



ADDITIONAL MATHEMATICS

0606/22

Paper 22

March 2017

MARK SCHEME

Maximum Mark: 80

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge will not enter into discussions about these mark schemes.

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MARK SCHEME NOTES

The following notes are intended to aid interpretation of mark schemes in general, but individual mark schemes may include marks awarded for specific reasons outside the scope of these notes.

Types of mark

- M** Method marks, awarded for a valid method applied to the problem.
- A** Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.
- B** Mark for a correct result or statement independent of Method marks.

When a part of a question has two or more ‘method’ steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. The notation ‘**dep**’ is used to indicate that a particular M or B mark is dependent on an earlier mark in the scheme.

Abbreviations

awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
nfww	not from wrong working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied
www	without wrong working

Question	Answer	Marks	Guidance
1	$-\frac{5}{3}$ isw	B1	or exact equivalent
	Solve $5 - 3x = -10$ or $(5 - 3x)^2 = 100$	M1	
	$x = 5$	A1	
2 (i)	\$12 000	B1	
(ii)	$\frac{8000}{12000} = e^{-0.2t}$ oe	M1	
	$[t =] 2(.0273\dots)$ years	A1	

Question	Answer	Marks	Guidance
<p>3 (i)</p> <p>(ii)</p>	<p>multiply out correctly</p> <p>Finding another factor</p> <p>Either $(x - 1)^2(x^2 - 4)$ Or $(x - 1)(x + 2)(x^2 - 3x + 2)$ Or $(x - 1)(x - 2)(x^2 + x - 2)$</p> <p>Attempts to factorise quadratic $(x - 1)^2(x + 2)(x - 2)$ oe</p>	<p>B1</p> <p>B1</p> <p>B1</p> <p>M1</p> <p>A1</p>	<p>or divide out correctly</p> <p>$(x - 1)$ or $(x + 2)$ or $(x - 2)$; method must be seen</p> <p>For stating a relevant quadratic factor for <i>their</i> linear factors</p> <p>mark final answer</p> <p>Alternative method: B1 for finding a second linear factor using any valid method and B1 for finding a third linear factor using any valid method and B1 for finding the final linear factor using any valid method and B1 for fully correct product stated; mark final answer</p> <p>If fully correct product stated but no method shown then B1 only.</p>
<p>4</p>	<p>Eliminates y $3x + k = 2x^2 - 3x + 4$</p> <p>Collects terms $2x^2 - 6x + 4 - k = 0$ soi</p> <p>Applies $b^2 - 4ac$ $(-6)^2 - 4(2)(4 - k)$ or better</p> <p>$k < -\frac{1}{2}$ oe</p>	<p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p>	<p>Alternative calculus method: Equates gradients $4x - 3 = 3$</p> <p>Finds point of tangency $(1.5, 4)$</p> <p>Substitutes into $y = 3x + k$ $4 = 3(1.5) + k$</p>

Question	Answer	Marks	Guidance
5	$\sqrt{20} = \sqrt{4 \times 5} = 2\sqrt{5}$ seen $(3 + \sqrt{5})x + \frac{1}{2}x(\text{their } 2\sqrt{5}) = 13 + 5\sqrt{5}$ oe leading to $(3 + \text{their } 2\sqrt{5})x = 13 + 5\sqrt{5}$ $[x =] \frac{13 + 5\sqrt{5}}{3 + \text{their } 2\sqrt{5}} \times \frac{3 - \text{their } 2\sqrt{5}}{3 - \text{their } 2\sqrt{5}}$ $[x =] \frac{39 - 26\sqrt{5} + 15\sqrt{5} - 50}{9 - 20}$ $1 + \sqrt{5}$ www	B1 M1 M1 M1 A1	may be later in working; must be convinced that calculator has not been used equates <i>their</i> area to given area and factorises to collect x terms; may still have $\sqrt{20}$ divides and attempts to rationalise; may still have $\sqrt{20}$ or forms a pair of simultaneous equations e.g. $3p + 10q = 13$ $2p + 3q = 5$ numerator must have at least 3 terms; denominator may be -11 or solves their simultaneous equations to find one unknown or $p = 1, q = 1$
6 (a) (i)	$-2x^{\frac{5}{2}}$ oe or $a = -2$ and $b = \frac{5}{2}$ oe (ii) $[x =] \left(\frac{-6250}{\text{their } (-2)} \right)^{\text{their } \frac{2}{5}}$ oe 25 (b) (i) Valid explanation (ii) $1 = \log_a a$ $2 \log_a (4x - 3) = \log_a (4x - 3)^2$ soi completion to given result	B2 M1 A1 B1 M1 M1 A1	mark final answer B1 for -2 and B1 for $\frac{5}{2}$ may be in steps e.g. If $x > 0.75$ then all the arguments are positive as required. oe may be seen in e.g. $\log_a(ax) = 1 + \log x$

