Examiners' Report
Principal Examiner Feedback

Summer 2023

Pearson Edexcel GCE

In A Level Further Mathematics (9FM0)

Paper 4D Decision Mathematics 2

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Introduction

The paper proved to be accessible to almost all candidates, with many able to gain high marks on the first four questions, although some aspects of these proved to be challenging for some candidates. The final four questions differentiated well, challenging the most able candidates and producing a good spread of marks. Responses to unstructured questions proved particularly challenging.

A key piece of advice to candidates is to ensure that they read the demands of the question carefully and to ensure that they answer the question as set. Many candidates lost marks by overlooking parts of a question, which, in one case, made the question more complicated.

Question 1

This question proved to be accessible for most candidates. Most candidates stated the value of the initial flow correctly. Some made errors calculating the value of the cuts, either by omitting an arc or by including arcs flowing from the sink to the source. Most candidates found the correct flow augmenting route. A significant number of candidates made errors attempting to prove that the flow is maximal. Most either drew or stated a cut, although some incorrectly including AF in their cut. The most common error was failing to state the value of either the flow or the cut (or both) and some candidates failed to make reference to the Maximum Flow – Minimum Cut Theorem.

Question 2

This question also proved to be accessible. As a relatively new topic, it is pleasing to see that candidates are able to produce good solutions. Most candidates drew a decision tree with the correct structure and used the correct shapes for the decision node, chance nodes and end pay offs, although a small number omitted either the decision node or end pay-offs, which was resulted in the loss of accuracy marks. Candidates need to ensure that the decision node and chance nodes are drawn sufficiently large to allow the calculated values to be written inside them. Some candidates failed to label the branches of the decision tree correctly, omitting either the option and/or the associated probabilities. Most candidates obtained at least 3 of the end pay-offs correctly, although a small number attempted to incorrectly combine the values and probabilities in their end pay-offs. Many candidates failed to obtain the final mark, either because they had not written the final EMV in the decision node or because they had failed to cross through (with a double line) the inferior option.

Question 3

This question also proved to be accessible. Most candidates attempted to write down the constraints for the problem as inequalities, although a small number used equations, with the majority preferring to use Sigma notation. Some candidates made errors in their choice of inequality and a small number used incorrect notation. Most candidates wrote down the initial North West corner solution. Some went on to unnecessarily calculate shadow costs and improvement indices here. Most found the correct stepping stone route and improved solution, although some made errors in the route and a number incorrectly had a zero in the exiting cell (CR). Most candidates then attempted to calculate shadow costs and improvement indices, although some made numerical errors. Candidates generally used their most negative improvement index to try to find a second stepping stone route and improved solution. A number of errors were seen at this stage, either with an incorrect route, the use of costs instead of values to be transported or the failure to state the entry or exit cells.

Question 4

This question was very accessible. Most candidates recognised that this was a maximisation problem and correctly modified the table by subtracting all values from either 52 or a value greater than 52, although a small number simply treated this as a minimisation problem. Most candidates reduced both rows and columns, although a few just reduced rows. Some numerical errors were seen at this stage. Most candidates correctly applied the algorithm twice to go from 2 lines required to three lines and again from three to four lines, again with a small number of arithmetical errors. Most candidates listed the optimum solution, although some just indicated this on their final table and were penalised. Most candidates also stated the correct total score.

Question 5

This question proved to be very challenging. The question was structured so that the correct use of the transformation reduced the problem to the easier homogenous relationship, however the majority of candidates failed to engage with this transformation, being penalised both with a loss of marks and a more complicated question. Those candidates who did use the transformation, were generally able to obtain the homogenous relationship, although a small number made an arithmetical error and did not do so. Many candidates (whether they had used the transformation or not) recognised that this was a second order relationship and wrote down the correct auxiliary equation. Most went on to solve this and wrote down the complimentary function. Those who had used the transformation generally wrote down the associated solution to the original problem. Many of those candidates who had not used the transformation, attempted to find a particular solution, but there were often errors seen at this stage. Those candidates who obtained a general solution to the original problem attempted to use the conditions given to calculate the values of the constants. Those candidates who obtained a final solution generally considered what happened to the relationship as n gets large, with some correctly recognising that it approximates to a linear relationship, while others incorrectly stated that it tended to infinity.

Question 6

Although this was an unstructured dynamic programming question, there were many good answers seen. There were two alternative, fully correct solutions, one with the earnings from a location being added when that location first appeared in the table (as a state) and the second with the earnings added when the location was used as a destination. In both cases candidates correctly worked backwards from S adding the cost of travel, earnings and previous values into each stage. There were occasional arithmetical errors seen. Those candidates with good solutions correctly identified the optimum schedule, stating this clearly and giving the expected earnings, although a small number made an error here. There were a number of common errors seen, with a significant number of candidates attempting to work forwards. Some of those working backwards omitted the first stage, attempting to start at H, I and J instead of S and some interchanged the state and destination. All of these attempts lost a significant number of marks.

Question 7

Many candidates struggled to engage with this question and were unable to set up the correct initial model for the problem and therefore failed to make progress with the question. Most of those candidates who did set up the initial model, then wrote down the complimentary function and attempted the trial solution. However, there were errors seen at this stage when rearranging the trial solution to calculate λ. Candidates obtaining a value for λ, generally attempted to use the initial condition to find the particular solution and stated an expression in terms of n. Most candidates who obtained a final expression then attempted to use it to calculate the minimum amount of money that needed to be credited. However, many made an error with their final answer by rounding the value down.

Question 8

Candidates' attempts at this question gained marks across the full range.. Most candidates attempted to find the row minima and column maxima, although a small number found the row maxima and column minima, and then stated that the row maximin was not equal to the column minimax. Some candidates failed to clearly identify the maximin and minimax values and a few failed to show all the minima and maxima and were penalised. Most candidates realised that Option Q was always better than Option T, but a number failed to use the word dominate in their explanation and were penalised. Some candidates failed to list the three comparative inequalities to justify their explanation. Many candidates correctly augmented the table (either by adding 3 or 4) and attempted to set up the problem by writing down a series of constraints. Some candidates only listed these as inequalities instead of equations. A small number of candidates incorrectly used rows instead of columns to form their constraints. Most candidates wrote down the objective function, but a number omitted to state maximise with this. When writing the probability constraint, a number of candidates incorrectly set this equal to zero. Many candidates attempted to complete the simplex tableau, although some included errors from their earlier working. A very small number of candidates recognised that Option Y dominated Option Z for Player B and reduced the problem further at this stage, before writing down their constraints and completing the tableau. In part d, there were two alternative

approaches seen, both of which produced fully correct solutions. Some candidates calculated the value of p_3 and then used this to calculate the value of the game by considering all three options for B. Some candidates only used one option for B to obtain a possible value for the game and were penalised here. Candidates then defined probabilities for Player B, setting up and solving these correctly. They then stated the correct strategy for B, although a small number failed to state that B never plays Option Z. With the alternative approach, candidates recognised that Option Y dominated Option Z for B and reduced the problem accordingly. These candidates then defined probabilities for Player B, set up a pair of expressions or equations and solved these. Again, candidates stated the optimum strategy for B.

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