Examiners' Report

Principal Examiner Feedback

Summer 2022

Pearson Edexcel GCE

AL Further Mathematics (9FM0)

Paper 3D Decision Mathematics 1

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Introduction

This paper proved accessible to most candidates although examiners noted that a significant number of candidates are still struggling to cope with the new content not previous seen in the legacy D1 and D2 modules, and some had difficulty with the problem-solving nature of some of the questions (which forms part of the assessment objectives for this qualification). However, the questions differentiated well, with most giving rise to a good spread of marks. All questions contained marks available to the E grade candidates and there also seemed to be enough material to challenge the A grade candidates.

Candidates should be reminded of the importance of displaying their method clearly. Decision Mathematics is a methods-based examination and spotting the correct answer, with no working, rarely gains any credit. The space provided in the answer book and the marks allotted to each section should assist candidates in determining the amount of working they need to show. Some very poorly presented work was seen and some of the writing, particularly numbers, was very difficult to decipher.

Candidates should ensure that they use technical language correctly. This was a problem in questions 3(c) and 4(b).

Candidates are reminded that they should not use methods of presentation that depend on colour but are advised to complete diagrams in (dark) pencil. Furthermore, several candidates are using highlighter pens even though the front cover of the examination paper specifically mentions that this type of pen should not be used.

Report on Individual Questions

Question 1

This question was accessible to nearly all candidates. The modal score was full marks and most candidates found this to be a straightforward start to the paper. There was however a common misconception in (a) in that several candidates added up all the items and dividing by the number of items rather than the size of each bin. In general candidates should ensure that their numbers are written clearly as often mistakes in reading their own handwriting meant that some candidates did not achieve an answer of 3.75 (and therefore 4) in (a).

Part (b) was also well answered by most candidates. However, the most common error was when it came to placing the fifth (and subsequent) items, where sometimes these values found their way into the wrong bin, implying that some candidates are not checking carefully each bin starting with the first bin which is not completely full. A small minority of candidates repeated values or missed a value out or applied the first-fit decreasing algorithm.

Question 2

Part (a) was done extremely well with most candidates applying Dijkstra's algorithm correctly. Where full marks were not awarded, this was usually the result of arithmetic errors or missing temporary labels. In most cases, the correct shortest path and length were identified.
Part (b) was also generally completed well with candidates recognising which route needed to be repeated and were able to state the correct edges. Some candidates did not realise initially that for the inspection route there were only 2 odd vertices, so they clearly spent time working through pairings of odd vertices before realising this fact. Others spent time re-calculating the shortest route from A to H, not realising this could be read off their completed version of Dijkstra's algorithm from (a). In a small number of cases, the answer was given as a path rather than a list of edges. In most cases, the length of the route was correctly found using the value at H from the graph without extensive additional work.
Examiners reported that it was sadly rare to see a fully correct response in (c). Although most candidates that attempted this part were applying the route inspection algorithm correctly, many chose ADEH as the odd vertices that needed pairing. This resulted from not reading the question carefully, and not updating the degrees of the vertices given the information in the question. Of those that selected the correct 4 odd vertices (DEHK), some did not show all 3 pairings and thus could not gain full credit. Furthermore, very few candidates found the correct shortest distances from the graph (especially for the DE-HK pairing).

Question 3

A high proportion of candidates gained the two marks in (a), adding the correct five arcs, although a few omitted AE. It is possible that some did not know how to represent this directed arc (from A to E), as a small number omitted the arrow. However, there were already directed arcs on the diagram with arrows to assist candidates with this. The only other error noted by examiners was a small number of candidates transcribing a weight incorrectly or omitting one altogether. Many candidates drew AF and AD around the outsides of the network (therefore preserving planarity) which was not essential but made their answers easier to mark.

The second part of the question required candidates to complete two iterations of Floyd's Algorithm. Almost all candidates gained the two method marks, and many scored all four marks in this part, as very few instances were seen of candidates changing entries in rows/columns that they should have been leaving unchanged for that iteration. Several cases were noted of candidates leaving one cell blank in their second table. When errors did occur, it was most often a single mistake in the first table. Entries AE and BE had most errors, some clearly arithmetic, others apparently due to reading from the wrong row or column rather than not understanding the method. In the second table it was again entry AE that occasionally caused the loss of the final mark, as it was left as 41 rather than improved to 40.
It was the final part of this question that caused most problems for candidates. As has been noted before, many candidates failed to appreciate that the standard method of applying the nearest neighbour method on a table with undirected arcs would not apply in the same way with directed arcs. It would therefore be advisable to apply nearest neighbour using the rows rather than the corresponding columns. A few did not end their routes by returning to E or thought a diagram of their routes, with or without direction arrows, was sufficient. Almost all candidates with both correct routes were able to gain the final two marks for stating the corresponding lengths and choosing the shorter one as a better upper bound. This was an example of the importance of using correct methods on this paper, as very many candidates

with incorrect routes had their lengths correct and an appropriate choice of upper bound but still could not score any marks.

