Examiners' Report

Principal Examiner Feedback

Summer 2022

Pearson Edexcel GCE

AL Further Mathematics (9FM0)

Paper 4D Decision Mathematics 2

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Summer 2022
Publications Code 9FM0_4D_2206_ER*

Introduction

The paper proved to be accessible to almost all candidates. It was pleasing to see many candidates able to gain high marks on the first two questions. The remaining questions differentiated well producing a good spread of marks. Responses to the newer content in the specification were encouraging. Those parts of questions requiring explanations continue to challenge all but the most able.

A key piece of advice to candidates is to answer the question as it is stated and re-read it as necessary, while completing their solution. Marks were lost through candidates overlooking parts of questions or disregarding detail in the wording.

Examiners commented that, in general, work was well presented, and poor handwriting was rarely a problem for them, or the candidates, in contrast to previous series.

Question 1

This question proved to be a very accessible, with well over half the candidates earning full marks. Row then column reduction was well done, as was developing an improved solution from three correct zero cover lines to four. A few candidates did fail to cover all the zeros with lines, but otherwise errors were mostly numerical slips. One of the two possible allocations was found by most, with many clearly stating both, though a few candidates lost the mark for failing to distinguish between B's and D's allocations. The calculation of the minimum value was almost always correct. A handful of candidates overcomplicated the problem, attempting to maximise the cost rather than minimise it, and consequently lost four marks.

Question 2

Again the majority of candidates gained full marks, though part (a) did cause difficulties for a minority. A few failed to recognise that the given solution implied an auxiliary equation with repeated roots, so were unable to make progress. Others wrote the incorrect equation $(m-3)^2 = 0$, rather than $(m+3)^2 = 0$. Those that found the correct values for k_1 and k_2 generally gained both marks provided their working was not incorrect. Some candidates' working left a lot to be desired, with the use of x, or even n, rather than m, or just the expression $(m+3)^2$ written rather than the equation, but these were not penalised. Almost all candidates went on to correctly answer (b).

Question 3

Decision analysis is a relatively new topic in the specification, so it was pleasing to see a good number of excellent solutions. Whilst many candidates interpreted the question correctly a substantial minority were unable to draw a correct decision tree. Candidates are advised to learn the style for the three types of node: boxes for decision nodes, circles for chance nodes and triangles for end pay-off nodes, with the former two drawn sufficiently large to allow figures to be entered inside them. For this problem the optimum structure consists of nine end pay-off nodes, three chance nodes and one decision nodes. A few candidates used an alternative correct structure, with six chance nodes, which overcomplicated the solution, necessitating the recalculation of several probabilities, and completion of additional intermediate chance nodes. Of those that constructed a correct tree diagram, many were then unable to annotate it correctly, in spite of showing the correct travel time calculations elsewhere in their solution. Both chance and decision nodes must have their calculated values entered inside them. All arcs must be appropriately labelled. Two short double lines through arcs should be used to indicate inferior options, though just on this occasion single lines or crosses were not penalised. A few candidates used negative values to indicate delays, and were not penalised this time, but again this would not be condoned in future.

Question 4

Most candidates correctly listed all 7 saturated arcs, although a few failed to do so, only giving 6 of them. Almost all candidates then stated the correct initial flow of 95 and many gave a correct explanation that the maximum flow into F was 22 which is less than 24 the capacity of FT. Some did not give both figures and were penalised here. Most candidates found the correct value of the cut C_1but a significant number made an error with C_2 stating 108 having incorrectly subtracted the capacity of BD. A significant number of candidates failed to find the correct flow augmenting route of SABDFT and other errors here included a descriptive approach, listing the route as a series of arcs with associated actions, or trying to give multiple routes. While many candidates had some idea of the max-flow-min-cut theorem, it was often not used correctly. Some failed to state the value of the flow. Others did not draw or list the arcs in the cut correctly or did not state the value of the cut. Some then failed to use correct wording and make the deduction that the flow was maximal. A surprising number of candidates called their augmented flow of 98 'initial flow', which, though incorrect, was not penalised.

