

# Mark Scheme (Results)

June 2011

GCE Mechanics M5 (6681) Paper 1

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## 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

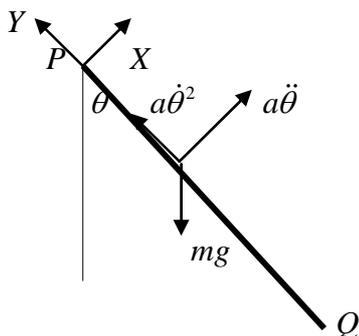
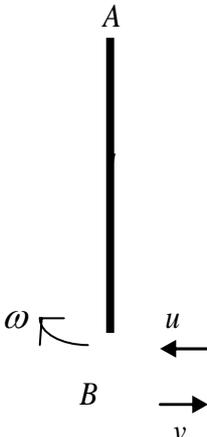
These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN.

- 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

**June 2011  
 Mechanics M5 6681  
 Mark Scheme**

Question Number	Scheme	Marks
1.	$\mathbf{AB} = (\mathbf{i} - 2\mathbf{j} - 4\mathbf{k}) - (3\mathbf{i} - \mathbf{j} + 3\mathbf{k}) = (-2\mathbf{i} - \mathbf{j} - 7\mathbf{k})$ $(2\mathbf{i} - 3\mathbf{j} - \mathbf{k}) \cdot (-2\mathbf{i} - \mathbf{j} - 7\mathbf{k}) = -4 + 3 + 7 = 6 \text{ J}$	M1 A1 M1 A1 <p style="text-align: right;"><b>4</b></p>
2.	$m^2 - 4 = 0 \Rightarrow m = 2 \text{ or } -2$ CF is $\mathbf{r} = \mathbf{A}e^{2t} + \mathbf{B}e^{-2t}$ PI try $\mathbf{r} = \mathbf{C}e^t$ $\dot{\mathbf{r}} = \mathbf{C}e^t$ $\ddot{\mathbf{r}} = \mathbf{C}e^t$  $\mathbf{C}e^t - 4\mathbf{C}e^t = -3e^t \mathbf{j}$ $\mathbf{C} = \mathbf{j}$ GS is $\mathbf{r} = \mathbf{A}e^{2t} + \mathbf{B}e^{-2t} + \mathbf{j}e^t$ $\mathbf{v} = 2\mathbf{A}e^{2t} - 2\mathbf{B}e^{-2t} + \mathbf{j}e^t$ $t = 0, \mathbf{r} = \mathbf{0}, \mathbf{v} = 2\mathbf{i} + \mathbf{j}$ $\mathbf{0} = \mathbf{A} + \mathbf{B} + \mathbf{j}$ $2\mathbf{i} + \mathbf{j} = 2\mathbf{A} - 2\mathbf{B} + \mathbf{j}$ $\mathbf{i} = \mathbf{A} - \mathbf{B}$ $\mathbf{A} = \frac{1}{2}(\mathbf{i} - \mathbf{j}); \mathbf{B} = -\frac{1}{2}(\mathbf{i} + \mathbf{j})$ $\mathbf{r} = \frac{1}{2}(\mathbf{i} - \mathbf{j})e^{2t} - \frac{1}{2}(\mathbf{i} + \mathbf{j})e^{-2t} + \mathbf{j}e^t$	M1 A1  B1  M1 A1 A1 M1 M1  A1  A1  <p style="text-align: right;"><b>10</b></p>

Question Number	Scheme	Marks
3.	$(m + \delta m)(v + \delta v) + (-\delta m)(v - c) = mv$ $m\delta v + c\delta m = 0$ $\int_0^v dv = -c \int_M^{M(1-k)} \frac{dm}{m}$ $V = c[\ln m]_{M(1-k)}^M$ $V = c \ln\left(\frac{1}{1-k}\right)$	M1A2  M1A1  A1  A1  <b>7</b>
4. (a)	$\mathbf{R} = (3\mathbf{j} + \mathbf{k}) + (4\mathbf{i} + \mathbf{j} - \mathbf{k})$ $= (4\mathbf{i} + 4\mathbf{j}) \text{ (N)}$	M1 A1  <b>(2)</b>
(b)	$(i + 2j + k) \times (4i + 4j) + \mathbf{G} = (2i - j + 3k) \times (3j + k) + (-3i + 2k) \times (4i + j - k)$ $(-4i + 4j - 4k) + \mathbf{G} = (-10i - 2j + 6k) + (-2i + 5j - 3k)$ $\mathbf{G} = (-8i - j + 7k) \text{ (N m)}$	M1 A2  A1  <b>(4)</b>
(c)	$\mathbf{F}_3 = -\mathbf{R} = (-4i - 4j)$ $\mathbf{G} = (2i - k) \times (-4i - 4j) + (-12i + 3j + 3k)$ $= (-16i + 7j - 5k)$ $ \mathbf{G}  = \sqrt{(-16)^2 + 7^2 + (-5)^2}$ $= \sqrt{330} \text{ (N m)}$	B1 M1 A1 A1 M1 A1  <b>(6)</b> <b>12</b>

