GCE Examinations

Advanced Subsidiary / Advanced Level

# Mechanics
# Module M2

Paper B

# 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.


*Written by Shaun Armstrong & Chris Huffer*

# M2 Paper B – Marking Guide

**1.** *(a)* work done = force × dist. = $8000 \times 0.04 = 320$ J — M1 A1

*(b)* work done = change in KE = $\frac{1}{2}m(v^2 - u^2)$ — M1

$= \frac{1}{2}0.025(v^2 - 200^2)$ $\therefore v^2 - 40\,000 = {}^{-}25\,600$ — M2 A1

$v^2 = 14\,400$ $\therefore v = 120$ ms$^{-1}$ — A1 **(7)**

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**2.** *(a)* at max. speed, $a = 0$, $\frac{P}{v} - R = 0$ $\therefore \frac{P}{30} - 2000 = 0$ — M1 A1

$P = 60\,000$ W $\therefore H = 60$ — A1

*(b)* $1.2 \times 60 = 72$ — A1

$\frac{P}{v} - R = ma$ $\therefore \frac{72000}{30} - 2000 = m \times 0.32$ — M1 A1

$400 = 0.32m$ $\therefore m = 1250$ kg — A1 **(7)**

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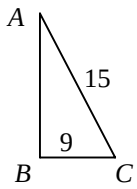
**3.** *(a)*



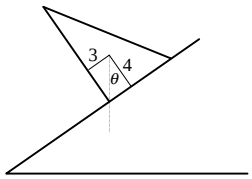

(i) c.o.m. = $\frac{1}{3}$ dist. from $B$ to $C$ = $\frac{1}{3} \times 9 = 3$ cm from $AB$ — M1 A1

(ii) $AB = \sqrt{(15^2 - 9^2)} = 12$ cm — M1 A1

c.o.m. = $\frac{1}{3}$ dist. from $B$ to $A$ = $\frac{1}{3} \times 12 = 4$ cm from $BC$ — M1 A1

*(b)* lamina will not topple if vertical through c.o.m. passes between $B$ and $C$ — B1

max. $\theta$ when it passes through $B$ — B1




$\tan\theta = \frac{3}{4}$ $\therefore \theta = 36.9°$ (1dp) — M1 A1 **(10)**

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**4.** *(a)* $\mathbf{a} = \frac{d\mathbf{v}}{dt} = 3\mathbf{i} - 2t\mathbf{j}$ and when $t = 2$, $\mathbf{a} = 3\mathbf{i} - 4\mathbf{j}$ — M1 A1

mag. of $\mathbf{a} = \sqrt{[(3)^2 + ({}^{-}4)^2]} = 5$ ms$^{-2}$ — M1 A1

*(b)* $s = \int v\,dt = \frac{3}{2}t^2\mathbf{i} - \frac{1}{3}t^3\mathbf{j} + A\mathbf{i} + B\mathbf{j}$ — M1 A1

when $t = 0$, $s = 6\mathbf{i} + 12\mathbf{j}$ so $A = 6$, $B = 12$ — M1

$s = (\frac{3}{2}t^2 + 6)\mathbf{i} + (12 - \frac{1}{3}t^3)\mathbf{j}$ — A1

disp. when $t = 6$ is $60\mathbf{i} - 60\mathbf{j} = 60(\mathbf{i} - \mathbf{j})$ $\therefore k = 60$ — M1 A1 **(10)**

