Examiners' Report

Principal Examiner Feedback

Summer 2019

Pearson Edexcel GCE AS Mathematics (8FM0)

In Decision Mathematics 2 Paper 28

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications are awarded by Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk. Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

Summer 2019
Publications Code 8FM0_24_1906_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 second 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.

Report on Individual Questions

Question 1

This question on applying the Hungarian algorithm to obtain an allocation which maximised the total earnings proved to be accessible to nearly all candidates with the majority scoring the marks for the application of the algorithm. When errors were seen these were usually down to numerical slips rather than errors in method as nearly all candidates correctly applied row and column reduction followed by correct augmentations. A small number of candidates failed to deduce the optimal allocation from the location of the zeros in their final table. However, many candidates failed to read the question carefully and did not adequately explain how the table should be modified in part (a) (by subtracting each entry from a constant and adding a dummy row with equal values) or in part (b) many failed to explain how any initial row/column reductions were made and also how to determine if the table was optimal at each stage.

Question 2

As stated in the introduction, the responses to this question on the relatively new topic of recurrence relations were mixed. While some candidates scored full marks, a significant number made very little progress after correctly stating the complementary function in part (a). Examiners noted that many candidates seemed to need to re-write the recurrent relation in terms of u_n instead of working with the given form in terms of u_{n+1} (which seemed to display a lack of understanding of how these types of equations work) and many incorrectly re-wrote $u_{n+1} = 3u_n + 2^n$ as $u_n = 3u_{n-1} + 2^n$ so scoring nothing but possibly the first mark in part (a). Those who correctly stated the complementary function as $A(3)^n$ and then used $u_n = k\left(2^n\right)$ as a trial solution in the given recurrence relation usually went on to derive the correct general solution but some incorrectly stated this as $u_{n+1} = A(3)^n - 2^n$ instead of in terms of u_n.

In part (b) those who had a general solution of the correct form could usually score the method mark for finding a value for their constant based on the condition that $u_1 = u_2$. However, a correct particular solution was rarely seen in this part.

Question 3

In part (a) nearly all candidates correctly stated the initial flow as 45.

In part (b) many candidates struggled to explain why arcs DF and DG can never **both** by full to capacity. Very few explained that the total capacity of these two arcs is 16 but the maximum flow of the two arcs that flow into D (AD and BD) is only 14. Many incorrectly based their argument on the flow out of D without realising that flow could leave D via arc DE.

In part (c) the most common error in calculating the value of the given cut was to include a value for arc DE even though this arc was directed from the sink set of nodes to the source set of nodes for this cut.

Most candidates could correctly apply the labelling procedure in part (d) to find at least two correct flow-augmenting routes (and corresponding flows) but not all managed to increase the flow by the correct amount of 8 (and some surprisingly managed to increase the flow to 10).

In part (e) candidates are reminded of the following two points when showing a flow on a diagram.

- There should only be one number on each arc and
- all arcs should be assigned a value (even if this value is zero).

Both points were condoned by examiners this series, but this may not be so in the future.

Part (f) discriminated well with very few **proving** that the flow in part (e) 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 CH, CF, AD, BD, DE, EG and EJ or as set of nodes $\{S, A, B, C, E\}, \{D, F, G, H, J, T\}$.
- 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 ≤ 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 ≥ 53
- Conclude the proof by referring to the maximum flow-minimum cut theorem e.g. the min. cut is ≤ 53 and the max. flow is ≥ 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 in part (e) is indeed optimal.

Question 4

Part (a)(i) 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 state that the game was stable with correct justification.

In part (ii) most correctly stated the value of the game to Brendan (B) but unsurprisingly gave the answer as 3 (which was the value to Aljaz (A)).

In (b) most candidates set up three correct probability expressions (though some had errors when simplifying these expressions) and then most subsequently went on to draw a graph with 3 lines; a few candidates attempted to just solve three 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 A (that is, that A should play option P with probability 0.6 and option Q with probability 0.4) although a number did not state their answer in context or did not define p initially as the probability of A playing option P (and hence $1 - p$ as the probability of A playing option Q).

Very few candidates could come up with a correct explanation for why B should never play option Y; many candidates gave a response that danced around the correct answer, but examiners were looking for an answer that strictly indicated that the graph indicated that for all value of p Brendan could gain more by playing either option X or Z.

The responses to part (d)(i) were very mixed with many candidates failing to **explain** why q satisfied the given equation – many simply stated the given equation or derived it without explaining that if A plays option P then B can expect to gain $-\left(-6q+2\left(1-q\right)\right)$ (as the values in the table are the pay-offs for player A) and the value of the game to player B is $-\left(5-11\left(0.6\right)\right)=1.6$ which implies that $-\left(-6q+2\left(1-q\right)\right)=1.6$ which leads to the given equation. Many candidates simply stated the value of 1.6 without any indication of where it had come from and therefore did not 'show it'.

Part (d)(ii) was done much better but some candidates are clearly not conversant with certain mathematical command words and many derived the value of q from scratch and did not use the given equation in (d)(i). While many correctly found the value of q as 0.45 many did not give the best strategy for B in context or refer to the fact that B should 'play' option X with prob. 0.45 (and option Z with prob. 0.55).

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London, WC2R 0RL, United Kingdom