

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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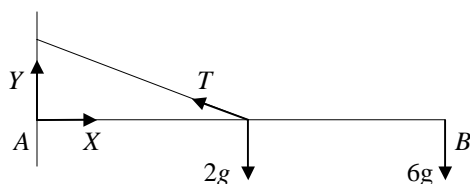
M2 Paper D – Marking Guide

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 \mathbf{i} and \mathbf{j} are both zero M1
 $3t-3=0 \quad t^2-k=0$ M1
 both satisfied when $k=1$ A1 (6)

2. cons. of mom: $2mu_1 - 5mu_2 = -2m(3) + 5m(4)$ M1 A1
 $2u_1 - 5u_2 = 14$ M1 A1
 $\frac{4-(-3)}{u_1+u_2} = \frac{1}{2} \therefore u_1 + u_2 = 14$ M1 A1
 solve simul. giving $u_1 = 12 \text{ ms}^{-1}$, $u_2 = 2 \text{ ms}^{-1}$ M1 A1 (6)

3. (a) $R \propto v \therefore R = kv$, where k is a constant M1
 $\frac{P}{v} - R = 0 \therefore \frac{90000}{50} - 50k = 0$ M1 A1
 $k = 36 \therefore R = 36v$ A1
- (b) $\frac{P}{v} - R - mg\sin\theta = 0 \therefore \frac{90000}{v} - 36v - 1200(9.8)\frac{1}{14} = 0$ M1 A1
 $90000 - 36v^2 - 840v = 0 \therefore 3v^2 + 70v - 7500 = 0$ M1 A1
 quad. form. giving $v = 39.7 \text{ ms}^{-1}$ (3sf) (clearly $\neq 63.0$ not suitable) M1 A1 (10)

4.



- (a) mom. about A $2ga + 6g(2a) - T\cos 60^\circ = 0$ M1 A1
 $14ga = \frac{1}{2}Ta \therefore T = 28g$ M1 A1
- (b) resolve \uparrow : $Y + T\cos 60^\circ - 8g = 0 \therefore Y = -6g$ M1 A1
 resolve \rightarrow : $X - T\sin 60^\circ = 0 \therefore X = 14\sqrt{3}g$ M1 A1
 mag. of force at hinge = $\sqrt{[(14\sqrt{3}g)^2 + (-6g)^2]} = 245 \text{ N}$ (3sf) M1 A1
 req'd angle = $\tan^{-1} \frac{6g}{14\sqrt{3}g} = 13.9^\circ$ (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 $c=3 \therefore v = 3t^2 - 10t + 3$ M1 A1
 $v=0$ when $(3t-1)(t-3)=0 \therefore t = \frac{1}{3}, 3$ M1 A1
- (b) $s = \int v dt = t^3 - 5t^2 + 3t + k$ M1 A1
 when $t=0$, $s=0$ so $k=0 \therefore s = t^3 - 5t^2 + 3t$ 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 = $2 \times \frac{13}{27} + 6 = 6\frac{26}{27} \text{ m}$ A1 (13)

6. (a) min. α when ball passes through (12, -0.6)
- $$12 = 14t\cos\alpha \quad \therefore t = \frac{6}{7\cos\alpha} \quad \text{M1 A1}$$
- $$-0.6 = 14t\sin\alpha - 4.9t^2 \quad \text{M1}$$
- $$\text{sub. in } t \text{ giving } -0.6 = 14\left(\frac{6}{7\cos\alpha}\right)\sin\alpha - 4.9\left(\frac{6}{7\cos\alpha}\right)^2 \quad \text{A1}$$
- $$-0.6 = 12\tan\alpha - 3.6\sec^2\alpha \quad \text{M1}$$
- $$\text{use } \sec^2\alpha \equiv 1 + \tan^2\alpha \text{ giving } 6\tan^2\alpha - 20\tan\alpha + 5 = 0 \quad \text{A1}$$
- $$\text{use of quad. form. giving } \tan\alpha = 0.27 \text{ (and 3.06)}$$
- $$\text{min. } \alpha = 15^\circ \text{ (nearest degree)} \quad \text{M1 A1}$$
- (b) $ut\cos\alpha = 12$
- $$12 = 14t\left(\frac{3}{5}\right) \quad \therefore t = \frac{10}{7} \quad \text{M1 A1}$$
- $$\text{vert. disp., } ut\sin\alpha - \frac{1}{2}gt^2 = 14\left(\frac{10}{7}\right)\left(\frac{4}{5}\right) - 4.9\left(\frac{10}{7}\right)^2 \quad \text{M1}$$
- $$= 16 - 10 = 6 \quad \text{M1 A1}$$
- $$\text{i.e. } 6 + 0.6 \text{ above } M \quad \therefore 6.6 - 2.4 = 4.2\text{m above crossbar} \quad \text{A1} \quad \mathbf{(14)}$$

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

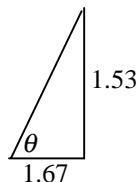
portion	mass	x	y	mx	my
rectangle	32ρ	4	2	128ρ	64ρ
semicircle	$2\pi\rho$	6	$4 + \frac{8}{3\pi}$	$12\pi\rho$	$(8\pi + \frac{16}{3})\rho$
total	$(32 + 2\pi)\rho$	\bar{x}	\bar{y}	$(128 + 12\pi)\rho$	$(8\pi + \frac{208}{3})\rho$

$\rho = \text{mass per unit area}$ x, y coords. taken horiz. / vert. from O M4 A2

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

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

- (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



$$\tan\theta = \frac{1.53}{1.67} \quad \therefore \theta = 42.5^\circ \text{ (3sf)} \quad \text{M1 A1} \quad \mathbf{(14)}$$

Total (75)

