AQA

GCE
MATHEMATICS
MFP4 Further Pure 4
Report on the Examination

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General

Most of the questions produced a full range of differentiated responses from students. This was even true of the earlier more straightforward questions, in particular Question 3. Questions 6 and Question 8 proved to be the most demanding of all.
The best scripts stood out as those for which students have provided full working and clear explanation. Students must realise that some method marks require full working to be shown. This is particularly true in 'Show that' questions.

Question 1

This question was meant to be a relatively easy starter and for the vast majority of students this proved to be the case. Errors in part (a) often related to the signs of the components. A handful of students incorrectly cancelled the vector down, thinking that
$\mathbf{i} - \mathbf{j}$ was a valid answer to the requested vector product. In part (b), a significant number of students did not understand what was required for 'the Cartesian equation of the plane', mixing it up with other forms for planes and even lines. Part (c) showed that triple scalar products are generally well understood, although a few students thought that the scalar product part gave a vector answer. A few other students incorrectly added in a fraction in front of $\overrightarrow{AB} \times \overrightarrow{AC} \,.\, \overrightarrow{AD}$ **,** thus finding the volume of a different shape.

Question 2

The most successful method in part (a) was to find the determinant and set it to equal zero. The least successful approach was to try to combine equations in a more traditional manner. Students simply got themselves lost in the algebra and could not complete the method. The row operation method of elimination was rarely seen but often proved successful and helped with part (b). Part (b) illustrated again that students are not confident or clear about consistent and inconsistent equations readily getting them mixed up. Part (c) was hit or miss in that some students thought that if the determinant was zero then the vectors were linearly independent. It was good to see other students able to show the connection between vectors and correctly deduce linear dependency.

Question 3

There was a clear factor, $x^2 + y^2 + z^2$, in the third row. Many students failed to find this factor and then struggled through line after line of, often incorrect, algebra. The key method here is to use row and column operations to be able to find and extract factors. The best solutions are clear and state which row or column operations are used. When correct operations were used and $y - x$ was extracted as a factor from $y^2 - x^2 - y + x$, a common error was to give $2(y + x)$ as the other factor as opposed to the correct factor of $y + x$ -1. Those who correctly answered part (a) generally achieved some success on part (b); they could explain why the linear factors could not be zero but did not generally explain why the quadratic factor was not zero.

Question 4

This was a well answered question with two equally common methods of solution. The more successful method was to use the vector product to find the direction vector of the line and then to search for a common point. Surprisingly students did not always choose x, y or $z = 0$ to find such a point. The alternative method of using a parameter often scored three marks due to errors in manipulation or being unable to isolate the direction vector and point. Understanding of direction cosines has improved. Again those who used the first method above were often more successful as others could often not identify the correct direction vector needed. In part (b)(ii), the favoured method was to calculate corresponding sines and show that the total was correct. It was disappointing to see that many did not know the result $\cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1$. Furthermore, full marks were not awarded for methods that did not clearly show the result fully but referred to generalised calculator expressions.

Question 5

The vast majority of students correctly set and expanded the determinant $|\mathbf{M} - \lambda\mathbf{I}| = 0$ although the request to show that $\lambda = 2$ was an eigenvector was sometimes overlooked. Part (b) was well done, although a minority of students mixed up methods and tried to solve $(\mathbf{M} - 2\mathbf{I})\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} x \\ y \\ z \end{pmatrix}$

In part (c)(i), most students were able to easily verify that $\lambda = 4$ was an eigenvector, although a significant number tried to replicate the method from part (a). Part (c)(ii) proved successful for the majority of students although not all of them realised how the answer could have been obtained from $2 \times 4 = 8$.

Question 6

This question proved to be the most demanding. Many students knew what to do for part (a) but often failed to show all working out leading to a loss of marks. Part (b)(i) proved elusive for all but the most able students. When asked to find all invariant lines the most efficient and valid method involves obtaining y' and x' in terms of x, y and c and then trying to make them fit the equation $y' = mx' + c$. This method was rarely seen and yet is the correct standard approach. Other approaches such as using eigenvalues are more appropriate to lines of invariant points only.

Question 7

A good response was received to this question. In part (a) it is not sufficient to give the determinant as 3 and deduce that the matrix is non-singular. The key point to secure the mark is to state that $3 \neq 0$ and then make the deduction. Inverse matrices are well understood, marks were dropped here for the standard types of errors with signs or miscalculation of minor determinants. Part (c) proved more differentiating. A minority of students were not aware of the result $(AB)^{-1} = B^{-1}A^{-1}$ and hence set off on a trail to find B^{-1} by other, often invalid, means.

Question 8

This topic of equations of lines and planes is not well understood by students. Surprisingly, part (a) was not always answered correctly with arguments concerning the scalar product often wrongly used. Part (b) was most often successful when two points on the line were used or if the scalar product of the normal to the plane and direction vector of the line was set equal to zero and solved to find p. Part (c)(i) proved very discriminating with students using both scalar and vector products in tandem but not using the correct trigonometric ratio and confusing $\sin$e and $\cos$ine.

Mark Ranges and Award of Grades

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

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

UMS conversion calculator www.aqa.org.uk/umsconversion