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Mathematics MFP4

(Specification 6360)

Further Pure 4

Report on the Examination

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General

Almost exactly 400 candidates sat this paper in this session – an increase of around 14% over last January's session. There was substantial evidence that many of the candidates were very capable mathematicians, and some of the ideas on display within the scripts showed insight and understanding a-plenty. However, this has to be balanced by evidence that they were not sufficiently familiar with the *whole* range of topics on this module's specification, nor at a sufficient stage of mathematical maturity and preparation to be in a position to sit this paper with a good chance of performing to the best of their abilities. Many of them would, in the event, have been better advised to sit this module in the summer.

Candidates would also be well advised to follow the instructions on the front of the question paper, in particular:

- Show all necessary working; otherwise marks for method may be lost.

Question 1

This was meant to be a straightforward starter, but proved instead to be the first stumbling-block. More than 150 candidates failed to get any marks at all on it; almost all candidates lost two marks by not using exact values. Candidates were not confident in using the definition of a vector product rather than simply calculating a vector product. Many candidates confused the sine and cosine of an angle with respect to the scalar and vector products. The greatest difficulty lay not so much in a lack of ability to cope comfortably with surd forms but with not knowing how to go from cosine to sine using exact reasoning.

Question 2

This turned out to be a much more straightforward and routine question than question 1 for almost all candidates. The mean mark achieved by candidates was almost 4½ out of the 5 available.

Question 3

This question was also generally well done. The only commonly lost mark was that for part (b) which should have been very straightforward; perhaps too straightforward.

Question 4

A significant number of candidates did not know what a transpose matrix is; 52 candidates failed to get the mark for writing down a correct transpose matrix for $\mathbf{X}$. Amongst those who did, it was a common mistake to attempt Det($\mathbf{XX}^\mathrm{T} - \mathbf{X}^\mathrm{T}\mathbf{X}$) as Det($\mathbf{XX}^\mathrm{T}$) – Det($\mathbf{X}^\mathrm{T}\mathbf{X}$). Even amongst those who attempted this build-up work with a correct method, algebraic errors were commonplace. More crucially, it was very disappointing indeed to see here (and in Question 8) that almost all candidates preferred to multiply out first, which meant that they were almost invariably stuck with a quartic expression that they stood very little chance of factorising. This led to the almost universal loss of at least two of the seven marks available on this question. Even those who tried to factorise out the obvious factor of $(x + 1)$ in each element of the matrix $\mathbf{XX}^\mathrm{T} - \mathbf{X}^\mathrm{T}\mathbf{X}$ failed to realise that they were "taking it out" of each row (or column) and so it was a repeated factor – without this, it was impossible to argue that the required determinant was always non-positive.

Of those candidates who obtained a correct quartic most did not distinguish between the words 'negative' and 'non-positive' and also stated that it must be negative because all the coefficients in the quartic were negative. Only a handful of candidates offered any explanation that $x^2 - 2x + 17 \geq 0$. Since the mark-scheme was designed to give the final mark in part (c) only to fully correct prior working, it was a mark lost by just about everyone; only 33 candidates scored more than 5 of the 7 marks available for the question.

Question 5

This was another generally popular and successful question for candidates. Most attempts scored all 4 marks on part (a) and most of those for part (b). However, the approaches taken often provided further evidence that the candidature, in general, was not at the appropriate level of mathematical maturity required for taking their MFP4 paper at this time. Having supplied three equations with a common coefficient of 1 for z, easing the work needed to establish the inconsistency of the system, most candidates preferred to work with the x's and y's instead, which just took a little longer and led more often to the introduction of numerical errors. Also, it was often the case that inconsistency was "established" on the basis that two constants weren't equal, when comparing a couple of equations, but candidates' lack of care in the arithmetic frequently meant that one or other of these two constants wasn't the correct one, which invalidated their conclusion and lost them a mark.

Question 6

This was another high-scoring question for many candidates, especially since the three parts were essentially completely independent of each other's results. Part (a) was straightforward and routine, though rather a lot of candidates lost marks by failing to give the acute angle required, subtracting the correct one from 90°, mixing up sines and cosines in the working, missing the minus sign in front of the "4" in the second of the two given normal vectors, or making numerical slips in adding up the three squares in each of the moduli.

Question 7

Although there were a few excellent, complete responses to this question, in general it turned out to reflect the lack of preparedness on the part of candidates for the demands presented to them here. The three marks in part (a) were readily and easily acquired by most candidates attempting it. However, 156 candidates were unable to proceed beyond the given result of part (a), and made no attempt at the remaining parts of this question.

In part (b)(i), it was not uncommon to find that candidates were less than comfortable with squaring out their x and y terms in the new variables X and Y, and collecting them up proved to be far more problematical than should have been the case. Rather a lot of candidates seemed to think that the XY term came exclusively from the xy term, and such efforts foundered at this point.

Few candidates got to the correct equation of the hyperbola. A suitable answer to part (b)(iii) required only an awareness that the original curve had been rotated into the final hyperbola, but only a few candidates answered it without having worked their way to it. Of these, most offered spurious reasons, such as the not uncommon reference to the suggestion that the original curve was a hyperbola because this final one was an ellipse.

Question 8

More than 200 candidates failed to score more than 2 marks on this question. The key problem was the candidates' enthusiasm for expanding determinants fully from the outset, or at least at a much earlier stage than is desirable.

Very few candidates were happy with performing more than one or two row/column operations. In this question's case, candidates had to formulate the determinant for themselves at the very beginning, and it was surprising to find that a significant number of candidates failed accurately to copy the entries down from the given vectors. Yet another sign of the lack of full, exam-standard assurance with the topic that is expected at this level was the way in which hardly any candidates took advantage of the very obvious factor of $(n - 1)$ embedded in the third column (or row) of the determinant.

Having said that, many candidates attempted this determinant in stages via $\mathbf{a} \bullet \mathbf{b} \times \mathbf{c}$; which approach went very messy, algebraically, very quickly and from which very few indeed made any kind of successful recovery. Those who chose to expand the determinant from the word go, or at least at a very early stage, were then unable to cope with the ensuing polynomial. Even amongst those who found the correct quartic equation to solve, hardly any produced much in the way of working, and most were content then to just state a proposed answer (the most common offerings being $n = 0$, 1 or the correct –1) without, unfortunately, any apparent thought to the fact that they should not only be showing that their suggested answer was indeed correct, but also that it was the *only* correct one.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results statistics page of the AQA Website. UMS conversion calculator www.aqa.org.uk/umsconversion