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Examiners' Report/ Principal Examiner Feedback

Summer 2016

Pearson Edexcel GCE Decision Mathematics 2 (6690)

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Principal Examiner's Report

GCE Mathematics

Decision Mathematics 2 (6690/01)

General Introduction

The majority of students 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. Students should be reminded of the importance of displaying their method clearly. Decision Mathematics is a methods-based paper and spotting the correct answer, with no working, rarely gains any credit.

Many marks are lost due to poor quality of handwriting only in a minority of cases, particularly when students misread their own written numbers and capital letters.

Most students were well prepared for the exam and there were very few blank pages.

In the final question, it was, however, evident that some students ran out of time, a few made no attempt at all and many more stopped mid-solution.

Report on Individual Questions

Question 1

For part (a), many students could accurately describe the difference between the practical and classical problem, with accurate and correct terminology seen in most responses. However, this initial question differentiated between those that had a secure grasp of the topic and those that were much less secure in their knowledge, with a significant number referring to 'arcs needing to be traversed', rather than the need to visit every vertex. Those that only scored partial marks on this part had the correct general idea without being able to pinpoint the need to visit every vertex.

Whilst part (b) was well answered by the majority of students, the most common error was to fail to return to the starting vertex. There were also a significant number of students who found an upper bound by doubling the length of a minimum spanning tree, so gave answers of 298 and 316, instead of finding nearest neighbour routes.

Part (c) was also well answered by most students, with many securing full marks for an answer of 113. A significant number of students did not find the correct RMST (found from deleting vertex A and all arcs incident to this vertex), but still managed to secure a mark for adding the correct two least weighted arcs.

Most students scored at least one mark in part (d) on the follow through from an earlier stated upper bound found in part (b). It was common, however, to lose the final mark in this part for either the use of a strict inequality for the upper limit, or because of inaccurate earlier working. It was rare but nonetheless worrying to see statements along the lines of $149 \leq$ optimal distance ≤ 113.

Question 2

It was noted that this question was answered well by most students.

In part (a), most students were able to correctly identify the correct saturated arcs. The most common error seen here was the occasional slip on missing a saturated arc.

In part (b) most students could correctly calculate the initial flow.

In part (c), a number of students showed a misunderstanding of the numbers given to them in the diagram when attempting to find the capacity of the two cuts. Students should be advised as to the difference between potential flow and actual flow in these questions and that it is vital that they use the capacity of each relevant arc to calculate the corresponding capacity of the required cut.

Part (d) of this question was generally answered well, with most students giving the correct answer of SABCFET. A number of students gave the solution in terms of arcs (SA, AB, BC, CF, FE and ET). Whilst this is a perfectly correct response, students might be advised that to save time in the exam it is acceptable to state the path via vertices/nodes rather than stating arcs.

Part (e) of this question produced a variety of responses. Many students were able to follow their working in part (d) to identify that 62 was their augmented flow, but many did not adequately prove that this was maximal. Some stated a value of a cut as 62 but they did not show this cut on a diagram or state a set of arcs to indicate their cut. Many did not state the theorem that the maximum flow is equal to the minimum cut. It is advisable for students to draw the cut on the diagram showing their maximal flow pattern rather than stating the arcs that the cut passes through. Finally, students are reminded to refer to the original diagram containing the flow capacities when considering possible cuts, rather than their optimal solution.

Question 3

This question proved to be a good source of marks for many students. A significant proportion were very well prepared for this question and provided perfect or near perfect solutions. It is clearly a well understood topic for many students. A small minority solved the problem of minimising scores, and as this drastically reduced the complexity of the problem, they were limited to maximum of only 2 marks. Some students did not fully undertake row and column reduction, in some cases prematurely augmenting their tables. The number of arithmetic errors was pleasingly few and most seemed to be caused by students misreading their own handwritten numbers. Despite all these issues apparent for some students, this was in general a very well attempted question and many students were able to apply the algorithm correctly to obtain a correct allocation and obtain the maximum total score.

Question 4

In part (a), there was a range in the quality of the answers. Most students knew that x had been increased first and some of the reasons provided included 'x, because it is a basic variable', 'x, because it is in the first column' or 'x, because it has only 1's and 0's in its column'. There was, however, a significant minority who had not understood/read the question carefully and believed they were being asked which variable was to be increased next and these students usually gave responses along the lines of 'z, because it has a negative value in the P row'. There were also a small number of responses which stated that 's had been increased because x had replaced it in the first column'. There were noticeably more blank responses in this part of the question than others.

Part (b) was generally very well done. Unfortunately, there were some students who made incorrect pivot choices for example, pivots from the y column or the '−1' in the z column. However, the majority chose either the correct pivot, or in a small number of cases, gained some credit for choosing to pivot on the '3' in the z column. Almost every student managed to divide their pivot row correctly, although examiners noted that some students subtracted 2 rather than divided by 2. Almost all remembered to change the basic variable correctly. There were some numerical errors in the application of row operations, but this was accurately done for the most part and the vast majority of students stated their row operations correctly. Most used a single table for their solution however there were some students who spread their work over two (or even more tables) which may have been time consuming. Furthermore, there were a handful of students who did not read the question carefully and did not stop after one iteration. These students completed two iterations (with the second gaining no credit) and therefore lost time and possibly some later marks as a result.

Part (c) was quite well done. There is still some confusion about the signs of the coefficients and some students completely neglected to include P, or sometimes the 27.