Question	Answer	Marks	Guidance
(iii)	$x^2(16x - 24) = 0$ oe or $x(16x - 24) = 0$ oe [$x =$] $\frac{24}{16}$ or $\frac{3}{2}$ oe	M1 A1	e.g. equates, anti-logs, rearranges and factorises or divides OR rearranges, combines using correct log law, anti-logs and factorises or divides inclusion of $x = 0$ is A0
7 (a)	[$r^2 =$] $5^2 + 10^2 - 2 \times 5 \times 10 \times \cos 120$ oe [$r =$] 13.2 or 13.22875.... rot to 4 or more sf $\frac{\sin x}{5} = \frac{\sin 120}{\text{their} 13.2}$ or better [$x =$] awrt 19.1 360 – 120 – <i>their</i> x	M1 A1 M1 A1 A1FT	or for [$r^2 =$] $5^2 + 10^2 - 2 \times 5 \times 10 \times \cos 60^\circ$ or for [$r^2 =$] $5^2 + 10^2 - 2 \times 5 \times 10 \times \cos 240^\circ$ not from wrong working or $\frac{\sin y}{10} = \frac{\sin 120}{\text{their} 13.2}$ or better or [$y =$] awrt 40.9 or 180 + <i>their</i> y
(b)	94 [km/h] west	B2	B1 for 94 [km/h]
8 (i)	$y - (-4) = \frac{1}{6}(x - 6)$ [$m_{AB} =$] $\frac{7-4}{3-8}$ or $-\frac{3}{5}$ oe $y - 7 = -\frac{3}{5}(x - 3)$ or $y - 4 = -\frac{3}{5}(x - 8)$ <i>their</i> $\left(\frac{1}{6}x - 5\right) = \text{their} \left(-\frac{3}{5}x + \frac{44}{5}\right)$ $x = 18$ $y = -2$ isw	B1 M1 A1 M1 A1 A1	or $y = \frac{1}{6}x + c$ and $c = -5$ or $y = -\frac{3}{5}x + c$ and $c = \frac{44}{5}$ valid method of solution for <i>their</i> equations; must be of equivalent difficulty

Question	Answer	Marks	Guidance
(ii)	$[m =] -\frac{3}{2}$ $y - \text{their}(-2) = -\frac{3}{2}(x - \text{their}18)$ isw	M1 A1FT	FT <i>their D</i> ; $y = -\frac{3}{2}x + c$ and $c = \text{their } 25$
9 (a)	$ke^{2x+1} (+c)$ $k = \frac{1}{2}$	M1 A1	for some non-zero integer k where $k \neq 2$
(b) (i)	$\frac{d(\ln x)}{dx} = \frac{1}{x}$ soi $\left[\frac{dy}{dx} = \right] \frac{(\text{their}1)\ln x - x\left(\text{their}\frac{1}{x}\right)}{(\ln x)^2}$ correct, isw	B1 M1 A1	correct form of quotient rule or equivalent product rule applied; brackets may be omitted or misplaced for M1 may be unsimplified; allow recovery of brackets
(ii)	$\int \frac{\ln x - 1}{(\ln x)^2} dx + \int \frac{1}{x^2} dx = \frac{x}{\ln x} + \int \frac{1}{x^2} dx$ $\int \frac{1}{x^2} dx = -\frac{1}{x} (+c)$ $\frac{x}{\ln x} + \left(\text{their} -\frac{1}{x}\right) (+c)$	M1 B1 A1FT	rearranges and uses their answer to (i) correct or correct FT completion; <i>their</i> $-\frac{1}{x}$ must not be $\frac{1}{x^2}$

