Version: 1.0 9/9/2005

ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Mathematics and Statistics 6320
Specification B

MBM2 Mechanics 2

Mark Scheme

2005 examination – June series

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.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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

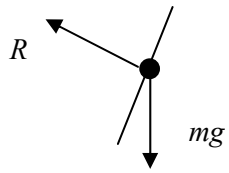
Application of Mark Scheme

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 2 MBM2 June 2005

Q	Solution	Marks	Total	Comments
1(a)	$v = \int t - \frac{t^2}{5}\,\mathrm{d}t$	M1		Integrating both terms
	$= \frac{t^2}{2} - \frac{t^3}{15} + c$	A1		Correct integral with or without c
	$v = 0,\ t = 0 \Rightarrow c = 0$	A1	3	Showing $c = 0$
	$v = \frac{t^2}{2} - \frac{t^3}{15}$			
(b)	$v(5) = \frac{5^2}{2} - \frac{5^3}{15} = 4.17\ \text{ms}^{-1}$	M1 A1	 2	Substituting $t = 5$ Correct v
(c)	$s = \int_0^5 \left(\frac{t^2}{2} - \frac{t^3}{15}\right)\mathrm{d}t$	M1		Integrating
	$= \left[\frac{t^3}{6} - \frac{t^4}{60}\right]_0^5$	A1 m1		Correct expression Substitution of two limits or finding c and substituting $t = 5$
	$= 10.4$ m	A1	4	Correct distance **sc** for only one limit M1A1A1
	Total		**9**	
2(a)(i)	$\text{KE} = \frac{1}{2} \times 35 \times 2^2 = 70$ J	M1 A1	 2	KE calculation using $v = 2$ Correct KE
(ii)	Gain in KE $= \frac{1}{2} \times 35 \times 6^2 - 70$	M1 A1		KE calculation using $v = 6$ Correct expression for gain in KE
	$= 560$ J	A1	3	Correct gain
(b)	PE lost $= 35 \times 9.8 \times 10 \sin 40°$	M1		PE calculation with attempt to find height
	$= 2200$ J	A1	2	**ag** Correct PE; allow 2204
(c)	$2204 - 560 = 10F$	M1 A1		Energy lost = Fx including 560 Correct equation
	$F = 164$ N	A1	3	Correct F **Alternative** M1: Three term equation of motion A1:Correct equation A1: Correct force
(d)	$\frac{1}{2} \times 35 \times 6^2 = Fs$	M1 A1√		Use of KE lost = Fx Correct equation
	$s = \frac{630}{F} = 3.83$ m	A1√	3	Correct length Follow through F Allow 3.84 **Alternative** M1: Finding acceleration A1: Correct use of a constant acceleration equation A1: Correct length from correct working
	Total		**13**	

MBM2 (cont)

Q	Solution	Marks	Total	Comments
3(a)	$\mathbf{v} = 50\cos(0.1t)\mathbf{i} - 50\sin(0.1t)\mathbf{j}$	M1 A1 A1	3	Differentiating Correct **i** component Correct **j** and **k** components
(b)	$v = \sqrt{(50\cos(0.1t))^2 + (-50\sin(0.1t))^2}$ $= \sqrt{2500(\cos^2(0.1t) + \sin^2(0.1t))}$ $= \sqrt{2500} = 50$ ms^{-1}	M1 A1 m1 A1	4	Finding magnitude of v Correct expression Use of trig identity **ag** Correct speed
(c)	$\mathbf{a} = -5\sin(0.1t)\mathbf{i} - 5\cos(0.1t)\mathbf{j}$	M1 A1	2	Differentiating Correct acceleration
(d)	$a = \sqrt{(-5\sin(0.1t))^2 + (-5\cos(0.1t))^2} = 5$ $F = 8000 \times 5 = 40000$ N	B1 M1 A1	3	Finding a Use of $F = ma$ with their acceleration Correct force
	Total		**12**	
4(a)		B1	1	Correct diagram (to include arrows and labels)
(b)	$R\cos 60° = mg$ $R = 2mg$	M1 A1	2	Resolving vertically **ag** Correct R from correct working
(c)	$R\cos 30° = \frac{mv^2}{r}$ $r = \frac{v^2}{g\sqrt{3}}$	M1 A1 m1 A1	4	Resolving horizontally Correct equation Solving for r Correct r
	Total		**7**	

MBM2 (cont)

