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General Certificate of Education

Mathematics 6360

MFP3 Further Pure 3

Mark Scheme

2007 examination - January 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		
✓ 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(a)	$y(1.05) = 0.6 + 0.05 \times [\ln(1 + 1 + 0.6)]$ $= 0.6477(7557..) = 0.6478$ to 4dp	M1A1 A1	3	Condone >4 dp
(b)	$k_1 = 0.05 \times \ln(1 + 1 + 0.6) = 0.0477(75...)$ $k_2 = 0.05 \times f(1.05, 0.6477...)$ $... = 0.05 \times \ln(1 + 1.05^2 + 0.6477...)$ $... = 0.0505(85...)$ $y(1.05) = y(1) + \frac{1}{2}[k_1 + k_2]$ $= 0.6 + 0.5 \times 0.09836...$ $= 0.6492$ to 4dp	M1 A1F M1 A1F m1 A1F	6	PI ft candidate's evaluation in (a) PI Dep on previous two Ms and numerical values for k 's Must be 4 dp... ft one slip
Total			9	
2	$r - r \sin \theta = 4$ $r - y = 4$ $r = y + 4$ $x^2 + y^2 = (y + 4)^2$ $x^2 + y^2 = y^2 + 8y + 16$ $y = \frac{x^2 - 16}{8}$	M1 B1 A1 M1 A1F A1	6	$r \sin \theta = y$ stated or used $r^2 = x^2 + y^2$ used ft one slip
Total			6	
3(a)	IF is $\exp\left(\int \frac{2}{x} dx\right)$ $= e^{2 \ln x}$ $= x^2$	M1 A1 A1	3	And with integration attempted CSO AG be convinced
(b)	$\frac{d}{dx}[yx^2] = 3x^2(x^3 + 1)^{\frac{1}{2}}$ $\Rightarrow yx^2 = \frac{2}{3}(x^3 + 1)^{\frac{3}{2}} + A$ $\Rightarrow 4 = \frac{2}{3}(9)^{\frac{3}{2}} + A$ $\Rightarrow A = -14$ $\Rightarrow y = x^{-2} \left\{ \frac{2}{3}(x^3 + 1)^{\frac{3}{2}} - 14 \right\}$	M1A1 m1 A1 m1 A1	6	PI $k(x^3 + 1)^{\frac{3}{2}}$ Condone missing 'A' Use of boundary conditions to find constant Any correct form
Total			9	

MFP3 (cont)

Q	Solution	Marks	Total	Comments
4(a)	Integrand is not defined at $x = 0$	E1	1	OE
(b)	$\int x^{\frac{1}{2}} \ln x \, dx = 2x^{\frac{1}{2}} \ln x - \int 2x^{\frac{1}{2}} \left(\frac{1}{x}\right) dx$ = $2x^{\frac{1}{2}} \ln x - 4x^{\frac{1}{2}} (+c)$	M1 A1 A1	3	... = $kx^{\frac{1}{2}} \ln x \pm \int f(x)$, with $f(x)$ not involving the 'original' $\ln x$ Condone absence of '+ c'
(c)	$\int_0^e \frac{\ln x}{\sqrt{x}} \, dx = \lim_{a \rightarrow 0} \int_a^e \frac{\ln x}{\sqrt{x}} \, dx$ = $-2e^{\frac{1}{2}} - \lim_{a \rightarrow 0} \left[2a^{\frac{1}{2}} \ln a - 4a^{\frac{1}{2}} \right]$ But $\lim_{a \rightarrow 0} a^{\frac{1}{2}} \ln a = 0$ So $\int_0^e \frac{\ln x}{\sqrt{x}} \, dx$ exists and = $-2e^{\frac{1}{2}}$	M1 M1 B1 A1	4	$F(b) - F(a)$ Accept a general form e.g. $\lim_{x \rightarrow 0} x^k \ln x = 0$
Total			8	
5	Auxl. eqn $m^2 - 4m + 3 = 0$ $m = 3$ and 1 CF is $Ae^{3x} + B e^x$ PI Try $y = a + b \sin x + c \cos x$ $y'(x) = b \cos x - c \sin x$ $y''(x) = -b \sin x - c \cos x$ Substitute into DE gives $a = 2$ $4c + 2b = 5$ and $2c - 4b = 0$ $b = 0.5,$ $c = 1$ GS: $y = Ae^{3x} + B e^x + 2 + 0.5 \sin x + \cos x$	M1 A1 A1F M1 A1 A1F M1 B1 A1 A1F A1F B1F	12	PI PI Condone 'a' missing here ft can be consistent sign error(s) ft a slip ft a slip $y =$ candidate's CF and candidate's PI (must have exactly two arbitrary constants)
Total			12	

MFP3 (cont)

