Edexcel Maths M2

Mark Scheme Pack

2001-2013

EDEXCEL FOUNDATION

Final Scheme for Examiners.

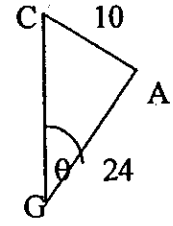
Stewart House 32 Russell Square London WC1B 5DN

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 integer values of t substituted and "second differences found", giving $2\,\mathbf{i} - 4\,\mathbf{j}$ scores 3/0M0, but allow M1A0 for magnitude.]	
2.	(a) Shape: Small circle; Large circle; Decoration	
	Relative masses: 100π (1); 400π (4); 500π (5)	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 triangle used 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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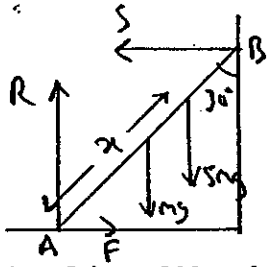
3.	[Wherever ≤ or ≥ used in scheme, can be replaced by =]	
	 Resolve →: S = F Resolve ↑: R = 6mg M(*A*): S 2a cos 30° = mg sin 30° (a + 5x) "F ≤ 0.5 R" ⇒ S ≤ 3mg	B1 M1A1 M1A1A1 M1
	⇒ (a + 5x) tan 30° ≤ 6 a, x ≤ $\frac{(6\sqrt{3}-1)a}{5}$ ⇒ k = $\frac{(6\sqrt{3}-1)}{5}$ or 1.88 or 1.9	M1A1 (9)
	[Alternatives: 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]	
4.	(a) Impulse = change in momentum 3.5 i + 3 j = 0.1[(10 i + 25 j) – (u i + v j)]	M1A1
	Answer: u i + v j = **(- 25 i – 5 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 ⇒ t = 5.10 s	M1A1
	or "half time" 0 = 25 – 9.8 *t'* ⇒ *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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Question number	Scheme	Marks
5.	(a) Using work/energy equation: (i) P.E. $= \pm 0.5gh$, $= \pm\ g \sin 20°$; (ii) K.E. $= \frac{1}{2} \times 0.5 \times 25$ $\frac{1}{2} \times 0.5 \times 25 = 0.5\,gh + 2R$ 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 : $0 = 25 \pm 2\,a$ (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: $\frac{1}{2} \times 0.5 \times 25 = s\,R + 0.5 \times 9.8 \times s \sin 40°$ 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) $\rightarrow v_1$ $\rightarrow v_2$ CoM: $4mu + 4mu = 2m\,v_1 + 4m\,v_2$ $\rightarrow 2u$ $\rightarrow u$ $\Rightarrow$ $4u = v_1 + 2\,v_2$ A 2m B 4m 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) $\rightarrow w_1$ $\rightarrow w_2$ CoM: $4m(\frac{3}{2}u) = 4m\,w_1 + m\,w_2$ $\rightarrow \frac{3}{2}u$ $\rightarrow 0$ $\Rightarrow$ $6u = 4w_1 + w_2$ B 4m C m 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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Subject MECHANICS 6678 Paper No. M2

Question number	Scheme	Marks
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

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January 2002

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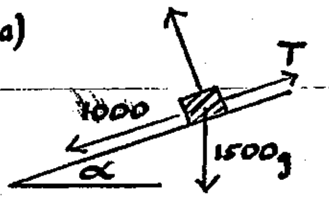
Subject **MECHANICS 6678** Paper No. **M2**

Question number	Scheme	Marks
1.	Work done = Loss in K.E.	
	$R \times 200 = \frac{1}{2} \times 4 \times 25^2$	M1 A1=A1
	$R = 6{\cdot}25$	A1 4 (4)
2.	(a)  $T = \frac{P}{v} = \frac{60\,000}{30} (=2000)$	B1
	N2L: $2000 - 1000 - 1500 \times 9{\cdot}8 \times \frac{1}{12}$	
	$= 1500\,a$	M1 A1
	$a = (-)\,0{\cdot}15\ (\text{ms}^{-2})$ cao	A1 4
	(b) ↗ $T' = 1000 + 1500 \times 9{\cdot}8 \times \frac{1}{12}\ (=2225)$	M1 A1
	$P = T'v$ $\quad 80\,000 = 2225\,v$	M1
	$v \approx 36\ (\text{ms}^{-1})$ accept 36·0	A1 4
	(c) The resistance is likely to increase with speed	B1 1 (9)
3.	(a) $\underset{\sim}{a} = 6t\,\underset{\sim}{i} + 6\underset{\sim}{j}$	M1
	$t=2$ $\quad \underset{\sim}{a} = 12\underset{\sim}{i} + 6\underset{\sim}{j}$	A1
	N2L $\quad \underset{\sim}{F} = m\underset{\sim}{a} = 3{\cdot}6\underset{\sim}{i} + 1{\cdot}8\underset{\sim}{j}$	M1
	$\lvert\underset{\sim}{F}\rvert = \sqrt{(3{\cdot}6^2 + 1{\cdot}8^2)} \approx 4{\cdot}02$ (accept 4·03) cao	M1 A1 5
	(b) $\underset{\sim}{r} = (t^3 + c_1)\underset{\sim}{i} + (3t^2 - 4t + c_2)\underset{\sim}{j}$ ignore constants	M1 A1+A1
	Using $t=0$, $\underset{\sim}{r} = (t^3+3)\underset{\sim}{i} + (3t^2 - 4t - 4)\underset{\sim}{j}$	M1
	$t=4$, $\underset{\sim}{r} = 67\underset{\sim}{i} + 28\underset{\sim}{j}$ (m)	A1 5 (10)

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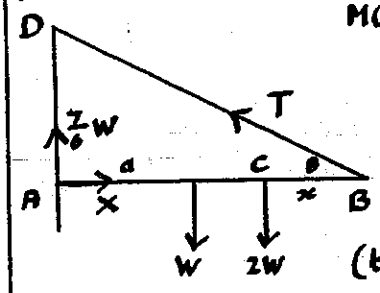
Question number	Scheme	Marks
4	(a) ABC WXYZ Template mass ratio $48a^2$ $4a^2$; $44a^2$ C.M. $\frac{8a}{3}$ $2a$ $\bar{x}$ M(AB) $44a^2\bar{x} + 8a^3 = 48a^2 \times \frac{8a}{3}$ solving to $\bar{x} = \frac{30}{11}a$ * cso (b) M(AB) or M(ZY) $KM \times 8a + M \times \frac{30}{11}a = M(1+K)3a$ $KM \times 5a = M(3a - \frac{30}{11}a)$ solving to $K = \frac{3}{55}$ $K = \frac{3}{55}$ or awrt 0.055	B1; B1√ B1 B1 M1 A1 A1 7 M1 A2(1,0) A1 4
5.	(a)  M(A) $T \times 2a\sin\theta = Wa + 2W(2a-x)$ $T \times \frac{6}{5}a = 5Wa - 2Wx$ $T = \frac{5(5a-2x)}{6a}W$ * cso (b) M(B) $\frac{7}{6}W \times 2a = Wa + 2Wx$ $x = \frac{2}{3}a$ o.e. (c) R(→) $X = T\cos\theta = \frac{5}{6}(5 - \frac{4}{3})W \times \frac{4}{5}$ ✓ $= \frac{22}{9}W$	M1 A2(1,0) M1 A1 5 M1 A1 A1 3 M1 A1√ M1 A1 4
	Alternative to (b) R(↑) $\frac{7}{6}W + T\sin\theta = 3W$ $\frac{7}{6}W + \frac{5(5a-2x)W}{6a} \times \frac{3}{5} = 3W$ $x = \frac{2}{3}a$	M1 A1 A1 3

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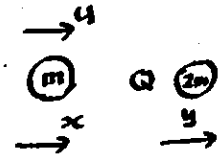
Subject **MECHANICS** ~~6440~~ 6678 Paper No. **M2**

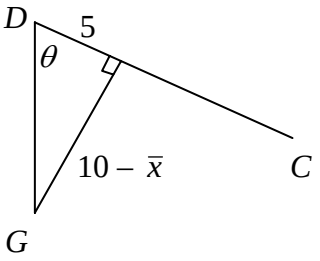
Question number	Scheme	Marks
6.	 (a) LM $mu = mx + 2my$	B1
	NEL $x - y = -eu$	M1 A1
	Solving to $y = \frac{1}{3}(1+e)u$ * cso.	M1 A1 5
	(b) Obtaining $x = \frac{1}{3}(1-2e)u$ allow angular	M1 A1
	Direction unchanged implies $x > 0$	M1
	$e < \frac{1}{2}$ ignore $e \geq 0$	A1 4
	(c) $y = \frac{5}{12}u$, $x = \frac{1}{6}u$	
	Final K.E $= \frac{1}{2}m(\frac{1}{6}u)^2 + \frac{1}{2}2m(\frac{5}{12}u)^2 \left(= \frac{27}{144}mu^2\right)$	M1 A1
	Loss in K.E $= \frac{1}{2}mu^2 - \frac{27}{144}mu^2 = \frac{5}{16}mu^2$	M1 A1 4
	(d) Heat, sound, (work done by) internal forces	B1 1 (14)
7.	(a) (↑) $u_y = 80\sin 60°$, $v_y = 0$	B1, B1
	$0^2 = (80\sin 60)^2 - 2\times 9.8\times s$	M1
	$s \approx 244.9$	
	Height is 260 m. Accept 265	A1 4
	(b) $0 = 80\sin 60° - 9.8t$	M1
	$t = 7.1$ (s) Accept 7.07	A1 2
	(c) (→) $u_x = 80\cos 60°$ $(=40)$	B1
	LM $100\times 40 = 40\times v + 60\times 80$	M1
	$v = (-)20$ * cso	A1 3
	(d) Let N be point on ground vertically below B	
	$ON = 80\cos 60° \times$ their (b) $(=282.79)$	M1
	↓ $264.9 = \frac{1}{2}\times 9.8\times t^2 \Rightarrow t \approx 7.35$ awrt	M1 A1
	$CN = 20\times 7.35 \approx 147$ awrt	M1 A1
	$OC = 140$ (m) accept 136	A1 6 (15)

EDEXCEL MECHANICS M2 (6678) – JUNE 2002 PROVISIONAL MARK SCHEME

Question Number		Scheme	Marks
1.	(*a*)	Differentiating: $\mathbf{a} = 3\mathbf{i} - 5\mathbf{j}$ (sufficient)	M1A1 **(2)**
	(*b*)	Integrating : $\mathbf{r} = (\frac{3}{2}t^2 - 2t)\mathbf{i} - \frac{5}{2}t^2\ \mathbf{j}\ (+C)$	M1A1
		Using initial conditions to find C ($3\mathbf{i}$); $\mathbf{r}(t = 2) = 5\mathbf{i} - 10\mathbf{j}$	M1; A1
		Distance = $\sqrt{\{5^2 + (10)^2\}}$; = $5\sqrt{5}$ or 11.2 or 11.18 (m)	M1; A1 **6)**
			(6 marks)
2.	(*a*)	$0 \le t \le 3$ $v = 2t^2 - \frac{1}{3}t^3\ (+C)$ Evidence of integration for M1	M1 A1
		$t = 3 \Rightarrow v = 9$ m s^{-1}	A1 **(3)**
	(*b*)	$t \ge 3$ $v = -\frac{27}{t}\ (+C)$	B1
		Using $t = 3$ and candidates' $v = 9$ to find C; $C = 18$	M1; A1 ft
		Substituting $t = 6$ in expression for v ; $v = 13.5$ m s^{-1}	M1; A1 **(5)**
			(8 marks)
3.	(*a*)	Change in KE: $\frac{1}{2} \times 80 \times (8^2 - 5^2)$ [loss: 2560 – 1000 = 1560 J]	B1
		Change in PE: $80 \times g \times (20 - 12)$ [loss: 15680 – 9408 = 6272 J]	B1
		WD by cyclist = 20×500 – (loss in K.E. + P.E.)	M1 A1 ft
		= 2168 Nm (allow 2170 and 2200)	A1 **(5)**
	(*b*)	Equation of motion: $F - 20 = 80 \times 0.5$ [M1 requires three terms]	M1 A1
		Power = $F_c \times 5$; = 300 W	M1 A1
			(9 marks)

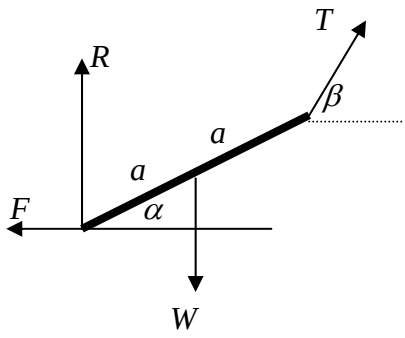
(ft = follow through mark)

EDEXCEL MECHANICS M2 (6678) – JUNE 2002 PROVISIONAL MARK SCHEME

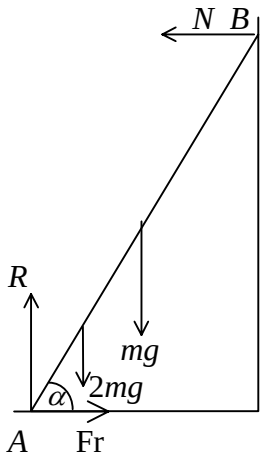
Question Number	Scheme	Marks
4. (*a*)	Shape: Square; Semi-circle; Lamina *L* Relative masses: 100; $12\frac{1}{2}\pi(39.3)$; $100 - 12\frac{1}{2}\pi(60.7)$ Centre of mass from *AB*: 5; $\frac{20}{3\pi}$ (2.12); $\bar{x}$	M1 A1 B1 B1
	Moments about *AB*: $100 \times 5 - 12\frac{1}{2}\pi \times \frac{20}{3\pi} = (100 - 12\frac{1}{2}\pi)\bar{x}$	M1 A1
	Answer: 6.86 cm	A1 (cao) **(7)**
(*b*)	 Correct angle, diagram sufficient Method to find θ [or $(90 - \theta)$] $\tan\theta = \frac{10 - \bar{x}_c}{5}$ Answer: 32.1°	M1 M1 A1 ft A1 (cao) **(4)** **(11 marks)**
5. (*a*)	$x = u\cos\alpha\, t$; $y = u\sin\alpha\, t - \frac{1}{2}gt^2$	B1; B1
	Eliminating *t*: $y = u\sin\alpha \frac{x}{u\cos\alpha} - \frac{1}{2}g\frac{x^2}{(u\cos\alpha)^2}$	M1
	$y = x\tan\alpha - \frac{gx^2}{2u^2\cos^2\theta}$	M1
	$y = x\tan\alpha - \frac{gx^2}{2u^2}(1+\tan^2\alpha)$ *	A1 **(5)**
(*b*)	$-2 = x\tan 45° - \frac{9.8\times x^2}{2\times 14^2}(1 + \tan^2 45°)$	M1 A1
	Simplifying "correctly" to quadratic of form $ax^2 + bx + c = 0$ (may be implied, e.g. $x^2 - 20x - 40 = 0$; $-0.05x^2 + x + 2 = 0$; $4.9x^2 - 98x - 196 = 0$)	M1
	Solving for *t* (2.205 s), $x = 14\cos 45°\, t$, $x = 21.8$ m	M1 A1 **(5)**
(*c*)	$21.8_c = 14\cos 45°\, t$; $t = 2.2$ s	M1 A1 (cao) **(2)** **(12 marks)**

(ft = follow through mark; cao = correct answer only; cso = correct solution only;
* indicates answer is given on the examination paper)

EDEXCEL MECHANICS M2 (6678) – JUNE 2002 PROVISIONAL MARK SCHEME

Question Number	Scheme	Marks
6. (*a*)	$\leftarrow v_1$ $\rightarrow v_2$ $\rightarrow u$ 0 A ○ B ○ m 3m	CoM: $mu = -mv_1 + 3mv_2$ M1 A1
		$\Rightarrow \quad u = -v_1 + 3v_2$
		NEL: $e\,u = v_2 + v_1$ M1 A1
	Solving : $v_1 = \frac{1}{4}(3e-1)u$	M1 A1
	$v_2 = \frac{1}{4}(1+e)u$	A1 **(7)**
	Speed of B after hitting wall $= \pm\frac{3}{16}(1+e)u \quad (v_2^*)$	B1 ft
	For second collision $v_2^* > v_1$; $\frac{3}{16}(1+e)u > \frac{1}{4}(3e-1)u$	M1
	Solving, $e < \frac{7}{9}$	M1 A1
	Finding lower bound using $v_1 > 0$; $e > \frac{1}{3}$	M1
	Complete range: $\frac{1}{3} < e < \frac{7}{9}$	A1 (cso) **(6)**
		(13 marks)
7. (*a*)		$F = 0.6R$ (seen anywhere) M1
		Moments about B: $R \times 2a\cos\alpha + F \times 2a\sin\alpha = W \times a\cos\alpha$ M1 A1
		Using $\cos\alpha = \frac{12}{13}$ and $\sin\alpha = \frac{5}{13}$ M1
		Solving for R $\frac{24}{13}R + \frac{6}{13}R = \frac{12}{13}W \Rightarrow 30R = 12$ M1
		$\Rightarrow \quad R = \frac{2}{5}W^*$ A1 **(6)**
(*b*)	Resolve $\leftrightarrow$: $T\cos\beta = F$; $= 0.6R = \frac{6}{25}W$	M1 A1
	Resolve $\updownarrow$: $T\sin\beta + R = W$ $\quad T\sin\beta = \frac{3}{5}W$	M1 A1
	Complete method for β [e.g $\tan\beta = 2.5$] ; $\quad \beta = 68.2°$	M1; A1 **(6)**
	Complete method for T: substitute for β or $\sqrt{\{(0.6W)^2 + (0.24W)^2\}}$	M1
	$T = 0.646...W \Rightarrow \quad k = 0.65$ or 0.646	A1 **(2)**
		(14 marks)

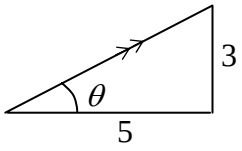
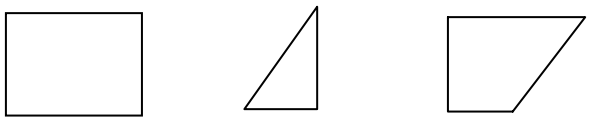
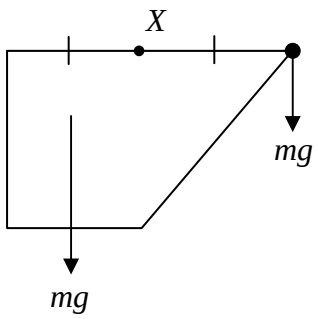
Question number	Scheme	Marks
1. (*a*)	Use of $(8 + \lambda)m$	B1
	i: $3m \times 4 + \lambda m \times 4 = (8 + \lambda)m \times 2$	M1
	Solving to $\lambda = 2$ (*)	M1 A1 (4)
	j: $5m \times (-3) + 2m \times 2 = 10m \times k$	M1 A1
	$k = -1.1$	A1 (3)
		(7 marks)
2. (*a*)	$T_r = \frac{24000}{12}$ (= 2000)	M1
	N2L: $T_r - 1200 = 1000 \times f$	M1 A1ft
	$f = 0.08$	A1 (4)
(*b*)	Work Energy $\frac{1}{2} \times 1000 \times 14^2 = 1200d$	M1 A1
	$d = 81\frac{2}{3}$ awrt 81.7	A1 (3)
(*c*)	Resistances may *vary* with speed	B1 (1)
		(8 marks)

Question number	Scheme	Marks
3.		
	$(\uparrow)$ $R = 3mg$	B1
	M(B) $mga\cos\alpha + 2mg \times \frac{3}{2}a\cos\alpha + \text{Fr} \times 2a\sin\alpha = R \times 2a\cos\alpha$	M1 A2 1,0
	Solving to Fr = $\frac{3}{4}mg$	M1 A1
	$\text{Fr} \le \mu R \Rightarrow \frac{3}{4}mg \le \mu 3mg$	M1
	$\mu \ge \frac{1}{4}$ (least value is $\frac{1}{4}$)	M1 A1 (9)
		(9 marks)
4. (a)	  	
	MR $48a^2$ $12a^2$ $60a^2$	B1, B1ft
	CM $4a$ $(-)\frac{1}{3} \times 4a$ $\bar{x}$	B1
	$48a^2 \times 4a - 12a^2 \times \frac{4}{3}a = 60\bar{x}$	M1 A1
	Solving to $\bar{x} = \frac{44}{15}a$ (*)	A1 (6)
(b)	$\lambda M \times 4a = M \times \frac{44}{15}a$	M1 A1
	$\lambda = \frac{11}{15}$	A1 (3)
		(9 marks)

Question number	Scheme	Marks
5. (*a*)	$v = \int a\,dt = 2t^2 - 8t \ (+c)$	M1 A1
	Using $v = 6$, $t = 0$; $v = 2t^2 - 8t + 6$	M1 A1 (4)
	$v = 0 \Rightarrow 2t^2 - 8t + 6 = 0, \Rightarrow t = 1,3$	M1 A1
	$S = \int (2t^2 - 8t + 6)\ \mathrm{d}t = \left[\frac{2}{3}t^3 - 4t^2 + 6t\right]$	M1 A2, 1, 0
	$= 0 - 2\frac{2}{3}$	M1
	Distance is $(\pm)2\frac{2}{3}$ m	A1 (7)
		(11 marks)
6. (*a*)	L.M. $2u = 2x + y$	M1 A1
	NEL $y - x = \frac{1}{3}u$	M1 A1
	Solving to $x = \frac{5}{9}u$ (*)	M1 A1
	$y = \frac{8}{9}u$ (*)	A1 (7)
(*b*)	$(\pm)\ \frac{8}{9}eu$	B1
	L.M $\frac{10}{9}u - \frac{8}{9}eu = w$	M1 A1
	NEL $w = \frac{1}{3}\left(\frac{5}{9}u + \frac{8}{9}eu\right)$	M1 A1
	Solving to $e = \frac{25}{32}$ accept 0.7812s	M1 A1 (7)
(*c*)	*Q* still has velocity and will *bounce back* from wall colliding with *stationary P*.	B1 (1)
		(15 marks)

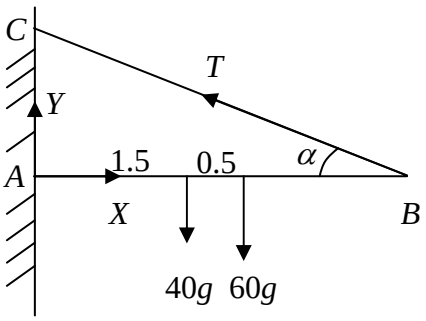
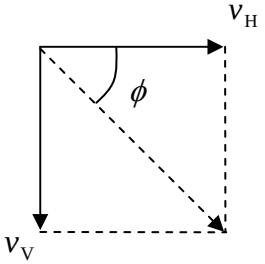
Question number		Scheme		Marks
7.	(*a*)	$\mathbf{I} = 0.4(15\mathbf{i} + 16\mathbf{j} + 20\mathbf{i} - 4\mathbf{j})$ $(= 0.4(35\mathbf{i} + 12\mathbf{j}) = 14\mathbf{i} + 4.8\mathbf{j})$		M1
		$\lvert\mathbf{I}\rvert = \sqrt{(14^2 + 4.8^2)}$ *or* $0.4\sqrt{(35^2 + 12^2)}$	M1 for any magnitude	M1 A1
		$= 14.8$ (Ns)		A1 (4)
	(*b*)	Initial K.E. $= \frac{1}{2}m(15^2 + 16^2)$ $(= 240.5m = 96.2$ J)		M1
		$\frac{1}{2}mv^2 = \frac{1}{2}m(15^2 + 16^2) = m \times 9.8 \times 1.2$	–1 each incorrect term	M1 A2, 1,0
		$v^2 = 504.52$		M1
		$v = 22$ (m s^{-1})	accept 22.5	A1 (6)
	(*c*)	$\arccos \frac{15}{22.5} = 48°$	accept 48.1°	M1 A1 A1 A1 (4)
	(*d*)	Air resistance Wind (problem not 2 dimensional) Rotation of ball (ball is not a particle)	any 2	B1, B1 (2)
				(16 marks)
Alt (*b*)		Resolve ↑ with 16 and 9.8		M1
		(↑) $v_y^2 = 16^2 + 2 \times (-9.8) \times (-1.2)$		M1 A1
		$(v_y^2 = 279.52, v_y \approx 16.7\ldots..)$		
		$v^2 = 15^2 + 279.52$		M1 A1
		$v = 22$ (m s^{-1})	accept 22.5	A1 (6)
Alt (*c*)		$\arctan \frac{16.7}{15} = 48°$		M1 A1 A1 A1 (4)

EDEXCEL MECHANICS M2 (6678) – JUNE 2003 **PROVISIONAL MARK SCHEME**

Question Number	Scheme	Marks
1. (*a*)	$x = \int 6t - 2t^2 \ \mathrm{d}x$	M1
	$= 3t^2 - \frac{2}{3}t^3$	A1
	$v = 0 \Rightarrow 6t - 2t^2 = 0 \Rightarrow t = 3$ (or 0)	M1
	$t = 3$: $x = (3 \times 9) - (\frac{2}{3} \times 27) = 9$ m	M1 A1
		(5 marks)
2. (*a*)	$\mathbf{I} = 0.2[(15\mathbf{i} + 15\mathbf{j}) - (-10\mathbf{i})]$	M1
	$= 5\mathbf{i} + 3\mathbf{j}$	M1
	$\lvert\mathbf{I}\rvert = \sqrt{(5^2 + 3^2)} = \sqrt{34} = 5.8$ Ns	M1 A1 (4)
(*b*)	 $\tan\theta = \frac{3}{5} \Rightarrow \theta = 31°$ (nearest degree)	M1 A1 (2)
(*c*)	K E Gain $= \frac{1}{2} \times 0.2[(15^2 + 15^2) - 10^2)] = 35$ J	M1 A1 (2)
		(8 marks)
3. (*a*)		
	Area: $6a^2$ a^2 $5a^2$ (ratio)	B1
	CM from *AD*: $\frac{3a}{2}$ $\left(2a + \frac{2a}{3}\right) = \frac{8a}{3}$ $\bar{x}$	B1 B1
	$6 \times \frac{3a}{2} - 1 \times \frac{8a}{3} = 5\bar{x}$	M1
	$\bar{x} = \frac{19a}{15}$	A1 (5)
(*b*)	 M(*X*), $Mg\left(\frac{3a}{2} - \frac{19a}{15}\right) = mg \times \frac{3a}{2}$	M1 A1 ft A1
	$\Rightarrow m = \frac{7M}{45}$	A1 (4)
		(9 marks)

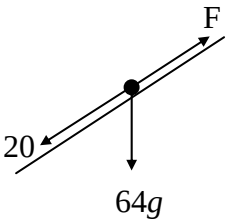
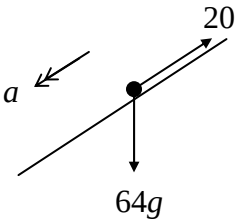
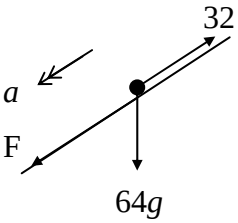
(ft = follow through mark)

EDEXCEL MECHANICS M2 (6678) – JUNE 2003 **PROVISIONAL MARK SCHEME**

Question Number		Scheme	Marks
4.	(*a*)	 M(*A*), $40g \times \frac{3}{2} + 60g \times 2 = T \sin \alpha \times 3$ use of $\sin \alpha = \frac{3}{5}$ $60g + 120g = \frac{9T}{5}$ $\Rightarrow T = 100g = 980$ N (*)	M1 A2, 1, 0 B1 A1 (5)
	(*b*)	$(\rightarrow)$: $X = T \cos \alpha$ $(\uparrow)$ $Y + T \sin \alpha = 100g$ $R = \sqrt{(X^2 + Y^2)} = \sqrt{(784^2 + 392^2)}$ $= 877$ N (3 sf)	B1 M1 A1 M1 A1 A1 (6)
	(*c*)	Cable light $\Rightarrow$ tension same throughout $\Rightarrow$ force on rod at *D* is $60g$	B1 (1)
			(12 marks)
5.	(*a*)	$(\rightarrow)$: $u \cos \alpha \times T = 8$ $u \times \frac{4}{5} \times T = 8$ $uT = 10$ (*)	 M1 A1 (2)
	(*b*)	$(\uparrow)$: $-4 = u \sin \alpha T - \frac{1}{2} gT^2$ $-4 = u \times \frac{3}{5}\left(\frac{10}{u}\right) - \frac{1}{2} \times 9.8\left(\frac{10}{u}\right)^2$ $u = 7$	M1 A1 M1 M1 A1 (7)
		 $v_H = u \cos \alpha = \frac{28}{5}$ $v_V^2 = (-u \sin \alpha) + 2g \times 4$ $\Rightarrow v_V = 9.8$ $(= \frac{49}{5})$ $\tan \phi = \frac{49/5}{28/5} = \frac{7}{4}$	B1 ft M1 A1 ft M1 A1 cao (5)
			(12 marks)

(ft = follow through mark; cao = correct answer only; (*) indicates final line is given on the paper)

EDEXCEL MECHANICS M2 (6678) – JUNE 2003 **PROVISIONAL MARK SCHEME**

Question Number	Scheme	Marks
6. (*a*)	 (↗): F = 20 + 64*g* sin α	M1
	= 64.8 N	A1
	$P = Fv = 64.8 \times 5 = 324$ W	M1 A1 (4)
(*b*)	 (↙): 64*g* sin α – 20 = 64*a*	M1 A1
	$a = 0.3875$ m s^{-2}	A1
	$v^2 = 5^2 + 2 \times 0.3875 \times 80$	M1
	$v = \sqrt{87} = 9.3$ m s^{-1} (2 sf)	A1 (5)
(*c*)	$\frac{8}{5} \times 20 = 32$ N	B1 (1)
(*d*)	 F = $\frac{200}{8}$	B1
	$\frac{200}{8}$ + 64*g* sin α – 32 = 64*a*	M1 A1
	$a = 0.59$ m s^{-2} (2 sf)	A1 (4)
		(14 marks)

EDEXCEL MECHANICS M2 (6678) – JUNE 2003 **PROVISIONAL MARK SCHEME**

Question Number	Scheme	Marks
7. (*a*)	$u \rightarrow$ $\quad$ $\rightarrow 0$ A (*m*) e (2*m*) B $\rightarrow$ $\quad$ $\rightarrow$ v_1 $\quad$ v_2	$mu = mv_1 + 2mv_2$ $eu = -v_1 + v_2$ $v_1 = \frac{u}{3}(1-2e)$; $\quad v_2 = \frac{u}{3}(1+e)$	M1 A1 M1 A1 M1 A1 A1 (7)
(*b*)	$v_1 > 0 \Rightarrow \frac{u}{3}(1-2e) > 0 \Rightarrow e < \frac{1}{2}$	M1 A1 (2)
(*c*)	$v_2 \rightarrow$ $\quad$ $\rightarrow 0$ A (2*m*) $\quad$ (4*m*) B $\rightarrow$ $\quad$ $\rightarrow$ v_3 $\quad$ v_4	$2mv_2 = 2mv_3 + 4mv_4$ $ev_2 = -v_3 + v_4$ $v_3 = \frac{v_2}{3}(1-2e) = \frac{u}{9}(1-2e)(1+e)$	M1 M1 A1
	Further collision if $v_1 > v_3$	
	i.e. if $\frac{u}{3}(1-2e) > \frac{u}{9}(1-2e)(1+e)$	M1
	i.e. if $3 > 1 + e$ (as $(1-2e) > 0$)	
	i.e. if $2 > e$	M1
	which is always true, so further collision occurs	A1 cso (6)
		(15 marks)

