EDEXCEL FOUNDATION

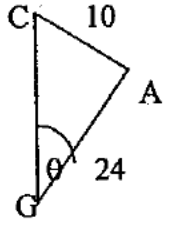
Stewart House 32 Russell Square London WC1B 5DN

JUNE 2001

Advanced Supplementary/Advanced Level

General Certificate of Education

Subject MECHANICS 6678 Paper No. M2

Question number	Scheme	Marks
1.	Finding $\dot{\mathbf{r}}$ $[(2t+2)\,\mathbf{i}+(1-4t)\,\mathbf{j}]$	B1
	Differentiating again to give $\ddot{\mathbf{r}} = 2\,\mathbf{i} - 4\,\mathbf{j}$ (any notation)	M1A1
	Method for magnitude: $\sqrt{\{2^2+(-4)^2\}}$; $= \sqrt{20}$ or **4.47** (ms^{-2})	M1A1 (5)
	[Note: use of consecutive values of t substituted and "second differences found", giving $2\,\mathbf{i} - 4\,\mathbf{j}$ scores B0M0, but allow M1A0 for magnitude.]	
2.	(a) Shape: Small circle (1) / Large circle (4) / Decoration (5)	
	Relative masses: 100π / 400π / 500π	M1A1
	Centre of mass from B: 30 / 0 / $\bar{y}$	B1
	[Other likely alternatives: from D : (10, 20); A : (0, 40) tangent to larger circle at lowest point "E": (50, 20)]	
	Appropriate moments equation: [Most likely: using B : $30 = 5\bar{y}$; using D : $4x20 - 1x10 = 5\bar{y}$ (14) using A : $4x30 = 5\bar{y}$ (24) ; using E : $4x20 + 1x50 = 5\bar{y}$ (26)]	M1
	Answer: **6 cm**	A1 (5)
	(b)  CG drawn vertical or CGA	M1
	Method to find θ [or (90 - θ)]	M1
	$\tan\theta = \frac{10}{AG}$ or $\tan(90-\theta) = \frac{AG}{10}$, or equivalent	A1√
	Answer: 22.6° (this answer only)	A1 (4)
	[Note: If finding AC to vertical, then can score first three marks]	

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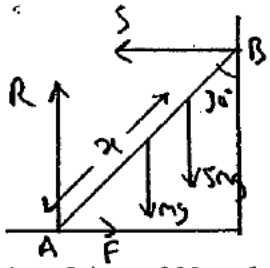
3. [Wherever ≤ or ≥ used in scheme, can be replaced by =]



Resolve → : S = F
Resolve ↑ : R = 6mg

M(*A*): S 2a cos 30° = mg sin 30° (a + 5x)
"F ≤ 0.5 R" ⇒ S ≤ 3mg

B1
M1A1
M1A1A1
M1

⇒ (a + 5x) tan 30° ≤ 6 a, $x \le \frac{(6\sqrt{3}-1)a}{5}$ ⇒ k = $\frac{(6\sqrt{3}-1)}{5}$ or 1.88 or 1.9 M1A1 **(9)**

[Alternatives:
M(*B*): R 2a sin 30° = F 2a cos 30° + mga sin 30° + 5mgdsin 30° M1A1A1
d = 2a – x B1; "F ≤ 0.5 R" ⇒ F ≤ 3mg M1 , rest as scheme.

M(centre) : Ra sin 30° + 5mg(x – a)sin 30° = (F +S) a cos 30° ; S ≤ 3mg etc.
Mark as scheme.]

[Note (i): MR - 30° to the ground - gives k = $\frac{(6-\sqrt{3})}{5}$ or 0.493

(ii) The same answer is obtained if only error is sin/cos confusion; both score 7/9.
(iii) m used for mg throughout, no penalty; inconsistent, as scheme but max -2]

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4. (a) Impulse = change in momentum
$3.5\,\mathbf{i} + 3\,\mathbf{j} = 0.1[(10\,\mathbf{i} + 25\,\mathbf{j}) - (u\,\mathbf{i} + v\,\mathbf{j})]$ M1A1
Answer: $u\,\mathbf{i} + v\,\mathbf{j} =$ **$(-25\,\mathbf{i} - 5\,\mathbf{j})$ ms^{-1}** A1 **(3)**

(b) Complete method to find height *s* above hit position M1
Correct equation in s only: $0 = 625 - 2(9.8)s$; $s = 25(25/g) - \frac{1}{2}g(25/g)^2$ A1
Answer: **32.9 m** or 33m A1 **(3)**

(c) Method for total time: $0 = 25\,t - 4.9\,t^2 \Rightarrow t = 5.10$ s M1A1
or "half time" $0 = 25 - 9.8\,t' \Rightarrow t' = 2.55$ s
Horizontal distance = 10 x t = **51 m** [√ for 10t or 20t'] M1A1√ **(4)**

