# GCE

# Mathematics

Advanced GCE

Unit **4729:** Mechanics 2

# Mark Scheme for June 2011

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| 1 i | PE = 70x3g | B1 | 2058 |
|---|---|---|---|
| | KE change =70x($2.1^2$ – $1.4^2$)/2 | B1 | 85.75 |
| | PE change + KE change | M1 | Must include evaluation |
| | 2143.75 J | A1 | Accept 2140. Allow all values to be negative. |
| | | [4] | |
| ii | | M1 | Work done = Energy change used |
| | 20(90 + T) = 2143.75 | A1ft | ft(cv(2143.75)) |
| | T = 17.1875 N | A1 | accept 17.2 |
| | | [3] | |
| **OR** | | M1 | Use of $v^2=u^2 + 2as$ to find a AND use of N2 law(4 terms) |
| | 70g.0.15 – 90 – T = 70.(-0.06125) | A1 | |
| | T = 17.1875 N | A1 | accept 17.2 |
| | | [3] | |

| 2 i | 21000/25 | B1 | Use of force = power/speed |
|---|---|---|---|
| | | M1 | 3 terms |
| | 0 = 21000/25 – 25k – 1250gsin2 | A1 | cv(21000/25) |
| | k = 16.5 | A1 | |
| | | [4] | |
| ii | | M1 | |
| | 21000/v= 16.5v | A1ft | ft on cv(k) |
| | v = 35.7 ms$^{-1}$ | A1 | |
| | | [3] | |

| 3 i | | M1 | Table of moments idea, may include g and/or density. |
|---|---|---|---|
| | - (8cos30/3)($8^2$sin60/2) | A1 | -2.309 x 27.7 |
| | + (4)($8^2$) | A1 | |
| | = ($8^2$ +$8^2$sin60/2)($x_G$) | A1 | |
| | $x_G$ = 2.09 cm | A1 | |
| | | [5] | |
| ii | tanθ = (2.09/4) | M1 | |
| | θ = 27.6° | A1ft | ft cv($x_G$) |
| | | [2] | |

| 4 ia | If reversed  2.9 + 2 = e(3 + 1.5) | M1 | |
|---|---|---|---|
| | e > 1 impossible | A1 [2] | Award B1 if no explicit numerical justification |
| b | 2.9 - 2 = e(3 + 1.5) | M1 | May be seen in ia |
| | e = 0.2 | A1 [2] | |
| ii | | M1 | Conservation of momentum |
| | 3m – 0.2x1.5 = 2m + 0.2x2.9 | A1 | Accept with g included consistently |
| | m = 0.88 | A1 [3] | Do not award if g used |
| iii | 0.68 = 0.2v + 0.2x2.9 | M1 | Impulse = change in momentum |
| | v = 0.5 | A1 | |
| | e = 0.5/2.9 | M1 | Separation speed not 2.9 |
| | e = 0.172 | A1 [4] | Allow 5/29 |

| 5 i | $x = (7\cos30)t$ | B1 | |
|---|---|---|---|
| | $y = (7\sin30)t – gt^2/2$ | B1 | |
| | | M1 | Attempt to eliminate t |
| | $y = x\tan30 - gx^2/(2x7^2\cos^230)$ | A1 [4] | $y = x/\sqrt3 – 2x^2/15$ or $y = 0.577x – 0.133x^2$ aef |
| ii | | M1 | Create a 3 term Q.E. in x or t with y = 0.6 |
| | $2x^2/15 – x/\sqrt3 + 0.6 = 0$ or $9.8t^2 – 7t + 1.2 = 0$ | M1 | Solve 3 term Q.E. for x or t |
| | x = 1.73 m or √3 m | A1 | |
| | 2.6(0) m or 3√3/2 m | A1 [4] | |
| iii | $v^2 = (7\sin30)^2 – 2x9.8x0.6$ | M1 | Using $v^2 = u^2 -2gs$ with u a component of 7; can find t first |
| | v = 0.7 ms$^{-1}$ | A1 | from their x in (i), and then use v = u + at. |
| | $\tan\theta = 0.7/(7\cos30)$ | M1 | Use component of 7 |
| | θ = 6.59° to horizontal or 83.4° to vertical | A1 [4] | |
| **OR** | Attempt to differentiate equation of trajectory | M1 | |
| | $\tan30 - gx/(7^2\cos^230)$ | A1 | |
| | Substitute x = √3 and equate to tanθ | M1 | Allow $1/\sqrt3 – 4x/15$ or $y' = 0.577 – 0.267x$ |
| | θ = 6.59° to horizontal or 83.4° to vertical | A1 [4] | |

