GCE 2005
January Series

ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark Scheme

Mathematics and Statistics B
(MBM3)

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Key to Mark Scheme

M ..... mark is for ..... method
m ..... mark is dependent on one or more M marks and is for ..... method
A ..... mark is dependent on M or m marks and is for ..... accuracy
B ..... mark is independent of M or m marks and is for ..... method and accuracy
E ..... mark is for ..... explanation
√ **or ft or F** ..... follow through from previous incorrect result
CAO ..... correct answer only
AWFW ..... anything which falls within
AWRT ..... anything which rounds to
AG ..... answer given
SC ..... special case
OE ..... or equivalent
A2,1 ..... 2 or 1 (or 0) accuracy marks
-*x* EE ..... deduct *x* marks for each error
NMS ..... no method shown
PI ..... possibly implied
SCA ..... substantially correct approach
c ..... candidate
SF ..... significant figure(s)
DP ..... decimal place(s)

Abbreviations used in Marking

MC – *x* ..... deducted *x* marks for mis-copy
MR – *x* ..... deducted *x* marks for mis-read
ISW ..... ignored subsequent working
BOD ..... given benefit of doubt
WR ..... work replaced by candidate
FB ..... formulae booklet

Application of Mark Scheme

No method shown:
Correct answer without working ..... mark as in scheme
Incorrect answer without working ..... zero marks unless specified otherwise

More than one method/choice of solution:

2 or more complete attempts, neither/none crossed out	mark both/all fully and award the mean mark rounded down
1 complete and 1 partial attempt, neither crossed out	award credit for the complete solution only

Crossed out work — do not mark unless it has not been replaced

Alternative solution using a correct or partially correct method — award method and accuracy marks as appropriate

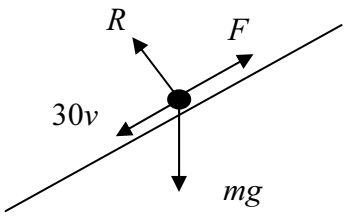
Mathematics and Statistics B Mechanics 3 MBM3 January 2005

Question Number and part	Solution	Marks	Total	Comments
1(a)	$4^2 = 20^2 + 2\times 48a$	M1		Use of constant acceleration equation to find a
	$a = \dfrac{16-400}{96} = -4 \text{ ms}^{-2}$	A1	2	**ag** Correct acceleration from correct working
(b)	$0^2 = 4^2 + 2\times(-4)s$	M1		use of constant acceleration equation to form equation for s
	$s = \dfrac{16}{8} = 2 \text{ m}$	A1		Correct equation
		A1	3	Correct s
(c)	$0 = 20 - 4t$	M1		Use of constant acceleration equation to form equation for t
	$t = 5$	A1	2	Correct t
(d)	$-F - 200 = 1100\times(-4)$	M1		Three term equation of motion
		A1		Correct equation
	$F = 4200$	A1	3	Correct F
	Total		**10**	
2(a)	$R = 2\times 9.8\cos 40°$	M1		Resolving perpendicular to the slope.
	$F = 0.3\times 2\times 9.8\cos 40°$	M1		Use of $F = \mu R$
	$= 4.50 \text{ N}$	A1	3	Correct F
(b)	$2a = -2\times 9.8\sin 40° - 4.50$	M1		Three term equation of motion
		A1		Correct equation
	$a = \dfrac{-2\times 9.8\sin 40° - 4.50}{2} = -8.55 \text{ ms}^{-2}$	A1	3	Correct acceleration
	Total		**6**	
3(a)	$\mathbf{v} = -4e^{-t}\mathbf{i} + (6 - 3e^{-t})\mathbf{j}$	M1		Differentiating position vector
		A1		Correct velocity
	$t = 0$			
	$\mathbf{v} = -4\mathbf{i} + 3\mathbf{j}$	A1	3	Substituting $t = 0$ to obtain initial velocity
(b)	$\mathbf{a} = 4e^{-t}\mathbf{i} + 3e^{-t}\mathbf{j}$	M1		Differentiating velocity
		A1	2	Correct acceleration
(c)	$\mathbf{a} = 4\mathbf{i} + 3\mathbf{j}$	M1		Finding acceleration when $t = 0$
	$a = \sqrt{4^2 + 3^2} = 5$	A1	2	Correct magnitude
(d)	$\mathbf{v} \to 0\mathbf{i} + 6\mathbf{j}$	B1		For **i** component
		B1	2	For **j** component
	Total		**9**	

MBM3 (cont)

