GCE 2004
June Series

ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark Scheme

Mathematics and Statistics B
MBM4

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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

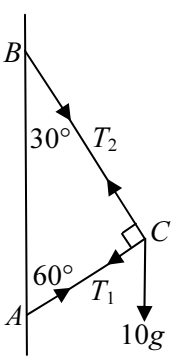
Abbreviations used in Marking

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**

Mathematics and Statistics B Mechanics 4 MBM4 June 2004

Question Number and Part	Solution	Marks	Total	Comments
1(a)	$\mathbf{F} = -\left\{\begin{pmatrix}1\\-5\\2\end{pmatrix}+\begin{pmatrix}2\\-7\\-6\end{pmatrix}\right\}$	M1 M1		[– sign]
	$= \begin{pmatrix}-3\\12\\4\end{pmatrix}$	A1	3	
(b)	Magnitude $= \sqrt{(-3)^2+12^2+4^2}$	M1		
	$= 13$	A1√	2	
	Total		**5**	
2	Dimension of a force is MLT^{-2}	B1		
	From Hooke's law; $\lambda = \dfrac{lT}{x}$	B1		
	$= \dfrac{L \times MLT^{-2}}{L}$	M1		
	$= MLT^{-2}$	A1	4	
	Total		**4**	
3				
	Resolve along BC:			
	$T_2 = 10g \cos 30$	M1		
	$T_2 = 5\sqrt{3}\,g$ or 84.9 N	A1		
	Resolve along AC:			
	$T_1 + 10g \sin 30 = 0$	M1		
	$T_1 = -5g$ or -49 N	A1		
	AC is in compression. BC is in tension.	B1 B1	6	Dependent on correct working **Or** Resolve vertically $T_1\cos 60 + 10g = T_2 \cos 30$ M1 Horizontally $T_2 \cos 30 + T_1 \sin 60 = 0$ M1
	Total		**6**	

MBM4 (cont)

Question Number and Part	Solution	Marks	Total	Comments
4(a)	Velocity of Q is $2u$			
	Impulse = $3m.2u$	M1		
	$= 6mu$	A1	2	
b(i)	Initial $\rightarrow$ $2u$			
	Q $3m$ R $5m$			
	Final $\rightarrow V$			
	C of momentum $3m.2u = 5mV$	M1A1		
	$V = \frac{6}{5}u$	A1	3	
(ii)	Restitution $e.2u = V$	M1		
	$\therefore e = \frac{3}{5}$	A1	2	
(iii)	Before P collides with Q again,			
	P travels distance a at speed $2u$	M1		
	$\therefore$ Time = $\frac{a}{2u}$	A1	2	
(c)	After impact velocity of B is V			
	Conservation of momentum $mu = MV$ Restitution $eu = V$	B1		
	$eMu = MV = mu$			
	$e \leq 1$	M1		
	$m \leq M$	A1	3	
	Total		**12**	

MBM4 (cont)

Question Number and Part	Solution	Marks	Total	Comments
5(a)	$\mathbf{R}_{B \text{ rel } P} = \mathbf{r}_B - \mathbf{r}_P$ $= \begin{pmatrix} 11 \\ 6 \\ 0 \end{pmatrix} - \begin{pmatrix} 39 \\ -7 \\ 0.2 \end{pmatrix}$	M1		
	$= \begin{pmatrix} -28 \\ 13 \\ -0.2 \end{pmatrix}$	A1	2	**sc**1 for $\begin{pmatrix} 28 \\ -13 \\ 0.2 \end{pmatrix}$
(b)	$\mathbf{V}_{B \text{ rel } P} = \mathbf{v}_B - \mathbf{v}_P$	M1		
	$= \begin{pmatrix} 3 \\ 4 \\ 0 \end{pmatrix} - \begin{pmatrix} -75 \\ 40 \\ -0.1 \end{pmatrix} = \begin{pmatrix} 78 \\ -36 \\ 0.1 \end{pmatrix}$	A1	2	**sc**1 for $\begin{pmatrix} -78 \\ 36 \\ -0.1 \end{pmatrix}$
(c)	At time t_1, $\mathbf{r}_{B \text{ rel } P} = \begin{pmatrix} -28 \\ 13 \\ -0.2 \end{pmatrix} + t\begin{pmatrix} 78 \\ -36 \\ 0.1 \end{pmatrix}$	M1		
	$= \begin{pmatrix} -28+78t \\ 13-36t \\ -0.2+0.1t \end{pmatrix}$	A1√		
	$\therefore$ Distance apart	M1		
	$= \sqrt{(-28+78t)^2 + (13-36t)^2 + (-0.2+0.1t)^2}$	A1√	4	Could be seen in (d)
(d)	When distance is 1 km, $(-28+78t)^2 + (13-36t)^2 + (-0.2+0.1t)^2 = 1$	M1		
	$953.04 - 5304.04t + 7380.01t^2 = 1$	A1		
	$7380.01t^2 - 5304.04t + 952.04 = 0$	M1		
	$t =$ 0.3708.. or 0.3478.. [hours]	A1		
	Time is 20.9.. and 22.2.. minutes	A1	5	Accept 20.87
	Total		**13**	

