



**Free-Standing Mathematics Qualification
June 2011**

Mathematics Advanced Level 6992

(Specification 6992)

Modelling with Calculus

Mark Scheme

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Key to mark scheme and abbreviations used in marking

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	MC	mis-copy
CAO	correct answer only	MR	mis-read
CSO	correct solution only	RA	required accuracy
AWFW	anything which falls within	FW	further work
AWRT	anything which rounds to	ISW	ignore subsequent work
ACF	any correct form	FIW	from incorrect work
AG	answer given	BOD	given benefit of doubt
SC	special case	WR	work replaced by candidate
OE	OE	FB	formulae book
A2,1	2 or 1 (or 0) accuracy marks	NOS	not on scheme
-x EE	deduct x marks for each error	G	graph
NMS	no method shown	c	candidate
PI	possibly implied	sf	significant figure(s)
SCA	substantially correct approach	dp	decimal place(s)

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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Answers and Marking Scheme - June 2011

Question 1

(a)	$\frac{dh}{dt} = 32t - 193$ $\frac{dh}{dt} = 0 \Rightarrow$ $32t - 193 = 0$ $t = \frac{193}{32} \text{ or } 6.03$ <p>When $t = \frac{193}{32}$,</p> $h = 16\left(\frac{193}{32}\right)^2 - 193\left(\frac{193}{32}\right) + 780$ $= 198$	<p>M1A1</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p>	<p>M1 2 terms, either correct</p> <p>SC5 for 197</p> <p>Use of $t = 6$ only etc SC5</p>
(b)(i)	<p>Quadratic shape with minimum point</p> <p>Cuts h axis at 780 and goes higher as $t \rightarrow 18$</p>	<p>B1</p> <p>B1</p>	<p>SC1 for plot not sketch</p>
(ii)	<p>The model is not appropriate for values of $t > 12$ and reason why</p>	<p>E1</p>	
	TOTAL	9	

Question 2

(a)	$\frac{dv}{dt} = -2 + 10t - 6t^2$ $\frac{dv}{dt} = 0 \Rightarrow$ $-2 + 10t - 6t^2 = 0$ $3t^2 - 5t + 1 = 0$ $t = \frac{5 \pm \sqrt{25-12}}{6}$ $= \frac{8.606}{6} \text{ or } \frac{1.394}{6}$ $= 1.43 \text{ or } 0.232$	M1A1 M1 M1 A1	M1 2 terms correct; could be seen in (b) SC4 either answer correct Accept 2 dp
(b)	$\frac{d^2v}{dt^2} = 10 - 12t$	M1A1ft	M1 Either term correct ft $\frac{dv}{dt}$
(c)	When $v = 1.43$, $v = 16 - 2 \times 1.43 + 5(1.43)^2 - 2(1.43)^3$ $= 17.516$ Maximum value is £17.52 When $t = 1.43$, $\frac{d^2v}{dt^2} = -7.211$ This is negative, hence answer is a maximum	M1 A1 B1 E1	Condone 17.5
(d)	$\frac{d^2v}{dt^2} = 0 \text{ when } 10 - 12t = 0$ $t = \frac{5}{6} \text{ or } 0.833$ The value of the shares is increasing at its fastest rate	M1 A1 E1	
TOTAL		14	

Question 4

(a)	When $x = 6$, $h = 70 + 40 \cos 2\pi$ $= 70 + 40 \times 1$ $= 110$	B1 B1	B1 for $\cos 2\pi = 1$ 109.9 ~ 110 SC1
(b)	$\frac{dh}{dx} = -40 \cdot \frac{\pi}{3} \sin \frac{\pi}{3} x$	B1 B1 B1	$\frac{\pi}{3}$ $\sin \frac{\pi}{3} x$ All correct
(c)	Maximum value of $-\sin \frac{\pi}{3} x$ is 1 Maximum value is $40 \cdot \frac{\pi}{3} = 41.88\dots$ $= 41.9$ or $\frac{40\pi}{3}$	M1 A1 A1	Condone max value of $\sin \frac{\pi}{3} x$ is 1 -41.9 SC2
	TOTAL	8	

Question 5

(a)	$\frac{dm}{dt} = -k m$ $\int \frac{dm}{m} = - \int k dt$ $\ln m = -k t + c$ $m = C e^{-kt}$	M1 A1 A1 M1 A1	Need this line for A2 M1 for + c Can be obtained in (b) Need correct working
(b)	When $t = 0, m = 40, \therefore C = 40$ $m = 40 e^{-kt}$	M1 A1	
(c)	When $t = 6, 20 = 40 e^{-k6}$ $e^{-6k} = \frac{1}{2}$ $\ln\left(\frac{1}{2}\right) = -6k$ $-6k = -0.693147$ $k = 0.1155$ $= 0.116$	M1 A1 A1	Or $\ln 2 = 6k$ (M1 A1 for $-k = -0.116$) Accept 0.115 SC1 – 0.116
(d)	When $t = 18, m = 40 e^{-18k}$ $= 5.002\dots$ $= 5$	B1 B1 B1	Condone 4.9 Accept 5.000... or 4.96 to 5 Exact answer (not rounded) NB Three ‘half-lives’ hence mass is 5 grams SC3
(e)	When $m = 2, 2 = 40 e^{-kt}$ $\ln 0.05 = -0.1155 t$ $t = 25.9$	M1 A1 A1	or $6 \ln 20 / \ln 2$ Condone 25.8 or 26
	TOTAL	16	
	TOTAL MARK FOR PAPER	60	