GCE Examinations

Advanced Subsidiary / Advanced Level

# Mechanics
# Module M2

Paper F

# MARKING GUIDE

This guide is intended to be as helpful as possible to teachers by providing concise solutions and indicating how marks should be awarded. There are obviously alternative methods that would also gain full marks.

Method marks (M) are awarded for knowing and using a method.

Accuracy marks (A) can only be awarded when a correct method has been used.

(B) marks are independent of method marks.


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# M2 Paper F – Marking Guide

**1.** $\mathbf{I} = \Delta\text{mom.} = 0.5[(13\mathbf{i} + 7\mathbf{j}) - (5\mathbf{i} - 8\mathbf{j})]$ M1 A1
$= 0.5(8\mathbf{i} + 15\mathbf{j})$ A1
mag. of $\mathbf{I} = 0.5\sqrt{(8^2 + 15^2)} = 8.5$ Ns M1 A1 **(5)**

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**2.** *(a)* change in KE $= \frac{1}{2}\,1000(10^2 - 20^2) = {}^{-}150\,000$ J M1 A1
change in PE $= 1000(9.8)(200\sin\theta) = 280\,000$ J M2 A1
change in ME $= 280\,000 - 150\,000 =$ increase of 130 000 J A1

*(b)* air resistance B1
friction B1 **(8)**

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**3.** *(a)* $s = t(2t^2 - 13t + 20) = t(2t - 5)(t - 4)$ M1 A1
particle at $O$ when $s = 0$ $\therefore$ at $t = 0$, $\frac{5}{2}$, 4 seconds M1 A1

*(b)* at rest when $v = 0$, $v = \frac{\mathrm{d}s}{\mathrm{d}t} = 6t^2 - 26t + 20$ M1 A1
$\therefore\ 3t^2 - 13t + 10 = 0$, $(t - 1)(3t - 10) = 0$ M1
$t = 1$, $\frac{10}{3}$ seconds A1 **(8)**

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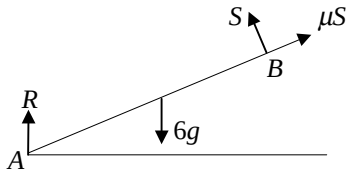
**4.** *(a)*




mom. about $B$: $6g\cos30° - R.2\cos30° = 0$ M1 A1
$\therefore\ R = 3g$ A1
mom. about $A$: $6g\cos30° - S.2 = 0$ M1 A1
$\therefore\ S = \frac{3}{2}\sqrt{3}g$ A1

*(b)* resolve $\rightarrow$: $\mu S\sin60° - S\sin30° = 0$ M1 A1

$$\mu = \frac{\frac{1}{2}}{\frac{\sqrt{3}}{2}} = \frac{1}{\sqrt{3}}$$ A1 **(9)**

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**5.** *(a)* at max. ht., $v_y = 0$ $\therefore\ 0 = (22\sin\alpha)^2 - 2gs$ M1 A1
$s_y = \frac{(22.\frac{7}{8})^2}{2g} = 18.91$ M1
starts 1.6 m above $P$ so max. ht. above ground = 20.5 m (3sf) A1

*(b)* $s_y = {}^{-}1.4$ $\therefore\ ut\sin\alpha - \frac{1}{2}gt^2 = {}^{-}1.4$
$\frac{77}{4}t - 4.9t^2 = {}^{-}1.4$ M1 A1
$14t^2 - 55t - 4 = 0$ $\therefore$ $(14t + 1)(t - 4) = 0$ M1
$t = 4$ in this case $\therefore$ ball in flight for 4 seconds A1

*(c)* $s_x = ut\cos\alpha = 22 \times 4 \times \frac{\sqrt{15}}{8} = 11\sqrt{15} = 42.6$ M1 A1
max. dist. fielder can run is $4 \times 6 = 24$ m A1
max. initial dist. between fielder and ball = 42.6 + 24 = 66.6 m (3sf) A1 **(12)**