Q	Solution	Marks	Total	Comments
6(a)(i)	$f'(x) = \frac{1}{2}(1+2x)^{-\frac{1}{2}}(2) = (1+2x)^{-\frac{1}{2}}$	M1A1	4	ft a slip
	$f''(x) = -(1+2x)^{-\frac{3}{2}}$	A1F		
(ii)	$f'''(x) = 3(1+2x)^{-\frac{5}{2}}$	A1	4	All three attempted ft on $k(1+2x)^m$
	$f(x) = (1+2x)^{\frac{1}{2}} \Rightarrow f(0) = 1;$ $f'(0) = 1; f''(0) = -1; f'''(0) = 3$	B1 M1 A1F		
(b)	$f(x) = f(0) + xf'(0) + \frac{x^2}{2}f''(0) + \frac{x^3}{6}f'''(0)$ $\dots \approx 1 + x - \frac{x^2}{2} + \frac{x^3}{2}$	A1	3	CSO AG
	$e^x(1+2x)^{\frac{1}{2}} \approx$ $\left(1+x+\frac{x^2}{2}+\frac{x^3}{6}\right)\left(1+x-\frac{x^2}{2}+\frac{x^3}{2}\right)$ $\approx 1+x(1+1)+x^2(-0.5+1+0.5)$ $+x^3\left(\frac{1}{2}-\frac{1}{2}+\frac{1}{2}+\frac{1}{6}\right)$ $\approx 1+2x+x^2+\frac{2}{3}x^3$	M1 A1 A1		
(c)	$e^{2x} = 1+2x+\frac{(2x)^2}{2}+\frac{(2x)^3}{6}+\dots$ $= 1+2x+2x^2+\frac{4}{3}x^3+\dots$	B1	1	
(d)	$1-\cos x = \frac{1}{2}x^2 + \{o(x^4)\}$	B1	4	Series used
	$\frac{e^x(1+2x)^{\frac{1}{2}} - e^{2x}}{1-\cos x} =$ $\frac{1+2x+x^2+\frac{2}{3}x^3 - \left[1+2x+2x^2+\frac{4}{3}x^3\right]}{\frac{1}{2}x^2 + \{o(x^4)\}}$ $\lim_{x \rightarrow 0} \dots = \lim_{x \rightarrow 0} \frac{-x^2 + \{o(x^3)\}}{\frac{1}{2}x^2 + \{o(x^4)\}} =$ $\lim_{x \rightarrow 0} \frac{-1+o(x)}{\frac{1}{2}+o(x^2)} = -2$	M1 A1F A1F		
Total			16	

MFP3 (cont)

Q	Solution	Marks	Total	Comments		
7(a)	Area = $\frac{1}{2} \int (6 + 4 \cos \theta)^2 d\theta$	M1	6	use of $\frac{1}{2} \int r^2 d\theta$		
	$= \frac{1}{2} \left(\int_{-\pi}^{\pi} 36 + 48 \cos \theta + 16 \cos^2 \theta \right) d\theta$	B1 B1		for correct expansion of $[6 + 4 \cos \theta]^2$ for limits		
	$= \left(\int_{-\pi}^{\pi} 18 + 24 \cos \theta + 4(\cos 2\theta + 1) \right) d\theta$	M1		Attempt to write $\cos^2 \theta$ in terms of $\cos 2\theta$		
	$= [22\theta + 24 \sin \theta + 2 \sin 2\theta]_{-\pi}^{\pi}$	A1F		correct integration ft wrong coefficients		
	$= 44\pi$	A1		CSO		
	(b)	At P , $r = 4$; At Q , $r = 2$;		B1	PI	
		$P \{x\} r \cos \theta = 4 \cos \frac{2\pi}{3} = -2$		M1	Attempt to use $r \cos \theta$	
		$Q \{x\} r \cos \theta = 2 \cos \pi = -2$		A1	Both	
	(c)(i)	Since P and Q have same 'x', PQ is vertical so QP is parallel to the vertical line $\theta = \frac{\pi}{2}$		E1	4	
		$OP = 4$; $OS = 8$;		B1		
(ii)	Angle $POS = \frac{\pi}{3}$	B1		or $S(4, 4\sqrt{3})$ and $P(-2, 2\sqrt{3})$		
	$PS^2 = 4^2 + 8^2 - 2 \times 4 \times 8 \times \cos \frac{\pi}{3}$ oe	M1		Cosine rule used in triangle POS OE $PS^2 = (4+2)^2 + (4\sqrt{3} - 2\sqrt{3})^2$		
	$PS = \sqrt{48} \quad \{= 4\sqrt{3}\}$	A1	4			
(ii)	Since $8^2 = 4^2 + (\sqrt{48})^2$,	E1	1	Accept valid equivalents e.g. $PR = 2PQ = 2(2\sqrt{3}) = PS$.		
	$OS^2 = OP^2 + PS^2 \Rightarrow OPS$ is a right angle. (Converse of Pythagoras Theorem)			$\angle SRP = \angle RSP = \angle RPO = \frac{\pi}{6}$ $\Rightarrow OPS$ is a right angle		
	Total		15			
	TOTAL		75			