Examiners' Report
Principal Examiner Feedback

Summer 2022

Pearson Edexcel GCE
Further Mathematics (8FM0)
Paper 28 Decision Mathematics 2

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Summer 2022
Publications Code 8FM0_28_2206_ER*

Introduction

The majority of candidates demonstrated sound knowledge of all topics and were able to produce well-presented solutions, making good use of the tables and diagrams printed in the answer book. 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. In a minority of cases marks are lost due to poor quality of handwriting, particularly when candidates misread their own written numbers and capital letters. Most candidates were well prepared for the exam and there were very few blank pages. In the final question on recurrence relations, it was, however, evident that some candidates were unfamiliar with this topic (not previously seen in either legacy modules 6689/01 or 6690/01) and several blank or low-scoring responses were seen by examiners.

Question 1

Many candidates scored very well on this question. Almost all modified the table correctly in (a) by inserting a large figure in each of the two blank cells; figures ranged from 100 to 1000, though 136 was common. The first mark in (b) proved elusive for many who failed to explain in sufficient numerical detail how the initial row and column reductions were made. However, most candidates did correctly carry out those row and column reductions. Accuracy errors at this stage were rare. Most candidates then recognised that two lines were needed to cover the zeros and were well versed in developing an improved solution twice to arrive at the optimal table. Many candidates though failed to clearly explain how they determined, at each stage, whether their solution was optimal. It is essential that candidates refer to the number of lines covering zeros and make it clear the number of such lines that are needed for optimality. However, candidates had no difficulty deducing the optimal allocation.

Question 2

In (a) and (b) nearly all candidates correctly stated the feasible flow from S to T as 50 and the eight saturated arcs respectively.

In (c) several candidates struggled to explain why arc EC could never by full to capacity. Not all candidates explained that the total capacity of the three arcs (BE, FE and GE) leading into E was 34 but the maximum flow of the one arc (EH) out of E was 37.

In (d) the most common error in calculating the value of the second cut was to include values for arcs FE, DC and/or GE even though these arcs were directed from the sink set of nodes to the source set of nodes for this cut.

Most candidates correctly stated the required flow-augmenting route in (e) although some gave more than one route (even though the question specifically asked for a single route).

Part (f) discriminated well with very few **proving** that the flow was optimal. To assist for future series please find below a way in which candidates can set out such a proof:

- It is best to state (and not just draw) a cut (that passes through saturated arcs that are directed from the source set to the sink set of nodes together with any arcs with zero flow that are directed from the sink set to source set) - so for this network as a list of arcs this was BE, FE, GE, GH, GT and DT or as set of nodes $\{S, A, B, C, D, F, G\}, \{E, H, T\}$.
- State the capacity of this cut and hence what this implies about the minimum cut e.g. the value of this cut is 53 which implies that the minimum cut $\leqslant 53$

- State the value of the flow through the network after augmentation and what this implied about the maximum flow e.g. the current flow through the network is 53 which implies that the maximum flow is $\geqslant 53$
- Conclude the proof by referring to the maximum flow-minimum cut theorem e.g. the min. cut is $\leqslant 53$ and the max. flow is $\geqslant 53$ but by the maximum flow-minimum cut theorem the max. flow is equal to min. cut therefore the maximum flow is 53 and therefore the flow is indeed optimal.

Question 3

A fair proportion of candidates demonstrated understanding of the term 'zero-sum game' in (a), but some were unable to clearly convey the idea that one player's losses equal the other player's gains.

Part (b) was done very well, with most candidates finding correct row minimum and column maximum values, with very few errors. A small number of candidates failed to either correctly identify the row maximin and column minimax, or to verify that the game was stable with correct justification.

In (c) the majority of candidates correctly wrote down the pay-off matrix for June.

In (d) most candidates set up four correct probability expressions (though some had errors when simplifying these expressions) and then most subsequently went on to draw a graph with 4 lines; a few candidates attempted to just solve pairs of simultaneous equations, scoring no marks. It was noted that some graphs:

- were poorly drawn without rulers,
- went beyond the axes at $p < 0$ and $p > 1$,
- had uneven or missing scales on the vertical axes,
- were so cramped that it was difficult to identify the correct optimum point.

Most candidates attempted to solve the pair of equations for which they considered to be their optimal point from their graph. Those that solved the correct pair usually went on to list the correct options for June (that is, that they should play option X with probability 8/15 and option Y with probability 7/15) although a number did not state their answer in context or did not define p initially as the probability of June playing option X (and hence $1 - p$ as the probability of them playing option Y). Those candidates who were successful in finding the correct value of p usually went on to correctly state the value of the game to Terry.

Very few candidates made any real progress in (e) indicating that candidates are still unfamiliar with how to solve the game for one player once the solution is known for the other.

Question 4

As expected, the final question on recurrence relations was the least well attempted on the paper and examiners noted that many candidates either left this question blank or made only minimal (unsuccessful) attempts. Some candidates did make a correct start though, writing down a correct complementary function plus a linear particular solution which they attempted to substitute into the recurrence relation, gaining the first two marks. Many attempts ended at this stage. However, a minority of candidates were well prepared for this topic and produced excellent solutions, particularly in (a). The final mark was lost in (a) for a number of candidates when they expressed their solution as $u_{n+1} = \dots$ rather than $u_n = \dots$. Relatively few candidates were able to complete (b), but it was encouraging to see a good number equating the coefficient of $(-3)^n$ to zero and solving for *k*.

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