Question	Answer	Marks	Guidance
<p>10 (i)</p> <p>(ii)</p>	$\tan(2x - 10) = \frac{4}{3}$ $2x - 10 = \tan^{-1}\left(\frac{4}{3}\right) \text{ soi}$ <p>31.6 and 121.6 isw</p> <p>211.6 and 301.6 isw</p> $1 - \cos^2 x - \cos^2 x = \cos x$ $2\cos^2 x + \cos x - 1 = 0 \text{ oe}$ $(2\cos x - 1)(\cos x + 1) [= 0]$ <p>[x =] 60, 300, 180</p>	<p>B1</p> <p>M1</p> <p>A1</p> <p>A1</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>A2</p>	<p>or for 31.6 and 211.6 isw</p> <p>or for 121.6 and 301.6 isw</p> <p>Penalty of 1 mark if all 4 angles given correctly but prematurely approximated OR if any extra angles are given besides the correct 4</p> <p>If A0 A0 then allow SC1 for 53.1(30...), 233.1(30...), 413.1(30...), 593.1(30...) seen OR for 63.1(30...), 243.1(30...), 423.1(30...), 603.1(30...) seen</p> <p>uses $\sin^2 x = 1 - \cos^2 x$</p> <p>factorises or solves <i>their</i> 3-term quadratic in $\cos x$</p> <p>A1 for any two correct</p>
<p>11 (i)</p> <p>(ii)</p> <p>(iii)</p>	$g \geq -\frac{1}{2}$ <p>$g(1) = 0$ valid comment e.g. domain of f is $x \geq 2$</p> $\frac{\left(\frac{x^2 - 2}{x}\right)^2 - 1}{2}$ $\left(\frac{x^2 - 2}{x}\right)^2 = \frac{x^4 - 4x^2 + 4}{x^2} \text{ soi}$ $\frac{1}{2}x^2 - \frac{5}{2} + \frac{2}{x^2}$	<p>B1</p> <p>B1</p> <p>B1</p> <p>M1</p> <p>B1</p> <p>A1</p>	<p>B1 for either</p> $\text{or } \frac{\left(x - \frac{2}{x}\right)^2 - 1}{2}$ $\text{or } \left(x - \frac{2}{x}\right)^2 = x^2 - 4 + \frac{4}{x^2}$ <p>or correct 3 term equivalent or $a = 0.5, b = -2.5, c = 2$</p>

Question	Answer	Marks	Guidance
(iv)	$x \geq 2$	B1	
(v)	$x^2 - yx - 2 = 0$	B1	or $y^2 - xy - 2 = 0$
	$[x =] \frac{-(-y) \pm \sqrt{(-y)^2 - 4(1)(-2)}}{2}$	M1	or $[y =] \frac{-(-x) \pm \sqrt{(-x)^2 - 4(1)(-2)}}{2}$
	Explains why negative square root should be discarded	B1	at some point
	$f^{-1}(x) = \frac{x + \sqrt{x^2 + 8}}{2}$	A1	allow $y = \frac{x + \sqrt{x^2 + 8}}{2}$
			If zero scored, allow SC2 for showing correctly that the inverse of the given f^{-1} is f .
12 (i)	[length of rectangle =] $\frac{20 - 3x}{2}$	B1	
	$[A =] x \times \text{their} \frac{20 - 3x}{2} - \frac{1}{2} \times x \times x \times \sin 60$ oe	M1	
	Correct completion to given answer		
	$A = 10x - \left(\frac{6 + \sqrt{3}}{4}\right)x^2$	A1	
(ii)	$10 - 2\left(\frac{6 + \sqrt{3}}{4}\right)x$ oe	B1	
	$\text{their} \left(10 - 2\left(\frac{6 + \sqrt{3}}{4}\right)x\right) = 0$ oe	M1	
	$x = 2.6$	A1	allow 2.586635... rot to 3 or more sf
	$A = 13$	A1	allow 12.9331.... rot to 3 or more sf