Q	Solution	Marks	Total	Comments
5(a)	$\text{EPE} = \dfrac{30\times 0.8^2}{2\times 2} = 4.8$ J	M1 A1	2	Use of EPE formula with 0.8 Correct EPE
(b)(i)	$4.8 = 0.15\times 9.8\times 2.8 + \dfrac{1}{2}\times 0.15\times v^2$	M1		Three term energy equation Accept $0.684 = \dfrac{1}{2}0.15v^2$
		A1		Correct equation
	$v = \sqrt{\dfrac{4.8-4.116}{0.075}} = 3.02$ ms^{-1}	m1 A1	4	Solving for v **ag** Correct v from correct working
(b)(ii)	$4.8 = 0.15\times 9.8\times 2.8 + 0.15\times 9.8h$	M1		Three term energy equation using height above O Accept $0.684 = mgh$
		A1		Correct equation
	$h = \dfrac{4.8-4.116}{1.47} = 0.465$ m	A1		Correct height above O Accept 0.47 or 0.46
	As $0.465 < 2$ the string does not become taut.	A1	4	Correct conclusion **Alternative** M1: Use of constant acceleration equation A1: Correct equation A1: Correct height A1: Correct conclusion
	Total		**10**	
6(a)	$\bar{x} = \dfrac{\int_0^5 x(0.4x)^2\,\mathrm{d}x}{\int_0^5 (0.4x)^2\,\mathrm{d}x}$	M1 A1 A1		Use of appropriate expression for $\bar{x}$ Correct expression excluding limits Correct limits of integration
	$= \dfrac{\int_0^5 x^3\,\mathrm{d}x}{\int_0^5 x^2\,\mathrm{d}x}$			
	$= \dfrac{625/4}{125/3} = \dfrac{15}{4}$	m1 A1	5	Evaluation of integrals **ag** Correct result from correct working using both limits
(b)	Radius = 2	B1		Radius of face = 2
	$\tan\alpha = \dfrac{2}{5/4} = \dfrac{8}{5}$	M1 M1 A1		Use of tan Use of $5 - \bar{x}$ Correct expression for tan α
	$\alpha = \tan^{-1}\left(\dfrac{8}{5}\right) = 58.0°$	A1	5	Correct angle; allow 58°
	Total		**10**	

MBM2 (cont)

Q	Solution	Marks	Total	Comments
7(a)	$mg = \frac{\lambda}{l} \times \frac{l}{4}$	M1		Consideration of forces in equilibrium
	$\lambda = 4mg$	A1	2	**ag** Correct λ from correct working
(b)(i)	$m\frac{\mathrm{d}^2x}{\mathrm{d}t^2} = mg - T$			
		M1		Two term expression for T
	$= mg - \frac{4mg}{l}\left(x + \frac{l}{4}\right)$	A1		Correct expression for T
		M1		Three term equation of motion
	$= -\frac{4mg}{l}x$	m1		Simplifying
	$\frac{\mathrm{d}^2x}{\mathrm{d}t^2} = -\frac{4g}{l}x$	A1	5	**ag** Correct result from correct working
(b)(ii)				
	Period $= 2\pi\sqrt{\frac{l}{4g}} = \pi\sqrt{\frac{l}{g}}$	M1		Identifying ω
		A1	2	Correct period
	Total		**9**	
8(a)	$mv\frac{\mathrm{d}v}{\mathrm{d}x} = -9.8m - 0.7mv$	M1		Three term equation of motion with $v\frac{\mathrm{d}v}{\mathrm{d}x}$
	$v\frac{\mathrm{d}v}{\mathrm{d}x} = -9.8 - 0.7v$			
	$= -0.7(v + 14)$	A1	2	**ag** Correct expression from correct working
(b)	$\int \frac{v}{v+14}\mathrm{d}v = \int -0.7\ \mathrm{d}x$	M1		Separating variables and forming two integrals
	$\int 1 - \frac{14}{v+14}\mathrm{d}v = -0.7x + c$			
		M1		Integrating to get ln $(v + 14)$ term
	$v - 14\ln\lvert v+14\rvert = -0.7x + c$	A1		Correct integration
	$v = 20, x = 0 \Rightarrow c = 20 - 14\ln(34)$	m1		Finding c
	$v - 14\ln(v+14) = -0.7x + 20 - 14\ln(34)$	A1		Correct c
	$0.7x = 20 - v + 14\ln(v+14) - 14\ln(34)$			
	$x = \frac{10}{7}\left(20 - v + 14\ln\left(\frac{v+14}{34}\right)\right)$	A1	6	**ag** Correct final result from correct working
(c)	$x = \frac{10}{7}\left(20 + 14\ln\left(\frac{14}{34}\right)\right) = 10.8$ m	M1		Substituting $v = 0$
		A1	2	Correct value
	Total		**10**	
	TOTAL		**80**	