(cso = correct solution only)

EDEXCEL MECHANICS M2 (6678) – JANUARY 2004 PROVISIONAL MARK SCHEME

Question Number	Scheme	Marks
1. (*a*)	$T = \frac{10000}{20}$ or equivalent	M1 A1
	$T - R - 400\text{ g}\sin\theta = 0$	M1 A1
	$R = 220$	A1
		(5 marks)
2. (*a*)	$\mathbf{a} = 2t\mathbf{i} - 6\mathbf{j}$	M1
	$t = 4$: $\mathbf{a} = 8\mathbf{i} - 6\mathbf{j}$	**dep**. M1
	$\lvert\mathbf{F}\rvert = 0.75\sqrt{(8^2 + 6^2)} = 7.5\text{N}$	M1 M1 A1 (5)
(*b*)	$\mathbf{I} = 9\mathbf{i} - 9\mathbf{j}$	B1
	$9\mathbf{i} - 9\mathbf{j} = \frac{3}{4}(\mathbf{v} - (27\mathbf{i} - 30\mathbf{j}))$	M1 A1 f.t.
	$\mathbf{v} = 39\mathbf{i} - 42\mathbf{j}\text{ m s}^{-1}$	A1 (4)
		(9 marks)
3. (*a*)	$\frac{1}{2} \times 2 \times 10^2 - \frac{1}{2} \times 2 \times v^2 = 2g\ 3\sin 30°$	M1 A1 A1
	$v = 8.4\text{ m s}^{-1}$ (8.40 m s^{-1})	A1 (4)
	Or ($a = -g\sin 30°$)	
	$v^2 = 10^2 - 2g\sin 30° \times 3$	M1 A1 A1
	$v = 8.4\text{ m s}^{-1}$ (8.40 m s^{-1})	A1 (4)
(*b*)	$R = 2g\cos 30°$	B1
	$3F$; $\frac{1}{2} \times 2 \times 10^2 - \frac{1}{2} \times 2 \times 7^2$; $2\text{g} \times 3\sin 30°$	B2 (–1 e.e.o.o)
	$3\mu R = \frac{1}{2} \times 2 \times 10^2 - \frac{1}{2} \times 2 \times 7^2 - 2\text{g} \times 3\sin 30°$	M1
	$\mu = 0.42(4)$	A1 (5)
	OR $R = 2\text{g}\cos 30°$	B1
	$a = \frac{(7^2 - 10^2)}{2\times 3} = \frac{17}{2}$; $-F$; $-2\text{g}\sin 30°$	B2 (–1 e.e.o.o)
	$-\mu R - 2\text{g}\sin 30° = -\frac{17}{2} \times 2$	M1
	$\mu = 0.42(4)$	A1 (5)
		(9 marks)

EDEXCEL MECHANICS M2 (6678) – JANUARY 2004 PROVISIONAL MARK SCHEME

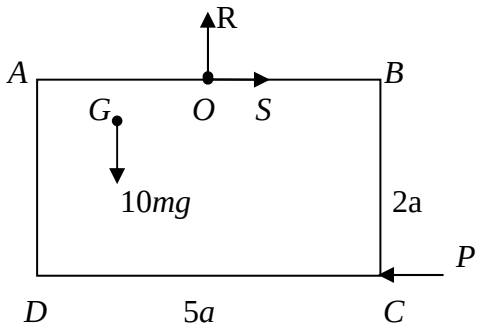
Question Number		Scheme	Marks
4.	(*a*)	$M(B)$, $N\ 2a\cos\theta = W\ a\cos\theta + \frac{1}{4}W\ \frac{3a}{2}\sin\theta$	M1 A2 (–1 e.e.)
		$N = \frac{7W}{8}$	dep. M1 A1 (5)
	(*b*)	$R = \frac{1}{4}W$; $F + N = W$	B1; B1
		$F \le \mu R$ or $F = \mu R$	M1
		$\frac{1}{2} \le \mu$ * (exact)	A1 c.s.o. (5)
	(*c*)	It does not bend Or has negligible thickness	B1 (1)
			(10 marks)
5.	(*a*)	$2ut = 735$	M1 A1
		$0 = 3ut - \frac{1}{2}gt^2$	M1 A1
		eliminating t	**dep.** M1
		$u = 24.5$ *	A1 (6)
	(*b*)	$t = \frac{735}{49} = 15$	M1 A1 (2)
	(*c*)	Initially: $v^2 = (2u)^2 + (3u)^2$ (7803.25)	M1
		$\frac{1}{2}mv^2 - \frac{1}{2}m\,65^2 = mgh$	M1 A1
		$h = 180$ m (183 m)	A1 (4)
	OR	$v_y^2 = 65^2 - (2u)^2$ (1824)	M1
		$v_y^2 = (3u)^2 - 2gh$	M1 A1
		$h = 180$ m (183 m)	A1 (4)
			(12 marks)

(ft = follow through mark; cao = correct answer only; (*) indicates final line is given on the paper)

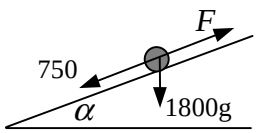
EDEXCEL MECHANICS M2 (6678) – JANUARY 2004 PROVISIONAL MARK SCHEME

Question Number	Scheme	Marks
6. (*a*)	$u \rightarrow \quad \rightarrow 0$ CLM: $mu = mv_1 + 3mv_2$	B1
	$m \quad 3m$ NIL: $eu = -v_1 + v_2$	M1 A1
	$v_1 \rightarrow \quad v_2 \rightarrow$ solving,	dep. M1
	$v_2 = \frac{u}{4}(1+e)$*	A1 (5)
(*b*)	Solving for v_1; $\left\|\frac{u}{4}(1-3e)\right\|$	M1 A1 (2)
(*c*)	$\frac{1}{2}\, m\, \frac{u^2}{16}\, (1-3e)^2 + \frac{1}{2}\, 3m\, \frac{u^2}{16}\, (1+e)^2 = \frac{1}{6}\, mu^2$	M1 A1 f.t. A1
	$e^2 = \frac{1}{9}$	dep. M1 A1
	$e = \frac{1}{3}$	A1 (6)
(*d*)	$v_1 = \frac{u}{4}(1 - 3 \times \frac{1}{3}) = 0 \Rightarrow$ at rest.	A1 c.s.o. (1)
		(14 marks)

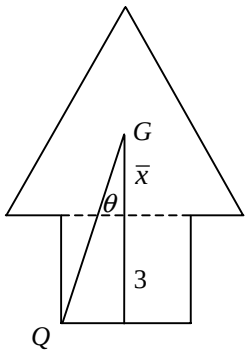
EDEXCEL MECHANICS M2 (6678) – JANUARY 2004 PROVISIONAL MARK SCHEME

Question Number	Scheme	Marks
7. (*a*)	*AD*: $10m\bar{x} = 3m\,\frac{5a}{2} + 3m \times 5a$	M1 A1
	$\bar{x} = 2.25a$ *	A1 (3)
(*b*)	*AB*: $10m\bar{y} = 2m \times 2a + 3m \times a$	M1
	$\bar{y} = 0.7a$	A1 (2)
(*c*)	$\tan\theta = \frac{2.5a - \bar{x}}{\bar{y}}$	M1 A1 f.t.
	$\theta = 20°$	A1 (3)
		
	M(0), $10mg \times \frac{a}{4} = P \times 2a$	M1 A1 A1
	(OR: $4mg \times \frac{5a}{2} - 3\,mg \times \frac{5a}{2} = P \times 2a$)	
	$P = \frac{5mg}{4}$ * (exact)	A1 (4)
(*e*)	$S = \frac{5mg}{4}$; $R = 10mg$	B1; B1
	$F = \sqrt{S^2 + R^2} = \frac{5mg\sqrt{65}}{4}$ (10.1 *mg*)	M1 A1 (4)
		(16 marks)

EDEXCEL MECHANICS M2 (6678) – JUNE 2004 **MARK SCHEME**

Question Number	Scheme	Marks
1. (a)	$F = \frac{36\,000}{20} \quad (=1800)$	B1
	N2L $\quad \frac{3600}{20} - 750 = 1500a$ ft their F	M1 A1ft
	$a = 0.7 \quad (\text{m s}^{-2})$	A1 4
(b)	 $\nearrow F = 750 + 1500g \times \frac{1}{10} \quad (=2220)$	M1 A1
	P = $2220 \times 20 = 44\,400$	
	Accept also 44000, 44 kW, 44.4 kW	A1 3 **7**
2. (a)	$\mathbf{I} = m\mathbf{v} - m\mathbf{u}$	
	$-4\mathbf{i} + 4\mathbf{j} = 0.2\mathbf{v} - 0.2 \times 30\mathbf{i}$	M1 A1
	$\mathbf{v} = 10\mathbf{i} + 20\mathbf{j} \quad (\text{m s}^{-1})$	A1 <u>3</u>
(b)	$\tan\theta = \frac{20}{10}$	M1
	$\theta = 63.4°$ accept awrt $63°$ or 1.1^c	A1 <u>2</u>
(c)	Final K.E. = $\frac{1}{2} \times 0.2 \times (10^2 + 20^2) \quad (=50)$ ft their $\mathbf{v}$	M1 A1ft
	K.E. lost = $\frac{1}{2} \times 0.2 \times 30^2 - \frac{1}{2} \times 0.2 \times (10^2 + 20^2)$	M1
	= 40 (J) cao	A1 <u>4</u> **9**

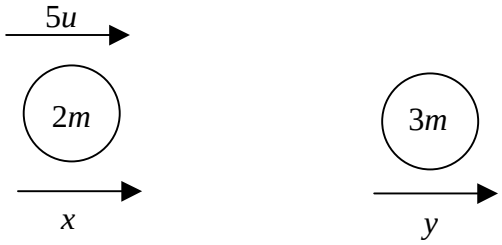
EDEXCEL MECHANICS M2 (6678) – JUNE 2004 **MARK SCHEME**

Question Number	Scheme	Marks
3. (a)	Rectangle Triangle Decoration	
	Mass Ratio 6 12 18 Ratio 1:2:3	B1
	CM from BG $(-)1\frac{1}{2}$ 2 $\bar{x}$	B1
	$18\times\bar{x}=-6\times1\frac{1}{2}+12\times2$	M1 A1
	$\bar{x}=\frac{5}{6}$ accept exact equivalents	A1 5
(b)		
	Identification and use of correct triangle	M1
	$\tan\theta=\frac{1}{3+\bar{x}}$ ft their $\bar{x}$	M1 A1ft
	$\theta=14.6°$ cao	A1 4 **9**

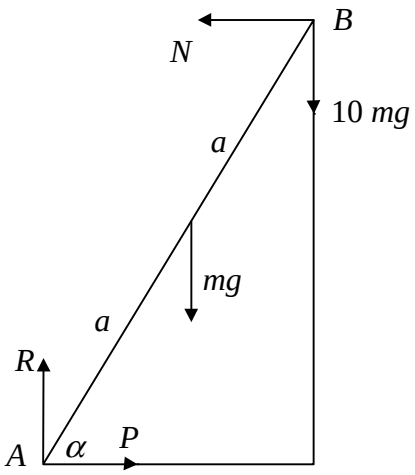
EDEXCEL MECHANICS M2 (6678) – JUNE 2004 **MARK SCHEME**

Question Number	Scheme	Marks
4.	(a) $\mathbf{p} = \left(2t^2 - 7t\right)\mathbf{i} - 5t\mathbf{j}, + 3\mathbf{i} + 5\mathbf{j}$ $= \left(2t^2 - 7t + 3\right)\mathbf{i} + \left(5 - 5t\right)\mathbf{j}$	M1, M1 A1+A1 4
	(b) $\mathbf{q} = \left(2\mathbf{i} - 3\mathbf{j}\right)t - 7\mathbf{i}$	M1 A1
	$\mathbf{j}$: $5 - 5t = -3t \Rightarrow t = 2.5$ equating and solving	M1 A1
	At $t = 2.5$ $\mathbf{i}$: $p_x = 2\times 2.5^2 - 7\times 2.5 + 3 = -2$ $q_x = 2\times 2.5 - 7 = -2$ both	M1
	$p_x = q_x \Rightarrow$ collision cso	A1 6 **10**
	Alternative in (b)	
	$\mathbf{i}$: $2t^2 - 7t + 3 = 2t - 7 \Rightarrow 2t^2 - 9t + 10 = 0$ $t = 2, 2.5$ equating and solving	M1 A1
	At $t = 2.5$ $\mathbf{j}$: $p_y = 5 - 5\times 2.5 = -7.5$ $q_y = -3\times 2.5 = -7.5$ both	M1
	$p_y = q_y \Rightarrow$ collision cso	A1
	In alternative, ignore any working associated with $t = 2$	

EDEXCEL MECHANICS M2 (6678) – JUNE 2004 **MARK SCHEME**

Question Number	Scheme	Marks
5.		
	(a) LM $10mu = 2mx + 3my$	M1 A1
	NEL $y - x = 5eu$	B1
	Solving to $y = 2(1+e)u$ * cso	M1 A1 5
	(b) $x = 2u - 3eu$ finding x, with or without $e = 0.4$	M1
	$x = 0.8u$	A1
	$x > 0 \Rightarrow P$ moves towards wall and Q rebounds from wall	
	$\Rightarrow$ second collision ft any positive x	A1 ft 3
	(c) $x = -0.4u$	B1
	Speed of Q on rebound is $3.6fu$	
	For second collision $3.6fu > 0.4u$	M1
	$f > \frac{1}{9}$ ignore $f \mid 1$	A1 3 **11**

EDEXCEL MECHANICS M2 (6678) – JUNE 2004 **MARK SCHEME**

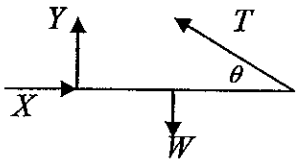
Question Number	Scheme	Marks
6.		
	(a) M(A) $N \times 2a\sin\alpha = mg \times a\cos\alpha + 10mg \times 2a\cos\alpha$	M1 A2(1, 0)
	$2N\tan\alpha = 21mg$	
	$N = 7mg$ * cso	M1 A1 5
	(b) $\uparrow \quad R = 11mg$	B1
	$F_r = 0.6\times 11mg = 6.6mg$	B1
	For min P $F_r \rightarrow$ $P_{\min} = 7mg - 6.6mg = 0.4mg$	M1 A1
	For max P $F_r \leftarrow$ $P_{\max} = 7mg + 6.6mg = 13.6mg$	M1 A1
	$0.4mg \mid P \mid 13.6mg$ cso	A1 7 **12**
	Note: *In* (a), *if moments are taken about a point other than A, a complete set of equations for finding N is needed for the first* M1. *If this* M1 *is gained, the* A2(1, 0) *is awarded for the moments equation as it first appears.*	

EDEXCEL MECHANICS M2 (6678) – JUNE 2004 **MARK SCHEME**

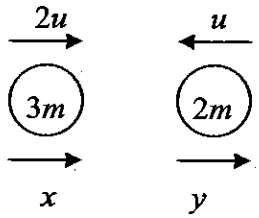
Question Number	Scheme	Marks
7.	(a) Work-Energy $R\times 60 = 80\times 9.8\times 24.4 - \frac{1}{2}\times 80\times 20^2$	M1 A2(1, 0)
	$\left(= 19129.6 - 16\,000 = 3129.6\right)$	
	$R = 52$ (N) accept 52.2	M1 A1 5
	(b) $-8.1 = 20\sin\alpha\times t - \frac{1}{2}gt^2$	M1 A2(1, 0)
	$4.9t^2 - 12t - 8.1 = 0$	M1
	$t = 3$ (s)	A1 5
	(c) $20\cos\alpha\times 3 = 16\times 3 = 48$ (m) ft their t	M1 A1ft 2
	(d) Energy $\frac{1}{2}mv^2 - \frac{1}{2}m\times 20^2 = m\times 9.8\times 8.1$	M1 A2(1, 0)
	$v = \sqrt{\left(558.56\right)} \approx 24 \quad \left(\text{m s}^{-1}\right)$ accept 23.6	M1 A1 5 **17**
	Alternative to (d)	
	$\uparrow \quad v_y = 12 - 3g = -17.4$	M1 A1
	$\rightarrow \quad v_x = 16$	A1
	$v = \sqrt{\left(17.4^2 + 16^2\right)} \approx 24 \quad \left(\text{m s}^{-1}\right)$ accept 23.6	M1 A1 5

January 2005

6678 Mechanics M2
Mark Scheme

Question Number	Scheme	Marks
1.	 (a) $M(A)$ $W\times 4a = T\times 8a\sin\theta$ Using a value of $\sin\theta$ and solving $T = \frac{5}{6}W$ * cso (b) $\rightarrow$ $X = T\cos\theta$ $= \frac{2}{3}W$	M1 A1 M1 A1 4 M1 A1 A1 3 **7**
2.	(a) Mass ratios: circle 9π; rectangle 200; plate $200-9\pi$ Centres of mass: 6; 10; $\bar{x}$ $9\pi\times 6+(200-9\pi)\bar{x} = 200\times 10$ $\bar{x}\approx 10.7$ (cm) cao (b) $\tan\theta = \frac{5}{10.7}$ ft their $\bar{x}$ $\theta\approx 25°$ cao	 B1; B1ft B1 M1 A1 5 M1 A1ft A1 3 **8**

Question Number	Scheme	Marks
3.	(a) KE lost is $\frac{1}{2}\times 0.6\times\left(10^2-9^2\right)$ $(=5.7\text{ J})$	B1
	PE lost is $0.6\times 9.8\times 12\sin 30°\,(=35.28\text{ J})$	B1
	Total loss in energy is 41.0 (J) accept 41	M1 A1 4
	(b) $R=0.6\times 9.8\times\cos 30°\,(\approx 5.09)$	B1
	WE $40.98=\mu\times 0.6\times 9.8\times\cos 30°\times 12$ ft their (a)	M1 A1ft
	$\mu\approx 0.67$ or 0.671	M1 A1 5 **9**
	Alternative for (b)	
	$a=\dfrac{9^2-10^2}{2\times 12}\left(=(-)\dfrac{19}{24}\right)$ awrt 0.79	B1
	N2L $mg\sin 30°-\mu mg\cos 30°=m\left(-\frac{19}{24}\right)$ ft their a	M1 A1ft
	$\mu\approx 0.67$ or 0.671	M1 A1 5
4.	(a) $\ddot{\mathbf{r}}=6\mathbf{i}+(2t+3)\mathbf{j}$	B1
	$\mathbf{F}=0.4(6\mathbf{i}+11\mathbf{j})$ 0.4×something obtained by differentiation, with $t=4$	M1
	$\lvert\mathbf{F}\rvert=\sqrt{\left(2.4^2+4.4^2\right)}$ modulus of a vector	M1
	≈ 5.0 accept more accurate answers	A1 4
	(b) $\mathbf{r}=\left(3t^2+4t\right)\mathbf{i}+\left(\frac{1}{3}t^3+\frac{3}{2}t^2\right)\mathbf{j}\,(+\mathbf{C})$	M1
	Using boundary values, $\mathbf{r}=\left(3t^2+4t-3\right)\mathbf{i}+\left(\frac{1}{3}t^3+\frac{3}{2}t^2+4\right)\mathbf{j}$	A1
	$t=4$, $\mathbf{r}=61\mathbf{i}+49\frac{1}{3}\mathbf{j}$	A1
	$OS=\sqrt{\left(61^2+49\frac{1}{3}^2\right)}\approx 78$ (m) accept more accurate answers	M1 A1 5 **9**

Question Number	Scheme	Marks
5.	(a) $50000 = F \times 25 \ (F = 2000)$ or equivalent	M1
	$\rightarrow \quad F = R + 750$	M1
	$R = 1250$ * cso	A1 3
	(b) N2L $1500 + 2000 = 2500a$ ignore sign of a	M1 A1
	$a = 1.4 \ (\text{m s}^{-2})$ cao	A1 3
	(c) Trailer: $T + R = 1500 \times 1.4$ *or* Car: $T - 1500 - 750 = 1000 \times -1.4$	M1
	$T = 850 \ (\text{N})$	A1 2
	(d) $25^2 = 2 \times 1.4 \times s \ (s = 223.2...)$	M1
	$W = 1500 \times s$ ft their s	M1 A1ft
	$= 335$ (kJ) accept 330	A1 4
	(e) Resistances vary with speeds	B1 1 **13**
6.	 (a) LM $6mu - 2mu = 3mx + 2my$	M1 A1
	NEL $y - x = 3eu$	B1
	Solving to $y = \frac{1}{5}u(9e + 4)$ * cso	M1 A1 5
	(b) Solving to $x = \frac{2}{5}u(2 - 3e)$ oe	M1 A1
	$x < 0 \ \Rightarrow \ e > \frac{2}{3}$	M1 A1
	$\frac{2}{3} < e \mid 1$ ft their e for glb	A1ft 5
	(c) $2m\left[\frac{1}{5}u(9e + 4) + u\right] = \frac{32}{5}mu$	M1 A1
	Solving to $e = \frac{7}{9}$ awrt 0.78	M1 A1 4 **14**

Question Number	Scheme	Marks
7.	(a) $\uparrow\ u_y = 32\times\frac{3}{5}\ (=19.2)$	B1
	$-20 = 19.2t - 4.9t^2$	M1 A2(1, 0)
	$t \approx 4.8$ or 4.77 (s)	A1 5
	(b) $\rightarrow\ u_x = 32\times\frac{4}{5}\ (=25.6)$	B1
	$d = 25.6\times 4.77...$	M1
	≈ 120 or 122 (m)	A1 3
	(c) $\uparrow\ v_y^2 = 19.2^2 + 2\times 9.8\times 4\quad [v_y^2 = 447.04,\ v_y \approx 21.14]$	M1
	$V^2 = 447.04 + 25.6^2$	M1 A1
	$V = 33$ or 33.2 (m s^{-1})	A1 4
	(d) $\tan\theta = \frac{21.14}{25.6}\quad \left(\text{or } \cos\theta = \frac{25.6}{33.2}, ...\right)$ ft their components or resultant	M1 A1ft
	$\theta \approx 40°$ or $39.6°$	A1 3 **15**
	Alternative for (c)	
	$\frac{1}{2}m\left(V^2 - 32^2\right) = mg\times 4$	M1 A1
	$V^2 = 1102.4$	M1
	$V = 33$ or 33.2 (m s^{-1})	A1 4
	There is a maximum penalty of one mark per question for not rounding to appropriate accuracy.	

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Mechanics M2 (6678)

Summer 2005

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Mark Scheme (Results)

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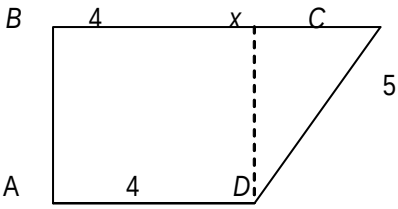
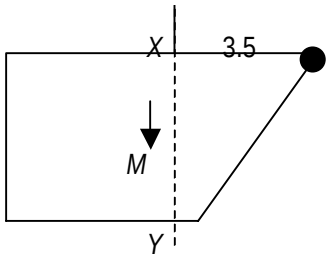
June 2005
6678 Mechanics M2
Mark Scheme

Question Number	Scheme	Marks
1 (a)	Driving force = $\frac{P}{v}$	B1
	$\frac{21000}{v} = 600 \Rightarrow v = 35$ m s^{-1}	M1 A1
		(3)
(b)	$\frac{P}{v} = 600 + 1200.g.\frac{1}{14}$	M1 A1
	(= 1440 N)	
	$\frac{21000}{v} = 1440 \Rightarrow v = \frac{21000}{1440} \approx 14.6$ or 15 m s^{-1}	M1 A1
		(4)
2 (a)	 (x = 3)	
	M(AB): $7 \times 3.5 + 5 \times 5.5 + 4 \times 2 = 20 \times \bar{x}$	M1 A2,1,0
	$\Rightarrow 20\bar{x} = 24.5 + 27.5 + 8 = 60 \Rightarrow \bar{x} = 3$ cm	dep M1 A1
		(5)
(b)	 M(XY):	
	$M \times (3.5 - 3) = kM \times 3.5$	M1 A1 √
	$\Rightarrow k = \frac{1}{7}$.	A1
		(3)

3 (a) $\mathbf{v} = (18 - 12t^2)\mathbf{i} + 2c\mathbf{j}$ M1 A1 A1

$t = \frac{3}{2}$: $\mathbf{v} = -9\mathbf{i} + 3c\mathbf{j}$ M1

$|\mathbf{v}| = 15 \Rightarrow 9^2 + (3c)^2 = 15^2$ M1

$\Rightarrow (3c)^2 = 144 \Rightarrow c = 4$ A1

(6)

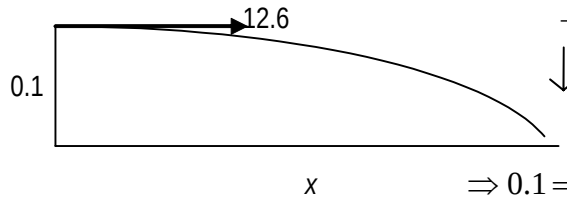
(b) $\mathbf{a} = -24t\mathbf{i} + 8\mathbf{j}$ M1

$t = \frac{3}{2}$: $\mathbf{a} = -36\mathbf{i} + 8\mathbf{j}$ M1

A1 √

(3)

4 (a)



$\rightarrow$ $12.6t = x$ B1

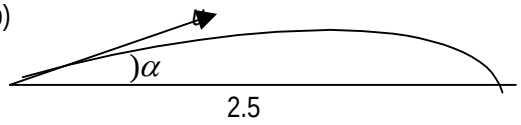
$\downarrow$ $0.1 = 4.9t^2$ B1

$\Rightarrow 0.1 = 4.9 \times \frac{x^2}{12.6^2}$ M1

$\Rightarrow x = 1.8$ m A1

(4)

(b)



$\rightarrow$ $u\cos\alpha.t = 2.5$ M1 A1

$\uparrow$ $u\sin\alpha.t = \frac{1}{2}gt^2$ M1 A1

$$u.\frac{24}{25}t = 2.5$$

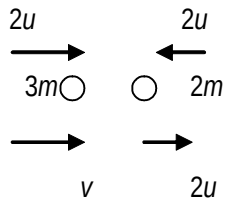
$$u.\frac{7}{25} = 4.9.\frac{2.5.25}{24u}$$

$$u^2 = \frac{4.9 \times 2.5 \times 25^2}{7 \times 24}$$

$\Rightarrow u \approx 6.75$ or 6.8 m s^{-1} M1 A1

(6)

5 (a)



CLM: $6mu - 4mu = 3mv + 4mu$ M1 A1

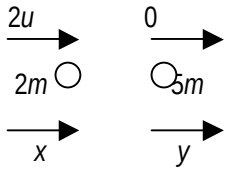
$\Rightarrow v = -\frac{2}{3}u$ A1

NLI: $2u - v = e.4u$ M1 A1

$\Rightarrow 4eu = \frac{8}{3}u \Rightarrow e = \frac{2}{3}.$ M1 A1

(7)

(b)



$5my + 2mx = 4mu$ M1 A1

$y - x = \frac{3}{5}.2u = \frac{6}{5}u$ A1

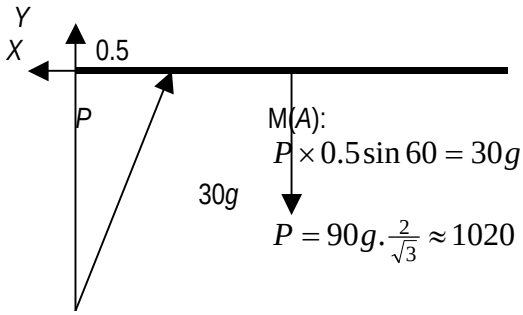
Solve: $x = -\frac{2}{7}u$ M1 A1

$\frac{2}{7}u < \frac{2}{3}u$ so B does not overtake A M1

So no more collisions A1 cso

(7)

6 (a)



M(A):

$P \times 0.5\sin 60 = 30g \times 1.5$ M1 A2

$P = 90g.\frac{2}{\sqrt{3}} \approx 1020$ N (1000N) A1

(4)

(b) $\rightarrow$ $X = P\cos 60 = \frac{1}{2}P$ M1 A1

(≈ 509 N (510N))

$\uparrow$ $Y + P\cos 30 = 30g$ M1 A1

($\Rightarrow Y = -588$ N)

resultant = $\sqrt{(X^2 + Y^2)} = \sqrt{(509^2 + 588^2)} \approx$ 778 N M1 A1

or 780N

(6)

(c) In equilibrium all forces act through a point M1

P and weight meet at mid-point;

hence reaction also acts through mid-point so reaction horizontal A1 cso

(2)

OR M(mid-point): Y x 1.5 = 0 $\Rightarrow$ Y = 0 M1

Hence reaction is horizontal A1

7 (a) PE lost = $3\times g\times 8\sin 30 = 3\times g\times 8\times 0.5$ = 117.6 J ≈ 118J M1 A1

or 120J (2)

(b) KE gained = $\frac{1}{2}\times 3\times 5^2 = 37.5$ J M1 A1

Work-energy: $F\times 8 = 117.6 - 37.5 = 80.1$ M1 A1√

$\Rightarrow F = 10.0125 \approx 10$ N A1

(5)

(c) $R = 3g\cos 30$ (= 25.46 N) B1

$F = \mu R \Rightarrow \mu = \dfrac{10}{25.46} \approx 0.393 \text{ or } 0.39$ M1 A1

(3)

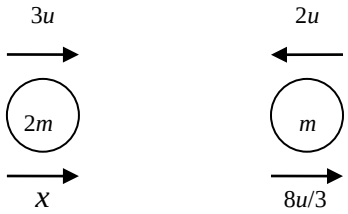
(d) Work done by friction = 80.1 as before M1

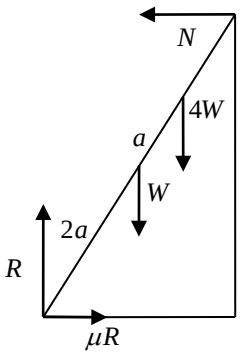
Work-energy: $\frac{1}{2}\times 3\times v^2 = \frac{1}{2}\times 3\times 2^2 + 117.6 - 80.1$ M1 A2,1,0√

$\Rightarrow v \approx 5.39$ or 5.4 m s^{-1} A1

(5)

