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General Certificate of Education (A-level)
January 2012

Mathematics MM2B

(Specification 6360)

Mechanics 2B

Final

Mark Scheme

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Key to mark scheme abbreviations

M	mark is for method
m or dM	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
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
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)

No Method Shown

Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded.

Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to candidates showing no working is that incorrect answers, however close, earn **no marks**.

Where a question asks the candidate to state or write down a result, no method need be shown for full marks.

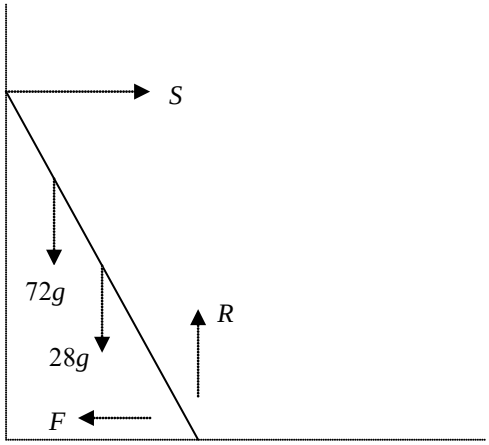
Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

Otherwise we require evidence of a correct method for any marks to be awarded.

MM2B

Q	Solution	Marks	Total	Comments
1(a)	KE at P = $\frac{1}{2}\times 25\times 60^2$	M1		correct
	= 45 000 J	A1	2	
(b)	change in PE as it falls:			
	mgh = 25 × 9.8 × 34	M1		correct
	= 8330	A1	2	ISW
(c)(i)	using Conservation of Energy:			
	KE at ground = 8330 + 45 000	M1		ft C's (a) and (b)
	= 53 330 J	A1	2	ft if M1 gained in (a) and (b)
	(= 53 300 J to 3sf)			
(ii)	speed of packet is $\sqrt{\frac{53330}{\frac{1}{2}\times 25}}$	M1		ft C's (c)(i)
	= 65.3 m s^{-1}	A1	2	CAO
	Total		**8**	
2(a)	using **F** = m**a**:	M1		ie dividing by 50
	a = (6t – 1.2 t^2) **i** + 2 e^{-2t} **j**	A1	2	
(b)	**v** = $\int$ **a** dt			
	= (3 t^2 – 0.4 t^3) **i** – e^{-2t}**j** + **c**	M1A1		condone lack of + c; M1 one term correct
	when t = 0, **r** = 7 **i** – 4 **j**			
	c = 7 **i** – 3**j**	m1A1	4	ft from ke $^{-2t}$ in (b); just adding 7**i** – 4**j**, m0
	v = (7 + 3 t^2 – 0.4 t^3) **i** – (3 + e^{-2t}) **j**			accept unsimplified. CAO
(c)	when t = 1, **v** = 9.6 **i** – 3.135 **j**	M1A1		ft from (b)
	speed = $\sqrt{9.6^2 + 3.135^2}$	m1		
	= 10.1 ms^{-1}	A1	4	ft from (b)
	Total		**10**	

MM2B (cont)

Q	Solution	Marks	Total	Comments
3(a)				accept 'weight of man' or w_m etc for $72g$
	force diagram	B2	2	B1 for any error
(b)(i)	moments about P: $72g \times 6 \times \cos 69 + 28g \times 4 \times \cos 69$ $= S \times 8 \times \sin 69$ $(432g + 112g)\cos 69 = 8\ S \sin 69$	M1 A1A1		3 terms including distance and angles A1 2 correct terms
	$S = 255.8$	A1		accept division seen eg $\frac{544g}{8\tan 69}$
	$= 256$N		4	
(ii)	resolve vertically: $R = 28g + 72g$ $= 100g$ resolve horizontally: $S = F$	 B1 B1		
	using $F = \mu R$: $\mu = 256 \div 100g$ $= 0.261$	 M1 A1	 4	
	Total		**10**	
4(a)	using power = force × velocity power = (25 × 42) × 42 ∴power is 44 100 watts	 M1 A1	 2	
(b)	when speed is 15 m s $^{-1}$, max force exerted is $\frac{44100}{15}$ $= 2940$N resistance force is $25 \times 15 = 375$N accelerating force is 2940 – 375N $= 2565$ using $F = ma$ $2565 = 1500a$ $a = 1.71$ m s $^{-2}$	 B1 M1 m1 A1	 4	
	Total		**6**	

MM2B (cont)

