GCE Examinations

Advanced Subsidiary / Advanced Level

Mechanics
Module M2

Paper D

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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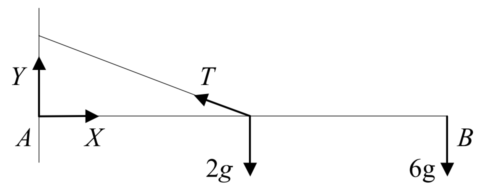
M2 Paper D – Marking Guide

1.	*(a)*	$\mathbf{v} = \frac{d\mathbf{r}}{dt} = (3t - 3)\mathbf{i} + (t^2 - k)\mathbf{j}$	M2 A1	
	(b)	at rest when coeffs of **i** and **j** are both zero	M1	
		$3t - 3 = 0 \qquad t^2 - k = 0$	M1	
		both satisfied when $k = 1$	A1	**(6)**
2.		cons. of mom: $2mu_1 - 5mu_2 = {}^-2m(3) + 5m(4)$		
		$2u_1 - 5u_2 = 14$	M1 A1	
		$\frac{4-(-3)}{u_1+u_2} = \frac{1}{2} \quad \therefore\ u_1 + u_2 = 14$	M1 A1	
		solve simul. giving $u_1 = 12\text{ ms}^{-1}$, $u_2 = 2\text{ ms}^{-1}$	M1 A1	**(6)**
3.	*(a)*	$R \propto v \quad \therefore\ R = kv$, where k is a constant	M1	
		$\frac{P}{v} - R = 0 \quad \therefore\ \frac{90000}{50} - 50k = 0$	M1 A1	
		$k = 36 \quad \therefore\ R = 36v$	A1	
	(b)	$\frac{P}{v} - R - mg\sin\theta = 0 \quad \therefore\ \frac{90000}{v} - 36v - 1200(9.8)\frac{1}{14} = 0$	M1 A1	
		$90000 - 36v^2 - 840v = 0 \quad \therefore\ 3v^2 + 70v - 7500 = 0$	M1 A1	
		quad. form. giving $v = 39.7\text{ ms}^{-1}$ (3sf) (clearly ${}^-63.0$ not suitable)	M1 A1	**(10)**

4.



	(a)	mom. about A $\quad 2ga + 6g(2a) - T\cos60° = 0$	M1 A1	
		$14ga = \frac{1}{2}Ta \quad \therefore\ T = 28g$	M1 A1	
	(b)	resolve ↑: $\quad Y + T\cos60° - 8g = 0 \quad \therefore\ Y = {}^-6g$	M1 A1	
		resolve →: $\quad X - T\sin60° = 0 \quad \therefore\ X = 14\sqrt{3}\,g$	M1 A1	
		mag. of force at hinge $= \sqrt{[(14\sqrt{3}\,g)^2 + ({}^-6g)^2]} = 245$ N (3sf)	M1 A1	
		req'd angle $= \tan^{-1}\frac{6g}{14\sqrt{3}g} = 13.9°$ (3sf) below horizontal (away from wall)	M1 A1	**(12)**
5.	*(a)*	$v = \int a\,dt = 3t^2 - 10t + c$	M1 A1	
		when $t = 0$, $v = 3$ so $c = 3 \quad \therefore\ v = 3t^2 - 10t + 3$	M1 A1	
		$v = 0$ when $(3t - 1)(t - 3) = 0 \quad \therefore\ t = \frac{1}{3}, 3$	M1 A1	
	(b)	$s = \int v\,dt = t^3 - 5t^2 + 3t + k$	M1 A1	
		when $t = 0$, $s = 0$ so $k = 0 \quad \therefore\ s = t^3 - 5t^2 + 3t$	A1	
		disp. when $t = \frac{1}{3}$ is $(\frac{1}{3})^3 - 5(\frac{1}{3})^2 + 3(\frac{1}{3}) = \frac{13}{27}$	M1 A1	
		disp. when $t = 2$ is $(2)^3 - 5(2)^2 + 3(2) = {}^-6$	A1	
		dist. travelled $= 2 \times \frac{13}{27} + 6 = 6\frac{26}{27}$ m	A1	**(13)**

6. *(a)* min. α when ball passes through $(12, ^{-}0.6)$

$12 = 14t\cos\alpha \quad \therefore \; t = \frac{6}{7\cos\alpha}$ M1 A1

$^{-}0.6 = 14t\sin\alpha - 4.9t^2$ M1

sub. in t giving $^{-}0.6 = 14(\frac{6}{7\cos\alpha})\sin\alpha - 4.9(\frac{6}{7\cos\alpha})^2$ A1

$^{-}0.6 = 12\tan\alpha - 3.6\sec^2\alpha$ M1

use $\sec^2\alpha \equiv 1 + \tan^2\alpha$ giving $6\tan^2\alpha - 20\tan\alpha + 5 = 0$ A1

use of quad. form. giving $\tan\alpha = 0.27$ (and 3.06)

min. $\alpha = 15°$ (nearest degree) M1 A1

(b) $ut\cos\alpha = 12$

$12 = 14t(\frac{3}{5}) \quad \therefore \; t = \frac{10}{7}$ M1 A1

vert. disp., $ut\sin\alpha - \frac{1}{2}gt^2 = 14(\frac{10}{7})(\frac{4}{5}) - 4.9(\frac{10}{7})^2$ M1

$= 16 - 10 = 6$ M1 A1

i.e. $6 + 0.6$ above M $\therefore$ $6.6 - 2.4 = 4.2$m above crossbar A1 **(14)**

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7. *(a)* (i), (ii)

portion	mass	x	y	mx	my
rectangle	32ρ	4	2	128ρ	64ρ
semicircle	$2\pi\rho$	6	$4 + \frac{8}{3\pi}$	$12\pi\rho$	$(8\pi + \frac{16}{3})\rho$
total	$(32 + 2\pi)\rho$	$\bar{x}$	$\bar{y}$	$(128 + 12\pi)\rho$	$(8\pi + \frac{208}{3})\rho$

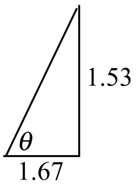
ρ = mass per unit area $\quad x, y$ coords. taken horiz. / vert. from O M4 A2

$\bar{x} = \frac{(128+12\pi)\rho}{(32+2\pi)\rho} = 4.33$ cm from OD (3sf) M1 A1

$\bar{y} = \frac{(8\pi+\frac{208}{3})\rho}{(32+2\pi)\rho} = 2.47$ cm from OA (3sf) M1A1

(b) $4 - 2.47 = 1.53$ from m'pt. of BC vertically M1

$6 - 4.33 = 1.67$ from m'pt. of BC horizontally M1



$\tan\theta = \frac{1.53}{1.67} \quad \therefore \; \theta = 42.5°$ (3sf) M1 A1 **(14)**

Total **(75)**

Performance Record – M2 Paper D

Question no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	Total
Topic(s)	**i**, **j** calculus	collisions	power	statics	variable accel.	projectiles	centre of mass	
Marks	6	6	10	12	13	14	14	75
Student								