

Mark Scheme (Results)

January 2011

GCE

GCE Mechanics M2 (6678) Paper 1

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Publications Code UA026580

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

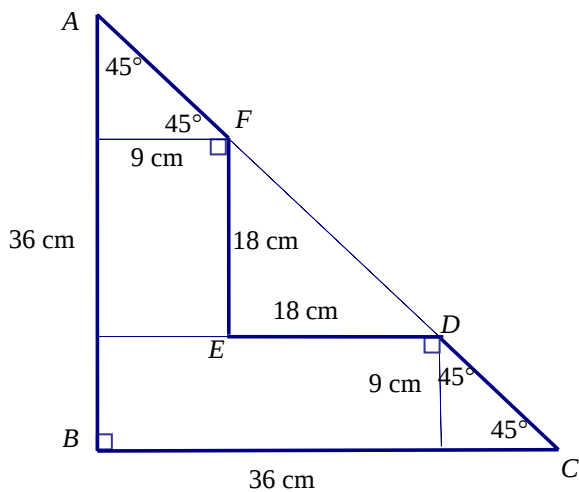
January 2011
Mechanics M2 6678
Mark Scheme

Question Number	Scheme	Marks
1.		
(a)	Constant speed $\Rightarrow$ Driving force = resistance , $F = 32$. $P = F \times v = 32v = 384$ $v = 12 \text{ (ms}^{-1}\text{)}$	B1 M1 A1 (3)
(b)	$P = F \times v \Rightarrow 384 = F \times 9, F = \frac{384}{9}$ Their $F - 32 = 120a$, $a = 0.089 \text{ (ms}^{-2}\text{)}$	M1 M1 A1 (3) [6]
2.		
	$\mathbf{I} = (-6\mathbf{i} + 8\mathbf{j}) = 2(\mathbf{v} - (5\mathbf{i} + \mathbf{j}))$ $-3\mathbf{i} + 4\mathbf{j} = \mathbf{v} - 5\mathbf{i} - \mathbf{j}$ $\mathbf{v} = 2\mathbf{i} + 5\mathbf{j}$ $\text{KE} = \frac{1}{2} \times 2 \times \mathbf{v} ^2 = (\sqrt{2^2 + 5^2})^2 = 29 \text{ (J)}$	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 $v = t^4 - 6t^2 + 8 \text{ (ms}^{-1}\text{)}$.	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 = $50 \times \mu R$ $= 50 \times \frac{1}{4} \times 30 \cos 20^\circ \times 9.8$ Gain in GPE = $30 \times 9.8 \times 50 \sin 20^\circ$ Total work done = WD against Friction + gain in GPE $= 8480(\text{J}), 8500(\text{J})$	M1 A1 M1 A1 DM1 A1 (6)
(b)	Loss in GPE = WD against friction + gain in KE 3 terms $30 \times 9.8 \times 50 \sin 20^\circ = 50 \times \frac{1}{4} \times 30 \times 9.8 \times \cos 20^\circ + \frac{1}{2} \times 30 \times v^2$ -1 ee $\frac{1}{2} v^2 = 50 \times 9.8 \times (\sin 20^\circ - \frac{1}{4} \cos 20^\circ),$ $v = 10.2 \text{ m s}^{-1}.$	M1 A2,1,0 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
Centres of mass

B1
B1

Take moments about AB:

$$6 \times 13.5 + 1 \times 30 + 4 \times 4.5 + 1 \times 3 = 132 = 12\bar{x},$$

$$\bar{x} = 11(\text{cm}) \text{ solve for } x \text{ (or } y) \text{ co-ord}$$

$$\bar{y} = 11(\text{cm}) \text{ using the symmetry}$$

M1
A(2,1,0)

A1
B1ft

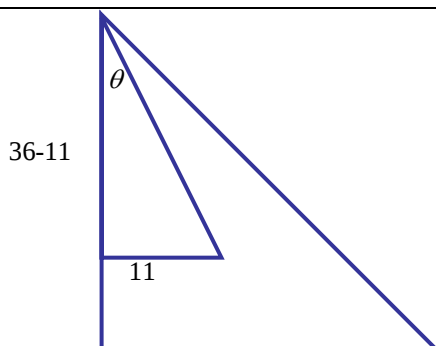
Alternative:

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

$$\frac{1}{2} \times 36 \times 36 \times 12 - \frac{1}{2} \times 18 \times 18 \times 15 = \frac{1}{2} (36 \times 36 - 18 \times 18) \bar{x} \text{ etc.}$$

(7)

(b)



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

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

$$\theta = 24^\circ$$

M1

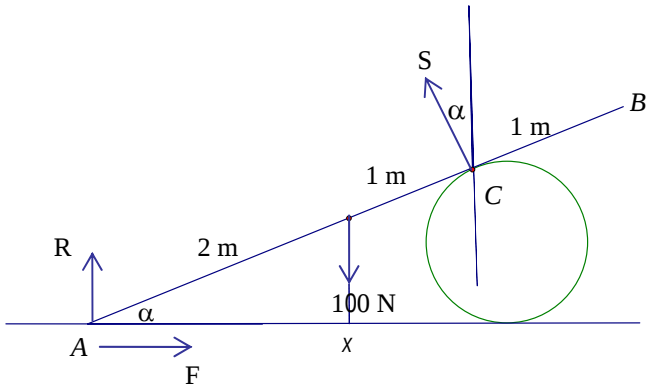
A1ft

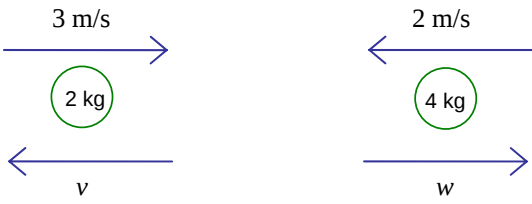
A1

(3)

[10]

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

Question Number	Scheme	Marks
7.	 Taking moments about A: $3S = 100 \times 2 \times \cos \alpha$ Resolving vertically: $R + S \cos \alpha = 100$ Resolving horizontally: $S \sin \alpha = F$ (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). $\left(S = \frac{200\sqrt{8}}{9} \right), R = 100 - \frac{1600}{27} = \frac{1100}{27} \approx 40.74, F = \frac{200\sqrt{8}}{27} \approx 20.95...$ $F \leq \mu R, 200\sqrt{8} \leq \mu \times 1100, \mu \geq \frac{200\sqrt{8}}{1100} = \frac{2\sqrt{8}}{11}.$ Least possible μ is 0.514 (3sf), or exact.	M1 A1 M1 A1 M1 A1 DM1 A1 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: $v = 1/3 \times 6 = 2$ 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: $v + w = \frac{1}{3}(2 + 3)$ their "2" $v = \frac{5}{3} - w$ Solve for w: $-2 = 4w - 2(\frac{5}{3} - w) = 6w - \frac{10}{3}$ $\frac{4}{3} = 6w$ $(w = 4/18 = 2/9 \text{ m s}^{-1})$ $w > 0 \Rightarrow$ will collide with the wall again	M1A1ft M1A1ft DM1 A1 A1 (7) [13]

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