Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

Summer 2019

Pearson Edexcel GCE AS Mathematics

In Decision Mathematics 2 (9FM0/4D)

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Introduction

This paper proved to be accessible to most candidates. The familiar areas of the specification which have transferred from the legacy module 6690/01 were particularly well answered although examiners noted that a significant number of candidates struggled to cope with the new content. Furthermore, some candidates had difficulty with the problem-solving nature of some of the questions (which is now part of the assessment objectives for this qualification). Nonetheless, 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 was sufficient 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 and some candidates lost marks when they misread their own writing.

Question 1

This question, was a generally very accessible start to the paper. The vast majority of candidates were able to gain some marks and most gained several marks here. Sometimes accuracy let candidates down although there were a number of opportunities to re-enter the scheme following errors.

Part (a) was well answered. Most candidates were able to find a valid route. Some candidates lost the accuracy mark when they left '0' in CQ in their improved solution. This seemed to occur more frequently than has perhaps been the case in recent years and despite the fact that it is often highlighted in examiners' reports.

Most candidates found the correct shadow costs and route in (b) for the two method marks; however, a reasonable minority managed to make an error in their improvement indices, thus losing an accuracy mark here. Some candidates found too many or two few improvement indices which was costly. It should be noted that the setting out of the shadow costs and improvement indices as shown in the published mark scheme (in which both sets of values are shown on the same table) is probably the clearest form of presentation; candidates who show many calculations at the side of the table can make it somewhat difficult for the examiner to find, or even to follow, their corresponding method/working. Furthermore, it is more straightforward for candidates to ensure that they have the correct number of both shadow costs and improvement indices if they are presented in this way. A number of candidates failed to state the entry/exit cells although this had been explicitly asked for the question.

Part (c) was generally well understood by candidates; again, many made slips in their calculations but understood that a negative improvement index meant a non-optimized solution. A surprising number of candidates did not seem to understand that they would need to recalculate shadow costs and improvement indices in this part and referred instead to shadow costs and improvement indices from the previous iteration. Others calculated more improvement indices than were strictly needed in order to ascertain whether an optimal solution had been reached – as soon as a negative improvement index is reached it is perfectly acceptable to stop calculating more indices.

The correct value in (d) was reached by a majority of candidates who had scored well in the previous three parts.

As mentioned in the introduction, the presentation of candidates' work was sometimes difficult to follow and at times cost marks when it was unclear which values were costs and which values were improvement indices. Candidates would be well advised to set their work out carefully and to clearly identify the different elements of their solution.

Question 2

Candidates were clearly very well prepared for this question and it proved to be a good source of marks for many candidates. A significant proportion were able to produce perfect or near perfect solutions. Candidates who lost marks sometimes did so due to slips in their application of the algorithm however these were not usually too costly due to the follow through marks available.

A small proportion failed to convert their initial matrix to a maximisation problem and thus lost a significant number of marks as they had oversimplified the problem. Some candidates did not fully undertake row and column reduction, in some cases prematurely augmenting their tables.

Most candidates though subtracted from 203 (or more rarely, numbers greater than 203) and then reduced rows and columns as expected. Augmentation was generally carried out very well. The main way in which candidate lost marks was simply inaccuracy in calculation or due to candidates' misreading of their own handwriting. Indeed, as already mentioned, candidates' handwriting was sometimes challenging to read, especially once lines covering zeros had been added onto the tables.

Question 3

Once again, testing a familiar area of the specification which migrated from the legacy qualification, this question provided a good source of marks for many candidates. However, part (a) was not generally as well answered as the rest of the question, many candidates failed to correctly indicate that the algorithm can only be applied to weights that are not negative. Still others, who did identify the key reason, lost the mark due to the inclusion of additional, false, reasons.

As already mentioned, most candidates proved to be well prepared for part (b). Those that didn't do well either forgot to carry forward previous optimal values. or had misunderstood the question to be a minimax/maximin problem but these candidates were in the minority.

One costly error, made by some candidates, was the inclusion of an insufficient number of rows in stage one of their table. It would be advisable for candidates to be reminded to perform a straightforward check that their table contains sufficient rows for the number of arcs on the digraph in cases such as these. In fact, most candidates appeared to find the application of a dynamic programming approach to a minimisation problem based on a digraph relatively straightforward and coped very well with the blank table and lack of scaffolding in the answer book. Occasionally, candidates mislabelled their states and destinations giving reversed actions and as with the legacy qualification, arithmetic errors were fairly common. A very small number of candidates did not evaluate their calculations at each stage: calculating only the optimal row. Candidates should be advised that in decision mathematics they must rigorously apply the algorithm in full. Most candidates' presentation here, however, was clear and easy to follow although a minority crossed out working and then attempted to squeeze in alternative answers, making it difficult for examiners to follow their working.