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**6.** *(a)* $\frac{1}{2}a$,since masses on $AD$ are equal to mass at $B$ A1

*(b)*

| portion | mass | $y$ | $my$ |
|---|---|---|---|
| lamina | $8m$ | $a$ | $8ma$ |
| particle at $A$ | $2m$ | 0 | 0 |
| particle at $B$ | $6m$ | 0 | 0 |
| particle at $D$ | $4m$ | $2a$ | $8ma$ |
| total | $20m$ | $\bar{y}$ | $16ma$ |

$y$ coords. taken vert. from $AB$ M2 A1

$\bar{y} = \frac{16ma}{20m} = \frac{4}{5}a$ M1 A1

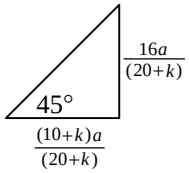
*(c)*

| portion | mass | $x$ | $mx$ |
|---|---|---|---|
| lamina | $8m$ | $\frac{a}{2}$ | $4ma$ |
| particle at $A$ | $2m$ | 0 | 0 |
| particles at $B$ | $(6 + k)m$ | $a$ | $(6 + k)ma$ |
| particle at $D$ | $4m$ | 0 | 0 |
| total | $(20 + k)m$ | $\bar{x}$ | $(10 + k)\ ma$ |

$x$ coords. taken horiz. from $AD$ M1 A1

$\bar{x} = \frac{(10+k)ma}{(20+k)m} = \frac{(10+k)a}{(20+k)}$ M1 A1

*(d)* new $\bar{y} = \frac{16ma}{(20+k)m} = \frac{16a}{(20+k)}$ M2 A1




$\tan 45° = \frac{16a}{(10+k)a}$ $\therefore$ $1 = \frac{16}{10+k}$ giving $k = 6$ M2 A1 **(16)**

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**7.** *(a)* cons. of mom: $7u_1 + 4u_2 = 7(\frac{u_1}{2}) + 4v_2$ M1

$8v_2 = 7u_1 + 8u_2$ A1

$\frac{v_2 - \frac{1}{2}u_1}{u_1 - u_2} = e$ $\therefore$ $v_2 = eu_1 - eu_2 + \frac{1}{2}u_1$ M1 A1

eliminate $v_2$ giving $7u_1 + 8u_2 = 8eu_1 - 8eu_2 + 4u_1$ M1 A1

$8u_2 + 8eu_2 = 8eu_1 - 3u_1$ $\therefore$ $8u_2(e + 1) = u_1(8e - 3)$ A1

*(b)* sub. in for $u_1$ and $u_2$: $24(e + 1) = 14(8e - 3)$ M1

$24e + 24 = 112e - 42$ giving $e = \frac{3}{4}$ M1 A1

*(c)* speeds of $A$, $B$ after impact are $v_1$ and $v_2$ resp.

$v_1 = 7\ \text{ms}^{-1}$, $v_2 = (\frac{7}{8})14 + 3 = 15.25\ \text{ms}^{-1}$ A1

original KE $= \frac{1}{2} \times 7 \times 14^2 + \frac{1}{2} \times 4 \times 3^2 = 704$ J M1 A1

final KE $= \frac{1}{2} \times 7 \times 7^2 + \frac{1}{2} \times 4 \times 15.25^2 = 636.625$ J M1 A1

% KE lost $= \frac{704 - 636.625}{704} \times 100 = 9.6\%$ (2sf) M1 A1 **(17)**

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Total **(75)**

# Performance Record – M2 Paper F

| Question no. | **1** | **2** | **3** | **4** | **5** | **6** | **7** | Total |
|---|---|---|---|---|---|---|---|---|
| Topic(s) | **i**, **j** impulse | energy | variable accel. | statics | projectiles | centre of mass | collisions, energy | |
| Marks | 5 | 8 | 8 | 9 | 12 | 16 | 17 | 75 |
| Student | | | | | | | | |
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