Question Number	Scheme	Marks
1.	(a) Kinetic Energy = $\frac{1}{2}\times 3\times 8^2 = 96$, J	B1 B1 (2)
	(b) $F = \mu 3g$	B1
	Work-Energy $\mu 3g \text{x} 12 = 96$	M1 A1ft
	$\mu = 0.27$ or 0.272	A1 (4)
	Alternative for (b) $a = \frac{8^2 - 0^2}{2\times 12} = \frac{8}{3}$	B1
	N2L $\mu 3g = 3 \text{ x } \frac{8}{3}$	M1 A1
	$\mu = 0.27$ or 0.272	A1 (4) **6**
2.	(a) $\dot{\mathbf{r}} = (2t+4)\mathbf{i} + (3-3t^2)\mathbf{j}$	M1 A1
	$\dot{\mathbf{r}}_3 = 10\mathbf{i} - 24\mathbf{j}$ substituting t =3	M1
	$\lvert\dot{\mathbf{r}}_3\rvert = \sqrt{(10^2 + 24^2)} = 26 \ (\text{m s}^{-1})$	M1 A1 (5)
	(b) $0.4(\mathbf{v} - (10\mathbf{i} - 24\mathbf{j})) = 8\mathbf{i} - 12\mathbf{j}$ ft their $\dot{\mathbf{r}}_3$	M1 A1ft
	$\mathbf{v} = 30\mathbf{i} - 54\mathbf{j} \ (\text{m s}^{-1})$	A1 (3) **8**
3.	(a) $T_r = \frac{12000}{15} \ (= 800)$	M1
	N2L $800 - R = 1000\times 0.2$ ft their 800	M1 A1ft
	$R = 600$ ✱ cso	A1 (4)
	(b) $1000g \times \frac{1}{40} + T_r = R$	M1 A1
	$T_r = \frac{7000}{U}$	M1
	$U \approx 20$ accept 19.7	M1 A1 (5) **9**

Question Number	Scheme	Marks
4.	(a) 	
	LM $6mu - 2mu = 2mx + \frac{8}{3}mu$ $\left(x = \frac{2}{3}u\right)$	M1 A1
	NEL $\frac{8}{3}u - x = 5ue$	M1 A1
	Solving to $e = \frac{2}{5}$	M1 A1 (6)
	(b) Initial K.E.$= \frac{1}{2}\times 2m(3u)^2 + \frac{1}{2}\times m(2u)^2 = 11mu^2$	
	Final K.E. $= \frac{1}{2}\times 2m\left(\frac{2}{3}u\right)^2 + \frac{1}{2}\times m\left(\frac{8}{3}u\right)^2 = 4mu^2$ both	M1
	Change in K.E. $= 7mu^2$ ✱ M1 Subtracting and simplifying to kmu^2 A1cso	M1 A1 (3)
	(c) $m\left(\frac{8}{3}u + v\right) = \frac{14}{3}mu$ $(v = 2u)$	M1 A1
	$e = \frac{2}{8/3} = \frac{3}{4}$	M1 A1 (4)
		13

Question Number	Scheme	Marks
5.	(a)	
	$12m\bar{x} = 6m \times 9$	M1
	$\bar{x} = 4\frac{1}{2}$	A1
	$12m\bar{y} = 16m - 8m$	M1
	$\bar{y} = \frac{2}{3}$	A1 (4)
	(b) $(12+k)m \times 4 = 12m \times 4\frac{1}{2} + km \times 3$ ft their $\bar{x}$	M1 A1ft
	$k = 6$	A1 (3)
	(c) $18m \times \lambda = 12m \times \frac{2}{3}, \Rightarrow \lambda = \frac{4}{9}$	M1 A1 (2)
	(d) $\tan\theta = \frac{4}{4/9}, \Rightarrow \theta \approx 83.7°$ ft their λ, cao	M1 A1ft A1 (3) **12**
6.	(a) 	
	μR	B1
	$\uparrow \; R = 5W$	B1
	M(B): $4Wa\cos\theta + W.2a\cos\theta + \mu R4a\sin\theta = R.4a\cos\theta$	M1 A1
	Having enough equations & solving them for μ	M1
	$\mu = 0.35$	A1 (6)
	(b) $\uparrow \; S = (5+k)W$	B1
	Use of $F = 0.35S$ or $F \le 0.35S$	M1
	M(B): $kW4a\cos\theta + W.2a\cos\theta + F4a\sin\theta = S.4a\cos\theta$	M1 A1
	Having enough equations & solving them for k	M1
	$k = \frac{10}{7}$ awrt 1.42	A1
	$k \square \frac{10}{7}$ ft their k, accept > and decimals	A1ft (7) **13**

Question Number	Scheme	Marks
7.	(a) $u_x = 11\cos 30°$	B1
	$\rightarrow \quad 11\cos 30° \times t = 10 \quad \Rightarrow \quad t = 1.05$ (s) cao	M1 A1 (3)
	(b) $s = \underline{11\sin 30°} \times t - 4.9t^2 \approx 0.37$	B1 M1 A1
	$(2-1) - 0.37 = 0.63$ (m)	A1 (4)
	(c) $V\cos 30° \times t = 10 \qquad \left(t = \dfrac{10}{V\cos 30°}\right)$	M1 A1
	$s = V\sin 30° \times \dfrac{10}{V\cos 30°} - \dfrac{4.9\times 100}{V^2\cos^2\theta} = 1$	M1 A1
	$V^2 = 136.86$	M1
	$V \approx 12$ accept 11.7	A1 (6)
	(d) B and/or T are not particles	
	(They have extension giving a range of answers)	B1 (1)
		14

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Mechanics
Unit no. 6678/01

June 2006

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Mark Scheme
(Results)

Edexcel GCE
Mechanics
6678/01

General Instructions

1. The total number of marks for the paper is 75.

2. Method (M) marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.

3. Accuracy (A) marks can only be awarded if the relevant method (M) marks have been earned.

4. (B) marks are independent of method marks.

5. Method marks should not be subdivided.

6. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. Indicate this action by 'MR' in the body of the script (but see also note 10).

7. If a candidate makes more than one attempt at any question:

   (a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.

   (b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

8. Marks for each question, or part of a question, must appear in the right-hand margin and, in addition, total marks for each question, even where zero, must be ringed and appear in the right-hand margin and on the grid on the front of the answer book. It is important that a check is made to ensure that the totals in the right-hand margin of the ringed marks and of the unringed marks are equal. The total mark for the paper must be put on the top right-hand corner of the front cover of the answer book.

9. For methods of solution not in the mark scheme, allocate the available M and A marks in as closely equivalent a way as possible, and indicate this by the letters 'OS' (outside scheme) put alongside in the body of the script.

10. All A marks are 'correct answer only' (c.a.o.) unless shown, for example, as A1 f.t. to indicate that previous wrong working is to be followed through. In the body of the script the symbol should be used for correct f.t. and for incorrect f.t. After a misread, however, the subsequent A marks affected are treated as A f.t., but manifestly absurd answers should never be awarded A marks.

11. Ignore wrong working or incorrect statements following a correct answer.

M2 June 2006

Mark scheme

1. $a = 5 - 2t \Rightarrow v = 5t - t^2, + 6$ M1 A1, A1

$v = 0 \Rightarrow t^2 - 5t - 6 = 0$ indep M1

$(t - 6)(t + 1) = 0$ dep M1

$t = \underline{6\text{ s}}$ A1

(6)

2. (a) $\frac{P}{24} = 600$ or $\frac{1000P}{24} = 600 \Rightarrow P = 14.4kW$ M1 A1

(2)

(b) $\frac{30000}{20} - 1200 \times 9.8 \times \sin\alpha - 600 = 1200a$ M1 A2,1,0

$\Rightarrow a = \underline{0.4\text{ m s}^{-2}}$ A1

(4)

3. (a) $I = \pm 0.5(16\mathbf{i} + 20\mathbf{j} - (-30\mathbf{i}))$ M1

$= \pm(23\mathbf{i} + 10\mathbf{j})$ indep M1

magn $= \sqrt{(23^2 + 10^2)} \approx \underline{25.1\text{ Ns}}$ indep M1 A1

(4)

(b) $\mathbf{v} = 16\mathbf{i} + (20 - 10t)\mathbf{j}$ M1

$t = 3 \Rightarrow \mathbf{v} = 16\mathbf{i} - 10\mathbf{j}$ indep M1

$v = \sqrt{(16^2 + 10^2)} \approx \underline{18.9\text{ m s}^{-1}}$ indep M1 A1

(4)

4. (a) Total mass = $12m$ (used) M1

(i) M(AB): $m.3a/2 + m.3a/2 + m.3a + 6m.3a + 2m.3a = 12m.x$ indep M1 A1

$\Rightarrow x = \frac{5}{2}a$ A1

(ii) M(AD): $m.a + m.a + m.2a + 6m.2a = 12m.y$ indep M1 A1

$\Rightarrow y = \frac{4}{3}a$ A1

(7)

(b) $\tan\alpha = \frac{2a - 4a/3}{5a/2}$ M1 A1 **f.t.**

$\Rightarrow \alpha \approx \underline{14.9°}$ A1 cao

(3)

5. (a) $x_A = 28t$ $x_B = 35\cos\alpha\ t$ B1 B1

Meet $\Rightarrow$ $28t = 35\cos\alpha\, t$ $\Rightarrow$ $\cos\alpha = 28/35 = 4/5$ * M1 A1

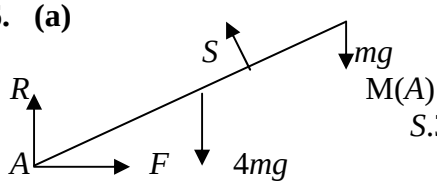
(4)

(b) $y_A = 73.5 - \frac{1}{2}gt^2$ $y_B = 21t - \frac{1}{2}gt^2$ B1 B1

Meet $\Rightarrow$ $73.5 = 21t \Rightarrow t =$ 3.5 s M1 A1

(4)

6. (a)



M(*A*):

$S.3a = 4mg.2a\cos\alpha + mg.4a\cos\alpha$ M1 A1

$= \frac{48}{5}mga \Rightarrow S = \frac{16}{5}mg$ * A1

(3)

(b) R(↑): $R + S\cos\theta = 5mg$ M1 A1

R(→): $F = S\sin\theta$ M1 A1

$F \le \mu R \Rightarrow \mu \ge \frac{48}{61}$ * dep on both previous M's M1 A1

(6)

(c) Direction of *S* is perpendicular to plank
or No friction at the peg B1

(1)

7. (a) $R = 4g\cos\alpha = 16g/5 \Rightarrow F = 2/7 \times 16g/5$ M1 A1

Work done = $F \times 2.5$ = 22.4 J or 22 J indep M1 A1

(4)

(b) $\frac{1}{2} \times 4 \times u^2 = 22.4 + 4g \times 2.5 \times 3/5$ M1 A2,1,0 **f.t.**

$\Rightarrow u \approx$ 6.37 m s^{-1} or 6.4 ms^{-1} A1cao

(4)

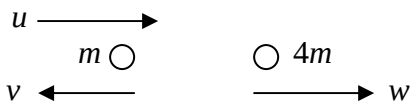
(c) $\frac{1}{2} \times 4 \times v^2 = \frac{1}{2} \times 4 \times u^2 - 44.8$ M1 A2,1,0 **f.t.**

[**OR** $\frac{1}{2} \times 4 \times v^2 = 0 + 4g \times 2.5 \times 3/5 - 22.4$]

$\Rightarrow v \approx$ 4.27 m s^{-1} or 4.3 ms^{-1} A1

(4)

8. (a)



$mu = 4mw - mv$ M1 A1

$eu = w + v$ M1 A1

$\Rightarrow w = (\frac{1+e}{5})u$, $v = (\frac{4e-1}{5})u$ indep M1 A1 A1

(7)

(b) $w' = (\frac{4+4e}{25})u$ B1 **f.t.**

Second collision $\Rightarrow w' > v$

$\Rightarrow \frac{4+4e}{25} > \frac{4e-1}{5}$ M1

$\Rightarrow e < 9/16$ dep M1 A1

Also $v > 0 \Rightarrow e > 1/4$ Hence result (*) B1

(5)

(c)

KE lost $= \frac{1}{2} mu^2 - [\frac{1}{2}.4m\{(u/5)(1+ e)\}^2 + \frac{1}{2} m\{(u/5)(4e - 1)\}^2]$ M1 A1 **f.t.**

$= \frac{3}{10} mu^2$

A1 cao

(3)

Mark Scheme (Results)
January 2007

GCE

GCE Mathematics

Mechanics M2 (6678)

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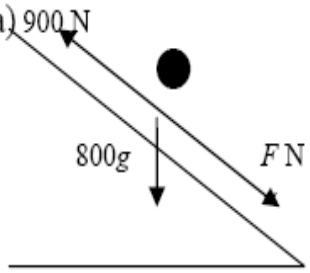
January 2007
6678 Mechanics M2
Mark Scheme

Question Number	Scheme	Marks
1.	(a) $\frac{1}{2}0.8\left(15^2-10^2\right)=50$ (J)	M1 A1 2
	(b) $F=\mu R=\mu 0.8g$	M1
	Work-energy $\mu 0.8g\times 20=50$ ft their (a)	M1 A1ft
	$\mu\approx 0.32$ accept 0.319	A1 4 **6**
	Alternative for (b)	
	$v^2=u^2+2as \Rightarrow a=\frac{15^2-10^2}{2\times 20}=3.125$	M1
	N2L $F=\mu mg=ma=3.125m$	M1 A1ft
	$\mu\approx 0.32$ accept 0.319	A1 4
	Alternative for (b)	
	WE $F=\frac{50}{20}\ (=2.5)$	M1
	$F=\mu R\Rightarrow\frac{50}{20}=\mu 0.8g$ ft their (a)	M1 A1 ft
	$\mu\approx 0.32$	A1 **4**
	The first M1 for *(b)* could be scored in *(a)*:	
	$v^2=u^2+2as\Rightarrow 10^2=15^2-2\times 20\times(-)a\Rightarrow a=(-)\frac{125}{40}$	*(b)*M1
	$F=ma\Rightarrow F=2.5$	
	$WD=F\times d\Rightarrow 2.5\times 20=50J$	*(a)*M1A1

2.

(a) 900 N



$F + 800g\sin\alpha = 900$ M1

$F = 573\frac{1}{3}$ A1

$W = 573\frac{1}{3} \times 15 = 8600$ M1

$= 8.6$ kW A1 4

NB. Going up hill is an error, not a Misread

(b) N2L $800 \times 9.8 \times \frac{1}{24} - 900 = 800a$ * M1

$a = -\frac{43}{60}$ awrt -0.72 A1

$0 = 15 - \frac{43}{60}T$ M1

$T \approx 21$ accept 20.9 A1cso 4 **8**

* If they are using their F from (a) then they need to have scored the M1 in (a) in order to score the M1 here.

Alternative for (b)

WD: $573\frac{1}{3}s = \frac{1}{2} \times 800 \times 15^2$

$s = 157$

Use of $v^2 = u^2 + 2as$ M1 for getting as far as an equation in a.

$a = 0.72$ A1

finish as above.

2nd Alternative for (b)

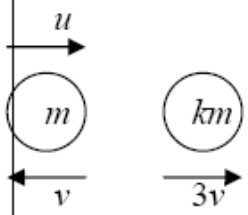
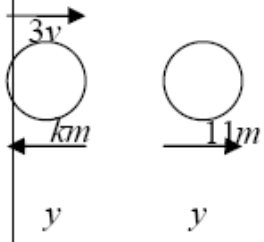
Ft = Change in momentum:

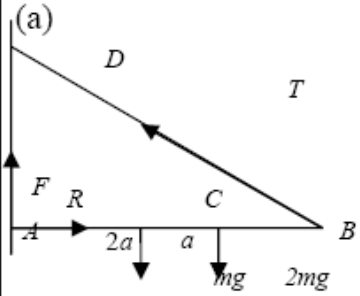
M1 Using the correct F

M1 Use of the method to form an equation

A1 Equation correct unsimplified but fully substituted

A1 $T \approx 21$

Question Number	Scheme	Marks
3.	(a) Large Small Template Mass Ratios 24^2 8^2, 512 anything in ratio 9 : 1 :8 *(c.1810 c.200 c.1610)* M(A) $9\times24=16\times1+8\bar{x}$ $\bar{x}=25$ (cm) exact	B1, B1ft M1* A1 DM1* A1 6
	(b) M(axis) $11M=12\times\frac{1}{4}m$ ft their $\bar{x}$ ($(36-\bar{x})M=12\times\frac{1}{4}m$) $M=\frac{3}{11}m$ (o.e.e.)	M1 † A1ft DM1 † A1 4 **10**
4. (a)	 NEL $3v-(-v)=eu$ $u=8v$	M1 A1 A1 3
(b)	LM $8mv=-mv+3kmv$ ft their u ($m\times(u)=-mv+3kmv$) $k=3$	M1 A1ft A1 3
(c)	 LM $9mv=-3my+11my$ ft their k NEL $2y=e\times3v$ $y=\frac{9}{8}v\Rightarrow e=\frac{3}{4}$ ★ cso	M1 A1ft M1 A1 4
	(d) $y=\frac{9}{8}v>v$ $\Rightarrow$ further collision between P and Q A1 is cso – watch out for incorrect statements re. velocity	M1 A1 2 **12**

Question Number	Scheme	Marks
5.	(a)  M(A) $T\sin\theta\times 4a = mg\times 2a + 2mg\times 3a$ $T = \frac{8mg}{4}\times\frac{5}{3} = \frac{10}{3}mg$ Accept 32.7*m*, 33*m*	M1* A1=A1 DM1* A1 5
	(b) $\rightarrow$ $R = T\cos\theta = \frac{10}{3}mg\times\frac{4}{5}$; $= \frac{8}{3}mg$ * cso ft their T	M1 A1ft; A1 3
	(c) $\uparrow$ $F + T\sin\theta = 3mg \Rightarrow F = mg$ ft their T Or: M(B) $F\times 4a = mg\times 2a + 2mg\times a \Rightarrow F = mg$ $F = \mu R \Rightarrow \mu = \frac{3}{8}$	M1 A1ft M1 A1 4 **12**
	(a) Alternative approach: $\rightarrow$ $R = T\cos\theta$ $\uparrow$ $F + T\sin\theta = 3mg$ M(B) $F\times 4a = mg\times 2a + 2mg\times a (\Rightarrow F = mg)$ $\Rightarrow mg + T\sin\theta = 3mg \Rightarrow T = \frac{2mg}{\sin\theta} = \frac{10mg}{3}$ If they use this method, watch out for F=mg just quoted in (c): M1A1	

6.	(a) N2L $(1.5t^2-3)\mathbf{i}+2t\mathbf{j}=0.5\mathbf{a}$		M1
	$\mathbf{a}=(3t^2-6)\mathbf{i}+4t\mathbf{j}$		A1 2
	(b) $\mathbf{v}=(t^3-6t)\mathbf{i}+2t^2\mathbf{j}\quad(+\mathbf{c})$		M1 A1
	$t=2\quad -4\mathbf{i}+5\mathbf{j}=-4\mathbf{i}+8\mathbf{j}+\mathbf{c}\qquad(\mathbf{c}=-3\mathbf{j})$		M1
	$\mathbf{v}=(t^3-6t)\mathbf{i}+(2t^2-3)\mathbf{j}\qquad(\mathrm{m\,s^{-1}})$		A1
	$t=3\qquad \mathbf{v}=9\mathbf{i}+15\mathbf{j}\ (\mathrm{m\,s^{-1}})$ *	cso	A1 5
	(c) $\mathbf{Q}=0.5(-3\mathbf{i}+20\mathbf{j}-(9\mathbf{i}+15\mathbf{j}))\quad(=0.5(-12\mathbf{i}+5\mathbf{j}))$		M1
	$\lvert\mathbf{Q}\rvert=0.5\sqrt{(5^2+12^2)}=6.5$		M1 A1 3
	(d) acute angle is $\arctan\frac{5}{12}\approx 23°$		M1 A1
	or required angle is $\arctan\frac{-5}{12}$		
	or acute angle is $\arccos\frac{12}{13}\approx 23°$		
	or required angle is $\arccos\frac{-12}{13}$		
	required angle is 157°	awrt 157°, 203°	A1 3 **13**

Question Number	Scheme	Marks
7.	(a) Energy $\frac{1}{2}m\left(24.5^2-u^2\right)=mg\times 15$	M1 A1=A1
	$u^2=24.5^2-30g=306.25$	
	$u=\sqrt{306.25}=17.5$ ★ cso	A1 4
	(b) $\rightarrow$ $u_x=u\cos\theta=17.5\times 0.8=14$	B1
	$\psi=\arccos\frac{14}{24.5}\approx 55°$ accept 55.2°	M1 A1 3
	(0.96 rads, or 0.963 rads)	
	(c) $\uparrow$ $u_y=u\sin\theta=17.5\times 0.6=10.5$	B1
	$s=ut+\frac{1}{2}at^2 \Rightarrow -45=10.5t-4.9t^2$	M1 A1
	leading to $t=4.3$, awrt $t=4.3$ or $t=4\frac{2}{7}$	A1
	$\rightarrow$ $BD=14\times 4\frac{2}{7}$ (14 x t) ft their t	M1 A1ft
	$=60$ (m) only	A1 7 **14**
	Alternative for (a)	
	$\rightarrow u_x=u\cos\theta=0.8u$, $\uparrow u_y=u\sin\theta=0.6u$	
	$v_y^2=0.36u^2+2\times 9.8\times 15=0.36u^2+294$	
	$24.5^2=u_x^2+v_y^2=0.64u^2,+0.36u^2+294$	M1 A1,A1
	$u^2=306.25 \Rightarrow u=17.5$ ★ cso	A1 4
	Alternative for (b) $\rightarrow$ $u_x=u\cos\theta=17.5\times 0.8=14$	B1
	$\uparrow$ $v_y^2=u^2\sin^2\theta+2\times 9.8\times 15=404.25$	
	$\psi=\arctan\frac{\sqrt{404.25}}{14}\approx 55°$ accept 55.2°	M1 A1 3
	Alternative for (c) Use of $y=x\tan\theta-\frac{g\sec^2\vartheta}{2u^2}x^2$	M1
	$-45=\frac{3}{4}x$, $-\frac{g}{2\times 17.5^2}\times\frac{25}{16}x^2$	B1,A1
	$x^2-30x-1800=0$ o.e.	A1
	Factors or quadratic formula	M1 A1ft
	BD = 60 (m)	A1

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Mark Scheme (Results)
Summer 2007

GCE

GCE Mathematics

Mechanics M2 (6678)

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June 2007
6678 Mechanics M2
Mark Scheme

General:
For M marks, correct number of terms, dimensionally correct, all terms that need resolving are resolved.
Omission of *g* from a resolution is an accuracy error, not a method error.
Omission of mass from a resolution is a method error.
Omission of a length from a moments equation is a method error.
Where there is only one method mark for a question or part of a question, this is for a *complete* method.
Omission of units is not (usually) counted as an error.
When resolving, condone sin/cos confusion for M1, but M0 for tan or dividing by sin/cos.

Question Number	Scheme	Marks
1	Force exerted = 444/6 (= 74 N) $R + 90g \sin\alpha = 444/6$ $\Rightarrow R = \underline{32\text{ N}}$	B1 M1 A1 A1 (4)
	B1 444/6 seen or implied M1 Resolve parallel to the slope for a 3 term equation – condone sign errors and sin/cos confusion A1 All three terms correct – expression as on scheme or exact equivalent A1 32(N) only	
2 .(a)	$a = dv/dt = 6t\mathbf{i} - 4\mathbf{j}$	M1 A1 (2)
(b)	Using F = ½a, sub $t = 2$, finding modulus e.g. at $t = 2$, $a = 12\mathbf{i} - 4\mathbf{j}$ $F = 6\mathbf{i} - 2\mathbf{j}$ $\lvert F \rvert = \sqrt{(6^2 + 2^2)} \approx \underline{6.32\text{ N}}$	M1, M1, M1 A1(CSO) (4)
	M1 Clear attempt to differentiate. Condone **i** or **j** missing. A1 both terms correct (column vectors are OK) The 3 method marks can be tackled in any order, but for consistency on epen grid please enter as: M1 **F**=m**a (**their **a**, (correct **a** or following from (a))**,** not **v.** **F**=$\frac{1}{2}$ **a).** Condone **a** not a vector for this mark. M1 subst t = 2 into candidate's vector **F** or **a** (**a** correct or following from (a), not **v**) M1 Modulus of candidate's **F** or **a** (not **v**) A1 CSO All correct (beware fortuitous answers e.g. from 6t**i**+4**j**)) Accept 6.3, awrt 6.32, any exact equivalent e.g. $2\sqrt{10}$,$\sqrt{40}$, $\frac{\sqrt{160}}{2}$	

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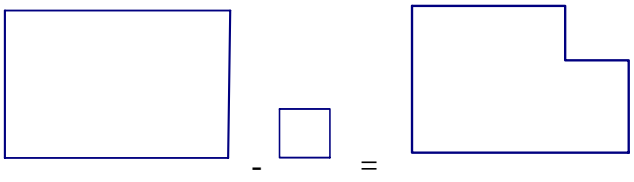
3		
(a)	M (*AF*) $4a^2.a - a^2.3a/2 = 3a^2.\bar{x}$ $\bar{x} = \underline{5a/6}$	M1 A2,1,0 A1 (4)
(b)	Symmetry $\Rightarrow \bar{y} = 5a/6$, or work from the top to get 7a/6 $\tan q = \frac{5a/6}{2a - 5a/6}$ $(\frac{\bar{x}}{2a-\bar{y}})$ $q \approx \underline{35.5°}$	B1√ M1 A1√ A1 (4)
	M1 Taking moments about AF or a parallel axis, with mass proportional to area. Could be using a difference of two square pieces, as above, but will often use the sum of a rectangle and a square to make the L shape. Need correct number of terms but condone sign errors for M1. A1 A1 All correct A1 A0 At most one error A1 5a/6, (accept 0.83a or better) *Condone consistent lack of a's for the first three marks.* *NB: Treating it as rods rather than as a lamina is M0* B1ft $\bar{x} = \bar{y} =$ their 5a/6, or $\bar{y}$ =distance from AB = 2a - their 5a/6. Could be implied by the working. Can be awarded for a clear statement of value in (a). M1 Correct triangle identified and use of tan. $\frac{2a - 5a/6}{5a/6}$ is OK for M1. Several candidates appear to be getting 45° without identifying a correct angle. This is M0 unless it clearly follows correctly from a previous error. A1ft Tan α expression correct for their 5a/6 and their $\bar{y}$ A1 35.5 (Q asks for 1d.p.) NB: Must suspend from point A. Any other point is not a misread.	

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4. (a)	PE lost = $2mgh - mgh\sin\alpha$ (= $7mgh/5$)	M1 A1 (2)
(b)	Normal reaction $R = mg\cos\alpha$ (= $4mg/5$)	B1
	Work-energy: $\frac{1}{2}mv^2 + \frac{1}{2}.2mv^2 = \frac{7mgh}{5} - \frac{5}{8}.\frac{4mg}{5}.h$	M1 A2,1,0
	$\Rightarrow \frac{3}{2}mv^2 = \frac{9mgh}{10} \Rightarrow v^2 = \frac{3}{5}gh$	A1 (5)
	M1 Two term expression for PE lost. Condone sign errors and sin/cos confusion, but must be vertical distance moved for A A1 Both terms correct, sinα correct, but need not be simplified. Allow 13.72*mh*. Unambiguous statement. B1 Normal reaction between A and the plane. Allow when seen in (b) provided it is clearly the normal reaction. Must use cosα but need not be substituted. M1(NB QUESTION SPECIFIES WORK & ENERGY) substitute into equation of the form PE lost = Work done against friction plus KE gained. Condone sign errors. They ***must include KE of both particles.*** A1A1 All three elements correct (including signs) A1A0 Two elements correct, but follow their GPE and μx their R x*h*. A1 V^2 correct (NB *kgh* specified in the Q)	

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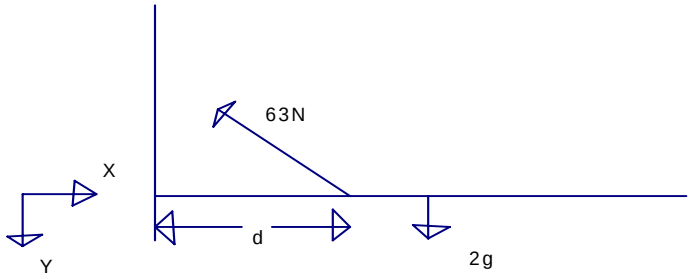
5.(a)	 M(*A*) 63 sin 30 . 14 = 2*g* . *d* Solve: *d* = 0.225m Hence *AB* = <u>45 cm</u>	M1 A1 A1 A1 (4)
(b)	R(→) *X* = 63 cos 30 (≈ 54.56) R(↑) *Y* = 63 sin 30 – 2*g* (≈ 11.9) *R* = √($X^2 + Y^2$) ≈ <u>55.8, 55.9 or 56 N</u>	B1 M1 A1 M1 A1 (5)
	M1 Take moments about A. 2 recognisable force x distance terms involving 63 and 2(g). A1 63 N term correct A1 2g term correct. A1 *AB* = 0.45(m) or 45(cm). No more than 2sf due to use of *g*. B1 Horizontal component (Correct expression – no need to evaluate) M1 Resolve vertically – 3 terms needed. Condone sign errors. Could have cos for sin. Alternatively, take moments about B : $0.225\times 2g = 0.31\times 63\sin 30 + 0.45Y$ or C : $0.14Y = 0.085\times 2g$ A1 Correct expression (not necessarily evaluated) - direction of Y does not matter. M1 Correct use of Pythagoras A1 55.8(N), 55.9(N) or 56 (N) OR For X and Y expressed as Fcosθ and Fsinθ . M1 Square and add the two equations, or find a value for tanθ, and substitute for sinθ or cosθ A1 As above . N.B. Part (b) can be done before part (a). In this case, with the extra information about the resultant force at A, part (a) can be solved by taking moments about any one of several points. M1 in (a) is for a complete method - they must be able to substitute values for all their forces and distances apart from the value they are trying to find..	

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6. (a)	$0 = (35 \sin \alpha)^2 - 2gh$ $h =$ <u>40 m</u>	M1 A1 A1 (3)
(b)	$x = 168 \Rightarrow 168 = 35 \cos\alpha \, . \, t$ $(\Rightarrow t = 8s)$	M1 A1
	At $t = 8$, $y = 35\sin\alpha \times t - \frac{1}{2}gt^2$ $(= 28.8 - ½.g.8^2 = -89.6$ m)	M1 A1
	Hence height of A = <u>89.6 m</u> or 90 m	DM1 A1 (6)
(c)	$½mv^2 = 1/2.m.35^2 + mg.89.6$	M1 A1
	$\Rightarrow$ v = <u>54.6 or 55 m s^{-1}</u>	A1 (3)

M1 Use of $v^2 = u^2 + 2as$, or possibly a 2 stage method using $v = u + at$ and $s = ut + \frac{1}{2}at^2$

A1 Correct expression. Alternatives need a complete method leading to an equation in h only.

A1 40(m) No more than 2sf due to use of *g*.

M1 Use of $x = u\cos\alpha . t$ to find *t*.

A1 $168 = 35 \times their \cos\alpha \times t$

M1 Use of $s = ut + \frac{1}{2}at^2$ to find vertical distance for their *t*. (AB or top to B)

A1 $y = 35\sin\alpha \times t - \frac{1}{2}gt^2$ (*u*,*t* consistent)

DM1 This mark dependent of the previous 2 M marks. Complete method for AB. Eliminate t and solve for s.

