GCE Examinations

Advanced Subsidiary / Advanced Level

Mechanics
Module M2

Paper E

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 E – Marking Guide

1. $\mathbf{I} = \Delta\text{mom.} \quad 12\mathbf{i} - 9\mathbf{j} = 0.6[(5\mathbf{i} + 3\mathbf{j}) - \mathbf{u}]$ — M1 A1

$20\mathbf{i} - 15\mathbf{j} = 5\mathbf{i} + 3\mathbf{j} - \mathbf{u}$ — M1

$\mathbf{u} = {}^{-}15\mathbf{i} + 18\mathbf{j}$ — A1 **(4)**

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2. *(a)* when $t = 0$, $x = 2 + 0 - \frac{1}{10} = 1.9$ m — M1 A1

(b) $v = \frac{dx}{dt} = 1 - \frac{1}{10}e^t$ — A1

at rest when $v = 0 \quad 1 - \frac{1}{10}e^t = 0 \quad \therefore \quad e^t = 10$ — M1 A1

$t = \ln 10 = 2.3$ (1dp) — A1 **(6)**

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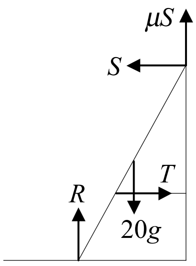
3. *(a)*



B2

(b) resolve ↑: $R + \mu S - 20g = 0 \therefore R = 20g - \mu S$ — M1

resolve →: $T - S = 0 \quad \therefore \quad S = T$ — M1

eliminating S gives $R = 20g - \frac{1}{3}T$ — A1

mom. about top of ladder $T(4\sin\theta) + 20g(3\cos\theta) - R(6\cos\theta) = 0$ — M1 A1

$4T\tan\theta + 60g - 6R = 0$ — M1

$10T + 60g - 120g + 2T = 0 \therefore 12T = 60g$ and $T = 5g$ — A1

(c) attach rope lower down ladder/wall — B1

gives larger moment about top of ladder with same tension — B1 **(11)**

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

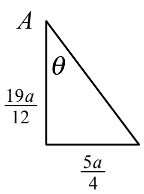
portion	mass	x	y	mx	my
AB	$2a\rho$	0	a	0	$2a^2\rho$
BC	$3a\rho$	$\frac{3}{2}a$	0	$\frac{9}{2}a^2\rho$	0
CD	$a\rho$	$3a$	$\frac{1}{2}a$	$3a^2\rho$	$\frac{1}{2}a^2\rho$
total	$6a\rho$	$\bar{x}$	$\bar{y}$	$\frac{15}{2}a^2\rho$	$\frac{5}{2}a^2\rho$

ρ = mass per unit area $\quad x, y$ coords. taken horiz./ vert. from B — M2 A2

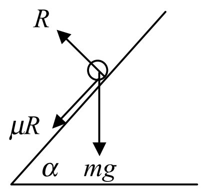
$\bar{x} = \frac{\frac{15}{2}a^2\rho}{6a\rho} = \frac{5a}{4}$ from AB — M1 A1

$\bar{y} = \frac{\frac{5}{2}a^2\rho}{6a\rho} = \frac{5a}{12}$ from BC — M1 A1

(b) $2a - \frac{5a}{12} = \frac{19a}{12}$ — A1



$\tan\theta = \frac{\frac{5}{4}a}{\frac{19}{12}a} = \frac{15}{19} \therefore \theta = 38°$ (nearest degree) — M2 A1 **(12)**

5.	*(a)*	$\frac{P}{v} - R - mg\sin\alpha = 0$	M1 A1	
		$\frac{P}{20} - 4400 - 40000(9.8)\frac{1}{20} = 0$	M1	
		$P = 20(4400 + 19600) = 480\,000$ W $= 480$ kW	M1 A1	
	(b)	$\frac{P}{v} - R = ma \;\therefore\; \frac{480000}{20} - 4400 = 40000a$	M1 A1	
		$a = 0.49$ ms^{-2}	A1	
	(c)	at max. speed, $a = 0 \;\therefore\; \frac{P}{v} - R = 0$	M1	
		$\frac{480000}{v} - 4400 = 0$ so $v = 109$ ms^{-1} (3sf)	M1 A1	
	(d)	model not suitable – lorry unable to attain 109 ms^{-1} ($\approx$ 245 mph)	B2	**(13)**
6.	*(a)*	cons. of mom: $2M(U) + 0 = 2M(V) + 5M(4)$	M1	
		$U = V + 10$	A1	
		$\frac{4-V}{U-0} = \frac{3}{4} \;\therefore\; 4 - V = \frac{3}{4}U$	M1 A1	
		solve simul. giving $U = 8$	M1 A1	
	(b)	$s_y = {}^{-}\frac{1}{2}gt^2 = {}^{-}19.6,\; t^2 = 4 \;\therefore\; t = 2$	M2 A1	
	(c)	$v_x = 4,\;\; v_y = 0 - gt = {}^{-}19.6$	M1 A1	
		req'd angle $= \tan^{-1}\frac{19.6}{4} = 78.5°$ (3sf) below horizontal	M1 A1	**(13)**
7.	*(a)*			
		m = mass of P $\quad d = AB$		
		resolve perp. to plane: $R - mg\cos\alpha = 0 \;\therefore\; R = mg(\frac{3}{5})$	M1 A1	
		frictional force $= \mu R = \frac{12}{35}mg$	A1	
		work done against friction = loss in KE – gain in PE	M1	
		$\frac{12}{35}mgd = \frac{1}{2}m(5.6)^2 - mgd\sin\alpha = 15.68m - \frac{4}{5}mgd$	M2 A2	
		$\frac{40}{35}gd = \frac{1}{2}(5.6)^2 \;\therefore\; d = 1.4\ m$	M1 A1	
	(b)	work done against friction = loss in KE (as PE returns to initial value)		
		$\frac{12}{35}mg \times 2.8 = \frac{1}{2}m(5.6^2 - v^2)$	M2 A1	
		$1.92g = 5.6^2 - v^2$	M1	
		$v^2 = 12.544 \;\therefore\; v = 3.5$ ms^{-1} (2sf)	M1 A1	**(16)**
			Total	**(75)**

Performance Record – M2 Paper E

Question no.	1	2	3	4	5	6	7	Total
Topic(s)	**i**, **j** impulse	variable accel.	statics	centre of mass	power	collisions, projectiles	work - energy	
Marks	4	6	11	12	13	13	16	75
Student								