Once candidates had completed the programming, most were able to find a suitable range for x based on the values in their final stage. Some candidates, however, appeared to be reluctant to carry the -30 into stage 3 and so obtained an incorrect value for SB at the end of the table which in turn led to an incorrect result for the range for x.

A significant number of candidates misunderstood the final part of the question, quoting the minimum total weight along the route (setting $x = 0$) rather than giving the route itself.

Question 4

This question tested a far less familiar area of the specification and as such provided something of a challenge to many candidates. Part (a) was well answered by almost all candidates, as a classic question from the legacy specification this was to be expected. Occasionally, some marks were lost either due to errors in writing down row minima or column maxima or for incomplete conclusions. Very few inverted the question, finding row maxima and column minima. Sometimes, working was incomplete where there were missing row minimums and column maximums. Candidates should be reminded that in order to be using the correct "method" they must show the row minimums and column maximums in full.

Part (b) was generally not well answered. The demand of the question was high and required candidates to provide reasons for the steps required to formulate the linear programming problem. The low number of responses that scored the two most challenging marks here demonstrated the difficulty that candidates seem to experience with this type of question. Many candidates were able to spot the required amendments but were unable to articulate the reasons for the changes. A substantial number of candidates were however, able to go on write down the three constraints correctly. There was, nonetheless, a significant minority who failed to adjust the coefficients of the matrix and/or correct the direction of the inequality sign which was costly in terms of the dependency marks that followed later in the question.

Unfortunately, if candidates did not correctly amend the constraints, the number of marks available in part (c) was limited. It is clear that setting up a simplex tableau is a far less familiar area of the course and is one that a significant minority did not attempt. Of those candidates that did attempt to populate the tableau, a good number scored full marks. Those that lost marks, did so either due to incorrect constraints from earlier in the question or due to slips and misreading of their own handwriting or simply from a lack of understanding of which rows and columns were required.

Parts d) and e) were somewhat unfamiliar and ultimately more challenging for many candidates. Whilst some candidates were able to substitute the values for p_1, p_2 and p_3 into the constraints for V quite a significant proportion either did not attempt this part of the question or simply substituted the values into one constraint only. Sometimes, candidates who used the transformed constraints forgot to adjust the value to be correct for the original problem. Part (e) was a good discriminator at the top end. It was, quite frequently not attempted. Of those that did attempt this part of the question, many candidates did not recognise that $p_2 = 0$ meant that a dominance argument then applied for B which ruled out option X. A number of candidates instead tried to set up simultaneous equations in three variables and were then unable to make further progress. For those candidates who did spot the dominance, about half used an approach involving the value of the game to B taken from the value their obtained in part (d) together with an expression in terms of p from the matrix. The other half found two expressions for the value of the game to B from their reduced matrix, equated them and solved to determine the probability. Some candidates unnecessarily drew graphs to demonstrate the optimality of the value of p they had found. Those that determined the required probability, usually went on to list the correct options for player B although a small number did not state that player B should never play option X. Candidates should be reminded that their final statement should include a strategy for each of the possible options.

Question 5

Covering a new area of the specification, this question was meant to provide an accessible introduction to recurrence relations. It was extremely well answered by many candidates, but interestingly was also frequently not attempted by candidates.

In part (a), a high proportion of candidates earned both marks. The most common loss of marks being due to sign errors when multiplying out brackets which is quite worrying at this level. Furthermore, a minority of candidates seemed unsure how to write down the mean of u_{n-1} and u_{n-2}.

Part (b) should have been quite standard and straightforward and for many candidates this was indeed the case. Worryingly though, some candidates set the right-hand side of their auxiliary equation equal to 12 and came unstuck almost immediately. However, the majority of candidates were able to form and solve the correct auxiliary equation although some misconceptions regarding the correct form of complementary function were apparent with some candidates writing, for example, $u_n = \frac{1}{2}A^n + B^n$.

