

**Mathematics**

Advanced GCE

Unit **4729**: Mechanics 2

**Mark Scheme for January 2011**

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| Question |      | Expected Answer   | Mark                                     | Rationale/Additional Guidance   |
|----------|------|---|--|---|
| 1        | (i)  | $3x_G = 2 \times 0.3 + 1 \times 0.6$ OR $3x_G = 2 \times 0.3 + 0$ OR $3x_G = 4 \times 0.3$<br>OR $3y_G = 1 \times 0.3 + 1 \times 0.6 + 0$ OR $3y_G = 4 \times 0.3 - 1 \times 0.3$<br>$x_G = 0.4$ (from AD) OR $x_G = 0.2$ (from BC)<br>$y_G = 0.3\text{m}$ from AB or CD<br>$AG^2 = 0.4^2 + 0.3^2$<br>$AG = 0.5\text{ m}$ | M1<br>A1<br>A1<br>M1<br>A1<br><b>[5]</b> | Table of moments idea. M0 for reducing to 1D problem. Masses/weights may be included.<br><br>Pythagoras with 2 appropriate distances. This may only be seen in (ii), allow M1A1 in this case. |
|          | (ii) | $v = 0.5 \times 3$<br>$v = 1.5\text{ ms}^{-1}$  | M1<br>A1<br><b>[2]</b>                   | Allow use of candidate's 0.2, 0.4, 0.3, 0.5   |
| 2        | (i)  | $(k25^{3/2}) \times 25 = 15000$<br>$k = 4.8$ <p style="text-align: center;"><b>AG</b></p>   | M1<br>A1<br>A1<br><b>[3]</b>             | Tractive force x speed = power  |
|          | (ii) | $R = 4.8 \times 16^{3/2}$<br><br>$T - 4.8 \times 16^{3/2} + 700g \times 1/15 = 700 \times 0.3$<br>$P = 59.9 \times 16$<br>$P = 958\text{ W}$  | B1<br>M1<br>A1<br>M1<br>A1<br><b>[5]</b> | 307.2<br>N2L, 4 terms to find tractive force (T)<br>Allow cv(R), R not 600; (T = 59.866..)<br>16xTractive force   |

|   |       |   |   |  |
|---|-------|---|---|--|
| 3 | (i)   | $T_A \cos 30 + T_B \cos 60 = 0.4g$<br>$2T \cos 30 + T \cos 60 = 0.4g$<br>$T_B = 1.76 \text{ N}$<br>$T_A = 3.51 \text{ N}$   | M1<br>A1<br>A1<br>A1<br><b>[4]</b>  | Resolves vertically, 3 terms<br>$T = 1.756$ . Watch for MR of $T \cos 30 + 2T \cos 60 = 0.4g$<br><br>Accept 3.52                             |
|   | (ii)  | $r = 0.5 \sin 30 (= 0.25)$<br><br>$3.51 \sin 30 + 1.76 \sin 60 = 0.4 \omega^2 0.5 \sin 30$<br>$\omega = 5.72 \text{ rad s}^{-1}$  | B1<br>M1<br>A1ft<br>A1<br><b>[4]</b>  | N2L radial, 3 terms<br>cv(1.76, 3.51, 0.25)<br>Accept 5.73   |
| 4 | (i)   | $WD = 100 \cos 20 \times 30$<br><br>$WD = 2820 \text{ J}$   | M1<br><br>A1<br><b>[2]</b>  | Product of 3 relevant elements. Angle could be 5, 25 or complements<br>2819.1...   |
|   | (ii)  | $PE = 25g \times 30 \sin 5$<br>$PE = 641$   | M1<br>A1<br><b>[2]</b>  | Product of weight and vertical height. Allow without g<br>640.6  |
|   | (iii) | <b>OR</b><br>$2819.1 = 640.6$<br>$+ 30 \times 70 + 25v^2/2$<br>$v = 2.51 \text{ ms}^{-1}$<br><br>$25a = 100 \cos 20 - 70 - 25g \sin 5$<br>$a = 0.105$<br>$v^2 = 2 \times 30 \times 'a'$<br>$v = 2.51$ | M1<br>A1ft<br>A1<br>A1<br><b>[4]</b><br>*M1<br>A1<br>dep*M1<br>A1<br><b>[4]</b> | 4 term energy equation<br>ft(cv 2820 and cv 641)<br><br>cao<br><br>4 term equation<br>Allow 0.1 here<br>Or equivalent complete method<br>cao |