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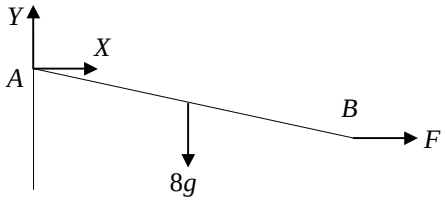
**5.** *(a)*




mom. about $A$ $\quad 8g(a\cos 20°) - F(2a\sin 20°) = 0$ — M1 A1

$F = \frac{4g}{\tan 20°} = 108$ N (3sf) — M1 A1

*(b)* resolve $\rightarrow$: $\quad F + X = 0 \ \therefore\ X = {}^{-}108$ — A1

resolve $\uparrow$: $\quad Y - 8g = 0 \ \therefore\ Y = 78.4$ N — A1

mag. of reaction at hinge $= \sqrt{[({}^{-}108)^2 + (78.4)^2]} = 133$ N (3sf) — M1 A1

req'd angle $= \tan^{-1}\frac{108}{78.4} = 54°$ (nearest degree) to the vertical — M1 A1 **(10)**

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**6.** *(a)* $s_y = (ut\sin\alpha - \frac{1}{2}gt^2) \ = t(u\sin\alpha - \frac{1}{2}gt)$ — M1 A1

$s_y = 0$ when $t = 0$ (at $A$) and when $t = \frac{2u}{g}\sin\alpha$ (at $B$) — A1

$s_x = ut\cos\alpha = u(\frac{2u}{g}\sin\alpha)\cos\alpha$ (at $B$) — M1

$= \frac{u^2}{g}(2\sin\alpha\cos\alpha) = \frac{u^2}{g}\sin 2\alpha$ — M1 A1

*(b)* $\frac{u^2}{g}\sin 2\alpha = 80 \quad \therefore\ \frac{45^2}{9.8}\sin 2\alpha = 80$ — M1 A1

$\sin 2\alpha = 0.387$ $\quad$ giving $\alpha = 11.4°, 78.6°$ (1dp) — M2 A1

*(c)* $11.4°$ as larger horiz. component of vel. — B2

*(d)* $t = \frac{2\times 45}{g}\sin(11.4°) = 1.8$ seconds (1dp) — M1 A1 **(15)**

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**7.** *(a)* cons. of mom: $4m(u) + 0 = 4mv_1 + 5mv_2$ — M1

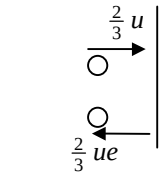
$4u = 4v_1 + 5v_2$ — A1

$\frac{v_2 - v_1}{u - 0} = \frac{1}{2} \ \therefore\ u = 2v_2 - 2v_1$ — M1 A1

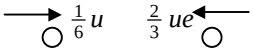
solve sim. eqns. to get $v_1 = \frac{1}{6}u$, $v_2 = \frac{2}{3}u$ — M1 A1

$\therefore\ v_2 = \frac{4}{6}u = 4 \times v_1$ — A1

*(b)*




speed of $B$ after collision with wall $= \frac{2}{3}ue$ — M1 A1




cons. of mom: $4m(\frac{1}{6}u) - 5m(\frac{2}{3}ue) = 4mw_1 + 0$ — M1 A1

$\frac{2}{3}u - \frac{10}{3}ue = 4w_1 \quad \therefore\ 12w_1 = 2u - 10ue$ — A1

$\frac{0 - w_1}{\frac{1}{6}u + \frac{2}{3}ue} = \frac{1}{2} \quad \therefore\ {}^{-}w_1 = \frac{1}{12}u + \frac{1}{3}ue$ $\quad$ giving $\quad {}^{-}12w_1 = u + 4ue$ — M1 A1

eliminating $w_1$ gives $u + 4ue + 2u - 10ue = 0$ — M1

$3u = 6ue \ \therefore\ e = \frac{1}{2}$ — A1 **(16)**

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Total **(75)**

# Performance Record – M2 Paper B

| Question no. | **1** | **2** | **3** | **4** | **5** | **6** | **7** | Total |
|---|---|---|---|---|---|---|---|---|
| Topic(s) | work - energy | power | centre of mass, toppling | **i**, **j** calculus | statics | projectiles | collisions | |
| Marks | 7 | 7 | 10 | 10 | 10 | 15 | 16 | 75 |
| Student | | | | | | | | |
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