Question 4

This question proved to be a good discriminator between candidates. A not-insignificant number of candidates left this question out entirely, but the vast majority attempted it and were able to access one or more marks, with a reasonable number achieving full marks.
The first half of (a) was generally answered well. A significant majority of candidates were able to give the correct inequalities for the three constraints, and the modal score for the two independent accuracy marks was full marks by some margin. The mistakes that were seen, with relatively low frequency, were to use strict inequalities, to reverse the direction of the inequality or, most commonly of these, to include the use of slack/artificial variables in their inequalities, thereby losing both marks. A small number of numerical slips were also seen.
In the second part of (a) candidates were asked to give the two possible objective functions. The standard on this part was much more variable. Several candidates omitted this part; a huge number of objective functions featuring M or artificial variables were also seen. Of those who did achieve a function, $-2x + 3y + z$ was marginally the more common.
A few candidates did correctly state both functions, but many did not attempt to classify them as max/min objectives.
Part (b) was unusual, in that several candidates clearly understood how to find the correct pivot but were either partially or entirely unable to explain what they were doing.
For the first mark, a good majority knew that pivoting on the x-column was required, and generally 'most negative' (in the objective row) was given as reasoning. However, several candidates failed to refer to either/both the '$2 - 4M$' or the objective row. There were very few mentions of M being arbitrarily large, however this was not required (on this occasion) to achieve the mark.
Many candidates failed to score the second mark as they simply stated that "3 (in the x-column/a_2 row) is the pivot because the θ value is the least (positive)" (or equivalent). This did not achieve the mark because it did not show the calculations for all the θ-values. A number of candidates also lost the mark for simply stating "3 is the pivot" after comparing the correct values – due to this being ambiguous it could not score full marks. Overall, it was a minority of candidates who responded with sufficient precision to earn this mark, and less than a quarter of responses seen scored both marks in (b).
As well as the above errors in (b), a surprisingly number completed the correct calculations but then proceeded to pivot on the incorrect item or stated the correct column but then proceeded to calculate θ-values for the wrong column.

Question 5

This question was accessible to most candidates. In (a) most candidates were able to list the immediately preceding activities, although a small number made errors e.g., omitting one of the activities from K or listing A, B, C instead of A, B, E for G and H. Most candidates recognized that the value of m depended on the late event times of D and F and the majority gave the correct value of 9. However, some gave an incorrect value of 8 or 10 and others incorrectly stated that $x = 9$. Answers giving the correct value of m as an inequality for x were accepted.

In (c) most candidates made a good attempt at completing the late event times although many failed to give the correct expression of $(15 – x)$ for the late event time at the end of activity A. Most candidates stated the correct critical activities and the value of the float for G in (d). Virtually all candidates extracted the required number of workers from the resource histogram and completed the table correctly in (e).

In (f) most candidates attempted to draw a Gantt Chart, although some did not attempt this, and a small number drew a scheduling diagram instead. Those candidates who attempted the Gantt Chart drew the critical activities correctly and most also drew activities B, G and J correctly. Some candidates explicitly stated the value of x and then went on to draw D and F correctly and others implied the correct value of x from D and F shown on their Gantt Chart. A significant number of candidates made errors with the float for activity A.

Question 6

This question was answered extremely well with most candidates making very good progress in the first three parts. In (a) some candidates did not output the value of c as requested even though an answer line was provided in the Answer Book. There was a definite improvement in the quality of responses seen in (b)(i) compared to previous series. A minority of candidates did not sort into ascending order and instead sorted into descending. Several candidates used a quick sort rather than the requested bubble sort. A few candidates are still unaware of how to end the algorithm; too many assumed that once the values in the list were in the correct order, they did not need to complete a sixth pass. Most candidates in (b)(ii) stated the total number of comparisons as 39 although some did get confused here and stated the value as 45 instead (which was the answer to the next part). Although there were several good responses to (d) many candidates found this part too demanding and many left this blank. Those candidates who realised the link between their answer to (c) and this part were usually successful in determining the maximum total number of comparisons required to sort the weights of the arcs of K_{50} into ascending order using bubble sort.

Question 7

Candidates found this to be one of the most challenging questions on the paper, with very few candidates scoring full marks. Each part of this question was independent of each other and therefore candidates who performed poorly, or didn't attempt some parts, were in some cases still able to score on other parts of the question.

For (a), many candidates chose not to write down the equations for the feasible region, choosing otherwise to complete the tableau immediately. For these candidates, the tableau had to be completely correct, whereas those candidates who had written down their equations with slack variables could gain some credit for these even if their tableau was incorrect. There were obviously many correct variations other than the one shown in the mark scheme which were perfectly acceptable, as the order of equations was not specified in the question. The main errors in the tableau involved sign errors, usually in the objective line or in the inequality $y - 2x \leqslant 1$ where several candidates failed to appreciate that negative values are not acceptable.

Most candidates gained the mark in (b). The most common error was omitting non-basic variables from the list and in a few cases adding in an extra z variable.

For (c), performing the iteration of the Simplex algorithm at the beginning of this part was generally well done. The vast majority used the correct pivot and so were able to make some progress, and most gained the mark for expressing their row operations correctly. A significant number of candidates gained partially correct solutions with errors on the objective row, some minor and some leaving values out, presumable because they did not know how to deal with the variable in this row. A few candidates chose a negative pivot and so therefore scored very few marks in this part.

Whilst most candidates were confident with the mechanics of applying the Simplex algorithm, very few were able to show that they fully understood how simplex worked to get the correct range of values for P. Many candidates did not attempt this, and of those who did, many did not make their working clear. Most who attempted this seemed to be either unclear about whether their inequality should be strict or not or tried to skip steps in their method in order to reach a solution. Therefore most failed to realise that $k < 2$ (from the knowledge that one of the entries in the pivot row of T must be negative), rather than $k \leqslant 2$ (from the fact that all the entries in their pivot row of their final tableau must be non-negative), leading to $P < 12$ rather than $P \leqslant 12$. Fully correct solutions to this question were therefore extremely rare.