

GCE 2004  
*June Series*



# Mark Scheme

## Mathematics and Statistics B *MBM3*

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Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

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*Dr Michael Cresswell Director General*

**Key to Mark Scheme**

<b>M</b>	mark is for	method
<b>m</b>	mark is dependent on one or more M marks and is for	method
<b>A</b>	mark is dependent on M or m marks and is for	accuracy
<b>B</b>	mark is independent of M or m marks and is for	accuracy
<b>E</b>	mark is for	explanation
<b>✓ or ft or F</b>		follow through from previous incorrect result
<b>cao</b>		correct answer only
<b>cso</b>		correct solution only
<b>awfw</b>		anything which falls within
<b>awrt</b>		anything which rounds to
<b>acf</b>		any correct form
<b>ag</b>		answer given
<b>sc</b>		special case
<b>oe</b>		or equivalent
<b>sf</b>		significant figure(s)
<b>dp</b>		decimal place(s)
<b>A2,1</b>		2 or 1 (or 0) accuracy marks
<b>-x ee</b>		deduct $x$ marks for each error
<b>pi</b>		possibly implied
<b>sca</b>		substantially correct approach

**Abbreviations used in Marking**

<b>MC – <math>x</math></b>	deducted $x$ marks for mis-copy
<b>MR – <math>x</math></b>	deducted $x$ marks for mis-read
<b>isw</b>	ignored subsequent working
<b>bod</b>	given benefit of doubt
<b>wr</b>	work replaced by candidate
<b>fb</b>	formulae book

**Application of Mark Scheme**

No method shown:	
<b>Correct answer without working</b>	<b>mark as in scheme</b>
<b>Incorrect answer without working</b>	<b>zero marks unless specified otherwise</b>
More than one method / choice of solution:	
<b>2 or more complete attempts, neither/none crossed out</b>	<b>mark both/all fully and award the mean mark rounded down</b>
<b>1 complete and 1 partial attempt, neither crossed out</b>	<b>award credit for the complete solution only</b>
Crossed out work	<b>do not mark unless it has not been replaced</b>
Alternative solution <b>using a correct or partially correct method</b>	<b>award method and accuracy marks as appropriate</b>

## Mathematics and Statistics B Mechanics 3 MBM3 June 2004

Question Number and Part	Solution	Marks	Total	Comments
1(a)	$v = 0 + 0.5 \times 10 = 5 \text{ ms}^{-1}$	M1 A1	2	Use of $v = u + at$ Correct $v$
(b)	$s = \frac{1}{2} \times 0.5 \times 10^2 = 25 \text{ m}$	M1 A1	2	Use of a constant acceleration equation to find $s$ Correct $s$
(c)	$F - 40000 = 200000 \times 0.5$ $F = 140000 \text{ N}$	M1 A1 A1	3	Three term equation of motion Correct equation Correct force
<b>Total</b>			<b>7</b>	
2(a)	$R = 60 \times 9.8 \times \cos 40^\circ = 450 \text{ N}$	M1 A1	2	Resolving perpendicular to the plane Correct reaction force
(b)	$F = 60 \times 9.8 \times \cos 50^\circ = 378$ $F \leq \mu R$ $\mu \geq 0.839$	M1 A1 m1 A1	4	Resolving parallel to the plane Correct $F$ Use of $F \leq \mu R$ or $F = \mu R$ Correct inequality Accept 0.840
(c)	$F = 0.2 \times 60 \times 9.8 \cos 40^\circ$ $60a = 60 \times 9.8 \cos 50^\circ - 0.2 \times 60 \times 9.8 \cos 40^\circ$ $a = 4.80 \text{ ms}^{-2}$	M1 A1 M1 A1 A1	5	Use of $F = \mu R$ to find $F$ but not with $R = 60g$ Correct $F$ Three term equation of motion Correct equation Correct acceleration
<b>Total</b>			<b>11</b>	
3(a)(i)	$0 = 8 - 4h$ $h = 2$	B1	1	Correct value of $h$
(ii)	$a = 8 - 2t$	B1	1	Correct expression
(b)	$v = \int 8 - 2t \, dt$ $= 8t - t^2 + c$ $2 = 32 - 16 + c$ $c = -14$ $v = 8t - t^2 - 14$	M1 A1 m1 A1	4	Integrating acceleration Correct velocity with or without $c$ Finding $c$ Correct final expression
<b>Total</b>			<b>6</b>	