A1 cso.

(NB some candidates will make heavy weather of this, working from A to max height (40m) and then down again to B (129.6m))

OR : Using $y = x\tan\alpha - \frac{gx^2\sec^2\alpha}{2u^2}$

M1 formula used (condone sign error)

A1 x,u substituted correctly

M1 α terms substituted correctly.

A1 fully correct formula

M1, A1 as above

M1 Conservation of energy: change in KE = change in GPE. All terms present. One side correct (follow their h).

(will probably work *A* to *B*, but could work top to *B*).

A1 Correct expression (follow their h)

A1 54.6 or 55 (m/s)

OR: M1 horizontal and vertical components found and combined using Pythagoras

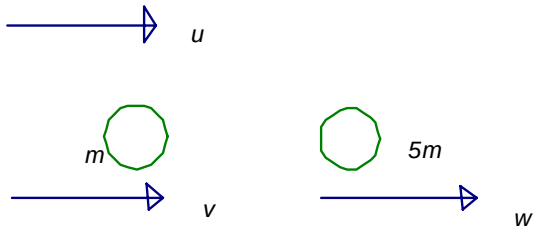
$v_x = 21$

$v_y = 28 - 9.8x8$ (-50.4)

A1 v_x and v_y expressions correct (as above). Follow their *h*,*t*.

A1 54.6 or 55

NB Penalty for inappropriate rounding after use of g only applies once per question.

Question Number	Scheme	Marks
7.		
(a)	CLM: $mv + 5mw = mu$ NLI: $w - v = eu$ Solve v: $v = \frac{1}{6}(1-5e)u$, so speed = $\frac{1}{6}(5e-1)u$ (**NB – answer given on paper**) Solve w: $w = \frac{1}{6}(1+e)u$ * The M's are dependent on having equations (not necessarily correct) for CLM and NLI	B1 B1 M1* A1 M1* A1 (6)
(b)	After B hits C, velocity of B = "v" = $\frac{1}{6}(1-5.\frac{4}{5})u = -\frac{1}{2}u$ velocity $< 0 \Rightarrow$ change of direction $\Rightarrow$ B hits A	M1 A1 A1 CSO (3)
(c)	velocity of C after = $\frac{3}{10}u$ When B hits A, "u" = $\frac{1}{2}u$, so velocity of B after = $-\frac{1}{2}(-\frac{1}{2}u) = \frac{1}{4}u$ Travelling in the same direction but $\frac{1}{4} < \frac{3}{10} \Rightarrow$ <u>no second collision</u>	B1 B1 M1 A1 CSO (4)
	B1 Conservation of momentum – signs consistent with their diagram/between the two equations B1 Impact equation M1 Attempt to eliminate w A1 correct expression for v. Q asks for speed so final answer must be verified positive with reference to e>1/5. **Answer given so watch out for fudges**. M1 Attempt to eliminate v A1 correct expression for w M1 Substitute for e in speed or velocity of P to obtain ***v*** in terms of ***u***. Alternatively, can obtain v in terms of w A1 (+/-) u/2 $(v = -\frac{5w}{3})$ A1 CSO <u>Justify direction</u> (and correct conclusion) B1 speed of C = value of w = $(\pm)\frac{3u}{10}$ (Must be referred to in (c) to score the B1.) B1 speed of B after second collision $(\pm)\frac{1}{4}u$ or $(\pm)\frac{5}{6}w$ M1 Comparing their speed of B after 2nd collision with their speed of C after first collision. A1 CSO. Correct conclusion .	

8. (a)	$0 \le t \le 4$: $a = 8 - 3t$ $a = 0 \Rightarrow t = 8/3$ s $\rightarrow v = 8.\frac{8}{3} - \frac{3}{2}.\left(\frac{8}{3}\right)^2 = \frac{32}{3}$ (m/s) second M1 dependent on the first, and third dependent on the second.	M1 DM1 DM1 A1 (4)
(b)	$s = 4t^2 - t^3/2$ $t = 4$: $s = 64 - 64/2 = \underline{32 \text{ m}}$	M1 M1 A1 (3)
(c)	$t > 4$: $v = 0 \Rightarrow t = \underline{8 \text{ s}}$	B1 (1)
(d)	*Either* $t > 4$ $s = 16t - t^2$ $(+ C)$ $t = 4, s = 32 \rightarrow C = -16 \Rightarrow s = 16t - t^2 - 16$ $t = 10 \rightarrow s = 44$ m But direction changed, so: $t = 8, s = 48$ Hence total dist travelled = 48 + 4 = $\underline{52 \text{ m}}$	M1 M1 A1 M1 A1 M1 DM1 A1 (8)
	Or (probably accompanied by a sketch?) t=4 v=8, t=8 v=0, so area under line = $\frac{1}{2} \times (8-4) \times 8$ t=8 v=0, t=10 v=-4, so area above line = $\frac{1}{2} \times (10-8) \times 4$ Hence total distance = 32(from b) + 16 + 4 = $\underline{52 \text{ m.}}$	M1A1A1 M1A1A1 M1A1 (8)
	Or M1, A1 for t > 4 $\frac{dv}{dt} = -2$, =constant t=4, v=8; t=8, v=0; t=10, v=-4 M1, A1 $s = \frac{u+v}{2}t = \frac{32}{2}t$, =16 working for t = 4 to t = 8 M1, A1 $s = \frac{u+v}{2}t = \frac{-4}{2}t$, =-4 working for t = 8 to t = 10 M1, A1 total = 32+14+4, =52	

M1 Differentiate to obtain acceleration
DM1 set acceleration. = 0 and solve for t
DM1 use their t to find the value of v
A1 32/3, 10.7oro better

OR using trial an improvement:
M1 Iterative method that goes beyond integer values
M1 Establish maximum occurs for t in an interval no bigger than 2.5<t<3.5
M1 Establish maximum occurs for t in an interval no bigger than 2.6<t<2.8
A1

Or M1 Find/state the coordinates of both points where the curve cuts the x axis.
DM1 Find the midpoint of these two values.
M1A1 as above.

Or M1 Convincing attempt to complete the square:
DM1 substantially correct $8t - \frac{3t^2}{2} = -\frac{3}{2}(t - \frac{8}{3})^2 + \frac{3}{2} \times \frac{64}{9}$
DM1 Max value = constant term
A1 CSO

M1 Integrate the correct expression
DM1 Substitute t = 4 to find distance (s=0 when t=0 - condone omission / ignoring of constant of integration)
A1 32(m) only
B1 t = 8 (s) only

M1 Integrate 16-2t
M1 Use t=4, s= their value from (b) to find the value of the constant of integration.
or 32 + integral with a lower limit of 4 (in which case you probably see these two marks
occurring with the next two. First A1 will be for 4 correctly substituted.)
A1 $s = 16t - t^2 - 16$ or equivalent
M1 substitute t = 10
A1 44
M1 Substitute t = 8 (their value from (c))
DM1 Calculate total distance (M mark dependent on the previous M mark.)
A1 52 (m)

OR the candidate who recognizes v = 16 – 2t as a straight line can divide the shape into two triangles:
M1 distance for t = 4 to t = candidate's 8 = ½ x change in time x change in speed.
A1 8-4
A1 8-0
M1 distance for t = their 8 to t = 10 =½ x change in time x change in speed.
A1 10-8
A1 0-(-4)
M1 Total distance = their (b) plus the two triangles (=32 + 16 + 4).
A1 52(m)

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Mark Scheme (Results)
January 2008

GCE

GCE Mathematics (6678/01)

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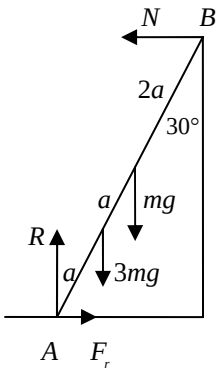
January 2008
6678 Mechanics M2
Mark Scheme

Question Number	Scheme	Marks
1.	(a) KE lost is $\frac{1}{2}\times 2.5\times 8^2 = 80 \ (\text{J})$	M1 A1 **(2)**
	(b) Work energy $80 = R\times 20$ ft their (a) $R = 4$	M1 A1 ft A1 **(3)** **[5]**
	Alternative to (b) $0^2 = 8^2 - 2\times a\times 20 \Rightarrow a = (-)1.6$ N2L $R = 2.5\times 1.6$ ft their a $= 4$	M1 A1ft A1 **(3)**
2.	(a) $\dot{\mathbf{p}} = (6t-6)\mathbf{i} + (9t^2-4)\mathbf{j} \quad (\text{m s}^{-1})$	M1 A1 **(2)**
	(b) $9t^2 - 4 = 0$ $t = \frac{2}{3}$	M1 DM1 A1 **(3)**
	(c) $t = 1 \Rightarrow \dot{\mathbf{p}} = 5\mathbf{j}$ ft their $\dot{p}$ (+/-) $2\mathbf{i} - 6\mathbf{j} = 0.5(\mathbf{v} - 5\mathbf{j})$ $\mathbf{v} = 4\mathbf{i} - 7\mathbf{j} \quad (\text{m s}^{-1})$	B1ft M1 M1 A1 **(4)** **[9]**

Question Number	Scheme	Marks
3.	(a) $20\,000 = 16F \quad (F = 1250)$	M1 A1
	↗ $F = 550 + 1000 \times 9.8 \sin\theta$ ft their F	M1 A1ft
	Leading to $\sin\theta = \frac{1}{14}$ ✱ cso	A1 **(5)**
	(b) N2L ↗ $550 + 1000 \times 9.8 \times \sin\theta = 1000a$	
	$(550 + 1000 \times 9.8 \times \frac{1}{14} = 1000a \quad)$	M1 A1
	or $1250 = 1000a$	
	$(a = (-)1.25)$	
	$v^2 = u^2 + 2as \Rightarrow 16^2 = 2 \times 1.25 \times y$	M1
	$y \approx 102$ accept 102.4, 100	A1 **(4)**
		[9]
	Alternative to (b)	
	Work-Energy $\frac{1}{2} \times 1000 \times 16^2 - 1000 \times 9.8 \times \frac{1}{14} y = 550y$	M1 M1 A1
	$y \approx 102$ accept 102.4, 100	A1 **(4)**
4.	(a) Triangle Circle S	
	Mass ratio 126 9π $126 - 9\pi$	B1 B1ft
	(28.3) (97.7)	
	$\bar{x}$ 7 5 $\bar{x}$	
	$\bar{y}$ 4 5 $\bar{y}$ 4, 7 seen	B1
	$126 \times 7 = 9\pi \times 5 + (126 - 9\pi) \times \bar{x}$ ft their table values	M1 A1ft
	$\bar{x} \approx 7.58 \ (\frac{882 - 45\pi}{126 - 9\pi})$ awrt 7.6	A1
	$126 \times 4 = 9\pi \times 5 + (126 - 9\pi) \times \bar{y}$ ft their table values	M1 A1ft
	$\bar{y} \approx 3.71 \ (\frac{504 - 45\pi}{126 - 9\pi})$ awrt 3.7	A1 **(9)**
	(b) $\tan\theta = \frac{\bar{y}}{21 - \bar{x}}$ ft their $\bar{x}, \bar{y}$	M1 A1ft
	$\theta \approx 15°$	A1 **(3)**
		[12]

Question Number	Scheme	Marks
5.	(a) 	
	M(A) $N \times 4a\cos 30° = 3mg \times a\sin 30° + mg \times 2a\sin 30°$	M1 A2(1,0)
	$N = \frac{5}{4}mg\tan 30°$ $\left(= \frac{5}{4\sqrt{3}}mg\right)$ = 7.07…m)	DM1 A1
	$\rightarrow \quad F_r = N \quad , \quad \uparrow \quad R = 4mg$	B1, B1
	Using $F_r = \mu R$	B1
	$\frac{5}{4\sqrt{3}}mg = \mu R$ for their R	M1
	$\mu = \frac{5}{16\sqrt{3}}$ awrt 0.18	A1 **(10)**
		[10]
	Alternative method:	
	M(B): $mg \times 2a\sin 30 + 3mg \times 3a\sin 30 + F \times 4a\cos 30 = R \times 4a\sin 30$	
	$11mga\sin 30 + F \times 4a\cos 30 = R \times 4a\sin 30$	M1A3(2,1,0)
	$\frac{11mg}{2} + F\frac{4\sqrt{3}}{2} = 2R$	DM1A1
	$\uparrow \quad R = 4mg$,	B1
	Using $F_r = \mu R$	B1
	$8\mu\sqrt{3} = \frac{5}{2}, \quad \mu = \frac{5}{16\sqrt{3}}$	M1 A1

6.

(a)

$\rightarrow \quad 30 = 2ut$ — B1

$\uparrow \quad -47.5 = 5ut - 4.9t^2$ — M1 A1

$-47.5 = 75 - 4.9t^2$ eliminating u or t — DM1

$t^2 = \dfrac{75 + 47.5}{4.9} \left(= 25\right)$ — DM1

$t = 5$ ✱ cso — A1 **(6)**

(b) $30 = 2ut \Rightarrow 30 = 10u \Rightarrow u = 3$ — M1 A1 **(2)**

(c)

$\uparrow \quad \dot{y} = 5u - 9.8t = -34$ M1 requires both — M1 A1

$\rightarrow \quad \dot{x} = 2u = 6$ $\dot{x}$ and $\dot{y}$ — A1

$v^2 = 6^2 + (-34)^2$ — DM1

$v \approx 34.5 \ \left(\text{m s}^{-1}\right)$ accept 35 — A1 **(5)**

[13]

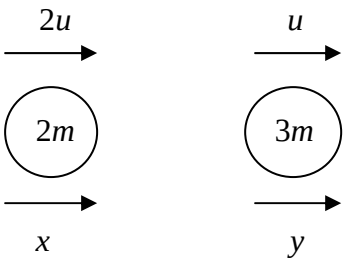
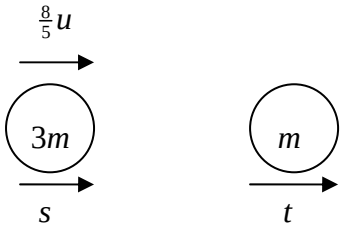
Alternative to (c)

$\frac{1}{2}mv_B^2 - \frac{1}{2}mv_A^2 = m \times g \times 47.5$ with $v_A^2 = 6^2 + 15^2 = 261$ — M1 A(2,1,0)

$v_B^2 = 261 + 2 \times 9.8 \times 47.5 \ \left(= 1192\right)$ — DM1

$v_B \approx 34.5 \ \left(\text{m s}^{-1}\right)$ accept 35 — A1 **(5)**

BEWARE : Watch out for incorrect use of $v^2 = u^2 + 2as$

Question Number	Scheme	Marks
7.	(a) 	
	LM $4mu + 3mu = 2mx + 3my$	M1 A1
	NEL $y - x = \frac{1}{2}u$	B1
	Solving to $y = \frac{8}{5}u$ ∗ cso	M1 A1 **(5)**
	(b) $x = \frac{11}{10}u$ or equivalent	B1
	Energy loss $\frac{1}{2}\times 2m\left(\left(2u\right)^2 - \left(\frac{11}{10}u\right)^2\right) + \frac{1}{2}\times 3m\left(u^2 - \left(\frac{8}{5}u\right)^2\right)$	M1 A(2,1,0)
	$= \frac{9}{20}mu^2$	A1 **(5)**
	(c) 	
	LM $\frac{24}{5}mu = 3ms + mt$	M1 A1
	NEL $t - s = \frac{8}{5}eu$	B1
	Solving to $s = \frac{2}{5}u\left(3 - e\right)$	M1 A1
	For a further collision $\frac{11}{10}u > \frac{2}{5}u\left(3 - e\right)$	M1
	$e > \frac{1}{4}$ ignore $e \leq 1$	A1 **(7)**
		[17]

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GCE

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Mathematics

Mechanics 2 M2 (6678)

June 2008

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Final Mark Scheme

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Mathematics

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

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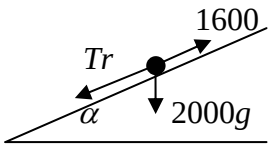
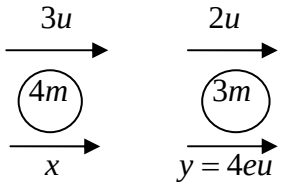
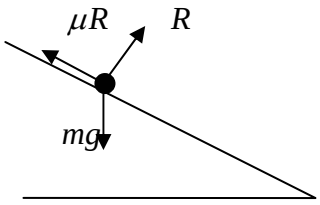
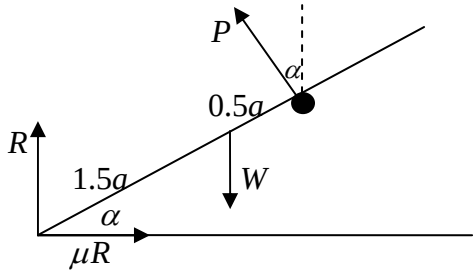
June 2008
6678 Mechanics M2
Mark Scheme

Question Number	Scheme	Marks
1.	 Resolve ↗ : $T_r + 2000g \times \sin\alpha = 1600$ $(T_r = 816)$ $P = 816 \times 14\,(\text{W})$ ft their T_r $\approx 11\,(\text{kW})$ accept 11.4	M1 A1 A1 M1 A1ft A1 cso **(6)** **[6]**
2.	(a)  LM $12mu + 6mu = 4mx + 12meu$ NEL $4eu - x = eu$ Eliminating x to obtain equation in e Leading to $e = \frac{3}{4}$ ∗ cso (b) $x = 3eu$ or $\frac{9}{4}u$ or 4.5u – 3eu seen or implied in (b) Loss in KE $= \frac{1}{2}4m(3u)^2 + \frac{1}{2}3m(2u)^2 - \frac{1}{2}4m\left(\frac{9}{4}u\right)^2 - \frac{1}{2}3m(3u)^2$ ft their x $= 24mu^2 - 23\frac{5}{8}mu^2 = \frac{3}{8}mu^2 = 0.375mu^2$	B1 M1 A1 DM1 A1 **(5)** B1 M1 A1ft A1 **(4)** **[9]**

Question Number	Scheme	Marks
3.	(a $\Delta\text{KE} = \frac{1}{2}\times 3.5\left(12^2 - 8^2\right)$ $(=140)$ or KE at A, B correct separately	B1
	$\Delta\text{PE} = 3.5\times 9.8\times 14\sin 20°$ (≈ 164.238) or PE at A, B correct separately	M1 A1
	$\Delta\text{E} = \Delta\text{KE} + \Delta\text{PE} \approx 304$, 300	DM1 A1 **(5)**
	(b) Using Work-Energy	
	$F_r = \mu \times 3.5g\cos 20°$	M1 A1
	$304.238... = F_r \times 14$ ft their (a), F_r	M1 A1 ft
	$304.238... = \mu 3.5g\cos 20°\times 14$	
	$\mu \approx 0.674$, 0.67	A1 **(5)**
		[10]
	Alternative using N2L	
	 $F_r = \mu \times 3.5g\cos 20°$	M1 A1
	$v^2 = u^2 + 2as \Rightarrow 8^2 = 12^2 - 2a\times 14$	
	$\left(a = \frac{20}{7}\right)(2.857\ldots.)$	
	N2L R ↖ : {their F_r}- $mg\sin 20° = ma$	M1 A1ft
	ft their F_r.	
	Leading to $\mu \approx 0.674$ or 0.67	A1 **(5)**
4.	(a) N2L $(6t-5)\mathbf{i} + (t^2 - 2t)\mathbf{j} = 0.5\mathbf{a}$	M1
	$\mathbf{a} = (12t-10)\mathbf{i} + (2t^2 - 4t)\mathbf{j}$	A1
	$\mathbf{v} = (6t^2 - 10t)\mathbf{i} + \left(\frac{2}{3}t^3 - 2t^2\right)\mathbf{j}$ $(+\mathbf{C})$ ft their **a**	M1 A1ft+A1ft
	$\mathbf{v} = (6t^2 - 10t + 1)\mathbf{i} + \left(\frac{2}{3}t^3 - 2t^2 - 4\right)\mathbf{j}$	A1 **(6)**
	(b) When $t = 3$, $\mathbf{v}_3 = 25\mathbf{i} - 4\mathbf{j}$	M1
	$-5\mathbf{i} + 12\mathbf{j} = 0.5(\mathbf{v} - (25\mathbf{i} - 4\mathbf{j}))$ ft their $\mathbf{v}_3$	M1 A1ft
	$\mathbf{v} = 15\mathbf{i} + 20\mathbf{j}$	A1
	$\lvert\mathbf{v}\rvert = \sqrt{(15^2 + 20^2)} = 25$ (ms^{-1}) cso	M1 A1 **(6)**
		[12]

Question Number	Scheme	Marks
5.	(a) 	
	$R(\uparrow)\quad R + P\cos\alpha = W$	M1 A1
	$M(A)\qquad P \times 2a = W \times 1.5a\cos\alpha$	M1 A1
	$\left(P = \frac{3}{4}W\cos\alpha\right)$	
	$R = W - P\cos\alpha = W - \frac{3}{4}W\cos^2\alpha$	DM1
	$= \frac{1}{4}\left(4 - 3\cos^2\alpha\right)W$ ✱ cso	A1 **(6)**
	(b) Using $\cos\alpha = \frac{2}{3}$, $\qquad R = \frac{2}{3}W$	B1
	$R(\rightarrow)\qquad \mu R = P\sin\alpha$	M1 A1
	Leading to $\mu = \frac{3}{4}\sin\alpha$	
	$\left(\sin\alpha = \sqrt{\left(1 - \frac{4}{9}\right)} = \frac{\sqrt{5}}{3}\right)$	
	$\mu = \frac{\sqrt{5}}{4}$ awrt 0.56	DM1 A1 **(5)**
		[11]

Question Number	Scheme	Marks
6.	(a) $M(Oy)$ $(8+k)m\times 6.4 = 5m\times 8 + km\times 8$ $1.6k = 11.2 \Rightarrow k = 7$ ✱ cso	M1 A1 DM1 A1 **(4)**
	(b) $M(Oy)$ $27m\bar{x} = 12m\times 4 + 5m\times 8 + 7m\times 8$	M1 A1
	$\bar{x} = \frac{16}{3}$ 5.3 or better	A1
	$M(Ox)$ $27m\bar{y} = 12m\times 2.5 + 8m\times 5$	M1 A1
	$\bar{y} = \frac{70}{27}$ 2.6 or better	A1 **(6)**
	(c) $\tan\theta = \frac{\bar{y}}{\bar{x}} = \frac{35}{72}$	M1 A1ft
	$\theta \approx 26°$ awrt 25.9 °	A1 **(3)** **[13]**

Question Number	Scheme	Marks
7.	(a) $(\downarrow)$ $u_y = 25\sin 30° \ (=12.5)$	B1
	$12 = 12.5t + 4.9t^2$ –1 each error	M1 A2 (1, 0)
	Leading to $t = 0.743$, 0.74	A1 **(5)**
	(b) $(\rightarrow)$ $u_x = 25\cos 30° \left(= \frac{25\sqrt{3}}{2} \approx 21.65\right)$	B1
	$OB = 25\cos 30° \times t \ (\approx 16.094\,58)$ ft their (a)	M1 A1ft
	$TB \approx 1.1$ (m) awrt 1.09	A1 **(4)**
	(c) $(\rightarrow)$ $15 = u_x \times t \Rightarrow t = \frac{15}{u_x} (= \frac{2\sqrt{3}}{5} \approx 0.693$ or $0.69)$	M1 A1
	either $(\downarrow)$ $v_y = 12.5 + 9.8t \ (\approx 19.2896)$	M1
	$V^2 = u_x{}^2 + v_y{}^2 \ (\approx 840.840)$	
	$V \approx 29 \ (\text{ms}^{-1})$, 29.0	M1 A1 **(5)**
		[14]
	or $(\downarrow)$ $s_y = 12.5t + 4.9t^2 \ (\approx 11.0)$	M1
	$\frac{1}{2}m \times 25^2 + mg \times s_y = \frac{1}{2}mv^2$	
	$V \approx 29 \ (\text{ms}^{-1})$, 29.0	M1A1

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Mark Scheme (Results)
January 2009

GCE

GCE Mathematics (6678/01)

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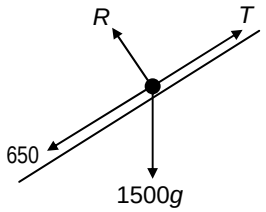
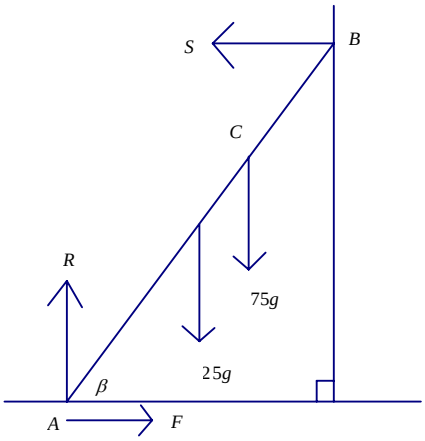
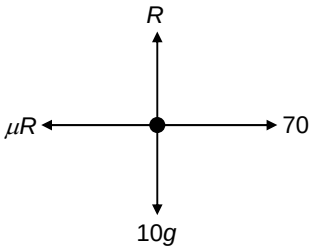
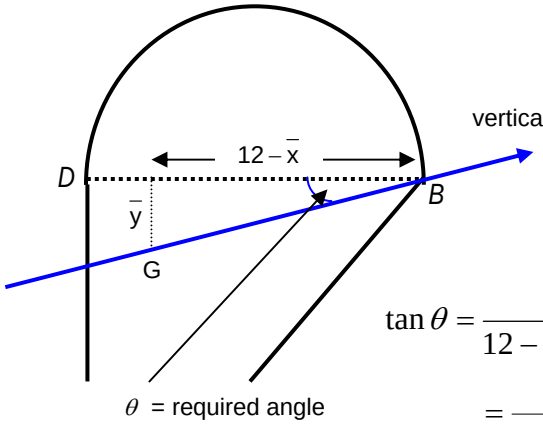
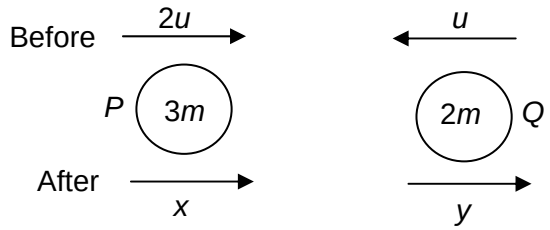
January 2009
6678 Mechanics M2
Mark Scheme

Question Number	Scheme	Marks
1	 F = ma parallel to the slope, $T - 1500g\sin\theta - 650 = 1500a$ Tractive force, 30000 = T x 15 $a = \frac{\frac{30000}{15} - 1500(9.8)(\frac{1}{14}) - 650}{1500}$ $\underline{0.2}$ (m s^{-2})	M1* A1 M1* d*M1 A1 (5) **[5]**
2 (a)	 $R(\uparrow): R = 25g + 75g (= 100g)$ $F = \mu R \Rightarrow F = \frac{11}{25} \times 100g$ = 44g (=431)	B1 M1 A1 (3)
(b)	M(A): $25g \times 2\cos\beta + 75g \times 2.8\cos\beta$ $= S \times 4\sin\beta$ $R(\leftrightarrow): F = S$ $176g\sin\beta = 260g\cos\beta$ $\beta = 56(°)$	M1 A2,1,0 M1A1 A1 (6)
(c)	So that Reece's weight acts directly at the point C.	B1 **[10]**

Question Number		Scheme	Marks
3	(a)		
		$R(\updownarrow): R = 10g$	B1
		$F = \mu R \Rightarrow F = \frac{4}{7}(10g) = 56$	B1
		$\therefore$ WD against friction $= \frac{4}{7}(10g)(50)$	M1
		$2800(\text{J})$	A1
			(4)
	(b)	$70(50) - \text{"}2800\text{"} = \frac{1}{2}(10)v^2 - \frac{1}{2}(10)(2)^2$	M1*
			A1ft
		$700 = 5v^2 - 20$, $5v^2 = 720 \Rightarrow v^2 = 144$	d*M1
		Hence, $v = \underline{12}$ (m s^{-1})	A1 cao
			(4)
Or	(b)	$\text{N2L}(\rightarrow): \ 70 - \frac{4}{7}R = 10a$	M1*
		$70 - \frac{4}{7} \times 10g = 10a$, $(a = 1.4)$	A1ft
		$AB(\rightarrow): v^2 = (2)^2 + 2(1.4)(50)$	d*M1
		Hence, $v = \underline{12}$ (m s^{-1})	A1 cao
			(4)
			[8]
4	(a)	$v = 10t - 2t^2$, $s = \int v dt$	M1
		$= 5t^2 - \frac{2t^3}{3}(+C)$	A1
		$t = 6 \Rightarrow s = 180 - 144 = \underline{36}$ (m)	A1
			(3)
	(b)	$\underline{s} = \int v\,dt = \underline{\frac{-432t^{-1}}{-1}}(+K) = \underline{\frac{432}{t}}(+K)$	<u>B1</u>
		t = 6, s = "36" $\Rightarrow 36 = \frac{432}{6} + K$	M1*
		$\Rightarrow K = -36$	A1
		At $t = 10$, $s = \frac{432}{10} - 36 = \underline{7.2}$ (m)	d*M1 <u>A1</u>
			(5)
			[8]

Question Number	Scheme				Marks
5 (a)					
	MR	108	18π	$108+18\pi$	B1
	x_i $(\rightarrow)$ from AD	4	6	$\bar{x}$	B1
	y_i $(\downarrow)$ from BD	6	$-\frac{8}{\pi}$	$\bar{y}$	
	$AD(\rightarrow): 108(4)+18\pi(6)=(108+18\pi)\bar{x}$				M1
	$\bar{x}=\frac{432+108\pi}{108+18\pi}=4.68731...=\underline{4.69}$ (cm) (3 sf) **AG**				A1
					(4)
(b)	y_i $(\downarrow)$ from BD	6	$-\frac{8}{\pi}$	$\bar{y}$	B1 oe
	$BD(\downarrow): 108(6)+18\pi(-\frac{8}{\pi})=(108+18\pi)\bar{y}$				M1
					A1ft
	$\bar{y}=\frac{504}{108+18\pi}=3.06292...=3.06$ (cm) (3 sf)				A1
					(4)
(c)					M1
	$\tan\theta=\frac{\bar{y}}{12-4.68731..}$				dM1
	$=\frac{3.06392..}{12-4.68731..}$				A1
	$\theta=22.72641...=\underline{23}$ (nearest degree)				A1
					(4) **[12]**