Question 5

This question was well answered by the majority of candidates. Almost all understood the relevance of a balanced problem and therefore found *k* to be 39. Most had a general idea of the meaning of the constraint and were able to gain one mark, but few earned two, for fully translating the constraint by mentioning supply points and the demand at destination R being not less than, or at least, 44. Most candidates wrote the correct initial north-west corner solution but many did not attempt to calculate the corresponding initial cost, and lost a relatively easy mark. The stepping-stone method, for part (d), was familiar to most candidates, who were generally able to correctly calculate shadow costs and improvement indices, with only occasional errors and omissions. It was rare for the initial solution figures to be wrongly used, instead of transportation costs, as has been seen in past series. Almost all used their most negative improvement index to identify the entering cell, AS. The correct ii for cell AS was -20, but a number of candidates mistakenly found it to be -10, leading to a more difficult s/s route and causing them to lose at least the two accuracy marks. Just a few lost a mark for failing to name the entering and exiting cells, or for including a zero in their exiting cell.

Question 6

Candidates' attempts at this question gained marks across the full range, with about a quarter gaining full marks and an approximately equal number gaining none. It was evident that the problem was made accessible to a proportion of candidates using the starting point of May as an example to scaffold their solution. Some candidates left the pages for this question blank. Others gained no marks due either to failing, throughout, to include one or more of the costs given in the question or failing to include earlier optimal results in their calculations. Candidates should be reminded that the essential feature of dynamic programming is to carry forward optimal results from stage to stage. Of those that earned some marks many were able to complete the stage, state, action and destination columns. Errors were mainly due to incorrect multiples of 35 and/or 80 being added. A few candidates lost marks for omitting state 0 for February and March, missing the possibility that no sheds were in storage. Others, however, were not penalised for including extra rows with more than 3 sheds stored or more than 4 sheds made. Pure arithmetic errors were not very common and mostly resulted in the loss of one mark, or occasionally two. Most of those who completed the table obtained the optimum solution and minimum cost.

Question 7

Almost all candidates found parts of this question challenging, so that very few gained full marks. In parts (a) and (b) many were unsure how to deal with the unknown k and consequently found incorrect row minima and column maxima, or omitted them altogether. Some gave single values failing to indicate the two possible values. Stating (-4 or k) rather than min(-4, k) and (-2 or k) rather than max(-2, k) were condoned. Most of those candidates who did give the choice of values then failed to fully explain why the play-safe is Q. Many candidates did however give the correct range of values for k. While many candidates realised that Option X is inferior to Option Y (or Z) they either did not use the word dominates or failed to list the three inequalities comparing values in their two options, so few gained both marks in (c). Many candidates then went on to attempt the solution of the problem although some failed to realise that they needed to reduce the matrix by deleting Option X. Most candidates augmented the matrix correctly, in many cases this was implicitly shown by correct coefficients in their V, p equations. Some candidates failed to augment at all, losing at least three marks, and a few incorrectly augmented the matrix by adding 5 instead of 4, losing two marks. A fair proportion of candidates went on to correctly write down their equations in V, p_1, p_2 and p_3 together with slack variables. A number of candidates (often those who had not deleted Option X) failed to write down the probability constraint as an equation. A small number of candidates incorrectly used the rows of the matrix to form their equations instead of the columns. Most candidates who obtained equations then wrote down their initial tableau, although this could contain errors, with the most common being the inclusion of the Option X equation and omission of the probability equation. Some candidates failed to attempt the final part of the question. The first mark was accessible to many, as it only required the knowledge that the probabilities sum to one. Some stopped here, whilst others either calculated V, or eliminated V from two equations to work out that k was 1, though arithmetic errors cropped up frequently.

Question 8

Many candidates struggled to engage with this final question, with over half gaining either no marks or just one. There were many blank pages, which may have been due to candidates running out of time. Many candidates were unable to set up a correct initial model for the problem. Some used the incorrect subscript ‘n’ for their iterative formula, even though the correct one ‘n+1’ was given in the question, and some were then able to write down the correct complementary function. Of those earning the first two marks few were then able to write down the correct trial solution and rearrange this to find λ. Candidates also failed to write down the general solution in the correct form. Most candidates who had some form of general solution attempted to use the initial condition to calculate an expression for their constant in terms of k and p, substituting this into their general solution. A common error, seen at this stage, was to use 500 instead of 5000. Those candidates who obtained some form of general solution mostly went on to use the given information in an attempt to calculate the value of m, generally using logarithms as instructed, with some able to gain full marks.