GCE 2004
June Series

ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark Scheme

Mathematics and Statistics B
MBM2

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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	accuracy
E	mark is for	explanation
√or ft or F		follow through from previous incorrect result
cao		correct answer only
cso		correct solution only
awfw		anything which falls within
awrt		anything which rounds to
acf		any correct form
ag		answer given
sc		special case
oe		or equivalent
sf		significant figure(s)
dp		decimal place(s)
A2,1		2 or 1 (or 0) accuracy marks
–*x* ee		deduct *x* marks for each error
pi		possibly implied
sca		substantially correct approach

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 book

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**

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Mathematics and Statistics B Mechanics 2 MBM2 June 2004

Question Number and Part	Solution	Marks	Total	Comments
1 (a)(i)	$0 = 8 - 4h$			
	$h = 2$	B1	1	Correct value of h
(ii)	$a = 8 - 2t$	B1	1	Correct expression
(b)	$v = \int 8 - 2t \mathrm{d}t$	M1		Integrating acceleration
	$= 8t - t^2 + c$	A1		Correct velocity with or without c
	$2 = 32 - 16 + c$			
	$c = -14$	m1		Finding c
	$v = 8t - t^2 - 14$	A1	4	Correct final expression
	Total		**6**	
2 (a)	$\mathbf{v} = 4\cos t\mathbf{i} - 4\sin t\mathbf{j} + 6\mathbf{k}$	M1		Differentiating position vector
		A1	2	Correct velocity vector
(b)	$\mathbf{a} = -4\sin t\mathbf{i} - 4\cos t\mathbf{j}$	M1		Differentiating the velocity vector
		A1	2	Correct acceleration
(c)	$a = \sqrt{16\sin^2 t + 16\cos^2 t}$	M1		Finding magnitude
		A1		Correct expression for magnitude
	$= \sqrt{16(\sin^2 t + \cos^2 t)}$			
	$= \sqrt{16}$	A1	3	**ag** Using trig identity to get the printed answer with correct working including the **k** component
	$= 4$			
(d)	$v = \sqrt{16\sin^2 t + 16\cos^2 t + 36}$	M1		Finding magnitude
		A1		Correct expression for magnitude
	$= \sqrt{52}$	A1	3	$\sqrt{52}$ or equivalent
	$= 7.21$			
	Or $v^2 = 52$			
	Total		**10**	
3 (a) (i)	$\mathrm{KE} = 2 \times 9.8 \times 4 = 78.4\ \mathrm{J}$	M1		Use of KE = change in PE with $h = 4$
		A1	2	Correct energy
(ii)	$78.4 = \frac{1}{2} \times 2 \times v^2$	M1		Use of kinetic energy or constant acceleration formula to form an equation in v based on a fall of 4 metres
		A1		Correct equation
	$v = \sqrt{78.4} = 8.85\ \mathrm{ms}^{-1}$	A1	3	Correct v
(b) (i)	$78.4 + 19.6x = \frac{80}{2 \times 4} x^2$	M1		Calculation of EPE shown
		A1		Correct EPE
		M1		Three term energy equation
	$0 = 10x^2 - 19.6x - 78.4$	A1	4	**ag** Correct equation from correct working
(ii)	$x = \frac{19.6 \pm \sqrt{19.6^2 - 4 \times 10 \times (-78.4)}}{2 \times 10}$	M1		Solving the quadratic equation
	$= 3.95$ or -1.99	A1		Correct solutions
	Max L = 7.95 m	A1√	3	ft Adding 4 to their x
(c)	No air resistance	B1	1	Appropriate assumption
	Total		**13**	

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MBM2 (cont)