Question Number		Scheme	Marks
6	(a)	Horizontal distance: $57.6 = p \times 3$ $p = 19.2$	M1 A1 (2)
	(b)	Use $s = ut + \frac{1}{2}at^2$ for vertical displacement.	M1
		$-0.9 = q \times 3 - \frac{1}{2}g \times 3^2$	A1
		$-0.9 = 3q - \frac{9g}{2} = 3q - 44.1$	
		$q = \frac{43.2}{3} = 14.4$ ***AG***	A1 cso (3)
	(c)	initial speed $\sqrt{p^2 + 14.4^2}$ (with their p)	M1
		$= \sqrt{576} = \underline{24}$ (m s^{-1})	A1 cao (2)
	(d)	$\tan\alpha = \frac{14.4}{p} (= \frac{3}{4})$ (with their p)	B1 (1)
	(e)	When the ball is 4 m above ground:	
		$3.1 = ut + \frac{1}{2}at^2$ used	M1
		$3.1 = 14.4t - \frac{1}{2}gt^2$ o.e $(4.9t^2 - 14.4t + 3.1 = 0)$	A1
		$\Rightarrow t = \frac{14.4 \pm \sqrt{(14.4)^2 - 4(4.9)(3.1)}}{2(4.9)}$ seen or implied	M1
		$t = \frac{14.4 \pm \sqrt{146.6}}{9.8} = 0.023389\ldots$ or $2.70488\ldots$ awrt 0.23 and 2.7	A1
		duration $= 2.70488... - 0.23389...$	M1
		$= 2.47$ or 2.5 (seconds)	A1 (6)
or 6	(e)	M1A1M1 as above	
		$t = \frac{14.4 \pm \sqrt{146.6}}{9.8}$	A1
		Duration $2 \times \frac{\sqrt{146.6}}{9.8}$ o.e.	M1
		$= 2.47$ or 2.5 (seconds)	A1 (6)
	(f)	Eg. : Variable 'g', Air resistance, Speed of wind, Swing of ball, The ball is not a particle.	B1 (1) **[15]**

Question Number		Scheme	Marks
7	(a)	 Correct use of NEL	M1*
		$y - x = e(2u + u)$ o.e.	A1
		CLM ($\rightarrow$): $3m(2u) + 2m(-u) = 3m(x) + 2m(y)$ ($\Rightarrow 4u = 3x + 2y$)	B1
		Hence x = y – 3eu, 4u = 3(y-3eu) + 2y, ($u(9e + 4) = 5y$)	d*M1
		Hence, speed of $Q = \underline{\frac{1}{5}(9e + 4)u}$ **AG**	A1 cso
			(5)
	(b)	$x = y - 3eu = \frac{1}{5}(9e + 4)u - 3eu$	M1#
		Hence, speed P $= \frac{1}{5}(4 - 6e)u = \frac{2u}{5}(2 - 3e)$ o.e.	A1
		$x = \frac{1}{2}u = \frac{2u}{5}(2 - 3e) \Rightarrow 5u = 8u - 12eu, \Rightarrow 12e = 3$ & solve for *e*	d#M1
		gives, $e = \frac{3}{12} \Rightarrow \underline{e = \frac{1}{4}}$ **AG**	A1
			(4)
Or	(b)	Using NEL correctly with given speeds of *P* and *Q*	M1#
		$3eu = \frac{1}{5}(9e + 4)u - \frac{1}{2}u$	A1
		$3eu = \frac{9}{5}eu + \frac{4}{5}u - \frac{1}{2}u$, $3e - \frac{9}{5}e = \frac{4}{5} - \frac{1}{2}$ & solve for *e*	d#M1
		$\frac{6}{5}e = \frac{3}{10} \Rightarrow e = \frac{15}{60} \Rightarrow e = \frac{1}{4}$.	A1
			(4)
	(c)	Time taken by *Q* from *A* to the wall $= \frac{d}{\underline{y}} = \left\{\frac{4d}{5u}\right\}$	M1†
		Distance moved by *P* in this time $= \frac{u}{2} \times \frac{d}{y}$ $\left(= \frac{u}{2}\left(\frac{4d}{5u}\right) = \frac{2}{5}d\right)$	A1
		Distance of *P* from wall $= d - x\left(\frac{d}{y}\right); = d - \frac{2}{5}d = \underline{\frac{3}{5}d}$ **AG**	d†M1; A1 cso
			(4)
or	(c)	Ratio speed P:speed Q = x:y = $\frac{1}{2}u : \frac{1}{5}(\frac{9}{4} + 4)u = \frac{1}{2}u : \frac{5}{4}u$ = 2:5	M1†
		So if *Q* moves a distance *d*, *P* will move a distance $\frac{2}{5}d$	A1
		Distance of *P* from wall $= d - \frac{2}{5}d; = \underline{\frac{3}{5}d}$ **AG** cso	d†M1; A1
			(4)

Question Number	Scheme	Marks
(d)	After collision with wall, speed $Q = \frac{1}{5}y = \frac{1}{5}\left(\frac{5u}{4}\right) = \frac{1}{4}u$ their y	B1ft
	Time for P, $T_{AB} = \frac{\frac{3d}{5} - x}{\frac{1}{2}u}$, Time for Q, $T_{WB} = \frac{x}{\frac{1}{4}u}$ from their y	B1ft
	Hence $T_{AB} = T_{WB} \Rightarrow \frac{\frac{3d}{5} - x}{\frac{1}{2}u} = \frac{x}{\frac{1}{4}u}$	M1
	gives, $2\left(\frac{3d}{5} - x\right) = 4x \Rightarrow \frac{3d}{5} - x = 2x$, $3x = \frac{3d}{5} \Rightarrow x = \underline{\frac{1}{5}d}$	A1 **cao**
		(4)
or (d)	After collision with wall, speed $Q = \frac{1}{5}y = \frac{1}{5}\left(\frac{5u}{4}\right) = \frac{1}{4}u$ their y	B1ft
	speed $P = x = \frac{1}{2}u$, speed P: new speed $Q = \frac{1}{2}u : \frac{1}{4}u = 2:1$ from their y	B1ft
	Distance of B from wall $= \frac{1}{3} \times \frac{3d}{5}; = \frac{d}{5}$ their $\frac{1}{2+1}$	M1; A1
		(4)
2nd or (d)	After collision with wall, speed $Q = \frac{1}{5}y = \frac{1}{5}\left(\frac{5u}{4}\right) = \frac{1}{4}u$ their y	B1ft
	Combined speed of P and $Q = \frac{1}{2}u + \frac{1}{4}u = \frac{3}{4}u$	
	Time from wall to 2nd collision $= \frac{\frac{3d}{5}}{\frac{3u}{4}} = \frac{3d}{5} \times \frac{4}{3u} = \frac{4d}{5u}$ from their y	B1ft
	Distance of B from wall = (their speed)x(their time) $= \frac{u}{4} \times \frac{4d}{5u}$; $= \underline{\frac{1}{5}d}$	M1; A1
		(4) **[17]**

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6678 Mechanics M2
Mark Scheme

Question Number	Scheme	Marks
Q1	$\mathbf{I} = m\mathbf{v} - m\mathbf{u}$ $5\mathbf{i} - 3\mathbf{j} = \frac{1}{4}\mathbf{v} - \frac{1}{4}(3\mathbf{i} + 7\mathbf{j})$ $\mathbf{v} = 23\mathbf{i} - 5\mathbf{j}$ $\lvert\mathbf{v}\rvert = \sqrt{23^2 + 5^2} = 23.5$	M1A1 A1 M1A1 **[5]**
Q2 (a)	$\frac{dv}{dt} = 8 - 2t$ $8 - 2t = 0$ Max $v = 8 \times 4 - 4^2 = 16\ (\text{ms}^{-1})$	M1 M1 M1A1 (4)
(b)	$\int 8t - t^2 dt = 4t^2 - \frac{1}{3}t^3 (+c)$ (t=0, displacement = 0 $\Rightarrow$ c=0) $4T^2 - \frac{1}{3}T^3 = 0$ $T^2(4 - \frac{T}{3}) = 0 \Rightarrow T = 0, 12$ T = 12 (seconds)	M1A1 DM1 DM1 A1 (5) **[9]**
Q3 (a)	Constant v $\Rightarrow$ driving force = resistance $\Rightarrow$ F=120 (N) $\Rightarrow$ P=120 x 10 = 1200W	M1 M1 (2)
(b)	Resolving parallel to the slope, zero acceleration: $\frac{P}{v} = 120 + 300g\sin\theta (= 330)$ $\Rightarrow$ v = $\frac{1200}{330} = 3.6\ (\text{ms}^{-1})$	M1A1A1 A1 (4) **[6]**

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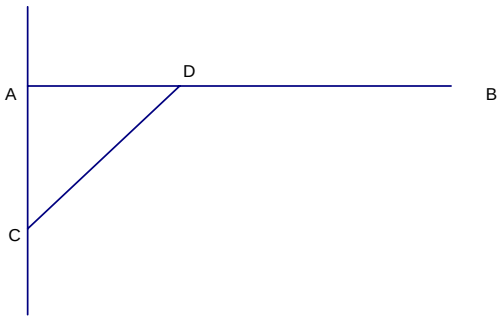
Question Number	Scheme	Marks
Q4 (a)	 Taking moments about A: $3g \times 0.75 = \frac{T}{\sqrt{2}} \times 0.5$ $T = 3\sqrt{2}g \times \frac{7.5}{5} = \frac{9\sqrt{2}g}{2} (= 62.4N)$	M1A1A1 A1 (4)
(b)	$\leftarrow \pm H = \frac{T}{\sqrt{2}} (= \frac{9g}{2} \approx 44.1N)$	B1
	$\uparrow \pm V + \frac{T}{\sqrt{2}} = 3g \quad (\Rightarrow V = 3g - \frac{9g}{2} = \frac{-3g}{2} \approx -14.7\,\text{N})$	M1A1
	$\Rightarrow \lvert R \rvert = \sqrt{81+9} \times \frac{g}{2} \approx 46.5(N)$	M1A1
	at angle $\tan^{-1}\frac{1}{3}$ = 18.4° (0.322 radians) below the line of BA 161.6° (2.82 radians) below the line of AB (108.4° or 1.89 radians to upward vertical)	M1A1 (7) **[11]**
Q5 (a)	Ratio of areas triangle:sign:rectangle = 1 : 5 : 6 (1800:9000:10800) Centre of mass of the triangle is 20cm down from *AD* (seen or implied)	B1 B1
	$\Rightarrow 6 \times 45 - 1 \times 20 = 5 \times \bar{y}$ $\bar{y} = 50cm$	M1A1 A1 (5)
(b)	Distance of centre of mass from *AB* is 60cm	B1
	Required angle is $\tan^{-1}\frac{60}{50}$ (their values) = 50.2° (0.876 rads)	M1A1ft A1 (4) **[9]**

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Question Number	Scheme	Marks
Q6 (a)	$\rightarrow \quad x = u\cos\alpha t = 10$	M1A1
	$\uparrow \quad y = u\sin\alpha t - \frac{1}{2}gt^2 = 2$	M1A1
	$\Rightarrow t = \frac{10}{u\cos\alpha}$	
	$2 = u\sin\alpha \times \frac{10}{u\cos\alpha} - \frac{g}{2} \times \frac{100}{u^2\cos^2\alpha}$	M1
	$= 10\tan\alpha - \frac{50g}{u^2\cos^2\alpha}$ (given answer)	A1 (6)
(b)	$2 = 10\times 1 - \frac{100g\times 2}{2u^2\times 1}$	M1A1
	$u^2 = \frac{100g}{8}$, $u = \sqrt{\frac{100g}{8}} = 11.1$ (m s^{-1})	A1
	$\frac{1}{2}mu^2 = m\times 9.8\times 2 + \frac{1}{2}mv^2$	M1A1
	$v = 9.1ms^{-1}$	A1 (6)
		[12]

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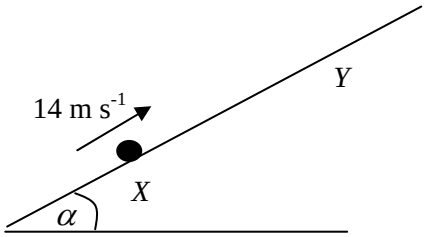
Question Number	Scheme	Marks
Q7 (a)		
	KE at $X = \frac{1}{2}mv^2 = \frac{1}{2}\times 2\times 14^2$	B1
	GPE at $Y =$ $mgd\sin\alpha \left(= 2\times g\times d\times \frac{7}{25}\right)$	B1 B1
	Normal reaction $R = mg\cos\alpha$	M1
	Friction = $\mu\times R = \frac{1}{8}\times 2g\times\frac{24}{25}$	M1A1
	Work Energy: $\frac{1}{2}mv^2 - mgd\sin\alpha = \mu\times R\times d$ or equivalent	
	$196 = \frac{14gd}{25}+\frac{6gd}{25} = \frac{20gd}{25}$	A1
	d = 25 m	(7)
(b)	Work Energy	
	First time at X: $\frac{1}{2}mv^2 = \frac{1}{2}m14^2$	
	Work done = $\mu\times R\times 2d = \frac{1}{8}\times 2g\times\frac{24}{25}\times 2d$	
	Return to X: $\frac{1}{2}mv^2 = \frac{1}{2}m14^2 - \frac{1}{8}\times 2g\times\frac{24}{25}\times 50$	M1A1
	v = 8.9 ms^{-1} (accept 8.85 ms^{-1})	DM1A1
		(4)
	OR: Resolve parallel to XY to find the acceleration and use of $v^2 = u^2 + 2as$	
	$2a = 2g\sin\alpha - F_{\max} = 2g\times\frac{7}{25}-\frac{6g}{25} = \frac{8g}{25}$	M1A1
	$v^2 = (0+)2\times a\times s = 8g$; v = 8.9 (accept 8.85 ms^{-1})	DM1;A1
		[11]

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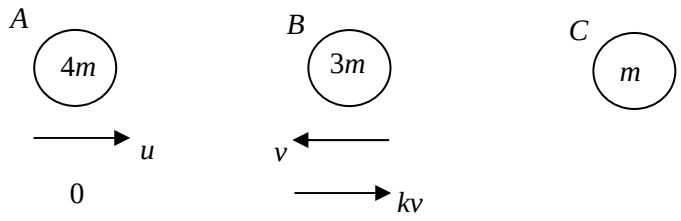
Question Number	Scheme	Marks
Q8 (a)		
	Conservation of momentum: $4mu - 3mv = 3mkv$	M1A1
	Impact law: $kv = \frac{3}{4}(u+v)$	M1A1
	Eliminate k: $4mu - 3mv = 3m \times \frac{3}{4}(u+v)$	DM1
	$u = 3v$ (Answer given)	A1
		(6)
(b)	$kv = \frac{3}{4}(3v+v)$, $k = 3$	M1,A1
		(2)
(c)	Impact law: $(kv + 2v)e = v_C - v_B$ $(5ve = v_C - v_B)$	B1
	Conservation of momentum : $3 \times kv - 1 \times 2v = 3v_B + v_c$ $(7v = 3v_B + v_c)$	B1
	Eliminate v_C : $v_B = \frac{v}{4}(7-5e) > 0$ hence no further collision with A.	M1 A1
		(4)
		[12]

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Mechanics M2 (6678)

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January 2010

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January 2010
6678 Mechanics M2
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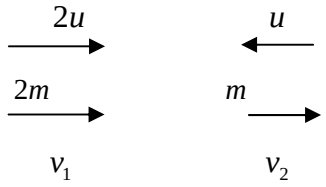
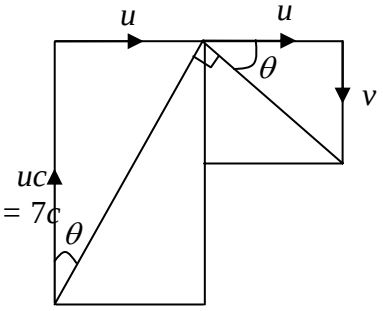
Question Number	Scheme	Marks
Q1.	$\frac{dv}{dt} = 6t - 4$	M1 A1
	$6t - 4 = 0 \Rightarrow t = \frac{2}{3}$	M1 A1
	$s = \int 3t^2 - 4t + 3 \, dt = t^3 - 2t^2 + 3t \ (+c)$	M1 A1
	$t = \frac{2}{3} \Rightarrow s = -\frac{16}{27} + 2$ so distance is $\frac{38}{27}$ m	M1 A1
		[8]
Q2.		
	CLM: $4mu - mu = 2mv_1 + mv_2$	M1 A1
	i.e. $3u = 2v_1 + v_2$	
	NIL: $3eu = -v_1 + v_2$	M1 A1
	$v_1 = u(1 - e)$	DM1 A1
	$v_2 = u(1 + 2e)$	A1
		[7]
Q3.	$\frac{1}{2}$ x 0.5 x 20^2 ; $0.5g$ x 10	B1 B1
	$10R = \frac{1}{2}$ x 0.5 x $20^2 - 0.5g$ x 10	M1 A1
	$\Rightarrow R = 5.1$	DM1 A1
		[6]

Question Number	Scheme	Marks
Q4.	(i) $I\uparrow = 0.25\times 40\sin 60 = 5\sqrt{3}$ (8.66) one component $I\leftarrow = 0.25(-20+30) = 2.5$ both $\lvert I\rvert = \sqrt{75+6.25} = 9.01$ (Ns)	M1 A1 M1 A1 (4)
	(ii) $\frac{\sin\theta}{40} = \frac{\sin 60^o}{\sqrt{1300}}$ $\theta = 106^o$ (3 s.f.)	M1 A1
	or $\tan\theta = \pm\frac{5\sqrt{3}}{2.5}$ oee $\theta = 106°$	M1 A1 (4)
		[8]
	Alternative to 4(i) Use of $\mathbf{I} = m(\mathbf{v}-\mathbf{u})$	M1
	$30^2 + 40^2 - 2 \text{ x } 30 \text{ x } 40\cos 60^o$ (= 1300)	M1 A1
	$I = 0.25\sqrt{1300} = 9.01$ N s (3 s.f.)	A1
	2nd Alternative to 4(i) $\mathbf{u} = 30\mathbf{i}$, $\mathbf{v} = 40\cos 60\mathbf{i} + 40\sin 60\mathbf{j} = 20\mathbf{i} + 20\sqrt{3}\mathbf{j}$ $\mathbf{I} = \frac{1}{4}(-10\mathbf{i} + 20\sqrt{3}\mathbf{j}) = -2.5\mathbf{i} + 5\sqrt{3}\mathbf{j}$	 M1 A1 etc

Question Number	Scheme	Marks
Q5.	(a) $\frac{490}{3.5} - R = 0$ $R = 140$ N	B1 M1 A1 A1 (4)
	(b) $\frac{24}{u} + 70g.\frac{1}{14} - 40u = 0$ $40u^2 - 49u - 24 = 0$ $(5u - 8)(8u + 3) = 0$ $u = 1.6$	B1 M1 A2,1,0 DM1 DM1 A1 (7) **[11]**
Q6.	$m(B): R \times 4\cos\alpha = F \times 4\sin\alpha + 20g \times 2\cos\alpha$ Use of $F = \frac{1}{2}R$ Use of correct trig ratios R = 160N or 157N	M1 A2 M1 B1 DM1 A1 **[7]**

Question Number	Scheme	Marks
Q7.	(a) Rectangle: $24x$; Semicircles: 4.5π, 4.5π; Template, T: $24x + 9\pi$	B2
	x; $\frac{4 \text{ x } 3}{3\pi}$, $\frac{4 \text{ x } 3}{3\pi}$; $\bar{x}$	B2
	$24x^2 - 4.5\pi \text{ x } \left(\frac{4 \text{ x } 3}{3\pi}\right) - 4.5\pi \text{ x } \left(\frac{4 \text{ x } 3}{3\pi}\right) = (24x + 9\pi)\bar{x}$	M1 A1
	distance $= \lvert\bar{x}\rvert = \frac{4\lvert 2x^2 - 3\rvert}{(8x + 3\pi)}$ **	A1 (7)
	(b) When $x = 2$, $\lvert\bar{x}\rvert = \frac{20}{16 + 3\pi}$	B1
	$\tan\theta = \frac{6}{4 - \lvert\bar{x}\rvert} = \frac{6}{4 - \frac{20}{16 + 3\pi}}$	M1 A1
	$= \frac{48 + 9\pi}{22 + 6\pi}$.	A1 (4)
		[11]

Question Number	Scheme	Marks
Q8.	(a) $x = ut$	B1
	$y = cut - 4.9t^2$	M1 A1
	eliminating t and simplifying to give $y = cx - \frac{4.9x^2}{u^2}$ **	DM1 A1 (5)
	(b)(i) $0 = cx - \frac{4.9x^2}{u^2}$	M1
	$0 = x(c - \frac{4.9x}{u^2}) \Rightarrow R = \frac{u^2 c}{4.9} = 10c$	M1 A1
	(ii) When x = 5c, $y = H$	M1
	$= 5c^2 - \frac{(5c)^2}{10} = 2.5c^2$	M1 A1 (6)
	(c) $\frac{dy}{dx} = c - \frac{9.8x}{u^2} = c - \frac{x}{5}$	M1 A1
	When x = 0, $\frac{dy}{dx} = c$	B1
	So, $c - \frac{x}{5} = \frac{-1}{c}$	DM1 A1
	$x = 5(c + \frac{1}{c})$	A1 (6)
		[17]
	Alternative to 8(c)  $\tan\theta = \frac{u}{cu} = \frac{1}{c} = \frac{v}{u}$	B1
	$\Rightarrow v = \frac{u}{c} = \frac{7}{c}$	M1 A1
	$v = u + at$; $-\frac{7}{c} = 7c - 9.8t$	M1
	$t = \frac{7}{9.8}(c + \frac{1}{c})$	A1
	$x = ut = 7t$; $x = 5(c + \frac{1}{c})$	A1

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GCE Mechanics M2 (6678/01)

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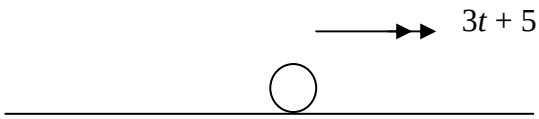
Summer 2010
Mechanics M2 6678
Mark Scheme

Question Number	Scheme	Marks
Q1		
	$\frac{dv}{dt} = 3t + 5$	
	$v = \int (3t+5)\,dt$	M1*
	$v = \frac{3}{2}t^2 + 5t \quad (+c)$	A1
	$t = 0 \quad v = 2 \quad \Rightarrow \quad c = 2$	B1
	$v = \frac{3}{2}t^2 + 5t + 2$	
	$t = T \qquad 6 = \frac{3}{2}T^2 + 5T + 2$	DM1*
	$12 = 3T^2 + 10T + 4$	
	$3T^2 + 10T - 8 = 0$	
	$(3T-2)(T+4) = 0$	M1
	$T = \frac{2}{3} \quad (T = -4)$	
	$\therefore T = \frac{2}{3} \quad (\text{or } 0.67)$	A1
		[6]

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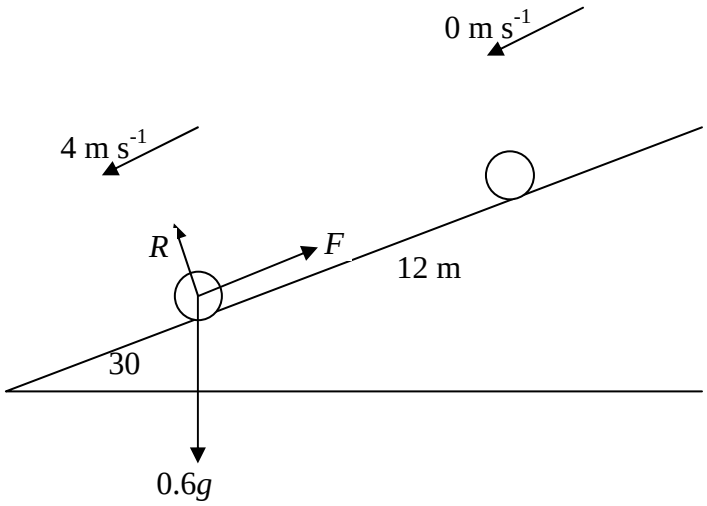
Question Number	Scheme	Marks
Q2		
(a)	K.E gained $= \frac{1}{2} \times 0.6 \times 4^2$ P.E. lost $= 0.6 \times g \times (12 \sin 30)$ Change in energy = P.E. lost - K.E. gained $= 0.6 \times g \times 12 \sin 30 - \frac{1}{2} \times 0.6 \times 4^2$ $= 30.48$ Work done against friction $= 30$ or 30.5 J	M1 A1 A1 A1 (4)
(b)	R$(\uparrow)$ $R = 0.6g \cos 30$ $F = \frac{30.48}{12}$ $F = \mu R$ $\mu = \frac{30.48}{12 \times 0.6g \cos 30}$ $\mu = 0.4987$ $\mu = 0.499$ or 0.50	B1 B1ft M1 A1 (4) **[8]**

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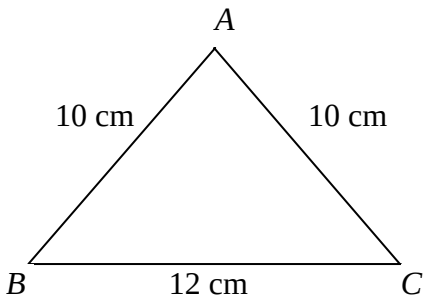
Question Number	Scheme	Marks

Q3



(a)

		AB	*AC*	*BC*	frame		
	mass ratio	10	10	12	32		B1
	dist. from *BC*	4	4	0	$\overline{x}$		B1

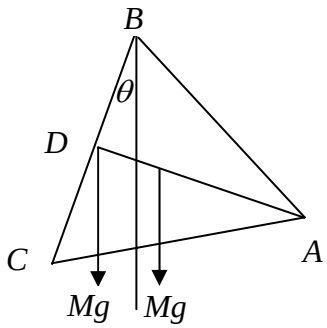
Moments about *BC*:

$$10\times 4+10\times 4+0=32\overline{x}$$ M1 A1

$$\overline{x}=\frac{80}{32}$$

$$\overline{x}=2\tfrac{1}{2}\quad(2.5)$$ A1 (5)

(b)



Moments about *B*:

$$Mg\times 6\sin\theta=Mg\times\left(\overline{x}\cos\theta-6\sin\theta\right)$$ M1 A1 A1

$$12\sin\theta=\overline{x}\cos\theta$$

$$\tan\theta=\frac{\overline{x}}{12}$$

$\theta = 11.768..... = 11.8^{o}$ A1 (4)

Alternative method :

C of M of loaded frame at distance $\frac{1}{2}\overline{x}$ from *D* along *DA* B1

$$\tan\theta=\frac{\frac{1}{2}\overline{x}}{6}$$ M1 A1

$\theta = 11.768..... = 11.8^{o}$ A1

[9]

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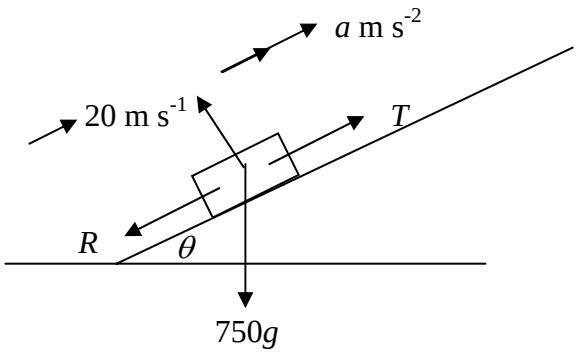
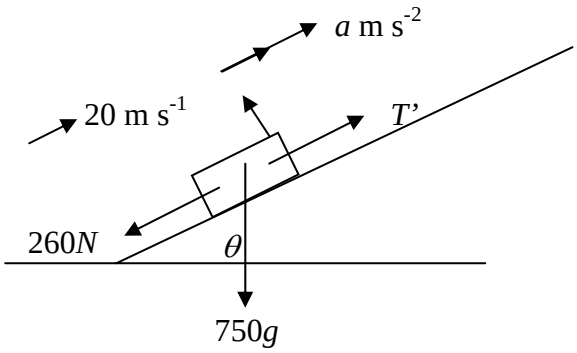
Question Number	Scheme	Marks
Q4		
(a)	$T = \frac{15000}{20} = 750$	M1
	R(parallel to road) $T = R + 750g\sin\theta$	M1 A1
	$R = 750 - 750\times 9.8\times \frac{1}{15}$	
	$R = 260*$	A1 (4)
(b)		
	$T' = \frac{18000}{20} = 900$	M1
	$T' - 260 - 750g \times \sin\theta = 750a$	M1 A1
	$a = \frac{900 - 260 - 750\times 9.8\times \frac{1}{15}}{750}$	
	$a = 0.2$	A1 (4)
		[8]

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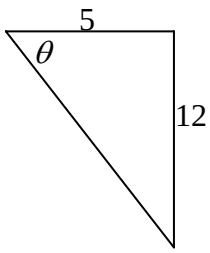
Question Number	Scheme	Marks
Q5 (a)	$\mathbf{I} = m\mathbf{v} - m\mathbf{u}$ $= 0.5\times 20\mathbf{i} - 0.5(10\mathbf{i} + 24\mathbf{j})$ $= 5\mathbf{i} - 12\mathbf{j}$ $\lvert 5\mathbf{i} - 12\mathbf{j}\rvert = 13$ Ns	M1 A1 M1 A1 (4)
(b)	 $\tan\theta = \frac{12}{5}$ $\theta = 67.38$ $\theta = 67.4°$	M1 A1 (2)
(c)	K.E.lost $= \frac{1}{2}\times 0.5(10^2 + 24^2) - \frac{1}{2}\times 0.5\times 20^2$ $= 69$ J	M1 A1 A1 (3) **[9]**

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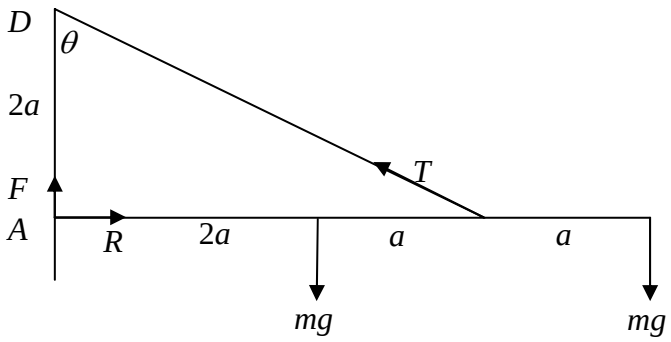
Question Number	Scheme	Marks
Q6		
(a)	M(A) $3a \times T\cos\theta = 2amg + 4amg$	M1 A1 A1
	$\cos\theta = \left(\frac{2}{\sqrt{9+4}} = \right)\frac{2}{\sqrt{13}}$	B1
	$\frac{6}{\sqrt{13}}T = 6mg$	
	$T = mg\sqrt{13}$ *	A1 (5)
(b)	$3a \times T \times \cos\theta = 2amg + 4aMg$	M1
	$T = \frac{(2mg + 4Mg)}{6}\sqrt{13} \leq 2mg\sqrt{13}$	A1
	$mg + 2Mg < 6mg$	
	$M \leq \frac{5}{2}m$ * cso	A1 (3)
		[8]

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Question Number	Scheme	Marks
Q7 (a)	Vertical motion: $v^2 = u^2 + 2as$ $(40\sin\theta)^2 = 2 \times g \times 12$ $(\sin\theta)^2 = \frac{2 \times g \times 12}{40^2}$ $\theta = 22.54 = 22.5°$ (accept 23)	M1 A1 A1 (3)
(b)	Vert motion $P \to R$: $s = ut + \frac{1}{2}at^2$ $-36 = 40\sin\theta t - \frac{g}{2}t^2$ $\frac{g}{2}t^2 - 40\sin\theta t - 36 = 0$ $t = \frac{40\sin 22.54 \pm \sqrt{(40\sin 22.54)^2 + 4 \times 4.9 \times 36}}{9.8}$ $t = 4.694...$ Horizontal P to R: $s = 40\cos\theta t$ $= 173$ m (or 170 m)	M1 A1 A1 A1 M1 A1 (6)
(c)	Using Energy: $\frac{1}{2}mv^2 - \frac{1}{2}m \times 40^2 = m \times g \times 36$ $v^2 = 2\left(9.8 \times 36 + \frac{1}{2} \times 40^2\right)$ $v = 48.0.....$ $v = 48$ m s^{-1} (accept 48.0)	M1 A1 A1 (3) **[12]**

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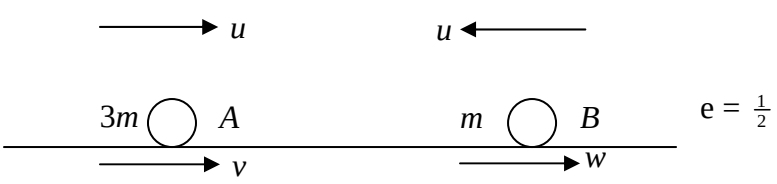
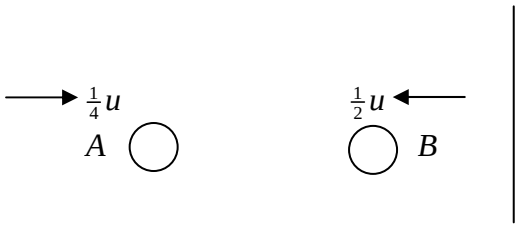
Question Number	Scheme	Marks
Q8		
(a) (i)	Con. of Mom: $3mu - mu = 3mv + mw$	
	$2u = 3v + w$ (1)	M1# A1
	N.L.R: $\frac{1}{2}(u+u) = w - v$	M1# A1
	$u = w - v$ (2)	
	(1) – (2) $u = 4v$	DM1#
	$v = \frac{1}{4}u$	A1
(ii)	In (2) $u = w - \frac{1}{4}u$	
	$w = \frac{5}{4}u$	A1 (7)
(b)	B to wall: N.L.R: $\frac{5}{4}u \times \frac{2}{5} = V$	M1
	$V = \frac{1}{2}u$	A1ft (2)
(c)		
	B to wall: time $= 4a \div \frac{5}{4}u = \frac{16a}{5u}$	B1ft
	Dist. Travelled by $A = \frac{1}{4}u \times \frac{16a}{5u} = \frac{4}{5}a$	B1ft
	In t secs, A travels $\frac{1}{4}ut$, B travels $\frac{1}{2}ut$	
	Collide when speed of approach = $\frac{1}{2}ut + \frac{1}{4}ut$, distance to cover = $4a - \frac{4}{5}a$	M1$
	$\therefore\ t = \frac{4a - \frac{4}{5}a}{\frac{3}{4}u} = \frac{16a}{5} \times \frac{4}{3u} = \frac{64a}{15u}$	DM1$ A1
	Total time $= \frac{16a}{5u} + \frac{64a}{15u} = \frac{112a}{15u}$ *	A1 (6)
		15

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Mark Scheme (Results)
January 2011

GCE

GCE Mechanics M2 (6678) Paper 1

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January 2011

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1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
   - **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
   - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
   - **B** marks are unconditional accuracy marks (independent of M marks)
   - Marks should not be subdivided.
3. Abbreviations

   These are some of the traditional marking abbreviations that will appear in the mark schemes.

