A-LEVEL
MATHEMATICAL STUDIES

MFP4 Further Pure 4
Report on the Examination

6360
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General

Overall the paper had questions on a wide variety of topics. Students were able to demonstrate key skills on such topics as matrix and determinant algebra, transformations and their associated matrices, inverting 3x3 matrices, Cartesian equations of lines, the intersection of lines and planes, solving and giving a geometric interpretation of three plane systems in various scenarios, writing the equations of planes in various different styles, finding the line of intersection of two planes, factorising determinants, shears, invariant lines and eigenvectors.

In each topic stronger students encountered more challenging sections that allowed them to demonstrate their ability, whilst weaker students were able to show their understanding and ability to do key skills. Once again students seemed to have been extremely well prepared for this paper, as evidenced by the number of students who successfully did question 9(c)(ii) using the sophisticated alternative method. Standard methods and skills seem to be very well understood. However, a surprising number of minus signs were lost in transcribing working to final results.

Question 1

A good starter question that required students to show their understanding of the relationship between $\det \mathbf{N}^{-1}$ and $\det \mathbf{N}$, calculating the determinant of a numerical 3x3 matrix and linking these together as the volume scale factor. Most students scored well, with the odd slip where they wrote –1.5=1.5

Question 2

A surprising number of students confused “the x=y plane” with “the x/y plane” writing $\mathbf{B} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{pmatrix}$ instead of $\mathbf{B} = \begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix}$. This lead to a matrix $\mathbf{C}$ that was not a rotation. A less common error was calculating $\mathbf{CB}^{-1}$ rather than $\mathbf{B}^{-1}\mathbf{C}$. As such this question allowed stronger students to show their ability.

Question 3

Both parts of this question were very well done. Students were well prepared in the finding of the inverse of a 3x3 matrix with algebra in it.

Question 4

The Cartesian equation in this question fully tested the knowledge and ability of students to extract the relevant data. Being given the angle between the line and the plane caused fewer issues than in previous series. Very few students attempted to use the cross product approach and those who did tended to be unsuccessful.

Question 5

Part **(a)** required careful handling of the algebra or the Augmented Matrix Method to get the full marks and as such was a place where the stronger students could really show their ability whilst the weaker students could demonstrate an understanding of the required method. Some students attempted to find the inverse of the matrix and hence find the point of intersection. Whilst this was possible it took a lot more work than the main method.

Part **(b)** was straightforward and was generally well done.

Part **(c)** was another question where the stronger students could show their ability. A number of students appeared to guess the number of solutions and the geometrical set up of the equations, without any attempt to fully justify their answers. Students had to show correct working to gain the marks in this part. A surprising number of students did not say what the number of solutions were.

Question 6

This question saw the most errors due to the loss of minus signs when transcribing the directional vectors that they'd found into the final equations in parts **(b)(i)**, **(ii)** and **(iii)**.

Part **(a)** allowed students to show their skill in calculating the volume of a parallelepiped and was done with a high degree of success.

Part **(b)(i)** asked students to find the parametric form of a relatively straightforward plane.

Part **(b)(ii)** involved finding, in scalar product form, the equation of a harder plane.

In order to be successful in part **(b)(iii)** students either needed to have obtained the correct answers to parts **(b)(i)** and **(ii)** or to have a very good spatial understanding, to spot the short cut. Unsurprisingly this was tricky question for many students.

Question 7

Students were well prepared for factorising an algebraic 3x3 determinant and generally did well in part **(a)**.

For part **(b)** students needed to score full marks in part **(a)** to get full marks here (unless they used the alternative method). Those who did generally finished this part off well.

Question 8

Nearly all students recognised that the determinant of a shear is 1 in part **(a)** and went on to find the values of a, b and c correctly in part **(b)(i)**.

Part **(b)(ii)** was more straightforward than in previous years. Most students correctly used the invariant line method, as was expected. Those who used invariant points rarely did well, unless they went on to clearly explain that for a shear, lines parallel to the line of invariant points are invariant lines.

Question 9

Part **(a)** was a question where the majority of students scored full marks.

In part **(b)(i)** an equal number of students took one of two approaches. In the main method, both lines of working had to be considered as students were proving that a vector is an eigenvector. In the alternative method, only one line needed to be considered, as they were using an eigenvalue and hence the vector they get from either line is an eigenvector. However, students using this approach often missed out on the last mark as they didn't fully show how they got the eigenvector from their working and simply copied down the answer from the question.

In part **(b)(ii)** most students started well, but many failed to get the last mark as they did not say that the eigenvector they had got was independent of p and q, as was asked for in the question.

Part **(c)(i)** was generally very well done, with most of the withheld marks being for using a zero column in the matrix $\mathbf{U}$.

Nearly all students were able to set up part **(c)(ii)**, but most missed out on marks by either getting the inverse matrix $\mathbf{U}^{-1}$ wrong, forgetting to discuss that if n is odd $(-q)^n = -q^n$ or simply making mistakes in all the algebra they had to work through.

An unexpectedly large number of students attempted the alternative method and were generally very successful, usually only dropping the mark for discussing that if n is odd $(-q)^n = -q^n$. It is of great credit to the teachers who had prepared these students to handle this sophisticated approach so well.

Mark Ranges and Award of Grades

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

Converting Marks into UMS marks

Convert raw marks into Uniform Mark Scale (UMS) marks by using the link below.

UMS conversion calculator