## MBM3 (cont)

Question Number and Part	Solution	Marks	Total	Comments
4(a)	$\mathbf{v} = 4 \cos t \mathbf{i} - 4 \sin t \mathbf{j} + 6\mathbf{k}$	M1 A1	2	Differentiating position vector Correct velocity vector
(b)	$\mathbf{a} = -4 \sin t \mathbf{i} - 4 \cos t \mathbf{j}$	M1 A1	2	Differentiating the velocity vector Correct acceleration
(c)	$a = \sqrt{16 \sin^2 t + 16 \cos^2 t}$ $= \sqrt{16(\sin^2 t + \cos^2 t)}$ $= \sqrt{16}$ $= 4$	M1 A1 A1	3	Finding magnitude Correct expression for magnitude Using trig identity to get the printed answer with correct working including the <b>k</b> component <b>ag</b>
(d)	$v = \sqrt{16 \sin^2 t + 16 \cos^2 t + 36}$ $= \sqrt{52}$ $= 7.21$ Or $v^2 = 52$	M1 A1 A1	3	Finding magnitude Correct expression for magnitude $\sqrt{52}$ or equivalent
<b>Total</b>			<b>10</b>	
5(a)(i)	$\text{KE} = 2 \times 9.8 \times 4 = 78.4 \text{ J}$	M1 A1	2	Use of $\text{KE} = \text{change in PE}$ with $h = 4$ Correct energy
(ii)	$78.4 = \frac{1}{2} \times 2 \times v^2$  $v = \sqrt{78.4} = 8.85 \text{ ms}^{-1}$	M1  A1 A1	3	Use of kinetic energy or constant acceleration formula to form an equation in $v$ based on a fall of 4 metres Correct equation Correct $v$
(b)(i)	$78.4 + 19.6x = \frac{80}{2 \times 4} x^2$  $0 = 10x^2 - 19.6x - 78.4$	M1 A1 M1 A1	4	Calculation of EPE shown Correct EPE Three term energy equation Correct equation from correct working
(ii)	$x = \frac{19.6 \pm \sqrt{19.6^2 - 4 \times 10 \times (-78.4)}}{2 \times 10}$ $= 3.95 \text{ or } -1.99$ Max L = 7.95 m	M1  A1 A1	3	Solving the quadratic equation  Correct solutions Adding 4 to their $x$
(c)	No air resistance Light rope	B1	1	Appropriate assumption
<b>Total</b>			<b>13</b>	

## MBM3 (cont)

Question Number and Part	Solution	Marks	Total	Comments
6(a)	$\mathbf{r} = 5\mathbf{j}$	B1	1	Correct vector
(b)	$4t - 0.01t^2 = 0$ $t = 0$ or $t = 400$ $t = 400$	M1 A1 M1 A1	4	Equation based on $\mathbf{i}$ component Correct equation Solving the quadratic Selecting $t = 400$
(c)	$\mathbf{v} = (4 - 0.02t)\mathbf{i} + (-3 - 0.08t)\mathbf{j}$ $4 - 0.02t = 3 + 0.08t$ $t = 10$	M1 A1 M1 A1 A1	5	Use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ Correct velocity vector Equation using both components Correct equation Correct $t$
<b>Total</b>			<b>10</b>	
7(a)	$F = 420 + 1200 \times 9.8 \sin 6^\circ$ $P = (420 + 1200 \times 9.8 \sin 6^\circ) \times 20$ $= 33000 \text{ W (to 3sf)}$	M1 A1 m1 A1	4	Finding force as the resultant of two forces Correct force Use of $P = Fv$ Correct answer from correct expression
(b)	$420 = 20k$ $k = 21$	M1 A1	2	Equation for $k$ involving 420 Correct value of $k$
(c)	$F = 21v$ $32985 = 21v^2$ $v = \sqrt{\frac{32985}{21}} = 39.6 \text{ ms}^{-1}$	M1 M1 A1✓ A1✓	4	Expression for $F$ in terms of $v$ Use of $P = Fv$ to form an equation with $v^2$ Correct equation Correct $v$
<b>Total</b>			<b>10</b>	

## MBM3 (cont)

Question Number and Part	Solution	Marks	Total	Comments
8(a)	$R \cos \theta = 1000g$ $R = \frac{9800}{\cos \theta}$	M1 A1	2	Resolving vertically to form a two term equation <b>ag</b> Correct equation from correct working
(b)	$R \sin \theta = m \times \frac{10^2}{40}$ $g \tan \theta = 2.5$ $\tan \theta = \frac{2.5}{9.8} = 0.2551$ $\theta = 14.3^\circ$	M1 A1 M1 A1	5	Resolving horizontally to get a two term equation Correct equation Substituting for $R$ Correct equation Correct angle
(c)	$F \cos 3^\circ + R \sin 3^\circ = 1000 \times \frac{10^2}{40}$ $R \cos 3^\circ - F \sin 3^\circ = 9800$ $F(\cos^2 3^\circ + \sin^2 3^\circ) =$ $\quad\quad\quad 2500 \cos 3^\circ - 9800 \sin 3^\circ$ $F = \frac{2500 \cos 3^\circ - 9800 \sin 3^\circ}{1}$ $= 1980 \text{ N (to 3 sf)}$ <b>Or</b> $1000 \times \frac{10^2}{40} \cos 3^\circ = F + 1000g \sin 3^\circ$ $F = 2497 - 513 = 1980$	M1 A1 M1 A1 m1 A1	6	Resolve horizontally with three terms Correct equation Resolve vertically with three terms Correct equation Solve for $F$ Correct $F$
	<b>Total</b>		<b>13</b>	
	<b>TOTAL</b>		<b>80</b>	