Question Number and Part	Solution	Marks	Total	Comments
4 (a)	$F = 420 + 1200 \times 9.8 \sin 6° = 1649$	M1		Finding force as the resultant of two forces
		A1		Correct force
	$P = (420 + 1200 \times 9.8 \sin 6°) \times 20$	m1		Use of $P = Fv$
	$= 33000$ W (to 3sf)	A1	4	Correct answer from correct expression
(b)	$420 = 20k$	M1		Equation for k involving 420
	$k = 21$	A1	2	Correct value of k
(c)	$F = 21v$	M1		Expression for F in terms of v
	$32985 = 21v^2$	M1		Use of $P = Fv$ to form an equation with v^2
		A1√		ft Correct equation
	$v = \sqrt{\frac{32985}{21}} = 39.6 \text{ ms}^{-1}$	A1√	4	ft Correct v
	Total		**10**	
5 (a)	$R \cos\theta = 1000g$	M1		Resolving vertically to form a two term equation
	$R = \frac{9800}{\cos\theta}$	A1	2	**ag** Correct equation from correct working
(b)	$R \sin\theta = m \times \frac{10^2}{40}$	M1		Resolving horizontally to get a two term equation
		A1		Correct equation
	$g \tan\theta = 2.5$	M1		Substituting for R
		A1		Correct equation
	$\tan\theta = \frac{2.5}{9.8} = 0.2551$			
	$\theta = 14.3°$	A1	5	Correct angle
(c)	$F \cos 3° + R \sin 3° = 1000 \times \frac{10^2}{40}$	M1		Resolve horizontally with three terms
		A1		Correct equation
	$R \cos 3° - F \sin 3° = 9800$	M1		Resolve vertically with three terms
		A1		Correct equation
	$F(\cos^2 3° + \sin^2 3°)$			
	$= 2500 \cos 3° - 9800 \sin 3°$			
	$F = \frac{2500 \cos 3° - 9800 \sin 3°}{1}$	m1		Solve for F
	$= 1980$ N (to 3 sf)	A1	6	Correct F
	Or			
	$1000 \times \frac{10^2}{40} \cos 3° = F + 1000g \sin 3°$	(M1A1)		for RHS
		(M1A1)		for LHS
	$F = 2497 - 513 = 1980$	(m1A1)		finding F
	Total		**13**	

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MBM2 (cont)

Question Number and Part	Solution	Marks	Total	Comments
6	$\bar{x} = \dfrac{\int_0^5 \sqrt{1+\left(\frac{1}{5}\right)^2}\, x^2 \mathrm{d}x}{\int_0^5 \sqrt{1+\left(\frac{1}{5}\right)^2}\, x \mathrm{d}x} = \dfrac{\int_0^5 x^2 \mathrm{d}x}{\int_0^5 x \mathrm{d}x}$	M1 M1 A1		x^2 in numerator x in denominator valid expression
	$= \dfrac{\left[\frac{x^3}{3}\right]_0^5}{\left[\frac{x^2}{2}\right]_0^5} = \dfrac{\frac{125}{3}}{\frac{25}{2}} = \dfrac{10}{3}$	m1 A1	5	Evaluation of integrals **ag** Correct answer from correct working
	Total		**5**	
7(a)	$a = 0.05$	B1		Amplitude = 0.05
	$6^2 = \omega^2(0.05^2 - 0.04^2)$	M1 A1		Use of SHM equation with $x = 0.04$ Correct equation
	$\omega = \sqrt{\dfrac{0.36}{0.0009}} = 20$	m1 A1		Solving for ω Correct ω
	$T = \dfrac{2\pi}{20} = \dfrac{\pi}{10}$	A1	6	**ag** Correct period from correct working
(b)	$v = 0.05 \times 20 = 1\,\mathrm{ms}^{-1}$	M1 A1	2	Using $v = a\omega$ Correct v
(c)	$a_{\max} = 0.05 \times 20^2 = 20\,\mathrm{ms}^{-2}$	M1 A1	2	Use of $a_{\max} = a\omega^2$ Correct acceleration Allow ± 20
	Total		**10**	

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MBM2 (cont)

Question Number and Part	Solution	Marks	Total	Comments
8 (a)	$mv\frac{\mathrm{d}v}{\mathrm{d}x} = -mg - mkv$	M1		Using Newton's second law to form a differential equation with $v\frac{\mathrm{d}v}{\mathrm{d}x}$
	$\frac{v}{g+kv}\frac{\mathrm{d}v}{\mathrm{d}x} = -1$	A1		Correct differential equation
	$\int\frac{v}{g+kv}\mathrm{d}v = \int -1\,\mathrm{d}x$	m1		Separation of variables
	$\int\frac{v}{g+kv}\mathrm{d}v = -x + c$	A1	4	**ag** Correct answer from correct working
(b)	$\int\frac{1}{k} - \frac{g}{k(g+kv)}\mathrm{d}v = -x + c$	M1		Substituting given identity
	$\frac{v}{k} - \frac{g}{k^2}\ln\lvert g+kv\rvert = -x + c$	M1		Integration to get v and ln terms
		A1		ln term correct
		A1		v term correct
	$x = 0, v = 20 \Rightarrow c = \frac{20}{k} - \frac{g}{k^2}\ln(g+20k)$	m1		Finding c
		A1		Correct c
	$x = \frac{20-v}{k} + \frac{g}{k^2}\ln\left(\frac{g+kv}{g+20k}\right)$	A1	7	**ag** Correct final answer from correct working
(c)	$v = 0$			
	$x = \frac{20-0}{k} + \frac{g}{k^2}\ln\left(\frac{g+k\times 0}{g+20k}\right)$	M1		Substituting $v = 0$
	$x = \frac{20}{k} + \frac{g}{k^2}\ln\left(\frac{g}{g+20k}\right)$	A1	2	Correct height
	Total		**13**	
	TOTAL		**80**	

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