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General Certificate of Education

Mathematics 6360

MFP3 Further Pure 3

Mark Scheme

2008 examination – June series



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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		
\surd 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	or equivalent	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)

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. However, there are situations in some units where part marks would be appropriate, particularly when similar techniques are involved. Your Principal Examiner will alert you to these and details will be provided on the mark scheme.

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.

MFP3

Q	Solution	Marks	Total	Comments
1	$k_1 = 0.1 \times \ln(2+3)$ $= 0.1609(4379\dots) \quad (= *)$	M1 A1		PI
	$k_2 = 0.1 \times f(2.1, 3+*...)$ $\dots = 0.1 \times \ln(2.1 + 3.16094\dots)$	M1		
	$\dots = 0.1660(31\dots)$	A1		PI
	$y(2.1) = y(2) + \frac{1}{2}[k_1 + k_2]$ $= 3 + 0.5 \times 0.3269748\dots$	m1		Dep on previous two Ms and numerical values for k 's
	$= 3.163487\dots = 3.1635$ to 4dp	A1	6	Must be 3.1635
	Total		6	
2(a)	PI: $y_{PI} = a + bx + c \sin x + d \cos x$ $y'_{PI} = b + c \cos x - d \sin x$ $b + c \cos x - d \sin x - 3a - 3bx - 3c \sin x - 3d \cos x = 10 \sin x - 3x$	M1		Substituting into DE
	$b - 3a = 0; -3b = -3; c - 3d = 0; -d - 3c = 10$	M1		Equating coefficients (at least 2 eqns)
	$a = \frac{1}{3}; b = 1; c = -3; d = -1$	A2,1	4	A1 for any two correct
	$y_{PI} = \frac{1}{3} + x - 3 \sin x - \cos x$			
(b)	Aux. eqn. $m - 3 = 0$	M1		Altn. $\int y^{-1} dy = \int 3 dx$ OE (M1)
	$(y_{CF} =) Ae^{3x}$	A1		Ae^{3x} OE
	$(y_{GS} =) Ae^{3x} + \frac{1}{3} + x - 3 \sin x - \cos x$	B1F	3	(c 's CF + c 's PI) with 1 arbitrary constant
	Total		7	
3(a)	$x^2 + y^2 = 1 - 2y + y^2 \Rightarrow x^2 + y^2 = (1 - y)^2$	B1	1	AG
	(b) $x^2 + y^2 = r^2$ $y = r \sin \theta$ $x^2 = 1 - 2y$ so $x^2 + y^2 = (1 - y)^2$ $\Rightarrow r^2 = (1 - r \sin \theta)^2$	M1 M1		Or $x = r \cos \theta$
	$r = 1 - r \sin \theta$ or $r = -(1 - r \sin \theta)$ $r(1 + \sin \theta) = 1$ or $r(1 - \sin \theta) = -1$	A1		OE eg $r^2 \cos^2 \theta = 1 - 2r \sin \theta$ PI by the next line
	$r > 0$ so $r = \frac{1}{1 + \sin \theta}$	m1 A1	5	Either CSO
	Total		6	

MFP3 (cont)

Q	Solution	Marks	Total	Comments
4(a)	$u = \frac{dy}{dx} \Rightarrow \frac{du}{dx} = \frac{d^2y}{dx^2}$	M1	2	AG Substitution into LHS of DE and completion
	$x \frac{du}{dx} - u = 3x^2 \Rightarrow \frac{du}{dx} - \frac{1}{x}u = 3x$	A1		
	(b) IF is $\exp\left(\int -\frac{1}{x} dx\right)$ $= e^{-\ln x}$ $= x^{-1}$ or $\frac{1}{x}$	M1 A1 A1		
	$\frac{d}{dx}[ux^{-1}] = 3$ $\Rightarrow ux^{-1} = 3x + A$ $u = 3x^2 + Ax$	M1 m1 A1	6	LHS as differential of $u \times \text{IF}$. PI Must have an arbitrary constant (Dep. on previous M1 only)
(c)	$\frac{dy}{dx} = 3x^2 + Ax$ $y = x^3 + \frac{Ax^2}{2} + B$	M1 A1F	2	Replaces u by $\frac{dy}{dx}$ and attempts to integrate ft on cand's u but solution must have two arbitrary constants
Total			10	
5(a)	$\int x^3 \ln x dx = \frac{x^4}{4} \ln x - \int \frac{x^4}{4} \left(\frac{1}{x}\right) dx$	M1	3	... = $kx^4 \ln x \pm \int f(x)$, with $f(x)$ not involving the 'original' $\ln x$
 = $\frac{x^4}{4} \ln x - \frac{x^4}{16} + c$	A1 A1		
(b)	Integrand is not defined at $x = 0$	E1	1	OE
(c)	$\int_0^e x^3 \ln x dx = \left\{ \lim_{a \rightarrow 0} \int_a^e x^3 \ln x dx \right\}$ $= \frac{3e^4}{16} - \lim_{a \rightarrow 0} \left[\frac{a^4}{4} \ln a - \frac{a^4}{16} \right]$	M1		F(e) - F(a)
	But $\lim_{a \rightarrow 0} a^4 \ln a = 0$ So $\int_0^e x^3 \ln x dx$ exists and $= \frac{3e^4}{16}$	B1 A1	3	Accept a general form eg $\lim_{x \rightarrow 0} x^k \ln x = 0$ CSO
Total			7	