When determining the particular solution, most candidates correctly realised they needed to substitute $u_n = \lambda n$ into the recurrence relation and most were able to deduce that $\lambda = 4$. Unfortunately, some candidates then made the costly error of deducing that the general solution was then $u_n = A + B(-\frac{1}{2})^n + 4$ rather than $u_n = u_n = A + B(-\frac{1}{2})^n + 4n$. Solutions of an incorrect form such as these were then unable to earn later marks. Those candidates who obtained general solutions of the correct form were almost always able to write down two equations for 'A' and 'B' and solve them simultaneously, often using calculators, to determine the correct solution.

As mentioned above, part (c) was not accessible to candidates who made critical errors earlier in the question that give rise to general solutions of an incorrect form. Of those candidates who were eligible for marks here, a majority could state the value of k, but too frequently candidates only considered the behaviour of $(-\frac{1}{2})^n$, and not the impact of the $-\frac{2}{3}$.

Question 6

This question produced a mixture of responses. With a heavy problem solving and reasoning emphasis, it was found to be challenging by many candidates despite being a familiar area of the specification.

Part (a) and (b) are very standard questions and as such were the most successful for candidates. Nonetheless, the number of incorrect answers in (a) – particularly (a)(ii) was worrying at this level. Part (b) was almost always correct although some responses which focussed on only the maximum flow into E or the maximum flow out of E rather than comparing the two values were insufficient for the mark here.

Part (c) was challenging and was often not attempted. Very few candidates correctly identified a cut of capacity 32 and deduced that a flow of 31 was not possible. Most candidates focussed instead on the flow into individual nodes or the flow at the source or sink and were unable to make progress.

Part (d) required a good understanding of flow in networks and required candidates to draw together their work in (a) and (c) to deduce the minimum and maximum flows. This was only very rarely achieved completely and indeed many candidates did not attempt this part of the question. However, a significant number of candidates that did were able to earn some marks for drawing consistent flows of 32 or 34 even if the justification for these flow values was missing. Unfortunately though, often the diagrams were left only partially complete or a number of errors were present such as multiple numbers on some (or all) of the arcs (even though, as in previous years, only a single number can be accepted on a flow diagram) and some candidates either left one arc blank or had an inconsistent flow pattern.

Question 7

This question tested another new area of the specification and was found to be the most challenging question on the paper. The majority of candidates demonstrated an understanding of decision trees to the extent that they could construct an appropriate tree starting with a decision node, including a chance node and concluding with three end pay-offs. An unexpected stumbling block presented in the form of the calculation of the probability of scoring 16 or more on three dice. This ultimately lost some marks but candidates were nonetheless able to earn later follow through marks for the application of a correct method. In the majority of cases, the chance node EMV for playing the game was correctly calculated albeit following on from a, sometimes incorrect, stated probability of success. Unfortunately, some candidates did not fully complete their decision tree, and lost marks for omitting one or more of the key components including ‘play’ and ‘not play’ labels, pay-offs at the tree ends, double lines through the inferior option or ‘0’ in the decision node. In (a)(i), candidates were asked to determine the optimal EMV and state the optimal strategy. However, often candidates lost this straightforward mark for stating only the EMV of playing the game rather than the optimal EMV of 0. Some candidates only stated the EMVs and did not conclude that the optimal strategy was ‘Not Play’. Candidates should be encouraged to check that they are answering the question that has been asked.

Parts (b) and (c) provided a challenge to the majority of candidates and many did not make much progress here. Of those candidates that did make some headway, some spread of marks was observed. It seems that candidates are unfamiliar with the application of the utility function and most problems arose from an incorrect substitution of $m = 3$ into the function rather than the correct $m = x + 3$; demonstrating a lack of understanding that the utility function is defined in terms of the total money Aisha has, rather than her winnings or losses. Furthermore, some candidates attempted to evaluate the utility function alone rather than calculating the *expected* utility as requested: thus, omitting the probability multiple(s). In (c), only a minority of candidates were able to make progress. Most seemed unclear that they should be comparing the expected utility of playing with the expected utility of not playing. Instead some candidates simply set the expected utility of playing greater than zero. Others wrote down a correct inequality but seemed unable to make progress in solving the inequality for x which is, perhaps, surprising at this level. Unfortunately, a handful of candidates who were able to navigate the algebra here slipped at the final hurdle by interpreting their solution for the minimum prize by incorrectly stating $x >$ £66.18 rather than $x =$ £66.18 or x $\geq$ £66.18 (which was condoned).

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