MBM4 (cont)

Question Number and Part	Solution	Marks	Total	Comments
6(a)	Ball leaves wall at an angle of 15° C of momentum along the wall: $u\cos30 = v\cos15$ $\therefore v = \frac{u\cos30}{\cos15}$ Restitution: $eu\sin30 = v\sin15$ $\therefore e\sin30 = \frac{\cos30\sin15}{\cos15}$ $e = \frac{\cos30\sin15}{\sin30\cos15}$ $= 0.464$	B1 M1 A1 M1 A1	5	
(b)	KE before impact $= \frac{1}{2}mu^2$ After impact $= \frac{1}{2}m\left(\frac{u\cos30}{\cos15}\right)^2$ $= 0.4019mu^2$ $\therefore$ Percentage loss in KE is $\frac{0.098}{0.5}\times100$ $= 19.6\%$	 B1 M1 A1	 3	 Dependent on B1 Accept 19.5 or 19.7
(c)	Impulse = change in momentum perpendicular to the wall $= mu\sin30 + mv\sin15$ $= mu(0.5 + 0.232)$ $= 0.732mu$ or $\frac{1}{2}(1+e)mu$	M1 m1 A1	 3	 + Accept $mu(\sin30 + \cos30\tan15)$
	Total		**11**	

MBM4 (cont)

Question Number and Part	Solution	Marks	Total	Comments
7	Mass of cylinder is $\pi(r)^2 l.\rho = \pi r^2\, l\rho$	B1		Condone not using ρ as long as 6 used
	Mass of cuboid is $(2r)^2 .r6\rho$ $= 24r^3\rho$	B1		
	Taking moments about *A(at point of toppling)*	M1		
	$24r^3\rho\,(\frac{r}{2}\sin\alpha - r\cos\alpha)$	M1 A1		
	$+\ \pi r^2 l\rho\,\{(\frac{l}{2}+r)\sin\alpha - r\cos\alpha\} = 0$	M1A1		
	$12r^2\tan\alpha - 24r^2 + \pi\frac{l^2}{2}\tan\alpha$ ... ...$+\ \pi r l\tan\alpha - \pi r l = 0$	M1		
	$\pi l^2 - 6\pi r l - 168\, r^2 = 0$	A1	9	
	Or using centre of gravity			
	Mass of cylinder is $\pi(r)^2 l.\rho = \pi r^2\, l\rho$	(B1)		
	Mass of cuboid is $(2r)^2 .r6\rho \quad = 24r^3\rho$	(B1)		
	Let $\bar{x}$ be distance of C of G from base of trophy			
	Taking moments about plane of base			
	$24r^3\rho\ \frac{r}{2} + \pi r^2 l\rho\,(\frac{l}{2}+r)$ $= \{24r^3\rho + \pi r^2 l\rho\}\,\bar{x}$	(M1) (A1)		
	$12r^2 + \frac{\pi}{2}l^2 + \pi r l = \{24r + \pi l\}\,\bar{x}$	(M1)		
	$\bar{x} = \dfrac{12r^2 + \frac{\pi}{2}l^2 + \pi r l}{24r + \pi l}$	(A1)		
	If, on point of toppling, C of G is vertically above *A*	(M1)		
	$\bar{x}\ \sin\alpha = \text{r}\cos\alpha$			
	$(24r^2 + 2\pi r l\ + \pi l^2)\tan\alpha = 48r^2 + 2\pi r l$	(M1)		
	$6r^2 + \frac{1}{2}\pi r l\ + \frac{1}{4}\pi l^2 = 48r^2 + 2\pi r l$			
	$\pi l^2 - 6\pi r l - 168\, r^2 = 0$	(A1)		
	Total		**9**	
	TOTAL		**60**	