| 6 i | $R\sin30 = 0.3g$ | M1<br>A1<br>M1<br>A1<br>A1<br>[5] | $R = 5.88$ or $0.6g$ |
| | $R\cos30 = 0.3\omega^2 \times 0.12$<br>$\omega = 11.9$ rads$^{-1}$ | | accept $v^2/0.12$ for acceleration<br>cao |
| ii | $S + R\cos30 = 0.3 \times 2.1^2/0.2$<br>$R = 5.88$<br>$S = 1.52$ N | M1<br>A1<br>B1ft<br>A1<br>[4] | Resolve and use N2L on sphere Q, 3 terms needed<br><br>ft cv(R) from (i) |
| iii | $v_P = 11.9 \times 0.12$, or $h = 0.2/\tan30$ or $0.12/\tan30$ or $0.08/\tan30$<br>$+/-(Q - P) =$<br>$\quad 0.5 \times 0.3(2.1^2 - (11.9 \times 0.12)^2)$<br>$\quad + (0.2/\tan30 - 0.12/\tan30) \times 0.3g$<br>$Q-P = +/- 0.763$ J | B1<br>M1<br>A2ft<br><br>A1<br>[5] | cv($\omega$) from (i)<br>Attempt to calculate KE or PE for both particles<br>KE difference (ft on cv($\omega$)) or PE difference<br><br>$Q - P = +/-(0.3556 + 0.4074)$ |

| 7 i | $F \times 0.8 =$<br>$0.6\cos60 \times 550$<br>$F = 206.25$ | M1<br>A1<br>A1<br>A1<br>[4] | Attempt at moments<br><br><br>Accept 206, cao |
| ii | $T \times 2 \times 0.8/\tan30$<br>$=$<br>$550 \times (0.8/\sin30 - 0.6\cos60)$<br>$T = 258$<br><br>$R = 550 - T\cos30$<br>$Fr = T\sin30$<br>$\mu = 129/326.6$<br>$\mu = 0.395$ | M1*<br>A1<br>M1*<br>A1<br>A1<br>M1*<br>A1<br>B1*<br>M1dep*<br>A1<br>[10] | Moment of T about P<br>$T \times 2.77$<br>Moment of weight about P<br>$550 \times (1.6 - 0.3)$<br>Accept to 2sf<br>Resolving vertically, 3 terms needed<br>Value for T not required<br>Value for T not required; accept < or ≤<br>For correct use of $F = \mu R$, $R \neq 550$ |

| | | | |
|---|---|---|---|
| **OR** | T x 0.8/tan30 + 550 x 0.6cos60 = R x 0.8/cos60 | M1*<br>A2<br>M1* | Moments about V, 3 terms needed<br>A1 for two terms correct<br>Resolving vertically, 3 terms needed |
| | R = 550 – Tcos30<br>Solve for T or R<br>T = 258 or R=326.5625<br>Fr = Tsin30<br>$\mu$ = 129/326.6<br>$\mu$ = 0.395 | A1<br>M1<br>A1<br>B1*<br>M1dep*<br>A1<br>[10] | Accept to 2sf<br>Value for T not required; accept < or ≤<br>For correct use of F = $\mu$R, R ≠ 550 |
| **OR** | Fr x 1.6cos30 + 550 x (1.6sin30 +0.6sin30) =<br>                                  R x (1.6 + 1.6sin30) | M1*<br><br>A2<br>M1* | Moments about Q, 3 terms needed<br><br>A1 for two terms correct<br>Resolving vertically, 3 terms needed |
| | R = 550 – Tcos30<br>Fr = Tsin30<br>Solving for at least one of R, Fr, or T<br>Either R = 326.5625, or Fr = 129(.0017008), or T=258<br>$\mu$ = 129/326.6<br>$\mu$ = 0.395 | A1<br>B1*<br>M1<br>A1<br>M1dep*<br>A1<br>[10] | <br>accept < or ≤<br><br>Only one needed. Accept to 2sf.<br>For correct use of F = $\mu$R, R ≠ 550 |

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