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Mark Scheme (Results)
January 2011

GCE

GCE Mechanics M2 (6678) Paper 1

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Publications Code UA026580

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
   - $\sqsubset$ The second mark is dependent on gaining the first mark

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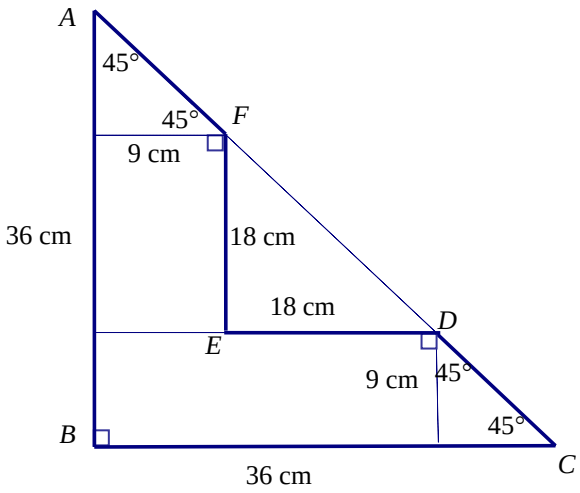
Mechanics M2 6678
Mark Scheme

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

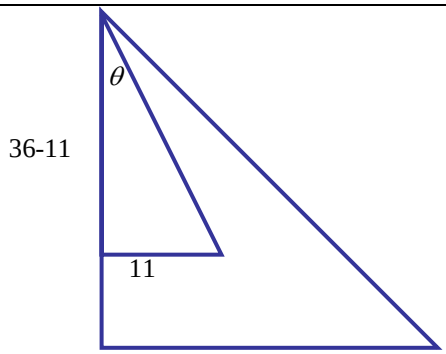
Alternative:

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)



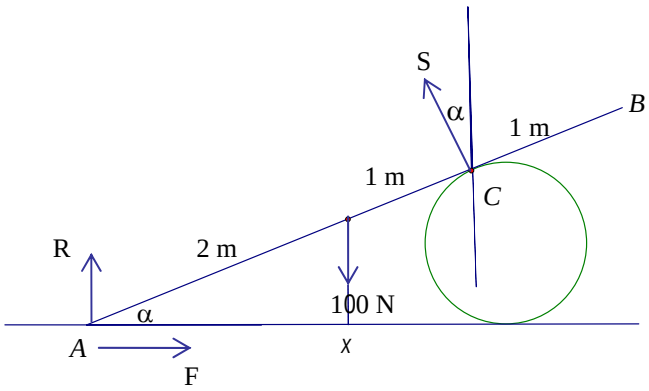
$\tan\theta=\frac{\bar{x}}{36-\bar{y}}$ M1

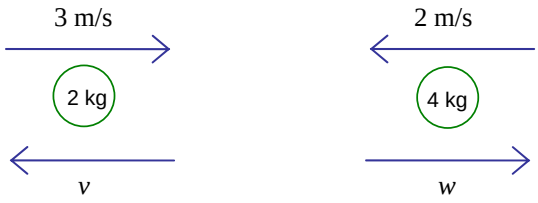
$\tan\theta=\frac{11}{25}=0.44$ A1ft

$\theta=24°$ 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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Order Code UA026580 January 2011

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