|   |       |     |  |  |  |
|---|-------|-----|--|--|--|
| 5 | (i)   |     | $x_H = 3 \times 0.6/8$<br>$\pi(0.6^2 \times 0.6)(0.6/2) - (0.6^3 \times 2\pi/3)0.225$<br>$= \pi \times 0.6^3(1+2/3)x_G$<br>$x_G = 0.09 \text{ m}$                              | B1<br>M1<br>A1<br>A1<br>A1<br><b>[5]</b> | CoM hemisphere ( $x_H = 0.225$ ), may be implied<br>Use of table of moments idea<br>SC Volume of sphere used, max B1M1A1, moment equation fully correct for A1 (3/5)<br>Accept -0.09 |
|   | (ii)  | (a) | $mg(0.09\cos 45) =$<br>$2(0.6+0.6\cos 45+0.6\sin 45)$<br>$m = 4.65\text{kg}$   | M1<br>A1<br>A1<br>A1<br><b>[4]</b>       | Attempt at moments (must resolve), allow without g<br><br>$2(0.6+\sqrt{[0.6^2+0.6^2]})$<br>(4.6451...)   |
|   | (ii)  | (b) | $2/4.6451g$<br>$\mu \geq 0.0439$   | M1<br>A1<br>A1<br><b>[3]</b>             | Ratio force/weight<br>cv(4.65)<br>Correct inequality sign, accept 0.044  |
| 6 | (i)   |     | $0 = (14\sin 30)^2 - 2gh$<br>$h = 2.5 \text{ m}$   | M1<br>A1<br><b>[2]</b>                   | $h = (14\sin 30)x1/1.4 - g(1/1.4)^2/2$ or use $(u^2\sin^2\theta)/2g$   |
|   | (ii)  |     | $0.4 \times 15 = 0.4(14\cos 30) + I$<br>$I = 1.15$   | M1<br>A1<br>A1<br><b>[3]</b>             | Impulse = change in momentum<br>Not 14 or 0 for horizontal speed before impulse<br>aef   |
|   | (iii) |     | $v^2 = (14\sin 30)^2 + 15^2$<br>$v = 16.6 \text{ ms}^{-1}$<br>$\tan\theta = 14\sin 30/15$ OR $\tan\psi = 15/14\sin 30$<br><br>$\theta = 25(.0)^\circ$ OR $\psi = 65(.0)^\circ$ | M1<br>A1<br>M1<br><br>A1<br><b>[4]</b>   | Not $(14\sin 30)^2 + (14\cos 30)^2$<br>Allow $\sqrt{274}$<br>Correct trig to find an appropriate angle; not $14\cos 30$ for 15   |
|   | (iv)  |     | $t = 14\sin 30/g (= 1/1.4 = 0.7142..)$<br>$T = 1.43 \text{ s}$<br>$R = 14\cos 30/1.4 + 15/1.4$<br>$R = 19.4 \text{ m}$   | M1<br>A1<br>M1A1<br>A1<br><b>[5]</b>     | Rise or fall time (not to be given in (i))<br>Accept 10/7<br>$(14^2\sin(2 \times 30) + 16.6^2\sin(2 \times 25))/2g$ . 14 resolved, 15 not  |

|   |     |                        |   |  |   |
|---|-----|------------------------|---|--|---|
| 7 | (i) |                        | $b + a = 1.8e$<br>$0.7b - 0.2a = 0.2 \times 1.8$<br>$b = 0.4(1+e)$<br>$a = 1.4e - 0.4$<br>$1.4e - 0.4 > 0.4 + 0.4e$<br>$e > 0.8$            | M1<br>A1<br>M1<br>A1<br>M1<br>A1<br>A1<br>M1<br>A1 | Uses restitution<br>$b - a = 1.8e$<br>Uses momentum<br>$0.7b + 0.2a = 0.2 \times 1.8$ , signs consistent with first eqn<br>Solves 2 simultaneous equations (eliminate a or b)<br>$a = 0.4 - 1.4e$<br>Using $a > b$ , correct signs in a essential |
|   |     | <b>OR Last 5 marks</b> | Using $a > b$<br>$a > 0.72$<br>$b > 0.72$<br>$1.8e > 0.72 + 0.72$<br>$e > 0.8$  | <b>[9]</b><br>M1<br>A1<br>A1<br>M1<br>A1           | correct signs in a essential  |
|   |     | <b>OR Last 5 marks</b> | Using $a = b$ to find a or b<br>a (or b) = 0.9e and a (or b) = 0.72<br>$e = 0.8$<br>Convincing argument for correct inequality<br>$e > 0.8$ | M1<br>A1<br>A1<br>M1<br>A1                         |   |
|   |     | <b>OR Last 5 marks</b> | $a = 1.4e - 0.4$ or $b = 0.4(1+e)$<br>Using $a > b$<br>$a > 0.9e$ or $b < 0.9e$<br>$e > 0.8$  | M1<br>A1<br>M1<br>A1<br>A1                         | Solves 2 simultaneous equations (eliminate a or b)<br>aef or multiples thereof<br>correct signs in a essential<br>aef or multiples thereof  |

|  |      |  |  |  |
|--|------|--|--|--|
|  | (ii) | <p> <math>c - (\pm 0.25) = 1 \times 0.75</math><br/> <math>c = 0.5, 1</math><br/> <math>0.75 \times 0.7 = 0.25 \times 0.7 + m(x1)</math><br/> <i>OR</i><br/> <math>0.75 \times 0.7 = -0.25 \times 0.7 + 0.5m</math><br/> <math>m = 0.35</math> (from first equation)<br/> <math>m = 1.4</math> (from second equation) </p> <p> <i>OR</i> </p> <p> <math>\frac{1}{2} \times 0.7 \times 0.75^2 = \frac{1}{2} \times 0.7 \times 0.25^2 + \frac{1}{2} mc^2</math><br/> <math>0.7 \times 0.75 = 0.7 \times (\pm 0.25) + mc</math> </p> <p> Solving simultaneous equations<br/> <math>m = 0.35</math><br/> <math>m = 1.4</math> </p> | M1<br>A1A1<br><br>M1<br>A1<br>A1<br><b>[6]</b><br>B1<br>M1<br>A1<br>M1<br>A1<br>A1 | <p> Uses restitution with <math>e = 1</math>, either<br/> Or <math>0.75 \pm 0.25</math><br/> Uses momentum conservation with correct combination of sign and <math>c</math> value<br/> <i>OR</i> <math>m \times (0.75 \pm 0.25) \pm 0.7 \times 0.25 = 0.75 \times 0.7</math> </p> <p> <math>\frac{1}{2}</math> may not be seen<br/> At least one momentum equation<br/> <math>mc = 0.35</math> and <math>0.7</math> </p> |
|  |      | <b>Total</b>   | <b>[72]</b>  |  |

[END]

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