Q	Solution	Marks	Total	Comments
5	$R = mg$	M1		
	$F = 0.85\ mg$	A1		
	$\frac{mv^2}{r} = 0.85\ mg$	M1A1		condone $\frac{mv^2}{r} = 0.85R$ (for M1A1)
	$v^2 = 34 \times 0.85 \times g$	m1		dependent on both M1s
	$= 283.22$			
	$v = 16.8\ \text{m s}^{-1}$	A1	6	
	Total		**6**	
6(a)	using $F = ma$			
	$0.4\ \frac{dv}{dt} = 2 - 4v$	M1		
	$\frac{dv}{dt} = -10\ (v - 0.5)$	A1	2	Needs line above
(b)	hence $\int \frac{1}{v - 0.5} dv = -\int 10 dt$			
	$\ln(v - 0.5) = -10t + c$	M1A1		M1 for any side integrated correctly
		m1		m1 for + c (and M1 gained)
	$v - 0.5 = Ce^{-10t}$			
	$t = 0,\ v = 1$			
	$\therefore C = 0.5$	A1		
	$\therefore v = 0.5 + 0.5e^{-10t}$	A1	5	condone $v = 0.5 + e^{-10t - 0.693}$
(c)	when $v = 0.55$, $0.55 = 0.5 + 0.5e^{-10t}$	M1		substitute 0.55 into C's (b), after finding c, possible numerical error
	$10 = e^{10t}$	A1		
	$t = \ln 10 \div 10$			
	$= 0.230$	A1	3	
	Total		**10**	

MM2B (cont)

Q	Solution	Marks	Total	Comments
7(a)	by conservation of energy:			
	$\frac{1}{2}m(u)^2 = \frac{1}{2}m(v)^2 + mg2a$	M1		M1 for 3 terms, 2 KE and PE; not $v^2 = u^2 + 2as$
	$v^2 = u^2 - 4ag$	A1	2	
(b)(i)	at point A; $T_1 = \frac{m(v)^2}{a} - mg$	M1A1		both signs incorrect M1 either correct M1A1
	at point B; $T_2 = \frac{m(u)^2}{a} + mg$	A1		
	$\frac{T_1}{T_2} = \frac{2}{5}$	B1		or $5T_A = 2T_B$ or $T_1 = 2T$, $T_2 = 5T$
	$5\left(\frac{m(v)^2}{a} - mg\right) = 2\left(\frac{m(u)^2}{a} + mg\right)$	A1		CAO
	$5\left(\frac{m(u^2 - 4ag)}{a} - mg\right)$ $= 2\left(\frac{m(u)^2}{a} + mg\right)$			
	$5u^2 - 20ag - 5ag = 2u^2 + 2ag$	m1		from ratio 2 : 5 or 5 : 2 and one tension equation correct
	$3u^2 = 27ag$			
	$u = 3\sqrt{ag}$	A1	7	condone $\sqrt{9ag}$
(ii)	$u^2 = v^2 + 4ag \rightarrow v = \sqrt{5ag}$	B1		condone $v^2 = 5ag$
	ratio $u : v = 3 : \sqrt{5}$	B1	2	accept 1.34 : 1 or 1 : 0.745
	Total		**11**	

MM2B (cont)

Q	Solution	Marks	Total	Comments
8(a)	using $\text{EPE} = \frac{\lambda x^2}{2l}$,	M1		
	$\text{EPE} = \frac{32 \times 2.2^2}{2 \times 0.8}$	B1		B1 for 2.2
	= 96.8 J	A1	3	
(b)	by C of Energy, when next at rest, EPE (initial) = work done against friction + EPE (when at rest)	M1A1		M1A1 for work done by friction or $5F$
	$96.8 = F \times 5 + \frac{32 \times 1.2^2}{2 \times 0.8}$	M1A1		M1 3 terms; A1 all correct
	$5F = 96.8 - 28.8$	B1		B1 28.8
	frictional force is 13.6N	A1	6	
(c)	at B, tension is $\frac{32 \times 1.2}{0.8}$			
	= 48N	B1		
	tension > friction hence particle starts to move	E1	2	
(d)	when particle is next at rest, work done against friction is EPE at B			
	13.6 × distance = 28.8	M1		
	distance is 2.1176 = 2.12 m	A1	2	CAO
(e)	total distance is 5 + 2.1176	B1	1	ft from M1 in (d) or total distance × 13.6 = original EPE, 96.8
	= 7.12 m			total distance is 7.12 m
	Total		**14**	
	TOTAL		**75**	