|           | $0.25 \frac{dv}{dt} = \frac{t^2}{2400} - \frac{3}{50}$
|           | $v = \frac{t^3}{1800} - 12t/50 + C_2$
|           | $[1.92 = 0.96 - 2.88 + C_2]$ |
|           | $v = \frac{t^3}{1800} - 12t/50 + 3.84$
|           | $v(24) = 5.76 = 3 \times v(12)$ |
(ii) Sketch has $v(0) = 0$ and slope decreasing (convex upwards) for $0 < t < 12$
Sketch has slope increasing (concave upwards) for $12 < t < 24$
Sketch has $v(t)$ continuous, single valued and increasing (except possibly at $t = 12$) with $v(24)$ seen to be $> 2v(12)$  
B1 B1 B1 [3]

5(i) For using amplitude as a coefficient of a relevant trigonometric function.
For using the value of $\omega$ as a coefficient of $t$ in a relevant trigonometric function.
$x_1 = 3\cos t$ and $x_2 = 4\cos 1.5t$  
B1 B1 B1 [3]

(ii) Part distance is 20m
$[20 - (-3.62)]$
Distance travelled by $P_2$ is 23.6 m  

(iii) \[ \dot{x}_1 = -3\sin t; \dot{x}_2 = -6\sin 1.5t \]
$v_1 = 0.867, v_2 = -2.55$; opposite directions
For differentiating $x_1$ and $x_2$
For evaluating when $t = 5.99$ (must use radians)

Alternative for (iii):
\[ v_1^2 = 3^2 - 2.87^2, v_2^2 = 2.25[4^2 - (-3.62)^2] \]
$[\pi < 5.99 < 2\pi \Rightarrow v_1 > 0, 4\pi/3 < 5.99 < 2\pi \Rightarrow v_2 < 0]$
$v_1 = 0.867, v_2 = -2.55$; opposite directions
For using $v^2 = \pi^2(a^2 - x^2)$ (must use radians to find values of $x$)
For using the idea that $v$ starts –ve and changes sign at intervals of $T/2$ s

6(i) PE loss at lowest allowable point = 25W
EE gain = $32000x5^2/(2\times20)$
$[25W = 20000]$
Value of $W$ is 800  
B1 M1 A1 A1 [5]

(ii) $[800 = 32000x/20]$
$\frac{1}{2} (800/9.8)v^2$
$= 800 \times 20.5 - 32000x0.5^2/(2\times20)$
Maximum speed is 19.9ms$^{-1}$  
M1 M1 A1 A1 [4]

(iii) \[ (800)x/g = 800 - 32000 \times 5/20 \]
Max. deceleration is 88.2 ms$^{-2}$  
M1 A1 A1 [3]
### 7(i)  
\[
\frac{1}{2} m v^2 - \frac{1}{2} m 6^2 = mg(0.7) \\
\text{Speed of P before collision is } 7.05\text{ms}^{-1} \\
\text{Coefficient of restitution is } 0.695
\]

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

For using the principle of conservation of energy for P (3 terms needed)

- ft \(4.9 \div \text{speed of P before collision}\)

### 7(ii)  
\[
\frac{1}{2} m v^2 = \frac{1}{2} m 4.9^2 - mg0.7(1 - \cos \theta) \\
v^2 = 3.43(3 + 4 \cos \theta) \\
T - m9.8\cos \theta = mv^2/0.7
\]

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

For using the principle of conservation of energy for Q

Accept any correct form

For using Newton's second law radially with \(a_r = v^2/r\)

For substituting for \(v^2\)

- **AG**

### 7(iii)  
\[
T = 0 \Rightarrow \theta = 120^\circ
\]

- **B1**

Radial acceleration is \((\pm)4.9\ \text{ms}^{-1}\) or

transverse acceleration is \((\pm)8.49\ \text{ms}^{-1}\)

Radial acceleration is \((\pm)4.9\ \text{ms}^{-1}\) and

transverse acceleration is \((\pm)8.49\ \text{ms}^{-1}\)

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

For using \(a_r = -g\cos \theta\)

\{or \(3.43(3 + 4\cos \theta)/0.7\}\}

or \(a_t = -g\sin \theta\)

SR for candidates with a sin/cos mix in the work for M1 A1 B1 immediately above. (max. 1/3)

Radial acceleration is \((\pm)8.49\ \text{ms}^{-1}\) and

transverse acceleration is \((\pm)4.9\ \text{ms}^{-1}\)

- **B1**

### 7(iv)  
\[
V^2 = 3.43\{3 + 4(-0.5)\} \times 0.5^2 \text{ or} \\
V^2 = (-g\cos120^\circ\times 0.7) \times \cos^260^\circ
\]

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

For using \(V = v(120^\circ)\times \cos60^\circ\)

- **AG**

For using the principle of conservation of energy

\[
mgH = \frac{1}{2} m(4.9^2 - 0.8575) \text{ or} \\
mg(H - 1.05) = \frac{1}{2} m(3.43 - 0.8575)
\]

Greatest height is 1.18 m

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

For using \(V = v(120^\circ)\times \cos60^\circ\)

- **AG**

For using the principle of conservation of energy