Part (d) proved to discriminate quite well between students. Most had learnt to recite 'not optimal because there is a negative in the profit row' or similar. However, relatively few engaged with the question and many failed to use part (c) to justify their answer. The most successful students were those who had rearranged the profit equation to make P the subject.

Question 5

The vast majority of students understood the need for a dummy demand point in parts (a), as total supply was greater than the total demand, and how to add such a column in part (b) and were able to use the north-west corner method correctly in part (c). In the more substantial parts (d) and (e), the responses were more mixed. Whilst there were many neatly presented and fully correct solutions, there were many more which were not clearly presented and the algorithm not followed accurately. In particular, some students did not make their shadow costs and improvement indices clear which made it very difficult for examiners to award the corresponding method marks. In general, students stated their entry and exit cells explicitly, though it was not uncommon that students lost accuracy marks by placing a zero in the exiting cell rather than leaving it blank as required by the algorithm. Furthermore, many students did not appear to notice that one complete iteration had been already performed despite being explicitly stated in the stem to part (d). This sometimes resulted in students needlessly performing the first iteration. Whilst full marks was possible in such instances, in practice this was not common as students frequently lost their way due to the increased number of calculations required. A more common error was for students to apply the stepping stone method with the given entry cell D3 to their north-west corner arrangement from part (c) rather than the given table resulting from the first iteration. Such an approach did lead to the optimum solution but did mean the loss of all the accuracy marks in part (d). For those students who had got this far, the majority were able to accurately calculate the improvement indices in part (e) and come to the correct conclusion.

Question 6

In part (a), almost all students found the correct row minima and column maxima, and most were able to select and compare the correct values to confirm no stable solution existed. A few inverted the question, finding row maxima and column minima. Others changed the sign of the column values, as if taking both rows and columns from the point of view of player A. A few failed to indicate the values they were choosing or failed to state clearly why there was no stable solution.

In part (b), a majority of students augmented the table by adding '5' or, less frequently seen, by adding '4'. A small number did not show the adjusted table but used augmented values in their constraints. Those who failed to augment the values lost a significant number of marks in parts (b) and (c). Most were able to define probability variables, some using probability notation but too many failed to state that their variables were probabilities, merely writing 'Let A plays 1 be p_1'. A small number confused the problem with a different algorithm (transportation or allocation). The third mark in this part was the one most commonly lost by students who introduced the variable *V* but did not define it as the value of the game (to player A). The fourth mark for Maximise *V* was often seen as 'max $P = V$'. Some students failed to include *V* in their equation, merely referring to p_1, p_2, p_3 whilst others tried to formulate an equation in terms of *P* and the entries in the table. Many students wrote correct inequalities but failed to add slack variables, or wrote the slack variables as positive on the opposite side to *V*, meaning that the corresponding accuracy mark was lost. A correct equation for the probability variables was often seen, with or without the slack variable. Some lost the final mark in this part as they did not have an equality, despite the question specifically asking for equations. A few chose the coefficients from the rows of the table rather than the columns.

Part (c) differentiated well with many students unable to label the table correctly. The basic variable column was often missing, as was the slack variable corresponding to the constraint on the summation of the probabilities and also the column for *V*. Some students who had omitted a row or a column (or both) were able to enter the remaining coefficients into the table correctly. Some students who had the correct equations in (b) lost marks here by making all the values corresponding to p_1, p_2, p_3 positive. Finally, the error most often seen in an otherwise correct tableaux was having '1' as the coefficient of *V* in the profit row rather than '–1'.

Question 7

This question produced a variety of responses, from perfect solutions to blank attempts. A good number of students showed a clear grasp of how to use the given information to work backwards through their table, from one stage to the next using the correct relevant values at each stage to find a correct final solution. Some students crossed out working and then attempted to squeeze in alternative answers, making it very difficult for examiners to follow their working. Almost all correctly started backwards from May, working from the scaffolding provided, and many were able to obtain values for the correct six rows each for April and March, though a minority of students forgot to carry forward previous optimal values. There were a number of errors made when choosing the correct elements to include, particularly involving storage costs, in spite of the given values for the first month (May). For example, April state 3 should have had £75, for all three actions, but £75, £50 and £25 were sometimes seen. As in previous sessions, arithmetic errors were quite common. These usually led to a loss of up to four marks, in spite of the availability of follow through marks, but in cases where the optimal value was affected, it sometimes proved even more expensive. Given that all contributory numbers were multiples of 25, it was surprising how many students came up with values such as £1365 and £1915. Some extra rows were seen but a good number of students annotated their extra rows with comments such as "impossible" or "not valid", and were therefore not penalised. For both February and January, some students lost all marks due to the omission of rows, possibly because they believed that their omitted rows would not be part of the final solution. Students should be advised that in decision mathematics they must rigorously apply the algorithm. Others gave up part way through but this could well have been a timing issue. Students who are running out of time would be well advised to successively complete whole rows including the "Value" column, rather than completing "Stage, State, Action and Destination" for the entire table. Almost all students did show the necessary working as requested. Virtually all students who completed their table up to and including January then correctly stated the optimum solution and associated cost. Of these, many went on in part (b) to attempt to calculate the profit, but it was quite common to see the incorrect answer of £7250, which came from forgetting to subtract £1700, the value they had just obtained in part (a).

Grade Boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:
http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx

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