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Mathematics MFP3

(Specification 6360)

Further Pure 3

Report on the Examination

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General

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

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

- Candidates should show their methods of solution clearly and take extra care when answering questions which ask for a printed result to be shown.
- The general solution of the differential equation $a\frac{\mathrm{d}^2y}{\mathrm{d}t^2} + b\frac{\mathrm{d}y}{\mathrm{d}t} + cy = \mathrm{f}(t)$ will be in the form $y = \mathrm{g}(t)$; it will not involve the variable x.
- A general solution to a first order differential equation should have one arbitrary constant and the general solution to a second order differential equation should have two arbitrary constants.

Question 1

Numerical solutions of first order differential equations continue to be a good source of marks for all candidates, and it was the best answered topic on the paper. However, a few candidates who had an incorrect value for k_1 and just gave a table of values without showing any methods gained no credit. Almost all candidates gave their final answer to the required degree of accuracy.

Question 2

Most candidates differentiated the given expression, substituted into the first order differential equation and equated coefficients to score the method marks. The most common error in solving the resulting equations was to write the solution of $26p = 13$ as $p = 2$.

In part (b), those candidates who wrote down the correct auxiliary equation, '$m + 5 = 0$', generally had no problems scoring all three marks. Those candidates who solved $\frac{\mathrm{d}y}{\mathrm{d}x} + 5y = 0$ sometimes forgot to include the constant of integration and so ended up with a general solution which had no arbitrary constant.

There was a minority of candidates who tried to use an integrating factor and appeared not to know the method of solving a first order differential equation by using complementary function and particular integral.

Question 3

This question on polar coordinates was generally answered well. In part (a), most candidates reached the stage $r + x = 2$, but some less able candidates squared incorrectly to reach $y^2 = 4 - 2x^2$. Those candidates who rearranged the equation to $r = 2 - x$ before squaring usually went on to gain all five marks. In part (b), those candidates who wrote the given equation as $4r\cos\theta = 3$, converted it to the cartesian equation $x = \frac{3}{4}$ and solved with their answer to part (a) usually had no difficulty in showing that the length of PQ is 2.

The other common approach was to solve the two polar equations simultaneously, but a significant proportion of candidates who used this approach stopped after reaching $\cos\theta = \frac{3}{5}$, not even finding the value for r. More able candidates, having found the values for $\cos\theta$ and r, went on to use basic trigonometry to find the correct length for PQ.

Question 4

Most candidates were able to show that they knew how to find and use an integrating factor to solve a first order differential equation, and many gained either full marks for the question or just lost the final accuracy mark. The only other error of note was losing the negative sign in setting up the integrating factor. This led to a more complicated integral which few solved 'correctly'.

Question 5

Most candidates found the correct value for C in part (a). A large majority of candidates realised that part (a) had some relevance to part (b) and duly wrote the integrand in terms of partial fractions and generally integrated correctly. Those who missed this step gained little or no credit for their later work. Although showing the limiting process is an area of the specification that candidates still find difficult, overall improvement continues to be noted.

Question 6

Although most candidates scored marks for substituting a correct expression for r^2 into $A = \frac{1}{2}\int r^2 \, \mathrm{d}\theta$ and inserting the correct limits, less able candidates made little further progress. A significant proportion of other candidates went further by either using the identity $\sin 2\theta = 2\sin\theta\cos\theta$ or writing $\sin^2 2\theta$ in terms of $\cos 4\theta$. A surprisingly common error amongst those solutions which used the latter approach is illustrated by '$(1-\cos 4\theta)\cos\theta = \cos\theta - \cos^2 4\theta$'. Some excellent solutions were seen from the more able candidates, which involved a variety of approaches including integration of $8\sin^2\theta\cos^3\theta$ by use of the substitution $s = \sin\theta$, direct integration by recalling that the integral of $\sin^n\theta\cos\theta$ with respect to θ is $\frac{\sin^{n+1}\theta}{n+1}$ or use of the identity $2\cos 4\theta\cos\theta = \cos 5\theta + \cos 3\theta$. Those candidates who used integration by parts were generally less successful. Only a few obtained the correct answer by applying integration by parts twice.

Question 7

Most candidates were able to write down the required two expansions in parts (a).
In part (b)(i), candidates generally used the chain rule to find $\frac{\mathrm{d}y}{\mathrm{d}x}$ and then applied the product rule to find $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$. Although a common error was to differentiate $\sec^2 x$ as $2\sec x \tan x$, those who did find $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ correctly often produced a convincing solution to reach the printed answer. Some very good solutions were seen for parts (b)(ii) and (b)(iii) but it was disturbing to see some other candidates make no attempt to find the third derivative in part (b)(ii), yet claim that $\mathrm{f}'''(0) = 3$ and write down the printed result in part (b)(iii). Clearly in such cases marks cannot be awarded.

Candidates who attempted part (c) generally showed a thorough understanding of the process required, including the need for explicitly reaching the stage of a constant term in both the numerator and denominator before taking the limit as $x \to 0$.

Question 8

In part (a), most candidates were able to convincingly show, by use of the chain rule, that $x\dfrac{\mathrm{d}y}{\mathrm{d}x} = \dfrac{\mathrm{d}y}{\mathrm{d}t}$. Part (b), as expected, was not answered well by the average candidate. Those more able candidates who differentiated the result in part (a) — either with respect to x, writing $\dfrac{\mathrm{d}}{\mathrm{d}x}(\dfrac{\mathrm{d}y}{\mathrm{d}t})$ as $\dfrac{\mathrm{d}t}{\mathrm{d}x}\dfrac{\mathrm{d}}{\mathrm{d}t}\left(\dfrac{\mathrm{d}y}{\mathrm{d}t}\right) = \dfrac{\mathrm{d}t}{\mathrm{d}x}\dfrac{\mathrm{d}^2 y}{\mathrm{d}t^2}$, or with respect to t, writing $\dfrac{\mathrm{d}}{\mathrm{d}t}\left(x\dfrac{\mathrm{d}y}{\mathrm{d}x}\right) = \dfrac{\mathrm{d}x}{\mathrm{d}t}\dfrac{\mathrm{d}}{\mathrm{d}x}\left(x\dfrac{\mathrm{d}y}{\mathrm{d}x}\right)$ — normally scored all or most of the marks in part (b).

In part (c), although most candidates realised what was required, it was not uncommon to see x appear in general solutions. Many candidates correctly tried a particular integral of the form $at + b$, but a common error was to write $4y$ as $4at + b$, which led to an incorrect particular integral. However, this error was classed as a slip and so some follow through was applied in marking part (d). In part (d), those candidates who had a general solution in part (c) that was entirely in terms of t were generally able to pick up at least the method marks in the final part of the question. A common error was to differentiate $\dfrac{1}{2}\ln x + \dfrac{1}{2}$ as $\dfrac{1}{2x} + \dfrac{1}{2}$, which led to the loss of the last two accuracy marks.

Mark Ranges and Award of Grades

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