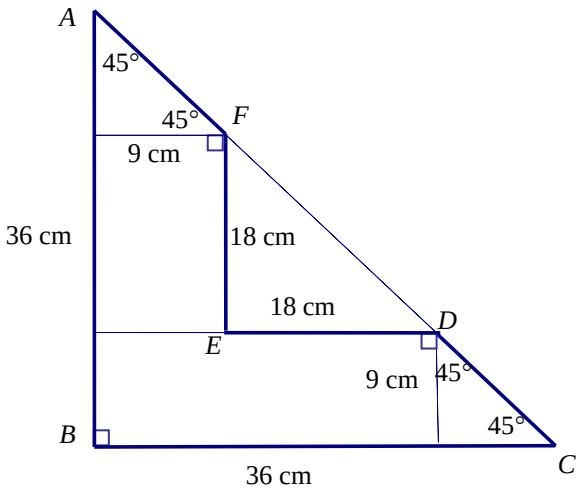
   - bod – benefit of doubt
   - ft – follow through
   - the symbol $\surd$ will be used for correct ft
   - cao – correct answer only
   - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
   - isw – ignore subsequent working
   - awrt – answers which round to
   - SC: special case
   - oe – or equivalent (and appropriate)
   - dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - $*$ The answer is printed on the paper
   - $\lfloor$ The second mark is dependent on gaining the first mark

January 2011
Mechanics M2 6678
Mark Scheme

Question Number	Scheme	Marks
1. **(a)**	Constant speed $\Rightarrow$ Driving force = resistance, $F = 32$. $P = F \times v = 32v = 384$ $v = 12 \ (\text{ms}^{-1})$	B1 M1 A1 (3)
(b)	$P = F \times v \Rightarrow \ 384 = F \times 9, \ F = \frac{384}{9}$ Their $F - 32 = 120a$, $a = 0.089 (\text{ms}^{-2})$	M1 M1 A1 (3) **[6]**
2.	$\mathbf{I} = (\mathbf{-6i + 8j}) = \mathbf{2}(\mathbf{v} - (\mathbf{5i + j}))$ $-3\mathbf{i} + 4\mathbf{j} = \mathbf{v} - 5\mathbf{i} - \mathbf{j}$ $\mathbf{v} = 2\mathbf{i} + 5\mathbf{j}$ $\text{KE} = \frac{1}{2} \times 2 \times \lvert v \rvert^2 = \left(\sqrt{2^2 + 5^2}\right)^2 = 29 \ (\text{J})$	M1A1 A1 M1 A1 **[5]**
3. **(a)**	$a = 4t^3 - 12t$ Convincing attempt to integrate $v = t^4 - 6t^2 \ (+c)$ Use initial condition to get $v = t^4 - 6t^2 + 8 (\text{ms}^{-1})$.	M1 A1 A1 (3)
(b)	Convincing attempt to integrate $s = \frac{t^5}{5} - 2t^3 + 8t \ (+0)$ Integral of their v	M1 A1ft (2)
(c)	Set their $v = 0$ Solve a quadratic in t^2 $(t^2 - 2)(t^2 - 4) = 0 \Rightarrow$ at rest when $t = \sqrt{2}, \ t = 2$	M1 DM1 A1 (3) **[8]**

Question Number	Scheme	Marks
4. **(a)**	Work done against friction $= 50 \times \mu R$ $= 50 \times ¼ \times 30\cos 20° \times 9.8$	M1 A1
	Gain in GPE $= 30 \times 9.8 \times 50 \sin 20°$	M1 A1
	Total work done = WD against Friction + gain in GPE $= 8480(\text{J}),\ 8500(\text{J})$	DM1 A1 (6)
(b)	Loss in GPE = WD against friction + gain in KE 3 terms	M1
	$30 \times 9.8 \times 50\sin 20° = 50 \times ¼ \times 30 \times 9.8 \times \cos 20° + ½ \times 30 \times v^2$ -1 ee	A2,1,0
	$½\ v^2 = 50 \times 9.8 \times (\sin 20° - ¼\cos 20°)$, $v = 10.2\ \text{m s}^{-1}$.	DM1 A1 (5) **[11]**

5. **(a)**



Divide the shape into usable areas, e.g.:

Shape	C of mass	Units of mass
Rectangle 27 x 9	(13.5,4.5)	243 (6)
Right hand triangle	(30,3)	40.5 (1)
Top triangle	(3,30)	40.5 (1)
Rectangle 9 x 18	(4.5,18)	162 (4)

Mass ratios B1
Centres of mass B1

Take moments about AB: M1
$6\times13.5+1\times30+4\times4.5+1\times3=132=12\bar{x}$, A(2,1,0)

$\bar{x}=11(\text{cm})$ solve for x (or y) co-ord A1
$\bar{y}=11(\text{cm})$ using the symmetry B1ft

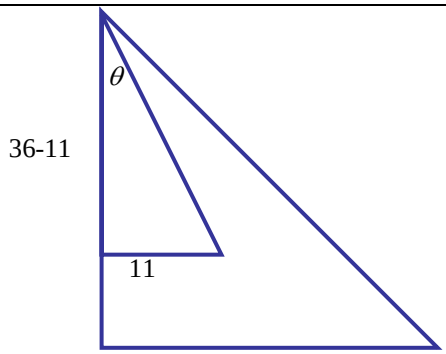
Alternative:

Shape	C of mass	Units of mass
Small triangle	(12,12)	.5 x 18x 18
Large triangle	(15,15)	.5 x 36 x 36

$\frac{1}{2}\times36\times36\times12-\frac{1}{2}\times18\times18\times15=\frac{1}{2}(36\times36-18\times18)\bar{x}$ etc.

(7)

(b)



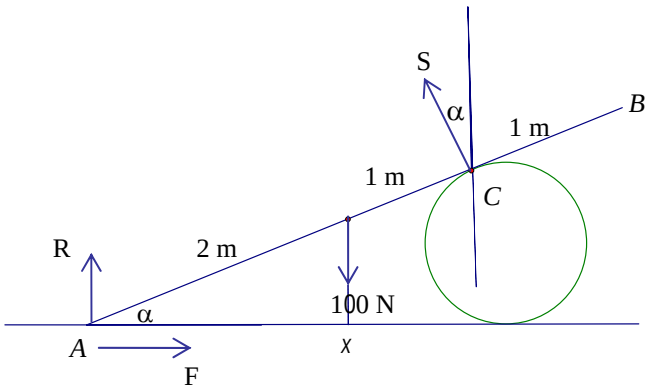
$\tan\theta=\frac{\bar{x}}{36-\bar{y}}$ M1

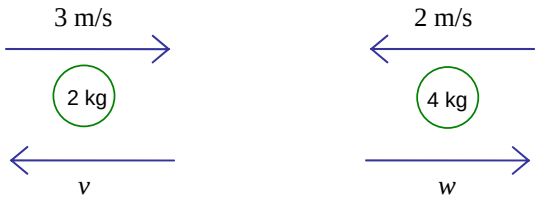
$\tan\theta=\frac{11}{25}=0.44$ A1ft

$\theta=24°$ A1

(3)
[10]

6. **(a)**	Using $s = ut + \frac{1}{2}at^2$ Method must be clear $\mathbf{r} = (3t)\mathbf{i} + (10 + 5t - 4.9t^2)\mathbf{j}$ Answer given	M1 A1 A1 (3)
(b)	**j** component $= 0$: $10 + 5t - 4.9t^2$ quadratic formula: $t = \frac{5 \pm \sqrt{25 + 196}}{9.8} = \frac{5 \pm \sqrt{221}}{9.8}$ $T = 2.03$(s), 2.0 (s) positive solution only.	M1 DM1 A1 (3)
(c)	Differentiating the position vector (or working from first principles) $\mathbf{v} = 3\mathbf{i} + (5 - 9.8t)\mathbf{j}$ (ms^{-1})	M1 A1 (2)
(d)	At B the **j** component of the velocity is the negative of the **i** component: $5 - 9.8t = -3$, $8 = 9.8t$, $t = 0.82$	M1 A1 (2)
(e)	$\mathbf{v} = 3\mathbf{i} - 3\mathbf{j}$, speed $= \sqrt{3^2 + 3^2} = \sqrt{18} = 4.24\,(\text{m s}^{-1})$	M1A1 (2) **[12]**

Question Number	Scheme	Marks
7.		
	Taking moments about A: $3S = 100 \times 2 \times \cos\alpha$	M1 A1
	Resolving vertically: $R + S\cos\alpha = 100$	M1 A1
	Resolving horizontally: $S\sin\alpha = F$	M1 A1
	(Most alternative methods need 3 independent equations, each one worth M1A1. Can be done in 2 e.g. if they resolve horizontally and take moments about X then $R \times 2 \times \cos\alpha = S \times (3 - 2 \times \cos^2\alpha)$ scores M2A2)	
	Substitute trig values to obtain correct values for F and R (exact or decimal equivalent). $\left(S = \frac{200\sqrt{8}}{9}\right)$, $R = 100 - \frac{1600}{27} = \frac{1100}{27} \approx 40.74$, $F = \frac{200\sqrt{8}}{27} \approx 20.95...$	DM1 A1
	$F \le \mu R$, $200\sqrt{8} \le \mu \times 1100$, $\mu \ge \frac{200\sqrt{8}}{1100} = \frac{2\sqrt{8}}{11}$. Least possible μ is 0.514 (3sf), or exact.	M1 A1 **[10]**

Question Number	Scheme	Marks
8. **(a)**	KE lost : $\frac{1}{2}\times m\times 36-\frac{1}{2}\times m\times v^2=64$ Restitution: v = 1/3 x 6 = 2 Substitute and solve for m: $\frac{1}{2}\times m\times 36-\frac{1}{2}\times m\times 4=64=16m$ m = 4 answer given	M1A1 M1A1 DM1 A1 (6)
(b)	 Conservation of momentum: $6-8=4w-2v$ their "2" Restitution: $v+w=⅓(2\ +\ 3)$ their "2" $v=\frac{5}{3}-w$ Solve for w: $-2=4w-2(\frac{5}{3}-w)=6w-\frac{10}{3}$ $\frac{4}{3}=6w$ $\left(w=4/18=2/9\,\text{m s}^{-1}\right)$ $w>0\ \Rightarrow$ will collide with the wall again	M1A1ft M1A1ft DM1 A1 A1 (7) **[13]**

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June 2011

GCE Mechanics M2 (6678) Paper 1

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   - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
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   - awrt – answers which round to
   - SC: special case
   - oe – or equivalent (and appropriate)
   - dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - * The answer is printed on the paper
   - ⌊ The second mark is dependent on gaining the first mark

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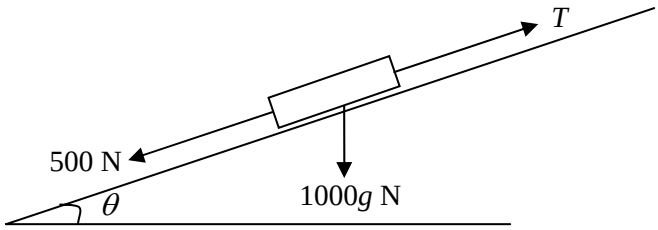
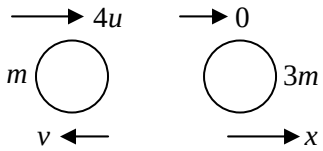
June 2011
6678 Mechanics M2
Mark Scheme

Question Number	Scheme	Marks
1.	 $12000 = TV$ $T - 500 - 1000g\sin\theta = 0$ $V = \dfrac{12000}{500 + 1000 \times 9.8 \times \frac{1}{30}}$ $V = 15$ (accept 14.5)	 M1 M1 A1 DM1 A1 (5) **5**
2.	 $4mu = 3mx - mv$ $4ue = x + v$ $4u = 3(4ue - v) - v$ $4u = 12ue - 4v$ $v = (3e - 1)u$ $v > 0 \Rightarrow 3e > 1$ $\therefore e > \frac{1}{3}$ **	 M1 A1 M1 A1 DM1 A1 DM1 A1 (8) **8**

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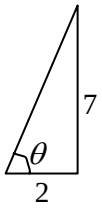
Question Number	Scheme	Marks
3. **(a)**	$\mathbf{I} = m\mathbf{v} - m\mathbf{u}$ $-4\mathbf{i} + 7\mathbf{j} = 0.5(\mathbf{v} - 12\mathbf{i})$ $4\mathbf{i} + 14\mathbf{j} = \mathbf{v}$ Speed $= \sqrt{16+196} = \sqrt{212}$ m s^{-1} (14.6 or better)	M1 A1 M1 A1 (4)
(b)	 $\tan\theta = \frac{7}{2}$ $\theta = 74.0....$ $\theta = 74°$	M1 A1ft (2)
(c)	Gain in K.E. $= \frac{1}{2} \times 0.5(212 - 12^2)$, $= 17$ J	M1 A1 (2) **8**

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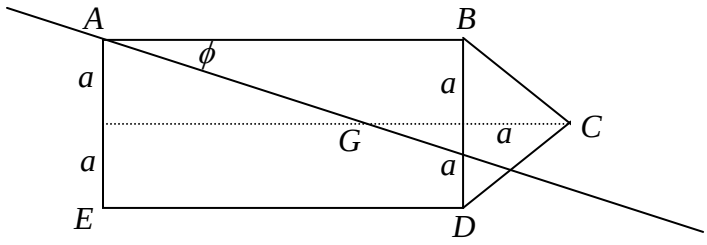
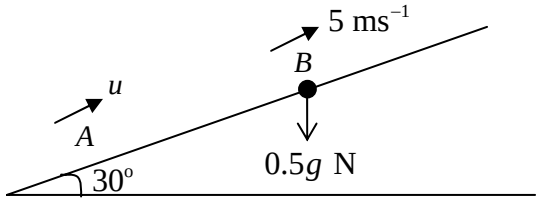
Question Number	Scheme	Marks
4 . **(a)**		
	ABDE | *BCD* | Lamina	
	Mass ratio: $8a^2\rho$ | $a^2\rho$ | $9a^2\rho$	B1
	8 | 1 | 9	
	Dist of C of M From AE: 2a | $4\frac{1}{3}a$ | $\bar{x}$	B1
	$8\times 2a + 1\times\frac{13}{3}a = 9\bar{x}$	M1
	$\bar{x} = \frac{61}{27}a$ (2.26*a*)	A1 (4)
(b)	$\tan\phi = \frac{a}{\frac{61}{27}a} = \frac{27}{61}$	M1 A1 ft
	$\phi = 23.87... = 24°$ (accept 23.9), 0.417 radians	A1 (3)
		7

Question Number	Scheme	Marks
5. **(a)**	 $0.5g \times 2\sin 30 = \frac{1}{2}\times 0.5u^2 - \frac{1}{2}\times 0.5\times 5^2$ $\frac{1}{4}u^2 = 0.5g + \frac{1}{2}\times 0.5\times 5^2$ $u = 6.7$ m s^{-1} (accept 6.68)	M1 A1 DM1 A1 (4)
(b)	$R = 0.5g\cos 30$ $F = 0.5g\cos 30\times\mu$ Work done by friction $= 1.5F$ $\frac{1}{2}\times 0.5\times 5^2 = 1.5F + 0.5g\times 1.5\sin 30$ $\mu = \frac{\frac{1}{2}\times 0.5\times 5^2 - 0.5g\times 1.5\sin 30}{0.5g\cos 30\times 1.5}$ $\mu = 0.40$ (accept 0.4 or 0.405)	B1 M1 M1 A1 A1 A1 (6) **10**

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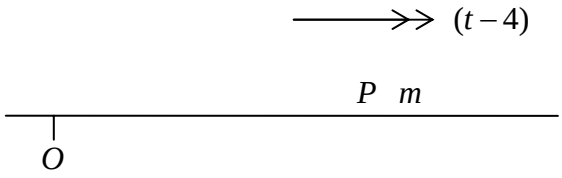
Question Number	Scheme	Marks
6. **(a)**	 $\frac{dv}{dt} = t - 4$ $v = \frac{1}{2}t^2 - 4t(+c)$ $t = 0 \quad v = 6 \quad \Rightarrow c = 6$ $\therefore v = \frac{1}{2}t^2 - 4t + 6$	 M1 A1 M1 A1 (4)
(b)	$v = 0 \quad 0 = t^2 - 8t + 12$ $(t-6)(t-2) = 0$ $t = 6 \quad t = 2$	M1 DM1 A1 (3)
(c)	$x = \frac{t^3}{6} - 2t^2 + 6t + k$ $x_6 - x_2 = \frac{6^3}{6} - 2\times 6^2 + 6^2 + k$ $-\left(\frac{2^3}{6} - 2\times 2^2 + 6\times 2 + k\right)$ $= -5\frac{1}{3}$ $\therefore$ Distance is $5\frac{1}{3}$m	M1 A1 ft DM1 A1 (4) **11**

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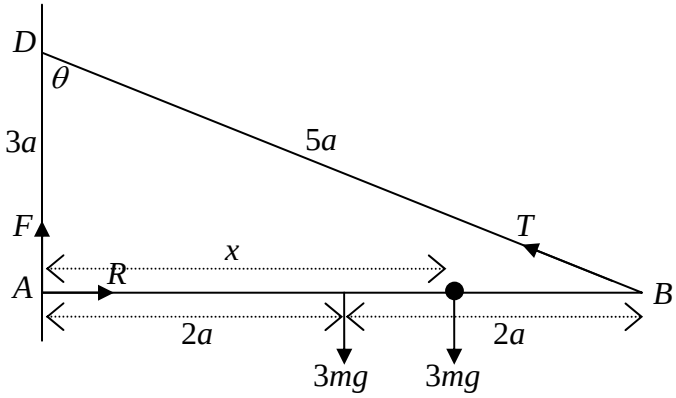
Question Number	Scheme	Marks
7 . **(a)**		
	M(A) $3mg \times 2a + 3mgx = T\cos\theta \times 4a$	M1 A2,1,0
	$= \frac{12}{5}aT$	
	$\frac{12}{5}aT = 6mga + 3mgx$	
	$T = \frac{25}{4}mg \qquad \frac{12}{5}a \times \frac{25}{4}mg = 6mga + 3mgx$	M1
	$15a = 6a + 3x$	
	$x = 3a$ **	A1
		(5)
(b)	R$(\rightarrow)$ $R = T\sin\theta$	M1
	$= \frac{25}{4}mg \times \frac{4}{5}$	A1
	$= 5mg$ **	A1
		(3)
(c)	R$(\uparrow)$ $F + \frac{25}{4}mg \times \frac{3}{5} = 3mg + 3mg$	M1 A2,1,0
	$F = 6mg - \frac{15}{4}mg = \frac{9}{4}mg$	
	$\mu = \frac{F}{R} = \frac{\frac{9}{4}mg}{5mg} = \frac{9}{20}$	DM1 A1
		(5)
		13

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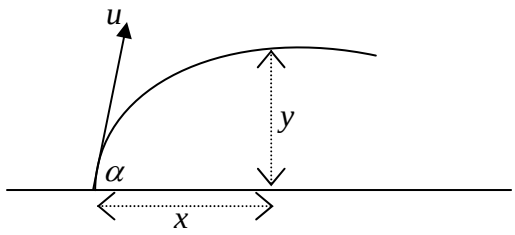
Question Number	Scheme	Marks
8. **(a)**		
	Horiz: $x = u\cos\alpha t$	B1
	Vert: $y = u\sin\alpha t - \frac{1}{2}gt^2$	M1
	$y = u\sin\alpha \times \frac{x}{u\cos\alpha} - \frac{1}{2}g \times \frac{x^2}{u^2\cos^2\alpha}$	DM1
	$y = x\tan\alpha - \frac{gx^2}{2u^2\cos^2\alpha}$ **	A1
		(4)
(b)	$y = -7$: $-7 = \tan 45x - \frac{gx^2}{2\times 7^2\cos^2 45}$	M1 A1
	$-7 = x - \frac{9.8x^2}{7^2}$	
	$-7 = x - \frac{x^2}{5}$	M1
	$x^2 - 5x - 35 = 0$	
	$x = \frac{5 \pm \sqrt{25 + 4\times 35}}{2}$	M1
	$x = 8.92$ or 8.9	A1
		(5)
(c)	Time to travel 8.922 m horizontally $= \frac{8.922}{7\cos 45} = 1.802...$s	M1
	$v = \frac{8.922}{1.402}$	M1 A1 ft
	$= 6.36$ or 6.4 $\left(\text{m s}^{-1}\right)$	A1
		(4)
		13

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January 2012

GCE Mechanics M2 (6678) Paper 1

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January 2012
Publications Code UA030773

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS

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- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- $*$ The answer is printed on the paper
- ⌐ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

General Principals for Core Mathematics Marking

(But note that specific mark schemes may sometimes override these general principles).

Method mark for solving 3 term quadratic:

1. Factorisation

$(x^2 + bx + c) = (x + p)(x + q)$, where $|pq| = |c|$, leading to x = ...

$(ax^2 + bx + c) = (mx + p)(nx + q)$, where $|pq| = |c|$ and $|mn| = |a|$, leading to x = …

2. Formula

Attempt to use correct formula (with values for a, b and c), leading to x = …

3. Completing the square

Solving $x^2 + bx + c = 0$: $\left(x \pm \frac{b}{2}\right)^2 \pm q \pm c, \quad q \neq 0$, leading to x = …

Method marks for differentiation and integration:

1. Differentiation

Power of at least one term decreased by 1. ($x^n \rightarrow x^{n-1}$)

2. Integration

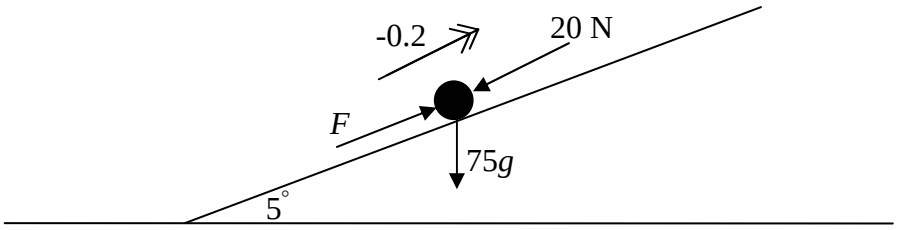
Power of at least one term increased by 1. ($x^n \rightarrow x^{n+1}$)

Use of a formula

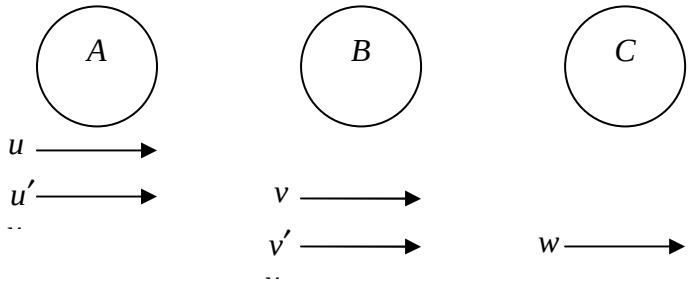
Where a method involves using a formula that has been learnt, the advice given in recent examiners' reports is that the formula should be quoted first.
Normal marking procedure is as follows:
Method mark for quoting a correct formula and attempting to use it, even if there are mistakes in the substitution of values.
Where the formula is not quoted, the method mark can be gained by implication from correct working with values, but may be lost if there is any mistake in the working.

January 2012
6678 Mechanics M2
Mark Scheme

Question Number	Scheme	Marks
1	Use of $m(\mathbf{v}-\mathbf{u}) = \mathbf{I}$ $0.1 \times (\mathbf{v} - 30\mathbf{i}) = -2\mathbf{i} - 4\mathbf{j}$ Solve for $\mathbf{v}$: $0.1\mathbf{v} = 3\mathbf{i} - 2\mathbf{i} - 4\mathbf{j} = \mathbf{i} - 4\mathbf{j}$ $\mathbf{v} = 10\mathbf{i} - 40\mathbf{j}$	M1 A1 DM1 A1 **4**
2 **(a)**	Speed $= \sqrt{8^2 + 48^2} = \sqrt{2368} = 48.7\,(\text{ms}^{-1})$	M1 A1 (2)
(b)	$\mathbf{a} = 2\mathbf{i} - 6t\,\mathbf{j}$ When $t = 4$, $\mathbf{a} = 2\mathbf{i} - 24\,\mathbf{j}\ (\text{ms}^{-2})$	M1 A1 A1 (3)
(c)	$\mathbf{r} = t^2\mathbf{i} - t^3\mathbf{j} + \mathbf{C}$ $t = 1$, $-4\mathbf{i} + \mathbf{j} = \mathbf{i} - \mathbf{j} + \mathbf{C}$, $\mathbf{C} = -5\mathbf{i} + 2\mathbf{j}$ $\mathbf{r} = (t^2 - 5)\mathbf{i} + \left(-t^3 + 2\right)\mathbf{j}$ When $t = 4$, $\mathbf{r} = (16-5)\mathbf{i} + (-64 + 2)\mathbf{j} = 11\mathbf{i} - 62\mathbf{j}$	M1 A1 DM1 DM1 A1 (5) **10**

Question Number	Scheme	Marks
3 **(a)**		
	Driving force = F	M1
	Resolving parallel to the plane: $F - 20 - 75g\sin 5 = -75\times 0.2 = -15$	A2 – lee
	$F = 5 + 75g\sin 5°$	
	$P = Fv$ $\therefore$ working at $12\times(5 + 75g\sin 5°) = 828.7.....$	DM1
	≈ 830 W	A1
		(5)
(b)		
	Loss in KE = gain in GPE + work done against resistance	M1
	$\frac{1}{2}\times 75\times 64 = 75\times 9.8\times\sin 5°d + 20d = d\times 84.059....$	A2 – lee
	d = 28.6 m	DM1 A1
		(5)
		10

Question Number	Scheme	Marks
4		
(a)	For an appropriate division of the trapezium into standard shapes with:	
	correct ratio of masses	B1
	correct distances of c.o.m. from AB	B1
	e.g three equilateral triangles of height $\sqrt{3}$, mass m kg,	
	com $\frac{\sqrt{3}}{3}$ from bases of each	
	$3md = \left(m\times\frac{2}{3}\times\sqrt{3}\right)+\left(2\times m\times\frac{1}{3}\sqrt{3}\right)=\frac{4\sqrt{3}}{3}m$,	M1 A1
	$d=\frac{4\sqrt{3}}{9}$ **AG**	A1
		(5)
(b)	Horizontal distance of c of m from D = 1m	B1
	Vertical distance $\sqrt{3}-\frac{4\sqrt{3}}{9}=\frac{5\sqrt{3}}{9}$ (0.962….)	B1
	$\tan^{-1}\frac{0.962...}{1}$	M1 A1ft
	Angle = 43.9°	A1
		(5)
		10
5		
(a)	Taking moments about A:	M1
	$4g\times 0.7\times\cos 20° = 1.4T$	A1 A1
	T = 18.4 N	A1
		(4)
(b)	↑ $R + T\cos 20 = 4g$	
	$R = 4g - T\cos 20°$	M1 A1
	→ $F = T\sin 20$	M1 A1
	$F=\mu R \Rightarrow T\sin 20° = \mu(4g - T\cos 20°)$	DM1 A1
	$\mu=\frac{T\sin 20°}{4g - T\cos 20°}=0.29$	A1
		(7)
		11

Question Number	Scheme	Marks
6 **(a)**		
	Momentum: $u = u' + v$	M1 A1
	NEL: $v - u' = eu$	M1 A1
	$2v = u(1 + \frac{2}{3}),\ v = \frac{1}{2}u \times \frac{5}{3} = \frac{5u}{6}$	DM1 A1
	$u' = u - v = \frac{u}{6}$	A1
		(7)
(b)	KE lost $= \frac{1}{2}mu^2 - \left(\frac{1}{2}m \times \frac{25}{36}u^2 + \frac{1}{2}m \times \frac{1}{36}u^2\right)$ their speeds	M1
	$= \frac{1}{2}mu^2 - \left(\frac{1}{2}m \times \frac{26}{36}u^2\right)$	A2 – 1ee
	$= \frac{1}{2}mu^2 \times \frac{10}{35} = \frac{5}{36}mu^2$ **AG**	A1
		(4)
(c)	Speed of C $= \frac{1}{2}\left(\frac{1}{2}u\left(\frac{5}{3}\right)\right)\left(\frac{5}{3}\right) = \frac{1}{2} \cdot \frac{5u}{6} \cdot \frac{5}{3}, = \frac{25}{36}u$	M1 A1 DM1 A1
		(4)
		15

Question Number	Scheme	Marks
7		
(a)	**i** → distance = $6t$	B1
	j ↑ distance = $12t - \frac{1}{2}gt^2$	M1 A1
	At B, $2\left(12t - \frac{1}{2}gt^2\right) = 6t$	M1 A1
	$(24-6)t = gt^2$	DM1
	$18 = gt$, $t = \frac{18}{g} (= 1.84\text{s})$	A1
		(7)
(b)	**i** → speed = 6	B1
	j ↑ velocity = $12 - gt = -6$	M1 A1
	$\therefore$ speed at A	
	$= \sqrt{6^2 + 6^2} = \sqrt{72} = 6\sqrt{2} (= 8.49) (\text{ms}^{-1})$	M1 A1
		(5)
(c)	↑ speed = $12 - gt = +6$	M1 A1 ft
	$t = \frac{6}{g} (= 0.61\text{s})$	A1
		(3)
		15

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Mark Scheme (Results)

Summer 2012

GCE Mechanics M2
(6678) Paper 1

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Summer 2012
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Summer 2012
6678 Mechanics 2
Mark Scheme

General Marking Guidance

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- cso – correct solution only. There must be no errors in this part of the question to obtain this mark
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- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- * The answer is printed on the paper
- ⌐ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the first 2 A or B marks affected are lost, and the subsequent A marks affected are treated as A ft; but manifestly absurd answers should never be awarded A marks.

