

GCE Examinations
Advanced Subsidiary / Advanced Level
Mechanics
Module M2

Paper F

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.

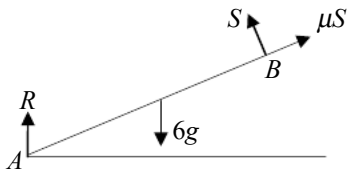


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M2 Paper F – Marking Guide

1. $\mathbf{I} = \Delta \text{mom.} = 0.5[(13\mathbf{i} + 7\mathbf{j}) - (5\mathbf{i} - 8\mathbf{j})]$
 $= 0.5(8\mathbf{i} + 15\mathbf{j})$
 mag. of $\mathbf{I} = 0.5\sqrt{8^2 + 15^2} = 8.5 \text{ N s}$ M1 A1
A1
M1 A1 (5)
-
2. (a) change in KE $= \frac{1}{2} 1000(10^2 - 20^2) = -150000 \text{ J}$ M1 A1
 change in PE $= 1000(9.8)(200\sin\theta) = 280000 \text{ J}$ M2 A1
 change in ME $= 280000 - 150000 = \text{increase of } 130000 \text{ J}$ A1
- (b) air resistance B1
 friction B1 (8)
-
3. (a) $s = t(2t^2 - 13t + 20) = t(2t - 5)(t - 4)$ M1 A1
 particle at O when $s = 0 \therefore$ at $t = 0, \frac{5}{2}, 4$ seconds M1 A1
- (b) at rest when $v = 0, v = \frac{ds}{dt} = 6t^2 - 26t + 20$ M1 A1
 $\therefore 3t^2 - 13t + 10 = 0, (t - 1)(3t - 10) = 0$ M1
 $t = 1, \frac{10}{3}$ seconds A1 (8)
-
4. (a)  M1 A1
- mom. about B: $6g\cos 30^\circ - R \cdot 2\cos 30^\circ = 0$ A1
 $\therefore R = 3g$ M1 A1
- mom. about A: $6g\cos 30^\circ - S \cdot 2 = 0$ A1
 $\therefore S = \frac{3}{2}\sqrt{3}g$
- (b) resolve $\rightarrow: \mu S \sin 60^\circ - S \sin 30^\circ = 0$ M1 A1

$$\mu = \frac{\frac{1}{2}}{\frac{\sqrt{3}}{2}} = \frac{1}{\sqrt{3}}$$
 A1 (9)
-
5. (a) at max. ht., $v_y = 0 \therefore 0 = (22 \sin \alpha)^2 - 2gs$ M1 A1
 $s_y = \frac{(22 \frac{7}{8})^2}{2g} = 18.91$ M1
 starts 1.6 m above P so max. ht. above ground = 20.5 m (3sf) A1
- (b) $s_y = -1.4 \therefore ut \sin \alpha - \frac{1}{2}gt^2 = -1.4$
 $\frac{77}{4}t - 4.9t^2 = -1.4$ M1 A1
 $14t^2 - 55t - 4 = 0 \therefore (14t + 1)(t - 4) = 0$ M1
 $t = 4$ in this case \therefore ball in flight for 4 seconds A1
- (c) $s_x = ut \cos \alpha = 22 \times 4 \times \frac{\sqrt{15}}{8} = 11\sqrt{15} = 42.6$ M1 A1
 max. dist. fielder can run is $4 \times 6 = 24 \text{ m}$ A1
 max. initial dist. between fielder and ball = $42.6 + 24 = 66.6 \text{ m}$ (3sf) A1 (12)

6. (a) $\frac{1}{2}a$, since masses on AD are equal to mass at B A1

(b)

portion	mass	y	my
lamina	$8m$	a	$8ma$
particle at A	$2m$	0	0
particle at B	$6m$	0	0
particle at D	$4m$	$2a$	$8ma$
total	$20m$	\bar{y}	$16ma$

y coords. taken vert. from AB

$$\bar{y} = \frac{16ma}{20m} = \frac{4}{5}a$$

M2 A1

M1 A1

(c)

portion	mass	x	mx
lamina	$8m$	$\frac{a}{2}$	$4ma$
particle at A	$2m$	0	0
particles at B	$(6+k)m$	a	$(6+k)ma$
particle at D	$4m$	0	0
total	$(20+k)m$	\bar{x}	$(10+k)ma$

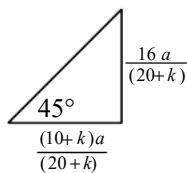
x coords. taken horiz. from AD

$$\bar{x} = \frac{(10+k)ma}{(20+k)m} = \frac{(10+k)a}{(20+k)}$$

M1 A1

M1 A1

(d) new $\bar{y} = \frac{16ma}{(20+k)m} = \frac{16a}{(20+k)}$ M2 A1



$$\tan 45^\circ = \frac{16a}{(10+k)a} \therefore 1 = \frac{16}{10+k} \text{ giving } k = 6$$

M2 A1 (16)

7. (a) cons. of mom: $7u_1 + 4u_2 = 7\left(\frac{u_1}{2}\right) + 4v_2$ M1

$$8v_2 = 7u_1 + 8u_2$$

A1

$$\frac{v_2 - \frac{1}{2}u_1}{u_1 - u_2} = e \therefore v_2 = eu_1 - eu_2 + \frac{1}{2}u_1$$

M1 A1

eliminate v_2 giving $7u_1 + 8u_2 = 8eu_1 - 8eu_2 + 4u_1$ M1 A1

$$8u_2 + 8eu_2 = 8eu_1 - 3u_1 \therefore 8u_2(e+1) = u_1(8e-3)$$

A1

(b) sub. in for u_1 and u_2 : $24(e+1) = 14(8e-3)$ M1

$$24e + 24 = 112e - 42 \text{ giving } e = \frac{3}{4}$$

M1 A1

(c) speeds of A, B after impact are v_1 and v_2 resp.

$$v_1 = 7 \text{ ms}^{-1}, v_2 = \left(\frac{7}{8}\right)14 + 3 = 15.25 \text{ m s}^{-1}$$

A1

$$\text{original KE} = \frac{1}{2} \times 7 \times 14^2 + \frac{1}{2} \times 4 \times 3^2 = 704 \text{ J}$$

M1 A1

$$\text{final KE} = \frac{1}{2} \times 7 \times 7^2 + \frac{1}{2} \times 4 \times 15.25^2 = 636.625 \text{ J}$$

M1 A1

$$\% \text{ KE lost} = \frac{704 - 636.625}{704} \times 100 = 9.6\% \text{ (2sf)}$$

M1 A1 (17)

Total (75)