Question Number	Scheme	Marks
5.	 <p style="text-align: center;"><math>\ddot{\theta} = 0</math></p> <p style="text-align: center;"><math>X - mg \sin \theta = ma\ddot{\theta} (= 0)</math></p> <p style="text-align: center;"><math>X = mg \sin \theta</math></p> <p style="text-align: center;"><math>Y - mg \cos \theta = ma\dot{\theta}^2 = ma \frac{g}{a} = mg</math></p> <p style="text-align: center;"><math>Y = mg(1 + \cos \theta)</math></p> <p style="text-align: center;"><math>R = mg\sqrt{(1 + \cos \theta)^2 + \sin^2 \theta}</math></p> <p style="text-align: center;"><math>= mg\sqrt{2(1 + \cos \theta)}</math></p> <p style="text-align: center;"><math>= mg\sqrt{2 \cdot 2 \cos^2(\frac{1}{2}\theta)}</math></p> <p style="text-align: center;"><math>= 2mg  \cos(\frac{1}{2}\theta) ^*</math></p>	<p>B1</p> <p>M1 A1</p> <p>M1 A1</p> <p>M1</p> <p>DM1</p> <p>A1</p> <p style="text-align: right;"><b>8</b></p>
6.	 <p style="text-align: center;"><math>I_A = \frac{1}{3}4ml^2</math></p> <p style="text-align: center;">CAM: <math>mul = \frac{1}{3}4ml^2\omega - mvl</math></p> <p style="text-align: center;">NIL: <math>3u = 4l\omega - 3v</math></p> <p style="text-align: center;"><math>u = \omega l + v</math></p> <p style="text-align: center;">eliminating <math>\omega l</math></p> <p style="text-align: center;"><math>u = 7v^*</math></p>	<p>B1</p> <p>M1 A1</p> <p>M1 A1</p> <p>DM1</p> <p>A1</p> <p style="text-align: right;"><b>7</b></p>

Question Number	Scheme	Marks
7.	$r_x = \frac{rx}{h}$ $\delta m = \pi r_x^2 \delta x \cdot \rho$ $= \pi \left(\frac{rx}{h}\right)^2 \delta x \cdot \frac{3M}{\pi r^2 h}$ $= \frac{3M}{h^3} x^2 \delta x$ $\delta I = \frac{1}{2} \delta m r_x^2$ $= \frac{1}{2} \frac{3M}{h^3} x^2 \delta x \left(\frac{rx}{h}\right)^2$ $= \frac{3Mr^2}{2h^5} x^4 \delta x$ $I = \frac{3Mr^2}{2h^5} \int_0^h x^4 dx$ $= \frac{3Mr^2}{2h^5} \left[ \frac{x^5}{5} \right]_0^h$ $= \frac{3Mr^2}{10}$	<p>M1A1</p> <p>M1</p> <p>A1</p> <p>M1A1</p> <p>A1 (DM1)</p> <p>M1</p> <p>A1</p> <p>A1</p> <p style="text-align: right;"><b>10</b></p>

Question Number	Scheme	Marks
<b>8.</b> <b>(a)</b>	$I_{DISC} = \frac{ma^2}{4} + m(2a)^2 = \frac{17ma^2}{4}$ $I_{ROD} = \frac{3m(2a)^2}{3} = 4ma^2$ $I_{PENDULUM} = \frac{17ma^2}{4} + 4ma^2 = \frac{33ma^2}{4}$	M1A1 B1 M1 A1 (5)
<b>(b)</b>	$3mga(\cos \theta - \cos \alpha) + mg \cdot 2a(\cos \theta - \cos \alpha) = \frac{1}{2} \frac{33ma^2}{4} \dot{\theta}^2$ $\frac{40g(\cos \theta - \cos \alpha)}{33a} = \dot{\theta}^2 *$	M1A2 A1 (4)
<b>(c)</b>	$2\dot{\theta}\ddot{\theta} = -\frac{40g}{33a} \sin \theta \cdot \dot{\theta}$ $\ddot{\theta} = -\frac{20g}{33a} \sin \theta$	M1A1 A1 (3)
<b>(d)</b>	<p>For small <math>\theta</math>, <math>\ddot{\theta} = -\frac{20g}{33a} \theta</math> i.e. SHM</p> $\omega = \sqrt{\frac{20g}{33a}} = \sqrt{\frac{20g}{33 \times \frac{4}{33}}} = 7$ $\theta = \alpha \cos \omega t$ $\dot{\theta} = -\alpha \omega \sin \omega t$ $= -7 \frac{\pi}{20} \sin 1.4$ $ \dot{\theta}  = 1.08 \text{ rad s}^{-1} \text{ (3SF)}$	M1 A1 M1 M1 A1 (5) <b>17</b>



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