General Principles for Mechanics Marking

Usual rules for M marks: correct no. of terms; dim correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.
Omission or extra g in a resolution is accuracy error not method error.
Omission of mass from a resolution is method error.
Omission of a length from a moments equation is a method error.
Omission of units or incorrect units is not (usually) counted as an accuracy error.
DM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.
Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.
Use of g = 9.81 should be penalised once per (complete) question.
N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *ONCE* per complete question.
However, premature approximation should be penalised every time it occurs.
MARKS MUST BE ENTERED IN THE SAME ORDER AS THEY APPEAR ON THE MARK SCHEME.

In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.

Accept column vectors in all cases.

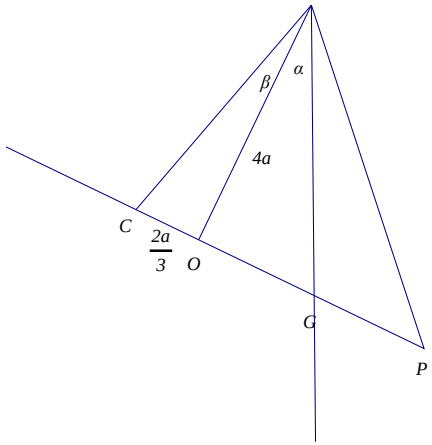
Summer 2012
6678 Mechanics M2
Mark Scheme

Question Number	Scheme	Marks	Notes
1			
(a)	$\mathbf{a} = \frac{d\mathbf{v}}{dt} = 6t\mathbf{i} + (4-2t)\mathbf{j}$	M1	Differentiate **v** to obtain **a**.
		A1	Accept column vector or **i** and **j** components dealt with separately.
	When $t = 1$, $\mathbf{a} = 6\mathbf{i} + 2\mathbf{j}$	DM1	Substitute t = 1 into their **a.** Dependent on 1st M1
	$\lvert\mathbf{a}\rvert = \sqrt{6^2 + 2^2} = \sqrt{40} = 6.32$ (m s^{-2})	DM1	Use of Pythagoras to find the magnitude of their **a**. Allow with their t. Dependent on 1st M1
		A1	Accept awrt 6.32, 6.3 or exact equivalents.
		(5)	
(b)	$\mathbf{r} = \int (3t^2 - 1)\mathbf{i} + (4t - t^2)\mathbf{j}\, dt$	M1	Integrate **v** to obtain **r**
	$= (t^3 - t + C)\mathbf{i} + (2t^2 - \frac{1}{3}t^3 + D)\mathbf{j}$	A1	Condone C, D missing
	$t = 0, \mathbf{r} = \mathbf{i} \Rightarrow C = 1, D = 0$	DM1	Use t = 0, **r** = **i** to find C & D
	When $t = 3, \mathbf{r} = 25\mathbf{i} + 9\mathbf{j}$ (m)	DM1	Substitute t = 3 with their C & D to find **r**. Dependent on both previous Ms.
		A1	cao. Must be a vector.
		(5)	
		10	

Question Number	Scheme	Marks	Notes
2			
(a)	$3m.2u - 4mu = 3mv_1 + 4mv_2$	M1 A1	CLM. Need all terms. Condone sign slips. Correct but check their directions for v_1 & v_2.
	$e(2u+u) = -v_1 + v_2$	M1 A1	Impact law. Must be used the right way round, but condone sign slips. Directions of v_1 & v_2 must be consistent between the two equations. (Ignore the diagram if necessary)
	$\frac{u(2+9e)}{7} = v_2$	DM1 A1 (6)	Eliminate v_1 to produce an equation in v_2 only. Dependent on both previous M marks – must be using both equations. DO NOT accept the negative. The question asks for speed.
(b)	$v_1 = \frac{2u(1-6e)}{7}$	M1 A1	Use the work from (a) or restart to find v_1 or λv_1 for a constant λ. If using work from (a) this mark is dependent on the first 2 M marks. a.e.f. Correct for their direction. Allow for λv_1
	$v_1 < 0 \Rightarrow e > \frac{1}{6}$	DM1 A1	An appropriate inequality for their v_1 (seen or implied) – requires previous M1 scored. Work on $v_1=0$ scores M0 until the inequality is formed. Accept $\frac{2}{12}$. Answer must follow from correct work for v_1
	$1 \geq e > \frac{1}{6}$	B1 (5)**11**	For (their value) $< e \leq 1$ SR: from $v_1 \leq 0$ could score M1A0B1

Question Number	Scheme	Marks	Notes
3 **(a)**	$M(A), F.4\sin 40^o = 5g.2\cos 25^o$	M1	A complete method to find F , e.g. take moments about A. Condone sin/cos confusion. Requires correct ratio of lengths.
		A1	Correct terms with at most one slip
		A1	All correct
	$F = 35$	A1	35 or 34.5 (>3sf not acceptable due to use of 9.8, but only penalise once in a question)
		(4)	
(b)	$F\cos 75^o \pm Y = 5g$	M1	Resolve vertically. Need all three terms but condone sign errors. Must be attempting to work with their 75° or 15°.
		A1	Correct equation (their F)
	$Y = 40$; UP	A1	40 or 40.1 Apply ISW if the candidate goes on to find R.
		A1	cso (the Q does specifically ask for the direction, so this must be clearly stated)
		(4)	
		8	
(b)	OR1: $4m\cos 25 \times Y = 5g \times 2m\cos 25 + F\cos 15 \times 4m\sin 25$ etc.	M1 A1	Taking moments about the point vertically below B and on the same horizontal level as A.(Their F)
	OR2: $R\cos\alpha = F\cos 40 + 5g\cos 65$ $R\sin\alpha + F\sin 40 = 5g\cos 25$		Resolve parallel & perpendicular to the rod
	R=52.1, α=25.3°		Solve for R, α
	$Y = R\sin(25+\alpha)$ Etc.	M1A1	Need a complete strategy to find Y for M1.

Question Number	Scheme	Marks	Notes
4 **(a)**	$\pi(4a)^2 \quad \pi(2a)^2 \quad (\pi(4a)^2 - \pi(2a)^2)$ $4 \quad 1 \quad 3$ $4a \quad 2a \quad \bar{x}$	B1 B1	Correct mass ratios Distance of c of m from P (or from a point on QP).
	$(4 \text{ x } 4a) - (1 \text{ x } 2a) = 3\bar{x}$	M1	Moments about axis through P, or about a parallel axis then convert the answer to distance from P. Condone a sign slip.
	$\frac{14a}{3} = \bar{x}$ *	A1 (4)	Answer given – check working carefully. Must reach positive answer legitimately.
(b)	$OG = 4a\tan\alpha = \frac{10a}{3}\left(\Rightarrow PG = \frac{2a}{3}\right)$	M1 A1	Vertical through S cuts OP at G. Use trig to find the position of G on OP. $OG = \frac{10a}{3}$, $QG = \frac{22a}{3}$ or $PG = \frac{2a}{3}$ seen or implied
	$M(P), (m+km)g.\frac{2a}{3}\cos\alpha = mg.\frac{14a}{3}\cos\alpha$ $M(G): km \times \frac{2}{3}a = m \times \left(\frac{10}{3}a + \frac{2}{3}a\right) = 4ma$ $M(O): m(1+k) \times \frac{10}{3}a + m \times \frac{2}{3}a = km \times 4a$	M1	Take moments about a point on QP – terms should be dimensionally consistent. Masses must be associated with the appropriate distances, which might be incorrectly evaluated or not yet found – e.g. accept with QG. Must have the right terms but condone trig confusion. Also condone absence of trig.
	$M(C): \frac{12}{3}a \times (1+k)m = \frac{14}{3}a \times km$	A1	cso (C is the position of the original centre of mass.)
	$M(Q): \frac{22}{3}a \times m(1+k) = \frac{10}{3}a \times m + 8a \times km$ $k = 6$	A1 (5) **9**	cso See next page for more alternatives…..

OR	$(k+1)m\times PG = m\times\frac{14}{3}a$	M1	Moments about P
	$PG = \frac{14a}{3(k+1)}$	A1	Correct expression for PG
	$\tan\alpha = \frac{OG}{4a} = \frac{4a-\frac{14a}{3(k+1)}}{4a}\left(=1-\frac{7}{6(k+1)}\right)$	M1	Use of $\tan\alpha$ in the correct triangle.
	$\frac{5}{6} = 1-\frac{7}{6(k+1)} \quad k=6$	A1, A1	Correct equation in *k*, correct solution
OR			
	$\tan(\angle CSO) = \tan\beta = \frac{\frac{2a}{3}}{4a} = \frac{1}{6}$	M1	
	$km.\sqrt{32}a.\sin(45-\alpha) = m.\sqrt{16\frac{4}{9}}a.\sin(\alpha+\beta)$	M1A1	Moments about S
	$k.\sqrt{32}.\left(\frac{6-5}{\sqrt{2}.\sqrt{61}}\right) = \frac{\sqrt{148}}{3}.\frac{6\times5+1\times6}{\sqrt{37}.\sqrt{61}}$	A1	Do not expect accurate working
	$4k = \frac{2}{3}\times36, \quad k=6$	A1	Final answer 6.0

Question Number	Scheme	Marks	Notes
5			NB In a Q with parts labelled (i) & (ii) marks are awarded when seen – they do not belong to a particular part of the Q.
	$12.5\sin\alpha = \frac{1}{4}(v_1 - -30)$	M1	Impulse = change in momentum parallel to the initial direction. .
	or $-12.5\sin\alpha = \frac{1}{4}(v_1 - 30) \quad (v_1 = 0)$	A1	Correct equation
	$12.5\cos\alpha = \frac{1}{4}(v_2 - 0) \qquad (v_2 = 40)$	M1 A1	Impulse = change in momentum perpendicular to the initial direction. Condone sin/cos confusion Correct equation NB could be in the form: $\begin{pmatrix} -12.5\sin\alpha \\ 12.5\cos\alpha \end{pmatrix} = 0.25v - 0.25\begin{pmatrix} 30 \\ 0 \end{pmatrix}$
	speed is 40 m s^{-1};	A1	cwo. Correct magnitude of speed after impulse. NB Must be speed, not velocity.
	perpendicular to original direction	A1	cwo. Correct direction (relative to the line given on the diagram – e.g. accept "vertically", "North", **j** direction, "up").
		6	
OR	Using a vector triangle:	M1	Use cosine rule to find $\frac{1}{4}v$. Terms must be of correct form, but
	$(\frac{1}{4}v)^2 = 7.5^2 + 12.5^2 - 2\text{x}7.5\text{x}12.5\cos(90^\circ - \alpha)$		accept unsimplified or slips e.g. their $\frac{1}{4}\times 30$
		A1	Correct equation
	$v = 40\text{m s}^{-1}$	A1	cao (penultimate mark on epen)
	$\frac{12.5}{\sin\theta} = \frac{7.5}{\sin\alpha}$	M1	Use sine rule to find angle between initial and final directions.
		A1	Correct equation in α and θ
	$\theta = 90^\circ$	A1	cao. (final mark on epen)
		6	

Question Number	Scheme	Marks	Notes
6			
(a)	$F = \frac{60000}{10} = 6000$	B1	Correct application of $P = Fv$ seen or implied.
	$F - 1200g\sin\alpha - 400g\sin\alpha - 1000 - 200 = 1600a$	M1 A1 A1	Use of $F = ma$ parallel to the slope for the car and trailer. Must have all the terms, but condone sign errors. At most one error (with F or their F) Correct equation (with F or their F)
	$a = 2.3$ (m s^{-2})	A1	only
		(5)	
(b)	$T - 400g\sin\alpha - 200 = 400$ x 2.3	M1 A1 ft A1 ft	Use of $F = ma$ parallel to the slope for the trailer At most one error (their a) All correct (their a)
	$T = 1400$	A1	only
		(4)	
OR	$6000 - 1200g\sin\alpha - 1000 - T = 1200$ x 2.3	M1 A1 ft A1 ft	Use of $F = ma$ parallel to the slope for the car At most one error (their a) All correct (their a)
	$T = 1400$	A1	only
		(4)	
OR (a)	$F = 6000$	B1	
	$T - 400g\sin\alpha - 200 = 400$ x a $6000 - 1200g\sin\alpha - 1000 - T = 1200$ x a		Simultaneous equations in T and a
	$6000 - 1600g\sin\alpha - 1200 = 1600a$	M1A1A1	Add to eliminate T
	$a = 2.3$ (m s^{-2})	A1	
(b)	$-800a = 2T + 800g\sin\alpha + 800 - 6000$ $2T = 5200 - 800g\sin\alpha - 800\times 2.3$	M1A1A1	Subtract and / or substitute to eliminate a
	$T = 1400$	A1	

(c)	$200d = \frac{1}{2}400.12^2 - 400gd\sin\alpha$ $d = 60$ (m)	M1 A1 A1 DM1 A1 (5) **14**	Use of work-energy. Must have all three terms. Do not accept duplication of terms, but condone sign errors. Equation in only one unknown, but could be vertical distance. At most one error in the equation All correct in one unknown Solve for d – dependent on M for work-energy equation. only For vertical distance $\left(=\frac{60}{14}=4.29\right)$ allow 3/5

Question Number	Scheme	Marks	
7 (a)	$0^2 = u_V{}^2 - 2 \times 9.8 \times 10$	M1	Complete method using *suvat* to form an equation in u_v.
		A1	Correct equation e.g. $0 = u^2 - 20g$
	$u_V = 14$ *	A1	*Answer given* requires equation and working, including 196, seen.
		(3)	
OR	conservation of energy:	M1	Initial KE = gain in GPE + final KE
	$\frac{1}{2}m\left(u_h{}^2 + u_v{}^2\right) = mg \times 10 + \frac{1}{2}mu_h{}^2$, $\frac{1}{2}u_v{}^2 = 98$	A1	Correct equation
	$u_V = 14$ *	A1	*Answer given*
		(3)	
(b)		M1	Use the vertical distance travelled to find the total time taken.
	$(\uparrow),\ -52.5 = 14t - \frac{1}{2}gt^2$	A1	At most one error
		A1	Correct equation
	$49t^2 - 140t - 525 = 0$	DM1	Solve for t. Dependent on the preceding M mark
	$(t-5)(49t+105) = 0 \quad t = 5$	A1	only
	$(\rightarrow),\quad 50 = 5u_H$	M1	Use their time of flight to form an equation in u_H
	$u_H = 10$	A1	only
	$u = \sqrt{10^2 + 14^2}$	M1	Use of Pythagoras with two non-zero components, or solution of a pair of simultaneous equations in u and α.
	$= \sqrt{296}$; 17.2 m s^{-1}	A1	17.2 or 17 (method involves use of g = 9.8 so an exact surd answer is not acceptable)
		(9)	
			See next page for an alternative route to u, and (c).

OR			First 3 marks for the quadratic as above.
	$50 = u\cos\alpha t$ or $50 = u_H t$	M1	Used in their quadratic
	$49\left(\frac{50}{u_H}\right)^2 - 140\left(\frac{50}{u_H}\right) - 525 = 0$	A1	Correct quadratic in u_H
	$525(u_H)^2 + 140(u_H) - 122500 = 0$		
	Solve for u_H	DM1	Dependent on the M mark for setting up the initial quadratic equation in t.
	u_H = 10	A1	only
	etc.		Complete as above.
(c)	$\tan OBA = \frac{52.5}{50} = 1.05$	B1	Correct direction o.e. (accept reciprocal)
	$v_V = 1.05$ x $10 = 10.5$	M1	Use trig. with their u_H and correct interpretation of direction to find the vertical component of speed. Working with distances is M0. (condone $10 \div 1.05$)
	$(\uparrow),\ -10.5 = 14 - gt$	DM1	Use suvat to form an equation in t. Dependent on the preceding M.
		A1	Correct equation for their $u_{H.}$ For incorrect direction give A0 here.
	$t = 2.5$	A1	only
		(5)	
		17	

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Mark Scheme (Results)

January 2013

GCE Mechanics M2 (6678/01)

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January 2013
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- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

In some instances, the mark distributions (e.g. M1, B1 and A1) printed on the candidate's response may differ from the final mark scheme.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
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- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- $\ast$ The answer is printed on the paper
- $\sqsubset$ The second mark is dependent on gaining the first mark

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5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.

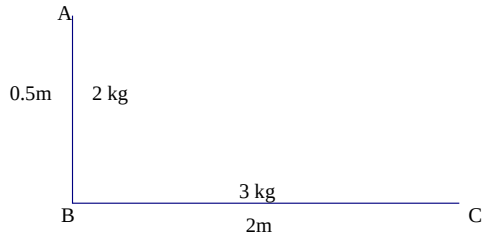
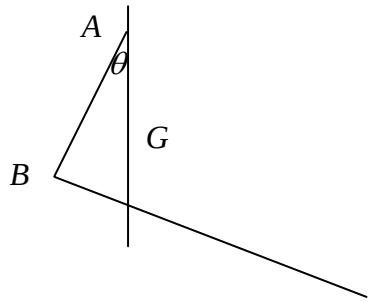
- If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

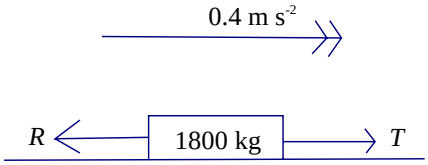
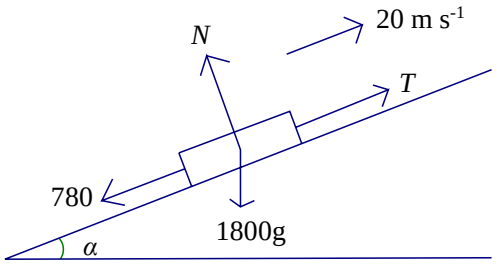
7. Ignore wrong working or incorrect statements following a correct answer.

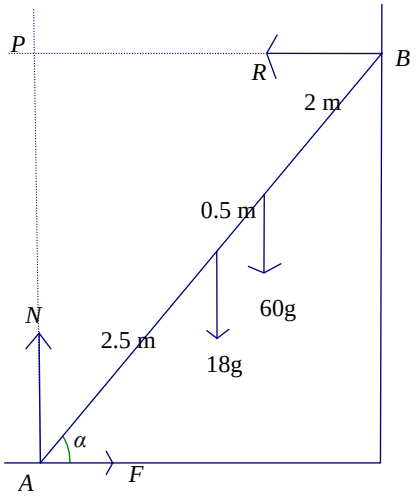
8. The maximum mark allocation for each question/part question(item) is set out in the marking grid and you should allocate a score of '0' or '1' for each mark, or "trait", as shown:

	0	1
aM		●
aA	●	
bM1		●
bA1	●	
bB	●	
bM2		●
bA2		●

January 2013
6678 M2
Mark Scheme

Q.	Scheme	Marks	
1. (a)		M1	
	$5\bar{y} - 2 \times 0.25(+0)$	A1	Moments equation with lengths ¼, 1 and (ratio of) masses 2, 3. Allow moments about a parallel axis Use of length for mass is M0.
	$\bar{y} = \frac{2 \times 0.25}{5} = 0.1$		For distance from *BC*
(b)			
		M1	
	$\tan\theta = \frac{0.6}{0.5 - 0.1}$	A1ft	Must suspend from *A*. Use of tan with 0.6 and $0.5 - \bar{y}$ Could be wrong way up. Must be using 0.6
		A1	Correct way up. ft their $\bar{y}$.
	$\theta = \tan^{-1}\left(\frac{6}{4}\right) = 56.3° = 56°$		Accept awrt 56.3

Q.	Scheme	Marks	
2 (a)		B1	
	$T = \frac{30000}{20} \quad (=1500)$	M1	Use of $P = Fv$
	$T - R = 1800a$	A1	Equation of motion. Need all 3 terms. Condone sign errors
	$T - R = 1800 \times 0.4$ $R = 1500 - 1800 \times 0.4$ $= 780$	A1	Equation correct (their T) Only
(b)		M1	
	$T - 1800g\sin\alpha - R = 0$	A1	Equation of motion. Need all 3 terms. Weight must be resolved. Condone cos for sin. Condone sign errors Correct equation. Allow with R not substituted or with their R.
	$T = 1800 \times \frac{1}{12}g + 780$	DM1	
	Power $= \left(1800 \times \frac{1}{12}g + 780\right) \times 20$	A1	Use of $P = Tv$
		A1	Correctly substituted equation (for their R)
	$= 45000$ W or 45 kW		cao

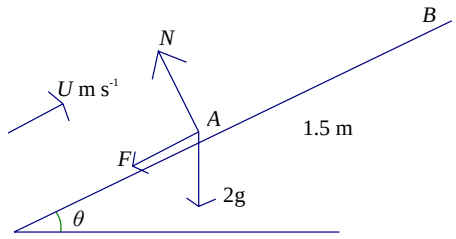
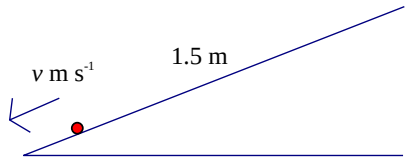
Q	Scheme	Marks	
3			
	$F = \mu N$	B1	Used. Condone an inequality.
	$\mathrm{R}(\uparrow)$ $18g + 60g = N$	M1	Resolve vertically
	$=78g$	A1	
	$\mathrm{R}(\rightarrow)$ $R = F = \mu N$		
P	$2.5 \times 18g\cos\alpha + 3 \times 60g\cos\alpha = 5F\sin\alpha$	M1A2	Moments equation. Condone sign errors. Condone sin/cos confusion
A	$18g \times 2.5\cos\alpha + 60g \times 3\cos\alpha = R \times 5\sin\alpha$		-1 each error
C	$\frac{1}{2}\cos\alpha \times 18g + 3\sin\alpha F + 2\sin\alpha R = 3\cos\alpha N$		
B	$5\cos\alpha N = 5\sin\alpha F + 2.5\cos\alpha \times 18g + 2\cos\alpha \times 60$		
W	$60g \times \frac{1}{2}\cos\alpha + 2.5N\cos\alpha = 2.5R\sin\alpha + 2.5F\sin\alpha$		
	$45\times\frac{3}{5}g + 180\times\frac{3}{5}g = 4R$	DM1	Eliminate α. Dependent on the second M1.
	$R = \frac{135}{4}g$		
	$78g\mu = \frac{135}{4}g$	DM1	Equation in μ only. (Dependent on the first two M marks.)
	$\mu = \frac{135}{4\times 78} = \frac{135}{312} = 0.432... = 0.43$	A1	NB g cancels. 0.43269..., $\frac{225}{520}$, $\frac{45}{104}$, awrt 0.433 Do not accept an inequality.
	NB If use just two moments equations, M1A2 for the better attempt, M1A1 for the other. Remaining marks as above.		
4		B1	

Q	Scheme	Marks	
(a)	$t = \frac{5}{4}$	M1	1.25
(b)	$\mathbf{r} = \left(2t^2 - 5t\right)\mathbf{i} + 3t\mathbf{j}\left(+\mathbf{c}\right)$		Integrate the velocity vector
		A1	NB Also correct to use suvat with $\boldsymbol{a}$ = 4**i** and $\boldsymbol{u}$ = -5**i** + 3**j**.
		DM1	Correct
	$t = 0 \quad 2\mathbf{i} + 5\mathbf{j} = \mathbf{c}$	A1	Use $\mathbf{r}_0$ to find C
	$\mathbf{r} = \left(2t^2 - 5t\right)\mathbf{i} + 3t\mathbf{j} + \left(2\mathbf{i} + 5\mathbf{j}\right)$		oe
	$(2t^2 - 5t + 2)\mathbf{i} + (3t + 5)\mathbf{j}$	B1	
(c)	$\mathbf{r}_Q = 11\mathbf{i} + 2\mathbf{j} - 2t\mathbf{i} + ct\mathbf{j}$		Correct **j** component of $\mathbf{r}_Q$
	$(11 - 2t)\mathbf{i} + (2 + ct)\mathbf{j}$		Do not actually require the whole thing - can answer the Q by considering only the **j** component.
	$\mathbf{r}_P = \left(2t^2 - 5t + 2\right)\mathbf{i} + \left(3t + 5\right)\mathbf{j}$		
	$\mathbf{r}_Q = \mathbf{r}_P = d\mathbf{i} + 14\mathbf{j}$	$2t^2 - 5t$	
	$3t + 5 = 14$	M1	Form an equation in t only
	$t = 3$	A1	
	$2 + ct = 14 \Rightarrow c = 4$	A1 ft	Their t
	$d = 11 - 2 \times 3 = 5$ or		
	$d = 2 \times 3^2 - 5 \times 3 + 2 \Rightarrow d = 5$		Their t
	Alt: $2t^2 - 5t + 2 = 11 - 2t = d \Rightarrow t = \frac{11 - d}{2}$		
	$2\left(\frac{11-d}{2}\right)^2 - 5\left(\frac{11-d}{2}\right) + 2 = d$,		
	$d^2 - 19d + 70 = 0 = (d - 5)(d - 14)$		

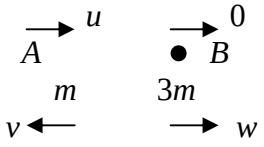
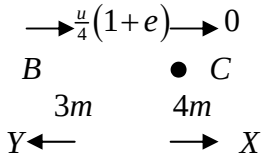
$2t^2 - 3t - 9$

$(2t + 3)(t - 3) = 0$

$t = 3$

Q.	Scheme	Marks	
5			
(a)	$N = 2g\cos\theta = \frac{14}{25}g$	M1	Resolve perpendicular to plane. Condone trig confusion.
	$F = \mu N = \frac{5}{12}\times\frac{14}{25}g = \frac{7g}{30}$	B1	Correct value of F seen or implied
	Work done $= \frac{7}{30}g\times 1.5 = 3.43... = 3.4$ J	DM1	Their F x 1.5
		A1	$\frac{7g}{20}$, 3.4 or 3.43 only
(b)	$3.43 + 2g\sin\theta\times 1.5 = \frac{1}{2}\times 2U^2$	M1	Energy equation - needs all 3 terms, but condone sign errors & trig confusion. Must have an expression for the vertical height.
		A1	Correct with one slip for their WD.
		A1	All correct for their WD
	$U = 5.626.... = 5.6$	A1	5.6 & 5.63 only
(c)			
	$2g\sin\theta\times 1.5 = 3.43 + \frac{1}{2}\times 2v^2$	M1	Energy equation - needs all three terms. Condone sign errors & trig. confusion. Extra terms give M0.
	OR: $\frac{1}{2}\times 2U^2 = 2\times 3.43 + \frac{1}{2}\times 2v^2$	A1	All correct (their WD & U)
	$v^2 = 3g\sin\theta - 3.43$		
	$v = 4.979...$		
	Speed = 5.0 m s^{-1}	A1	Accept 4.98
Alt			
(c)	$mg\sin\theta - F = ma$ and $v^2 = (u^2) + 2as$	M1	Equation of motion - needs all three terms. Condone sign errors & trig. confusion. Together with *suvat*
	$2g\sin\theta - \frac{7g}{30} = \frac{48g}{25} - \frac{7g}{30} = 2a$		
	$a = \frac{253g}{300} = 8.26...$	A1	
	$v^2 = 24.794$, v = 5.0	A1	Accept 4.98

Q.	Scheme	Marks	
6 (a)	$2 = -2u\sin\theta + \frac{1}{2}g\times 4$	M1	Vertical distance. Condone sign errors. Must have used $t = 2$, but could be using $u_y = u\sin\theta$
	$\left(-2 = u\sin\theta t - \frac{1}{2}gt^2\right)$ $u\sin\theta = g - 1$	A1	All correct
	$2u\cos\theta = 8 \quad (u\cos\theta = 4)$ $(u\cos\theta t = 8)$	B1	Horizontal distance. Accept $u_x = 4$ o.e.
	$\tan\theta = \frac{g-1}{4} = 2.2$ *	M1	Divide to obtain expression for $\tan\theta$
		A1	**Given answer** It is acceptable to quote and use the equation for the projectile path. Incorrect equation is 0/5.
(b)	$u\cos\theta = 4$	M1	Use the horizontal distance and θ to find u 9.67 or 9.7
	$u = \frac{4}{\cos\theta} = 9.66... = 9.7$ OR use components from (a) and Pythagoras.	A1	NB $\theta = 65.6°$ leading to 9.68 is an accuracy penalty.
(c)	$6 = (1-g)T + \frac{1}{2}\times 9.8T^2$	M1	Equation for vertical distance $= \pm 6$ to give a quadratic in T. Allow their u_y
	$4.9T^2 - 8.8T - 6 = 0$ $T = \frac{8.8 \pm \sqrt{\left[(-)8.8\right]^2 + 24\times 4.9}}{9.8}$	DM1	Solve a 3 term quadratic
	$T = 2.323... = 2.32$ or 2.3	A1	2.3 or 2.32 only
(d)	$v^2 = 8.8^2 + 2g\times 6$ or v = -8.8+gT	M1	Use *suvat* to find vertical speed
		A1	Correct equation their u_y, T
	$v = 13.96...$ Horiz speed = 4 $\tan\alpha = \frac{v}{4}$	DM1	Correct trig. with their vertical speed to find the required angle.
		A1	Correct equation
	$\alpha = 74.01... = 74°$	A1	$74°$ or $74.0°$. Allow 106.
	Alternative: $\frac{1}{2}m(9.6664)^2 + 6mg = \frac{1}{2}mv^2$	M1	Conservation of energy to find speed
	$v = 14.52719...$	A1	
	$\cos\alpha = \frac{4}{14.5}$	DM1	Correct method for α
		A1	
	$\alpha = 74.01... = 74°$	A1	Allow 106

Q	Scheme	Marks	
7(a)			If the signs on their diagram and in their working are inconsistent, ignore the diagram. Penalise inconsistency between the two equations in the second accuracy mark.
	$mu = -mv + 3mw$	M1	CLM. Allow for v in either direction. Needs all 3 terms. Condone sign errors.
	$u = -v + 3w$	A1	v in either direction. Ignore diagram if equations "correct" but inconsistent with diagram.
	$eu = w + v$	M1	Impact law. Must be the right way round, but condone sign errors
		A1	Correct equation. Signs consistent with CLM equn.
	$w = \frac{u}{4}(1+e)$	DM1	Solve for v or w.
		A1	One correct
	$v = -w + eu = \frac{u}{4}(3e-1)$	A1	Both correct. $1-3e \rightarrow$ A0 for v
(b)			If the signs on their diagram and in their working are inconsistent, ignore the diagram. Penalise inconsistency between the two equations in the B mark.
	$3mw = 4mX - 3mY$	M1	CLM for their w.
		A1ft	Correct unsimplified (their w)
	$2ew = X + Y$	B1ft	Impact law. Must be the right way up. Their w
	$7Y = W(8e-3)$	DM1	Solve for (7)Y
	Or $2ue(1+e) - \frac{3u}{4}(1+e) = 7Y$		
	$\rightarrow e > \frac{3}{8}$	A1	
	$Y > 0 \rightarrow \frac{3}{8} < e \leq \frac{1}{2}$	A1	NB No longer ft. Condone <.
(c)	$\frac{u}{28}(1+e)(8e-3) > \frac{u}{4}(3e-1)$	M1	For a second collision their Y > their v
	$2e^2 - 4e + 1 > 0$		
	$e = \frac{4 \pm \sqrt{16-8}}{4} = 1.707,\ 0.293$	DM1	Obtain the critical values
	$2e^2 - 4e + 1 < 0$ for $\frac{3}{8} < e \leq \frac{1}{2}$ so no second collision.	A1	Compare 0.293 (o.e.) with $\frac{3}{8}$ to reach correct conclusion for correct reason.