[Notes: If **i** and **j** interchanged, then can score Ms in (b) and (c); allow √ for 25x2.04 =51.
[Use of answer in (a) can score M marks in (b)(c) only
[Use of $\frac{V^2 \sin^2\theta}{2g}$ and $V^2 \frac{\sin 2\theta}{g}$: M1 method for V or θ, A1 both correct for first two marks]

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5.	(a) Using work/energy equation: (i) P.E. $= \pm 0.5gh$, $= \pm g \sin 20°$; (ii) K.E. $= \frac{1}{2} \times 0.5 \times 25$ $\frac{1}{2} \times 0.5 \times 25 = 0.5gh + 2R$ Solving for R; **R = 1.45** or 1.4 [Note: $2(R + 0.5 \times 9.8 \times \sin 20°) = \frac{1}{2}(0.5)25$ scores first 5 marks, mark as scheme]	M1,A1;B1 M1A1 M1A1 (7)
	Alternative method: Speed equation for a : $0 = 25 \pm 2a$ (2) $(a = \pm 6.25)$ Equation of motion: $(R + 0.5 \times 9.8 \times \sin 20°) = \pm 0.5a$ Totally correct equation: $-(R + 0.5 \times 9.8 \times \sin 20°) = 0.5a$, a –ve Solving for R	M1A1 M1A1 A1 M1A1
	(b) Complete method for s [Work/energy equation: $\frac{1}{2} \times 0.5 \times 25 = sR + 0.5 \times 9.8 \times s \sin 40°$ or $-(R + 0.5g \sin 40°) = 0.5a$ $(a = -9.2)$ **and** $0 = 25 + 2as$] Answer: **s = 1.36 m** or 1.4 m	M1A1√ A1 (3)
6.	(a) $\rightarrow v_1$ $\rightarrow v_2$ $\rightarrow 2u$ $\rightarrow u$ A (2m) B (4m) CoM: $4mu + 4mu = 2m\,v_1 + 4m\,v_2$ $\Rightarrow 4u = v_1 + 2v_2$ NEL: $\frac{1}{2}(2u - u) = v_2 - v_1$ Solving to find v_2 ; $v_2 = \frac{3u}{2}$	M1A1 M1A1 M1A1cso (6) whichever equation used
	(b) Substitute for v_2 in one equation; $v_1 = v_2 - \frac{1}{2}u = u$	M1A1 (2)
	(c) $\rightarrow w_1$ $\rightarrow w_2$ $\rightarrow \frac{3}{2}u$ $\rightarrow 0$ B (4m) C (m) CoM: $4m(\frac{3}{2}u) = 4m\,w_1 + m\,w_2$ $\Rightarrow 6u = 4w_1 + w_2$ NEL: $e(\frac{3}{2}u) = w_2 - w_1$ Solving for w_1 as f(e) : $w_1 = \frac{3u(4-e)}{10}$ or e as f(w_1) : $e = \frac{2(6u - 5w_1)}{3u}$ Requirement is that $w_1 \geq$ candidate's $v_1 = u$; $\Rightarrow e \leq \frac{2}{3}$ [Note: If w_1 or e not found (not asked for): Setting $w_1 = v = u \Rightarrow w_2 = 2u \Rightarrow e = \frac{2}{3}$ is M1A1 but need to deal with inequality for final M1A1]	M1A1 M1A1 M1A1 M1;A1 (8)

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7.	(a) $U_y = 23.75 \sin\alpha \ (= 19)$	B1
	Complete method to find time, e.g $-2.4 = 23.75 \sin\alpha\, t - \frac{1}{2} gt^2$	M1A1
	Solving to find t; $t = 4$	M1A1 (5)
	(b) $\frac{dv}{} = -\frac{1}{4} t^2$	
	$\Rightarrow v = -\frac{1}{12} t^3 + c$	M1A1
	$t = 0, v = 18 \Rightarrow v = 18 - \frac{1}{12} t^3$	A1 (3)
	(c) Putting $v = 0$ expression in (b)	M1
	Solving equation **[dependent on previous M1 and M1 in (b)]**	M1
	Finding $T = 6$, with no wrong working seen [Allow verification]	A1 cso (3)
	(d) Distance → travelled by package $= 23.75 \cos\alpha \times 4_c; = 57$ m [√ only on $14.25 \times 4_c$]	M1A1√
	For lorry $s = 18t - \frac{1}{48} t^4$	M1;A1√
	Showing $s = 66\frac{2}{3}$ for lorry, and distance them between is just under 10m	A1 cso (5)
	[If lorry moving in direction CA, allow final answer of just under 124m]	

Geoff Staley 25/6/01