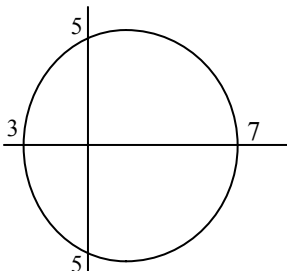
MFP3 (cont)

Q	Solution	Marks	Total	Comments
6(a)	Aux eqn: $m^2 - 2m - 3 = 0$	M1	10	(c's CF+c's PI) with 2 arbitrary constants
	$m = -1, 3$	A1		
	CF ($y_C =$) $Ae^{3x} + Be^{-x}$	M1		
	Try ($y_{PI} =$) $ae^{-2x} (+b)$	M1		
	$\frac{dy}{dx} = -2ae^{-2x}$	A1		
	$\frac{d^2y}{dx^2} = 4ae^{-2x}$	A1		
	Substitute into DE gives			
	$4ae^{-2x} + 4ae^{-2x} - 3ae^{-2x} - 3b = 10e^{-2x} - 9$	M1		
	$\Rightarrow a = 2$	A1		
	$b = 3$	B1		
(b)	$(y_{GS} =) Ae^{3x} + Be^{-x} + 2e^{-2x} + 3$	B1F	4	Must be using 'A' = 0 CSO
	$x = 0, y = 7 \Rightarrow 7 = A + B + 2 + 3$	B1F		
	$\frac{dy}{dx} = 3Ae^{3x} - Be^{-x} - 4e^{-2x}$			
	As $x \rightarrow \infty, e^{-kx} \rightarrow 0, \frac{dy}{dx} \rightarrow 0$ so $A = 0$	B1		
	When $A = 0, 5 = 0 + B + 3 \Rightarrow B = 2$	B1F		
	$y = 2e^{-x} + 2e^{-2x} + 3$	A1		
	Total		14	

MFP3 (cont)

Q	Solution	Marks	Total	Comments
7(a)	$\sin 2x \approx 2x - \frac{(2x)^3}{3!} + \dots = 2x - \frac{4}{3}x^3 + \dots$	B1	1	
(b)(i)	$\frac{dy}{dx} = \frac{1}{2}(3+e^x)^{-\frac{1}{2}}(e^x)$	M1 A1		Chain rule
	$\frac{d^2y}{dx^2} = \frac{1}{2}e^x(3+e^x)^{-\frac{1}{2}} - \frac{1}{4}(3+e^x)^{-\frac{3}{2}}(e^{2x})$	M1 A1		Product rule OE OE
	$y'(0) = \frac{1}{4}; y''(0) = \frac{1}{4} - \frac{1}{32} = \frac{7}{32}$	A1	5	CSO
(ii)	$y(0) = 2; y'(0) = \frac{1}{4}; y''(0) = \frac{1}{4} - \frac{1}{32} = \frac{7}{32}$			
	McC. Thm: $y(0) + x y'(0) + \frac{x^2}{2} y''(0)$ $\sqrt{3+e^x} \approx 2 + \frac{1}{4}x + \frac{7}{64}x^2$	M1 A1	2	CSO; AG
(c)	$\left[\frac{\sqrt{3+e^x} - 2}{\sin 2x} \right] = \left[\frac{2 + \frac{1}{4}x + \frac{7}{64}x^2 - 2}{2x - \frac{4}{3}x^3} \right]$	M1		
	$= \left[\frac{\frac{1}{4} + \frac{7}{64}x + \dots}{2 - \frac{4}{3}x^2 + \dots} \right]$	m1		Dividing numerator and denominator by x to get constant term in each
	$\lim_{x \rightarrow 0} \left[\frac{\sqrt{3+e^x} - 2}{\sin 2x} \right] = \frac{\frac{1}{4}}{2} = \frac{1}{8}$	A1F	3	Ft on cand's answer to (a) provided of the form $ax+bx^3$
	Total		11	

MFP3 (cont)

Q	Solution	Marks	Total	Comments
8(a)	$\theta = 0, r = 5 + 2\cos 0 = 7$ {A lies on C}	B1		
	$\theta = \pi, r = 5 + 2\cos \pi = 3$ {B lies on C}	B1	2	
(b)		B1		Closed single loop curve, with (indication of) symmetry
		B1	2	Critical values, 3,5,7 indicated
(c)	$\text{Area} = \frac{1}{2} \int (5 + 2\cos \theta)^2 d\theta$ $= \frac{1}{2} \int_{-\pi}^{\pi} (25 + 20\cos \theta + 4\cos^2 \theta) d\theta$ $= \frac{1}{2} \int_{-\pi}^{\pi} (25 + 20\cos \theta + 2(\cos 2\theta + 1)) d\theta$ $= \frac{1}{2} [27\theta + 20\sin \theta + \sin 2\theta]_{-\pi}^{\pi}$ $= 27\pi$	M1 B1 B1 M1 A1F A1	6	Use of $\frac{1}{2} \int r^2 d\theta$ OE for correct expansion of $(5 + 2\cos \theta)^2$ For correct limits Attempt to write $\cos^2 \theta$ in terms of $\cos 2\theta$ Correct integration ft wrong non-zero coefficients in $a + b\cos \theta + c\cos 2\theta$ CSO
(d)	Triangle OBQ with $OB = 3$ and angle $BOQ = \alpha$	B1		PI
	$OQ = 5 + 2\cos(-\pi + \alpha)$	M1		OE
	Area of triangle $OQB = \frac{1}{2} OB \times OQ \sin \alpha$	m1		Dep. on correct method to find OQ
	$= \frac{3}{2} (5 - 2\cos \alpha) \sin \alpha$	A1	4	CSO
	Total		14	
	TOTAL		75	