Question Number and part	Solution	Marks	Total	Comments
4(a)	$EPE = \frac{1}{2} \times \frac{40}{2} \times 3^2 = 90$ J	M1 A1	2	Finding EPE **ag** Correct EPE from correct working
(b)	$90 = \frac{1}{2} \times 5v^2$ $v^2 = 36$ $v = 6$	M1 A1 A1	3	Use of EPE = KE Correct equation **ag** Correct speed from correct working
(c)	$EPE = \frac{1}{2} \times \frac{40}{2} \times 1^2 = 10$ J $90\text{-}10 = \frac{1}{2} \times 5v^2$ $v^2 = 32$ $v = 5.66$ ms^{-1} (to 3 sf)	M1 A1 M1 A1 A1	5	Finding EPE 3 metres from O Correct EPE Using EPE lost = KE Correct equation Correct speed
			10	
5(a)	$P = 2000$ $Q = 100$	B1 B1	2	Correct value for P Correct value for Q
(b)	$a = -\frac{F}{1000} = \frac{t}{10} - 2$	M1 A1	2	Use of $F = ma$ **ag** Correct expression from correct working
(c)	$v = \frac{t^2}{20} - 2t + c$ $0 = \frac{20^2}{20} - 2 \times 20 + c$ $c = 20$ $v = \frac{t^2}{20} - 2t + 20$	M1 A1 M1 A1	4	Integrating acceleration to give velocity Correct velocity with or without c Finding c Correct expression for the velocity
(d)	$s = \int_0^{20} \frac{t^2}{20} - 2t + 20 \, dt$ $= \left[\frac{t^3}{60} - t^2 + 20t \right]_0^{20}$ $= 133$ m	M1 A1 A1 M1 A1√	5	Integrating velocity Correct integral Correct limits / value of c Finding distance by substituting limits Correct distance ft incorrect constants from (b)
	Total		**13**	

MBM3 cont

Question Number and part	Solution	Marks	Total	Comments
6(a)		B1	1	Correct force diagram
(b)				
	$F = 1500g\cos 85° + 300$	M1		Finding F
	$P = (1500g\cos 85° + 300)\times 10$	A1		Correct F
		M1		Use of $P = Fv$
	$= 15800$ W (to 3 sf)	A1	4	**ag** Correct answer from correct working
(c)	$F = 1500g\cos 85° + 30v$	M1		F in terms of v
	$35000 = v(1500g\cos 85° + 30v)$	A1		Correct expression for F
		m1		Using $P = Fv$ to obtain a quadratic
	$0 = 30v^2 + 1281v - 35000$	A1		Correct quadratic
	$v = \dfrac{-1281 \pm \sqrt{1281^2 + 4\times 30\times 35000}}{2\times 30}$	m1		Solving quadratic equation
	$= 18.9$ or -61.6			
	Max Speed $= 18.9$ ms^{-1}	A1	6	Correct speed
	Total		**11**	

MBM3 (cont)

Question Number and part	Solution	Marks	Total	Comments
7(a)	$\mathbf{v} = (3\mathbf{i} - 10\mathbf{j}) + (4\mathbf{i} + 2\mathbf{j})t$ $= (3 + 4t)\mathbf{i} + (2t - 10)\mathbf{j}$	M1 A1	2	Use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ **ag** Correct result from correct working
(b)	$2t - 10 = 0$ $t = 5$	M1 A1	2	**j** component equal to zero Correct time
(c)(i)	$\mathbf{r} = (3\mathbf{i} - 10\mathbf{j}) \times 10 + \frac{1}{2}(4\mathbf{i} + 2\mathbf{j}) \times 10^2$ $= 230\mathbf{i}$	M1 A1 A1	3	Finding **r** when $t = 10$ Correct expression Correct final answer
(c)(ii)	$\mathbf{v} = (3 + 4 \times 10)\mathbf{i} + (2 \times 10 - 10)\mathbf{j}$ $= 43\mathbf{i} + 10\mathbf{j}$	B1	1	Correct velocity
(d)	$\mathbf{r} = 230\mathbf{i} + (43\mathbf{i} + 10\mathbf{j}) \times 10$ $= 660\mathbf{i} + 100\mathbf{j}$ $r = \sqrt{660^2 + 100^2}$ $= 668$ m	M1 M1 A1 A1 M1 A1√	6	Uses zero acceleration Uses both answers from (c) Correct expression for **r** Correct simplified result Finding magnitude Correct distance Follow through from part (c)
	Total		**14**	
8(a)	$a = 0.6 \times 10^2 = 60$ ms^{-2}	M1 A1	2	Use of $a = r\omega^2$ Correct acceleration
(b)	$R = 0.05 \times 60 = 3$ N	M1 A1√	2	Finding product of mass and acceleration Correct R Follow though incorrect a.
(c)	$R - 0.05 \times 9.8 = 0.05 \times 60$ $R = 3.49$ N	M1 A1 A1√	3	Equation of motion at lowest point Correct equation Correct R Follow though incorrect a.
	Total		**7**	
	TOTAL		**80**	