GCE Examinations

Advanced Subsidiary / Advanced Level

Mechanics
Module M2

Paper C

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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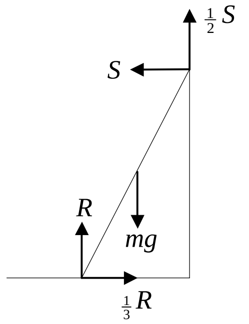
M2 Paper C – Marking Guide

1.	*(a)*	$\mathbf{v} = \frac{d\mathbf{r}}{dt} = 6t\mathbf{i} - 8t\mathbf{j}$	M1 A1	
		$\mathbf{a} = \frac{d\mathbf{v}}{dt} = 6\mathbf{i} - 8\mathbf{j}$ not dependent on t so constant	M1 A1	
	(b)	$\mathbf{F} = m\mathbf{a} = 2\mathbf{a} = 12\mathbf{i} - 16\mathbf{j}$	A1	
		mag. of $\mathbf{F} = \sqrt{[(12)^2 + (^-16)^2]} = 20$ N	M1 A1	**(7)**
2.	*(a)*	X-sect. area of pipe $= \pi r^2 = \pi(0.05)^2$	M1 A1	
		mass of water per second $= 6 \times 0.0025\pi \times 1000 = 15\pi$	M1 A1	
	(b)	energy gained $= \frac{1}{2}mv^2 + mgh = \frac{15}{2}\pi(6)^2 + (150\pi \times 9.8 \times 12)$	M2 A1	
		$= 6390$ J $= 6.39$ kJ (3sf)	A1	**(8)**
3.	*(a)*	when $t = 0$, $v = 4$ ms^{-1}	A1	
	(b)	particle at rest when $2t^2 - 9t + 4 = 0$ i.e. $(2t - 1)(t - 4) = 0$	M1 A1	
		$t = \frac{1}{2}, 4$	A1	
	(c)	$s = \int v \, dt = \frac{2}{3}t^3 - \frac{9}{2}t^2 + 4t + c$	M1 A1	
		when $t = 0$, $s = 9$ so $c = 9$ $\therefore s = \frac{2}{3}t^3 - \frac{9}{2}t^2 + 4t + 9$	A1	
		disp. when $t = 6$ is $\frac{2}{3}(6)^3 - \frac{9}{2}(6)^2 + 4(6) + 9$	M1	
		$= 144 - 162 + 24 + 9 = 15$ m	A1	**(9)**

4.



resolve ↑:	$\frac{1}{2}S + R - mg = 0$	M1	
resolve →:	$\frac{1}{3}R - S = 0$	M1	
solve simul. giving	$S = \frac{1}{3}R$ $\therefore R = \frac{6}{7}mg$	M1 A1	
mom. about top of ladder	$R.2a\cos\theta - \frac{1}{3}R.2a\sin\theta - mg.a\cos\theta = 0$	M1 A1	
	$\therefore \tan\theta = \frac{2R - mg}{\frac{2}{3}R} = \frac{5}{4}$	M2 A1	**(9)**

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5.	*(a)*	vert. disp. = 0 $\therefore$ $8u_y - \frac{1}{2}g(8)^2 = 0$	M1 A1	
		$u_y = \frac{1}{2}g(8) = 4g$	A1	
		horiz. disp. = 24 $\therefore$ $8u_x = 24$ so $u_x = 3$	M1 A1	
	(b)	initial speed = $\sqrt{[(4g)^2 + 3^2]}$ = 39.3 ms^{-1} (3sf)	M1 A1	
	(c)	max. ht. when vert. vel = 0 $\therefore$ $0 = (4g)^2 - 2gs$	M1 A1	
		$\therefore$ max. ht. = $8g$ = 78.4 m	A1	
	(d)	e.g. small X-section, reasonable to treat as particle and ignore air res. but, significant loss of mass during flight $\therefore$ model not very suitable	B3	**(13)**

6.	*(a)*	cons. of mom: $3mu + 0 = 3mv_1 + 2mv_2$	M1	
		$\therefore$ $3v_1 + 2v_2 = 3u$	A1	
		$\frac{v_2 - v_1}{u} = \frac{2}{3}$ $\therefore$ $3v_2 - 3v_1 = 2u$	M1 A1	
		solve simul. giving $v_1 = \frac{1}{3}u$ and $v_2 = u$	M1 A1	
	(b)	cons. of mom: $2mu + 0 = 2mw_1 + 2mw_2$	M1	
		$w_1 + w_2 = u$	A1	
		$\frac{w_2 - w_1}{u} = e$ $\therefore$ $w_2 - w_1 = eu$	A1	
		solve simul. giving $w_1 = \frac{1}{2}u(1 - e)$	M1 A1	
		A and *B* collide again so speed of *B* < speed of *A*	M1	
		$\frac{1}{2}u(1 - e) < \frac{1}{3}u$ so $\frac{1}{2}e > \frac{1}{2} - \frac{1}{3}$ $\therefore$ $e > \frac{1}{3}$	M1 A1	**(14)**

7. *(a)* from triangle properties, area of $BCD = \frac{1}{3}$ area of ABD — B1

$\therefore$ area of $BCD = \frac{1}{3}(\frac{1}{2} \times 2d \times \sqrt{3}d) = \frac{1}{3}\sqrt{3}d^2$ — M1 A1

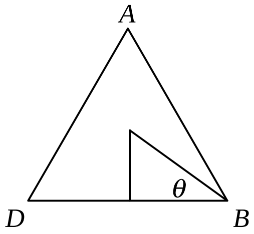
(b)

portion	mass	y	my
ABD	$\sqrt{3}d^2\rho$	$\frac{1}{3}\sqrt{3}d$	$d^3\rho$
BCD	$\frac{1}{3}\sqrt{3}d^2\rho$	$\frac{1}{9}\sqrt{3}d$	$\frac{1}{9}d^3\rho$
ABCD	$\frac{2}{3}\sqrt{3}d^2\rho$	$\bar{y}$	$\frac{8}{9}d^3\rho$

ρ = mass per unit area y coords. taken vert. from *BD* — M3 A3

$\bar{y} = \frac{\frac{8}{9}d^3\rho}{\frac{2}{3}\sqrt{3}d^2\rho} = \frac{4d}{3\sqrt{3}} = \frac{4}{9}\sqrt{3}d$ — M1 A1

(c)



$\theta = \tan^{-1}\frac{\frac{4}{9}\sqrt{3}d}{d} = \tan^{-1}\frac{4\sqrt{3}}{9}$ — M1 A1

req'd angle = $60 - \theta$ = 22.4° (1dp) — M1 A1 **(15)**

Total **(75)**

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Performance Record – M2 Paper C

Question no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	Total
Topic(s)	**i**, **j** calculus	KE + PE	variable accel.	statics ladder prob.	projectiles	collisions	centre of mass	
Marks	7	8	9	9	13	14	15	75
Student								

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