GCE Examinations

Advanced Subsidiary / Advanced Level

Mechanics
Module M2

Paper A

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 A – Marking Guide

1. cons. of mom: $m(5) - m(3) = mv_1 + mv_2$ M1
$v_1 + v_2 = 2$ A1
$\frac{v_2 - v_1}{5-(-3)} = \frac{1}{2}$ $\therefore\ v_2 - v_1 = 4$ M1 A1
solve simul. giving $v_1 = {}^-1$ ms^{-1} so speed is 1 ms^{-1}, $v_2 = 3$ ms^{-1} M1 A1 **(6)**

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2. *(a)* $\mathbf{v} = \frac{d\mathbf{r}}{dt} = (2t - 3)\mathbf{i} + \frac{1}{2}t^2\mathbf{j}$ M1 A1
when $t = 0$, $\mathbf{v} = {}^-3\mathbf{i}$ ms^{-1} A1

(b) at $t = 2$, $\mathbf{v} = \mathbf{i} + 2\mathbf{j}$ $\therefore\ |\mathbf{v}| = \sqrt{(1^2 + 2^2)} = \sqrt{5}$ M2 A1
KE lost $= \frac{1}{2}(3)(3^2 - 5) = 6$J M1 A1 **(8)**

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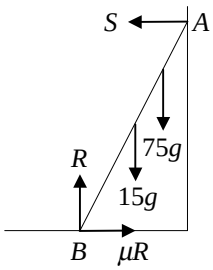
3. *(a)* (i) uniform rod B1
(ii) particle B1

(b)



resolve ↑: $R - 15g - 75g = 0$ $\therefore\ R = 90g$ M1
resolve →: $\mu R - S = 0$ $\therefore\ S = 30g$ M1 A1
mom. about B $S.8\sin\theta - 15g.4\cos\theta - 75g.d\cos\theta = 0$ M1 A1
$8S\tan\theta - 60g = 75gd$ M1
$d = \frac{420g}{75g} = 5.6$ $\therefore\ AP = 8 - 5.6 = 2.4$ m M1 A1 **(10)**

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4. *(a)* $a \propto (3t^2 - 5)$ $\therefore\ a = k(3t^2 - 5)$ M1
$v = \int a\,dt = k(t^3 - 5t) + c$ M1 A1
when $t = 0$, $v = 0$ so $c = 0$ A1
when $t = 3$, $v = 3$ so $3 = k(27 - 15)$ $\therefore\ k = \frac{1}{4}$ M1 A1
$a = \frac{1}{4}(3t^2 - 5)$ A1

(b) $s = \int v\,dt = \frac{1}{4}(\frac{1}{4}t^4 - \frac{5}{2}t^2) + c$ M1 A1
when $t = 0$, $s = 0$ so $c = 0$ $\therefore\ s = \frac{1}{4}(\frac{1}{4}t^4 - \frac{5}{2}t^2)$ M1
$s = \frac{1}{4}t^2(\frac{1}{4}t^2 - \frac{10}{4}) = \frac{1}{16}t^2(t^2 - 10)$ A1 **(11)**

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5. *(a), (b)*

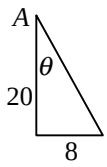
portion	mass	x	y	mx	my
$ABFG$	256ρ	4	16	1024ρ	4096ρ
$CDEF$	128ρ	16	4	2048ρ	512ρ
total	384ρ	$\bar{x}$	$\bar{y}$	3072ρ	4608ρ

ρ = mass per unit area x, y coords. taken horiz. / vert. from G — M3 A2

$\bar{x} = \frac{3072\rho}{384\rho} = 8$ so must lie on BF — M1 A1

$\bar{y} = \frac{4608\rho}{384\rho} = 12$ $\therefore$ dist. from AB = 20 cm — M1 A1

(c)



M1

$\tan\theta = \frac{8}{20}$ $\therefore$ $\theta = 21.8°$ (1dp) — M1 A1 **(12)**

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6. *(a)* $\frac{P}{v} - R = ma$ $\therefore$ $\frac{90000}{20} - 1800 = 1200a$ — M2 A1

$\therefore$ $a = 2.25$ ms^{-2} — A1

(b) at max. speed, $a = 0$, $\frac{P}{v} - R = 0$ $\therefore$ $\frac{90000}{v} - 1800 = 0$ so $v = 50$ ms^{-1} — M1 A1

KE = $\frac{1}{2} \times 1200 \times 50^2 = 1\,500\,000$ J = 1500 kJ — M1 A1

(c) $\frac{P}{v} - R - mg\sin\alpha = 0$ $\therefore$ $\frac{90000}{25} - 1800 - 1200(9.8)\sin\alpha = 0$ — M2 A1

$\sin\alpha = \frac{1.5}{9.8}$ $\therefore$ $\alpha = 8.8°$ (1dp) — M1 A1 **(13)**

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7. *(a)* particle moving freely under gravity — B2

(b) vert. disp. = 0 $\therefore t(u\sin\alpha - \frac{1}{2}gt) = 0$ — M1

$t = 0$ at O, we require $49\sin30° - 4.9t = 0$ $\therefore$ $t = 5$ — M1 A1

horiz. disp. = $u t\cos\alpha = 49(5)\cos30° = 212.17$ — M1 A1

i.e. 212 – 170 beyond hole = 42.2 m (3sf) — A1

(c) when horiz. disp. = 170, $u t\cos\alpha = 170$ $\therefore$ $t = 4.006$ — M1

horiz. vel. = $u\cos\alpha = 42.44$ vert. vel. = $u\sin\alpha - gt = {}^{-}14.76$ — A2

mag. of vel = $\sqrt{[(42.44)^2 + ({}^{-}14.76)^2]} = 44.9$ ms^{-1} (3sf) — M1 A1

req'd angle = $\tan^{-1}\frac{14.76}{42.44} = 19.2°$ below horizontal (3sf) — M1 A1 **(15)**

Total **(75)**

Performance Record – M2 Paper A

Question no.	1	2	3	4	5	6	7	Total
Topic(s)	collisions	**i**, **j** calculus	statics ladder prob.	variable accel.	centre of mass	power, KE	projectiles	
Marks	6	8	10	11	12	13	15	75
Student								