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General Certificate of Education

Mathematics 6360

MFP3 Further Pure 3

Report on the Examination

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General
Presentation of work was generally good and most candidates completed their solution to a question at the first attempt.

Candidates usually answered the questions in numerical order and most appeared to have sufficient time to attempt all eight questions. Questions 1, 2 and 5 were the three best answered questions on the paper; candidates found questions 4 and 8 to be the two most demanding questions on the paper.

Once again, many candidates failed to complete the boxes on the front cover of the answer book to indicate the numbers of the questions that they had answered.

Teachers may wish to emphasise the following points to their students in preparation for future examinations in this module:

- Writing down a formula in general form before substituting relevant values may lead to the award of method marks even if an error is made in the substitution.
- Where possible, answers should be left in exact form rather than given as an approximate decimal value, unless this is requested.
- To investigate an improper integral which has an infinite upper limit, the upper limit should first be replaced by 'a', for example, the resulting integral evaluated and then the limit as $a \to \infty$ investigated, ensuring that before the limit is taken all necessary manipulation is carried out.

Question 1
Numerical solutions of first order differential equations continue to be a good source of marks for all candidates. Although it was the best answered question on the paper, more candidates than usual mixed up the x and y values in applying the given formulae, or incorrectly used $\text{f}(3, 2)$ instead of $\text{f}(3.1, y(3.1))$ in the given formula in part (b). There were very few candidates who lost the final accuracy mark for failing to give their answer correct to three decimal places.

Question 2
Most candidates were able to show that they knew how to find and use an integrating factor to solve a first order differential equation. However, a significant number failed to find the correct integrating factor because they missed the negative sign and used $\text{e}^{\int \tan x \, \text{d}x}$. Candidates should be aware that, unless told otherwise in the question, it is acceptable to leave the solution in a form other than $y = \text{f}(x)$. Some candidates lost the final accuracy mark because either they had attempted to divide throughout by $\cos x$ but forgot to divide the $+ c$ as well before substituting in the boundary condition, or had made the arithmetical error "$2 = -\frac{1}{2} + c \Rightarrow c = \frac{3}{2}$".

Question 3
This question, which tested the relationship between cartesian and polar coordinates, caused candidates more problems than anticipated. In part (a), it was not uncommon to see solutions which assumed incorrectly that the angle between OA and the x-axis was 45°, which led to the incorrect coordinates $\left(\sqrt{50}, \sqrt{50}\right)$ for A. In part (b)(i), a common wrong value for k was 5 but the value of $\tan \alpha$ was usually stated correctly. Many candidates gave the correct polar equation for the circle in part (b)(ii).

Question 4

This question on improper integrals and limiting processes, which lacked the structure given in many previous papers, was the worse answered question on the paper. Examiners expected to see the infinite upper limit replaced by, for example, a, the integration then carried out and then consideration of the limiting process as $a \to \infty$. Most, although not all, reached '$\ln x - \ln(4x+1)$' for 1 mark, but many of the weaker candidates just stated that $\ln x - \ln(4x+1) = 0$ when $x \to \infty$ and gave the wrong value '$\ln 5$' as their answer. Better candidates scored 3 marks for reaching 'as $a \to \infty$, $\ln\left(\frac{5a}{4a+1}\right) = \ln\frac{5}{4}$' but only those who inserted the extra step to get, for example, 'as $a \to \infty$, $\ln\left(\frac{5}{4+\frac{1}{a}}\right) = \ln\frac{5}{4}$' were in line for full marks.

Question 5

In part (a), many candidates decided to ignore the given form of the particular integral and worked with $a\cos x + b\sin x$. Such an approach was not penalised by examiners provided the candidate showed that both $a = 0$ and $b = 2$. The vast majority of candidates showed that they knew the methods required to solve the second order differential equation, but arithmetical errors in solving the auxiliary equation $m^2 + 2m + 5 = 0$ or in applying the boundary condition $\frac{dy}{dx} = 4$ when $x = 0$ or the wrong differentiation of $\cos 2x$ were sources of loss of marks as well as the more serious error of applying the boundary conditions to the complementary function before adding on the particular integral.

Question 6

Most candidates were able to find $f'(x)$ correctly although some weaker candidates failed to apply the chain rule and were heavily penalised. The vast majority of the other candidates used the product rule (or quotient rule) but errors in differentiating $\sec^2 x$ were common. The majority of candidates showed good knowledge of Maclaurin's theorem but only those who had made no errors in earlier differentiations could score all 3 marks for showing the printed result in part (a)(i). Many weaker candidates failed to realise that the series expansion for $\sin 3x$ was required in part (b) and just stated the incorrect answer 0 for the limit. A significant minority of other candidates who used the expansion for $\sin 3x$ did not explicitly reach the stage of a constant term in both the numerator and denominator before taking the limit as $x \to 0$.

Question 7

Some candidates integrated r instead of r^2 to find the area of the shaded region. If they had first stated the formula $A = \frac{1}{2}\int r^2 \, d\theta$, which is given in the formulae booklet, before substituting for r further credit could have been awarded. The two most common errors were incorrectly squaring $6e^{-\frac{\theta}{\pi}}$ to get $6e^{-\frac{2\theta}{\pi}}$ and integrating $12e^{-\frac{\theta}{\pi}}$ incorrectly to get $-\frac{12}{\pi}e^{-\frac{\theta}{\pi}}$. The quality of sketches varied significantly with some even starting at the pole. A significant minority of candidates either just gave the coordinates of one end point, missing $(1, 0)$ or gave a decimal approximation for e^2 or gave the incorrect answer (e^2, 0). It was surprising to find some candidates giving the coordinates in reverse order. In part (c), most candidates formed a correct equation by equating the r terms but in general only the better candidates were then able to form and solve the resulting quadratic equation in $e^{\frac{\theta}{\pi}}$. Only a small number of candidates failed to reject the negative value for $e^{\frac{\theta}{\pi}}$ before going on to get the correct coordinates for the point P. Again candidates should use exact forms and not give a decimal approximation in place of $\pi \ln 3$. A common mistake seen in solving '$e^{\frac{\theta}{\pi}} = 1 + 6e^{-\frac{\theta}{\pi}}$' is illustrated by '$\frac{\theta}{\pi} = \ln 1 + 6\left(-\frac{\theta}{\pi}\right)$'.

Question 8

The bookwork in part (a) was similar to that tested in recent papers. Candidates generally answered part (a)(i) correctly but showing the printed result involving the second derivatives in part (a)(ii) proved to be more difficult. However, there were some excellent concise solutions to part (a)(ii) seen. As is the case in all questions which ask for results to be shown, sufficient detail in solutions must be provided that is fully correct. It was not uncommon to see incorrect working followed by the printed result. Candidates should realise that credit will not be given and in some cases marks can be lost for this. Candidates were generally able to use the printed results in part (a) to correctly transform the differential equation into the required form in part (b). Those candidates who attempted part (c) normally scored at least two marks. The most common error was to give the answer as $y = Ae^{-3x} + Be^{x}$ instead of $y = Ae^{-3\sqrt{x}} + Be^{\sqrt{x}}$ which followed from $y = Ae^{-3t} + Be^{t}$.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the **Results statistics** page of the AQA Website.