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# Mark Scheme (Results)
# January 2011

GCE

## GCE Mechanics M2 (6678) Paper 1

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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.

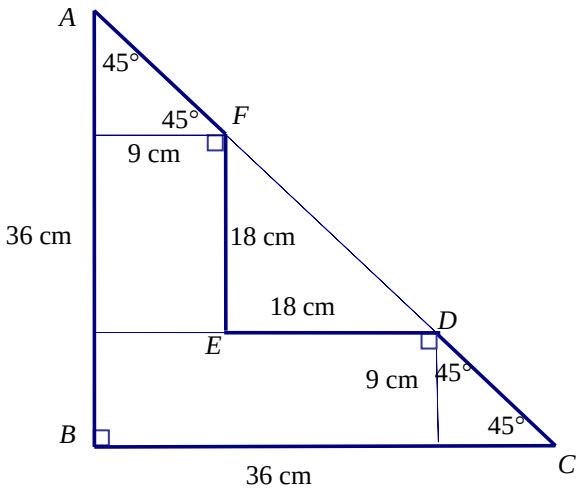
   - bod – benefit of doubt
   - ft – follow through
   - the symbol $\surd$ will be used for correct ft
   - cao – correct answer only
   - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
   - isw – ignore subsequent working
   - awrt – answers which 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

# January 2011
# Mechanics M2 6678
# Mark Scheme

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

| Question Number | Scheme | Marks |
|---|---|---|
| **4.** **(a)** | Work done against friction $= 50 \times \mu R$<br>$= 50 \times ¼ \times 30\cos 20° \times 9.8$ | M1<br>A1 |
| | Gain in GPE $= 30 \times 9.8 \times 50 \sin 20°$ | M1 A1 |
| | Total work done = WD against Friction + gain in GPE<br>$= 8480(\text{J}),\ 8500(\text{J})$ | DM1<br>A1<br>(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 |
| | $½\ v^2 = 50 \times 9.8 \times (\sin 20° - ¼\cos 20°)$,<br>$v = 10.2\ \text{m s}^{-1}$. | DM1<br>A1<br>(5)<br>**[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

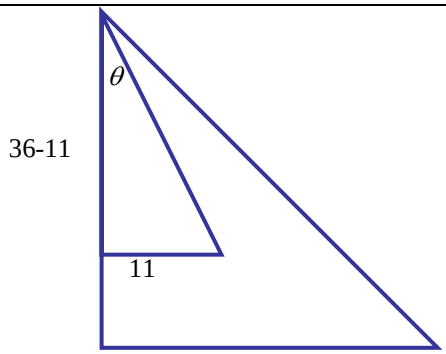
Alternative:

| 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)**



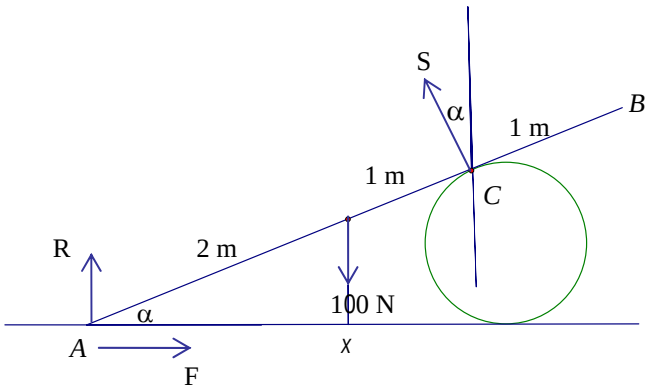

$\tan\theta=\frac{\bar{x}}{36-\bar{y}}$ M1

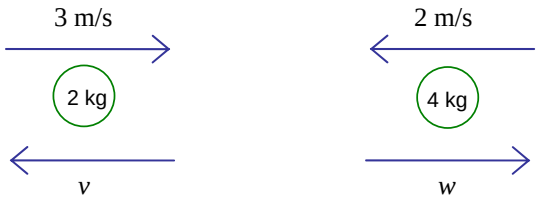
$\tan\theta=\frac{11}{25}=0.44$ A1ft

$\theta=24°$ A1

(3)
**[10]**

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

| Question Number | Scheme | Marks |
|---|---|---|
| **7.** |  | |
| | Taking moments about A:<br>$3S = 100 \times 2 \times \cos\alpha$ | M1 A1 |
| | Resolving vertically:<br>$R + S\cos\alpha = 100$ | M1 A1 |
| | Resolving horizontally:<br>$S\sin\alpha = F$ | 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).<br>$\left(S = \frac{200\sqrt{8}}{9}\right),\ R = 100 - \frac{1600}{27} = \frac{1100}{27} \approx 40.74\ ,\ F = \frac{200\sqrt{8}}{27} \approx 20.95...$ | DM1<br>A1 |
| | $F \le \mu R,\ 200\sqrt{8} \le \mu \times 1100,\quad \mu \ge \frac{200\sqrt{8}}{1100} = \frac{2\sqrt{8}}{11}.$ | M1 |
| | Least possible $\mu$ is 0.514 $(3\text{sf})$, or exact. | A1<br>**[10]** |

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

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