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Mark Scheme (Results)

Summer 2013

GCE Mechanics 2 (6678/01R)

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Summer 2013
Publications Code UA036424

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes:

- bod – benefit of doubt
- ft – follow through
- the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- $*$ The answer is printed on the paper
- ⌐ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

8. In some instances, the mark distributions (e.g. M1, B1 and A1) printed on the candidate's response may differ from the final mark scheme.

General Rules for Marking Mechanics

- Usual rules for M marks: correct no. of terms; dim correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.

- Omission or extra g in a resolution is accuracy error not method error.

- Omission of mass from a resolution is method error.

- Omission of a length from a moments equation is a method error.

- Omission of units or incorrect units is not (usually) counted as an accuracy error.

- DM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.

- Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.

- Use of g = 9.81 should be penalised once per (complete) question.

- N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *ONCE* per complete question.

- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.

- Accept column vectors in all cases.

- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft.

Question Number	Scheme	Marks	Notes
1.			
(a)	$F - 150 - 300 = 1500$ x 0.2	M1	Needs total mass and both resistances. Condone sign errors
		A1	Correct unsimplified equation
	$F = 750$	A1	
	$P = 750$ x 20 =15000 watts	M1	Independent M. 20 x their driving force
		A1	
		(5)	
(b)	Use their mass as a guide to which of these two alternatives is being used.		
	For caravan: $T - 150 = 600$ x 0.2	M1	Requires all forces acting on caravan. Condone sign error(s)
	$T = 270$ N	A1 **(2)**	
Or (b)	For car: $F - T - 300 = 900$ x 0.2	M1	Requires all forces acting on car. Condone sign error(s)
	$T = 270$ N	A1 **(2)**	
		[7]	

Question Number	Scheme	Marks	Notes
2.	NB This question tells candidates to use work-energy - suvat approach scores 0/6		
	1.24×8; $0.2g \times 8$; $\frac{1}{2}0.2.20^2$ or $\frac{1}{2}0.2.v^2$	B1;B1;B1	B1 for each term seen or implied 9.92, 15.68, 40 or $0.1v^2$
	$1.24 \times 8 = \frac{1}{2}0.2.20^2 - \frac{1}{2}0.2.v^2 - 0.2g \times 8$	M1	Condone sign errors but all terms should be present
		A1	Correct equation
	$v = 12$	A1	
		(6)	
		[6]	

Question Number	Scheme	Marks	Notes
3.			
(a)	$\frac{1}{2}t^2 - 3t + 4 = 0$	M1	Set $v = 0$
	$t^2 - 6t + 8 = 0$		
	$(t-2)(t-4) = 0$	DM1	Solve for v
	$t = 2$ s *or* 4 s	A1 A1	
		(4)	
(b)	$\int \frac{1}{2}t^2 - 3t + 4 \mathrm{d}t$	M1	Integration – majority of powers increasing
	$= \frac{1}{6}t^3 - \frac{3}{2}t^2 + 4t(+C)$	A1	Correct (+C not required)
	$s = \int_0^2 \frac{1}{2}t^2 - 3t + 4 \ \mathrm{d}t - \int_2^4 \frac{1}{2}t^2 - 3t + 4 \ \mathrm{d}t$	DM1	Correct strategy for finging the required distance. Follow their "2". Subtraction/swap limits/modulus signs
	$= \left[\frac{1}{6}t^3 - \frac{3}{2}t^2 + 4t\right]_0^2 - \left[\frac{1}{6}t^3 - \frac{3}{2}t^2 + 4t\right]_2^4$		
	$= \frac{8}{6} - 6 + 8 - (\frac{64}{6} - 24 + 16 - (\frac{8}{6} - 6 + 8))$	A1	Correct unsimplified
	$= \frac{10}{3} - \frac{8}{3} + \frac{10}{3}$		
	$= 4$	A1	
		(5)	
		[9]	

Question Number	Scheme	Marks	Notes
4.			
(a)	$AC = 4a\tan 60^o = 4a\sqrt{3}.$	M1 A1	Or $\frac{4a}{\tan 30}$ or $\sqrt{(8a)^2-(4a)^2}$
		(2)	
(b)	use of $F = \mu R$ at either A or C	M1	
	3 independent equations required. Award M1A1 for each in the order seen. If more than 3 relevant equations seen, award the marks for the best 3.		
	$M(A)$, $R_C.4a\sqrt{3} = W.3a\sqrt{3}\cos 60^o$	M1 A1	$R_C = \frac{3W}{8}$
	$(\uparrow)$, $R_A + R_C\cos 60^o + F_C\cos 30^o = W$	M1 A1	$R_A = \frac{5W}{8}$
	$(\rightarrow)$, $F_A - R_C\cos 30^o + F_C\cos 60^o = 0$	M1 A1	$F_A = R_C\frac{\sqrt{3}}{3}$
	M(C) $a\sqrt{3}\cos 60W + F_A.4a\sqrt{3}\sin 60 = R_A.4a\sqrt{3}\cos 60$		
	Parallel: $F_A\cos 60 + R_A\cos 30 + F_C = W\cos 30$		
	Perpendicular: $R_C + R_A\cos 60 = F_A\cos 30 + W\cos 60$		
	solving to give $\mu = \frac{\sqrt{3}}{5}$; 0.346 or 0.35.	DM1 A1	Equation in μ only. Dependent on 4 M marks for their equations.
	Reactions in the wrong direction(s) – check carefully		
		(9)	
		[11]	

Question Number	Scheme	Marks	Notes
5. (a)	$2mu = 2mv_P + mv_Q$	M1	CLM. Needs all 3 terms of corrwct form but condone sign slips
		A1	Correct equation
	$\frac{3}{4}mu^2 = \frac{1}{2}2mv_P^2 + \frac{1}{2}mv_Q^2$	M1	KE after impact. 3 terms of correct form
		A1	Correct equation
	$3v_Q^2 - 4uv_Q + u^2 = 0$ or $12v_P^2 - 16uv_P + 5u^2 = 0$	M1	Use CLM equation to form quadratic in v_P or v_Q
		A1	Correct equation
	$v_Q = \frac{u}{3}$, $v_P = \frac{5u}{6}$ or $v_Q = u, v_P = \frac{u}{2}$	DM1	Solve for a value of v_Q. Dependent on the previous M1.
		A1	A v_Q, v_P pair correct or two correct values for v_Q
	$v_Q = u$	DM1	Select solution from a choice of two. Dependent on all 4 M marks.
	..... since $v_Q > v_P$	A1	Correct justification
		(10)	
(b)	$e = \frac{u - \frac{u}{2}}{u}$ $\left(\frac{v_Q - v_P}{u}\right)$	M1	Impact law. Must be used correctly. Condone $\pm e$ Follow their speeds from (a).
		A1 ft	Correct for their speeds
	$= \frac{1}{2}$	A1	
		(3)	
		[13]	

Question Number	Scheme	Marks	Notes
6. (a)	*ABC* *ADE* *BCED*		
	M $\frac{4M}{9}$ $\frac{5M}{9}$	B1	Correct mass ratios
	$\frac{h}{3}$ $(\frac{h}{3}+\frac{1}{3}\frac{2h}{3})$ $\bar{y}$	B1	Correct distance ratios
		M1	Moments equation. Condone sign slip
	$M\frac{h}{3}-\frac{4M}{9}\frac{5h}{9}=\frac{5M}{9}\bar{y}$	A1	
	$\bar{y}=\frac{7h}{45}$ ***Answer Given***	A1 **(5)**	
(b)		M1	Moments equation for the folded shape. Requires correct mass ratios, and terms of correct structure.
	$\frac{5M}{9}\frac{7h}{45}+\frac{4M}{9}\left(\frac{h}{3}-\frac{1}{3}\times\frac{2h}{3}\right)=M\bar{x}$	A1 A1	-1 each error $\frac{h}{9}$
	$\bar{x}=\frac{11h}{81}$	A1 **(4)**	
(c)	$\tan\alpha=\frac{\frac{h}{3}-\bar{x}}{\frac{2a}{3}}$	M1 A1 ft	Use of tan in correct triangle. Allow reciprocal. Correct unsimplified for their $\bar{x}$
	$=\frac{8h}{27a}$	DM1 A1	Substitute and simplify
		(4)	
		[13]	

Question Number	Scheme	Marks	Notes
7. (a)	$(\rightarrow)\sqrt{27ag}\cos\theta.\ t = 9a$	M1	Horizontal motion. Condone trig confusion.
		A1	
	$(\uparrow)\sqrt{27ag}\sin\theta.\ t - \frac{1}{2}gt^2 = 6a$	M1	Vertical motion. Condone sign errors and trig confusion.
		A1	
	$(\uparrow)\sqrt{27ag}\sin\theta.\ \dfrac{9a}{\sqrt{27ag}\cos\theta} - \frac{1}{2}g\left(\dfrac{9a}{\sqrt{27ag}\cos\theta}\right)^2 = 6a$	DM1	Substitute for t (unsimplified). Dependent on both previous M marks
	$9a\tan\theta - \frac{1}{2}g.81a^2\dfrac{(1+\tan^2\theta)}{27ag} = 6a$	DM1	Express all trig terms in terms of tan. Dependent on preceding M.
	$\tan^2\theta - 6\tan\theta + 5 = 0$	A1 **(7)**	
(b)	$\tan^2\theta - 6\tan\theta + 5 = 0$		
	$(\tan\theta - 1)(\tan\theta - 5) = 0$	M1	Method to find one root of the quadratic
	$\tan\theta_2 = 1$ or $\tan\theta_1 = 5$	A1 A1 **(3)**	
(c)	$t = \dfrac{9a}{\sqrt{27ag}\cos\theta} = \dfrac{9a}{\sqrt{27ag}} \times \dfrac{\sqrt{26}}{1}$	M1 A1ft	Use $\tan\theta$ = their 5 to find t. Correct unsimplified. Correct $\cos\theta$ for their $\tan\theta$
	$= \sqrt{\dfrac{81a^2.26}{27a}} = \sqrt{\dfrac{78a}{g}}$ * **Answer given***	A1 **(3)**	Given answer →evidence of working is required

Question Number	Scheme	Marks	Notes
Question 7 continued...			
(d)	$\frac{1}{2}m(27ag - v^2) = mg6a$	M1 A1	Conservation of energy. Requires all 3 terms. Condone sign error Correct equation
	$v = \sqrt{15ag}$	A1 **(3)**	
Or (d)	$v^2 = \left(\sqrt{27ag}\cos\theta\right)^2 + \left(\sqrt{27ag}\sin\theta - g.\sqrt{\frac{78a}{g}}\right)^2$	M1	Horizontal and vertical components and Pythagoras. Condone trig confusion.
	$= \left(\frac{27ag}{26}\right) + \left(5\sqrt{\frac{27ag}{26}} - \sqrt{78ag}\right)^2 \left(= ag\left(\frac{27}{26} + \frac{363}{26}\right)\right)$	A1	Correctly substituted
	$v = \sqrt{15ag}$	A1 **(3)**	
		[16]	

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Mark Scheme (Results)

Summer 2013

GCE Mechanics 2 (6678/01)

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Summer 2013
Publications Code UA036421

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes:

- bod – benefit of doubt
- ft – follow through
- the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- * The answer is printed on the paper
- ⌐ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

8. In some instances, the mark distributions (e.g. M1, B1 and A1) printed on the candidate's response may differ from the final mark scheme

General Rules for Marking Mechanics

- Usual rules for M marks: correct no. of terms; dim correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.

- Omission or extra g in a resolution is accuracy error not method error.

- Omission of mass from a resolution is method error.

- Omission of a length from a moments equation is a method error.

- Omission of units or incorrect units is not (usually) counted as an accuracy error.

- DM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.

- Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.

- Use of g = 9.81 should be penalised once per (complete) question.

- N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *ONCE* per complete question.

- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.

- Accept column vectors in all cases.

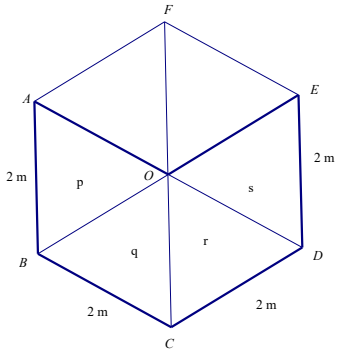
- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft.

Question Number	Scheme	Marks	Notes
1.	Use of **I** = m**v**-m**u**	M1	Must be subtracting. Condone subtraction in the wrong order
	$2\mathbf{v} = (3\mathbf{i} + 6\mathbf{j}) + 2(\mathbf{i} - 4\mathbf{j})$	A1	Correct unsimplified equation (= 5**i** – 2**j)**
	$\mathbf{v} = 2.5\mathbf{i} - \mathbf{j}$	A1	
	Speed = $\sqrt{2.5^2 + 1^2} = \sqrt{7.25} (= 2.69 (\text{m s}^{-1}))$	M1 A1 [5]	Use of correct Pythagoras with their **v** Exact form or 2s.f. or better. Watch out for fortuitous answers from 2.5**i** + **j.**

Question Number	Scheme	Marks	Notes
2a	Work done = $15\mu R = 15\times 0.4\times 3g\cos 20°$ $= 18g\cos 20 = 166\,(\text{J})$	M1 M1 A1 [3]	$F_{\max} = \mu\times 3g\cos 20\,(11.05)$. R must be resolved but condone trig confusion. $15\times$ their $F_{\max}$. Independent M $15\times\ F_{\max}+.....$ is M0 or 170 (J)
2b	Energy: WD against F + GPE + final KE = initial KE their WD $+ 3g\sin 20°\times 15 + \frac{1}{2}3v^2 = \frac{1}{2}3\times 20^2$ $v = 13.7\,(\text{m s}^{-1})$	 M1A2ft A1 [4]	Must include all four correct terms (including resolving). Condone sign errors and trig confusion. Any sign errors in the KE terms count as a single error. Follow their WD -1ee Follow their WD or 14
Or 2b	$3a = -\ 0.4\times 3g\cos 20 + 3g\sin 20$ and use of $v^2 = u^2 + 2as$ $v^2 = 20^2 + 2\times a\times 15 (= 188.93...)$ $v = 13.7\,(\text{m s}^{-1})$	M1 A1ft A1ft A1 [4]	Complete method. Their $F_{\max}$ +component of weight A correct equation with their $F_{\max}$. Allow for $a = +7.03...$ acting down the slope $a = -7.035....$ Correct equation for their a or 14 (m s^{-1})

Question Number	Scheme	Marks	Notes
3a	$v = 0 = 2t^2 - 14t + 20$ $= 2\ t - 2\quad t - 5$ $t = 2$ or $t = 5$	M1 M1 A1 [3]	Set $v = 0$ Solve for t
	There are many different approaches to part (b). The allocation of the two M marks is M1: A method to find the time when the velocity is a minimum M1: Evaluate the speed at that time		
e.g. b	$t = 0$, $v = 20$ (m s^{-1}) $a = 4t - 14 = 0$ $t = \frac{7}{2}$, $v = 2 \times \frac{3}{2} \times \frac{-3}{2} = \frac{-9}{2}$ Max speed = 20 ms^{-1}	B1 M1 M1A1 A1 [5]	 Must see ± 4.5 Clearly stated & correct conclusion. Depends on the two M marks. From correct solution only.
balt1	$t = 0$, $v = 20$ (m s^{-1}) Sketch with symmetry about their $t = 3.5$ v(their 3.5) -4.5 Max speed = 20 ms^{-1}	B1 M1 M1 A1 A1 [5]	 Evaluate v at min. Correct work Clearly stated & correct conclusion. Depends on the two M marks. From correct solution only.
b alt 2	$t = 0$, $v = 20$ (m s^{-1}) Justification of minimum or tabulate sufficient values to confirm location Evaluate v at min. Correct work Correct conclusion. Depends on the two M marks	B1 M1 M1 A1 A1 [5]	 Clearly stated & from correct solution only.

Question Number	Scheme	Marks	Notes
b alt 3	$t = 0$, $v = 20$ (m s^{-1})	B1	
	Complete the square as far as $\left(t - \frac{7}{2}\right)^2$	M1	
	$2\left(t - \frac{7}{2}\right)^2 - \frac{9}{2}$	M1A1	
	Max speed = 20 ms^{-1}	A1 [5]	Clearly stated & correct conclusion. Depends on the two M marks. From correct solution only.
c	$\int 2t^2 - 14t + 20 \, \mathrm{d}t = \frac{2}{3}t^3 - 7t^2 + 20t (+C)$	M1 A1	Integration. Need to see majority of powers going up All correct. Condone *C* missing
	Distance = $\left[\frac{2}{3}t^3 - 7t^2 + 20t\right]_0^2 - \left[\frac{2}{3}t^3 - 7t^2 + 20t\right]_2^4$	M1 A1	Correct method to find the distance, for their 2 Correct unsimplified
	$= 2 \times \left[\frac{2}{3}t^3 - 7t^2 + 20t\right]^2 - \left[\frac{2}{3}t^3 - 7t^2 + 20t\right]_4$ $= 2\left[\frac{16}{3} - 7 \times 4 + 40\right] - \left[\frac{2 \times 64}{3} - 7 \times 16 + 80\right] = 24$ (m)	A1 [5]	

Question Number	Scheme	Marks	Notes
4a	 | *AOCB* | OCDE | whole | | 1 | 1 | 2 | | 1/2 | 1/2 | $\bar{y}$ | $2\bar{y} = 1\times\frac{1}{2} + 1\times\frac{1}{2}$ $\bar{y} = 0.5$ (m)	B1 B1 M1 A1 A1 [5]	For a valid division into basic elements: e.g. pair of rhombuses Correct mass ratios for parts and the arrow shape Correct vertical distances from a horizontal axis Moments equation about a horizontal axis Correct equation for their axis
a alt 2	| AOB | OBCD | DOE | whole | | 1 | 2 | 1 | 4 | | 0 | 1 | 0 | $\bar{y}$ | $4\bar{y} = 2\times1$ $\bar{y} = 0.5$ (m)	B1 B1 M1A1 A1 [5]	Rhombus + two triangles Moments equation

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th><th>Notes</th></tr>
<tr><td>a alt 3</td><td>
<table>
<tr><td>Hexagon</td><td>AOEF</td><td>whole</td></tr>
<tr><td>6</td><td>2</td><td>4</td></tr>
<tr><td>0</td><td>-1</td><td>$\bar{y}$</td></tr>
</table>
$4\bar{y} = 0 - \ -2\times 1$

$\bar{y} = 0.5$ (m)
</td><td>B1
B1

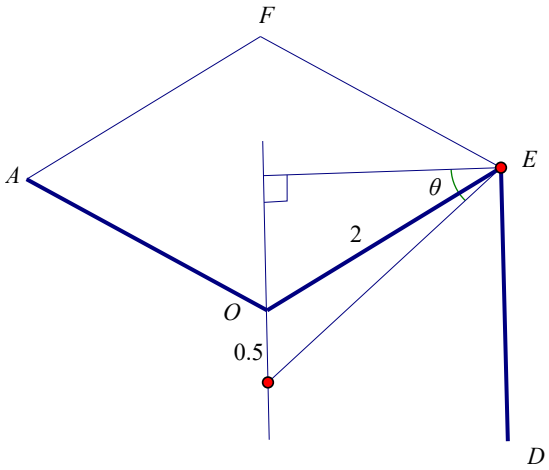
M1A1
A1
[5]</td><td>Hexagon – rhombus</td></tr>
<tr><td>a alt 4</td><td>
h = height of each triangle = $\sqrt{3}$

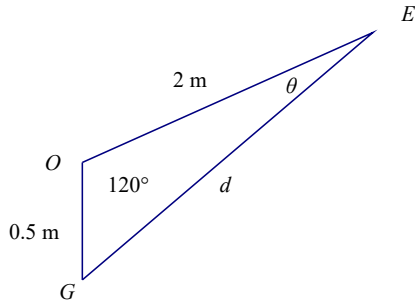
Distances of c of m from horizontal through O

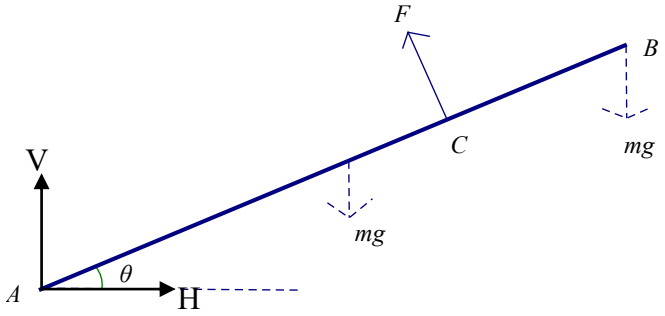
<table>
<tr><td>p</td><td>q</td><td>r</td><td>s</td><td>whole</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td><td>4</td></tr>
<tr><td>0</td><td>$\frac{2}{3}h\cos 30$</td><td>$\frac{2}{3}h\cos 30$</td><td>0</td><td>$\bar{y}$</td></tr>
</table>
$4\bar{y} = 2\times 1\times \frac{2\sqrt{3}}{3}\cos 30 \left(= \frac{4\sqrt{3}}{3}\times \frac{\sqrt{3}}{2} = 2 \right)$

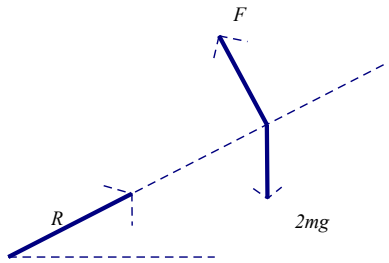
$\bar{y} = 0.5$ (m)
</td><td>B1
B1

M1A1
A1
[5]</td><td>4 triangles</td></tr>
</table>

Question Number	Scheme	Marks	Notes
4b	In 4(b) the first two marks are M1: Indentify a triangle, with one angle correct, and attempt to find the lengths of two sides A1ft: 2 sides correct, follow their answer to (a) DM1: Work sufficient to be able to go on to find the required angle. Dependent on the preceding M1 A1ft: follow their answer to (a) DM1: Find the required angle. Dependent on the preceding M1 A1 Correct answer …. for example ……  		
	$2\cos 30 = \sqrt{3}$, "0.5" + $2\sin 30 = 1.5$	M1A1ft	Their 0.5 & their √3
	$\tan\theta = \dfrac{\text{their } 1.5}{\text{their } \sqrt{3}}$	DM1	Use of tan in a right angled triangle. Accept the reciprocal
		A1ft	Correct for their angle. Ft their 0.5
	Required angle = $\theta - 30 = \tan^{-1}\dfrac{1.5}{\sqrt{3}} - 30 = 40.89... - 30 = 10.9°$	DM1	Correct strategy to find required angle e.g. "θ" − 30° or 90° − 30° − "θ"
		A1 [6]	Accept 11° , 10.9° or better

Question Number 4balt	Scheme	Marks	Notes
			
	SAS in a relevant triangle	M1A1ft	Their 0.5
	$d^2 = 2^2 + 0.5^2 - 2\times 2\times 0.5\cos 120 = 5.25$	DM1 A1ft	Correct cosine rule. Correct equation. Their 0.5
	$\frac{\sin\theta}{0.5} = \frac{\sin 120}{\sqrt{5.25}}$	DM1	
	$\theta = 10.9°$	A1 [6]	

Question Number	Scheme	Marks	Notes
5a	 Moments about A:	M1	Moments about A. Requires all three terms and terms of correct structure (force x distance). Condone consistent trig confusion
	$bF = a\cos\theta mg + 2a\cos\theta mg (= 3a\cos\theta mg)$	A2	-1 each error
	$F = \dfrac{3amg\cos\theta}{b}$ ***Answer given***	A1 [4]	
5b	$\rightarrow: \quad H = F\sin\theta = \dfrac{3amg\cos\theta\sin\theta}{b}$	M1 A1	Resolve horizontally. Condone trig confusion RHS correct. Or equivalent.
	$\uparrow: \quad 2mg = \pm V + F\cos\theta$	M1 A1	Resolve vertically. Condone sign error and trig confusion Correct equation
	$\pm V = 2mg - \dfrac{3amg\cos\theta}{b} \times \cos\theta \left(= 2mg - \dfrac{3amg\cos^2\theta}{b} \right)$	A1 [5]	RHS correct. Or equivalent

Question Number	Scheme	Marks	Notes
5c	$\dfrac{2mg-\dfrac{3amg\cos^2\theta}{b}}{\dfrac{3amg\cos\theta\sin\theta}{b}}=\tan\theta$ $\dfrac{2b-3a\cos^2\theta}{3a\cos\theta\sin\theta}=\dfrac{\sin\theta}{\cos\theta}$ $\Rightarrow 2b-3a\cos^2\theta=3a\sin^2\theta\Rightarrow 2b=3a,\ \dfrac{a}{b}=\dfrac{2}{3}$	M1 A1 DM1 A1 [4]	Use of tan, either way up. *V*, *H*, *F* substituted. Correct for their components in θ only Simplify to obtain the ratio of a and b, or equivalent
5c alt 2	The centre of mass of the combined rod + particle is $\dfrac{3}{2}a$ from *A*  3 forces in equilibrium must be concurrent $\Rightarrow b=\dfrac{3}{2}a$ $\Rightarrow \dfrac{a}{b}=\dfrac{2}{3}$	M1A1 M1 A1 [4]	 Not on the spec, but you might see it.
alt c 3	*R* acts along the rod, so resolve forces perpendicular to the rod. $F=mg\cos\theta+mg\cos\theta$ $2mg\cos\theta=\dfrac{3amg\cos\theta}{b}$ $\Rightarrow \dfrac{a}{b}=\dfrac{2}{3}$	M1 A1 DM1 A1 [4]	Resolve and substitute for *F* Eliminate θ

Question Number	Scheme	Marks	Notes
alt c 4	R acts along the rod. Take moments about C $mg\cos\theta\ \ 2a-b\ \ = mg\cos\theta\ \ b-a$ $2a-b=b-a,\quad \Rightarrow \frac{a}{b}=\frac{2}{3}$	M1 A1 DM1A1 [4]	Moments about B gives $2a-b\ \ F = amg\cos\theta$ and substitute for F
c alt 5	Resultant parallel to the rod $\Rightarrow R = 2mg\sin\theta$ And $V^2+H^2=R^2$ $2mg\sin\theta\ ^2 = \left(\frac{3amg\cos\theta\sin\theta}{b}\right)^2 + \left(2mg-\frac{3amg\cos^2\theta}{b}\right)^2$ Eliminate θ $\Rightarrow \frac{a}{b}=\frac{2}{3}$	M1 A1 DM1 A1 [4]	Substitute for V, H and R in terms of θ

Question Number	Scheme	Marks	Notes
6a	Conservation of energy: $\frac{1}{2}mu^2 + mg \times 8 = \frac{1}{2}m\ \ 2u\ ^2$ $mu^2 + 16mg = 4mu^2$ $16mg = 3mu^2, \quad u = \sqrt{\frac{16g}{3}}$ $u = 7.2$	M1 A2 -1ee DM1 A1 [5]	Energy equation must contain the correct terms, but condone sign error. Correct unsimplified Solve for u Accept 7.23. Accept $\sqrt{\frac{16g}{3}}$
6b	Vertical distance: $-8 = u\sin\theta \times 2 - \frac{g}{2} \times 4$ $\sin\theta = \frac{2g-8}{2u} = 0.802...$ $\theta = 53.3°$	M1 A2 -1ee A1 [4]	Condone sign errors or trig error. u must be resolved. Correct equation for their u. or 53°
6c	Min speed at max height, i.e. $u\cos\theta$ $= 4.3$ (m s^{-1})	M1 A1 [2]	Condone consistent trig confusion with part (b) or 4.32 (ms^{-1})

Question Number	Scheme	Marks	Notes
7a	CLM: $2mu = 2mv + 3mw$ Impact: $w - v = eu$ Subst $v = w - eu$: $2u = 2\ w - eu\ + 3w = 5w - 2eu$ $w = \frac{2}{5}\ 1 + e\ u$ ***Answer Given***	M1 A1 M1 A1 DM1 A1 (6)	All three terms required, but condone sign errors Condone sign error, but must be subtracting and e must be used correctly. Penalise inconsistent signs here. Solve for w. Requires the two preceding M marks
7b	$w = \frac{7u}{10}$ CLM: $3mw = 3mx + 4my$ and Impact: $y - x = \frac{3w}{4}$ Subst: $3w = 3x + 4\left(x + \frac{3}{4}w\right)$ $x = 0$, $y = \frac{3}{4}w = \frac{21}{40}u$	B1 M1A1 DM1 A1 A1 (6)	Seen, or implied by correct speeds. Both needed Solve for x or y. Dependent on the preceding M mark $0.525u$,
7c	$v = -\frac{u}{20}$ Speed of separation = $\frac{u}{20} + \frac{21u}{40} = \frac{23u}{40}$	B1 M1 A1 (3) [15]	Correct velocity of P Correct use of their values and substitute for e. Check directions carefully $0.575u$

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