

Examiners' Report/
Principal Examiner Feedback

Summer 2013

GCE Decision D2 (6690)
Paper 01

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Decision Mathematics D2 (6690)

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 advised to read questions carefully and answer as required. For example, marks were lost in question 1, by candidates stating a route, where its length was required, and vice versa.

Poor quality of handwriting causes a minority of candidates to lose many marks, particularly in misreading their own written numbers and capital letters.

There were many instances of candidates losing marks through poor basic arithmetic, evident in questions 1, 2, 3, 5 and 7. A remarkably common error in question 7 was “ $21 + 11 = 31$ ”.

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

It was evident though that in the final question some candidates ran out of time, a few making no attempt, and many more stopped mid-solution.

Question 1

This first question proved to be a good source of marks for many candidates with the mode being full marks obtained by 38.1% of candidates and only 20.9% scored 8 marks or fewer. However a considerable number did not respond correctly to the detail of the question, and lost marks that they could easily have gained. The majority found the correct minimum spanning tree, using Prim’s algorithm, but a significant proportion selected arcs in the wrong order, or failed to show the order of arc selection, in spite of this clearly being requested in the question. Candidates should be reminded that knowledge of D1 material is a requirement, and may be tested. Some candidates attempted to use the nearest neighbour algorithm instead of finding the tree. Those that did find a tree generally then doubled their answer for the initial upper bound.

Most candidates found both nearest neighbour routes in part (c) but some failed to return to A, or made arithmetic errors in calculating the lengths of these two routes. For part (d) the majority of candidates correctly stated their lowest value as the better upper bound, although some quoted a route instead of the value, and therefore lost the mark. The majority of candidates scored all 4 marks in part (e) for the lower bound calculation, finding the correct residual minimum spanning tree, and then adding the two shortest arcs to obtain a lower bound, although a few made errors in their choice of arcs. A small number deleted A instead of B, or even wasted time deleting each of the 5 arcs, in turn. Those candidates who obtained the correct upper and lower bounds realised that they had an optimum solution and many gave a correct route, though a substantial minority quoted the optimum value “78”, without giving a route.

Question 2

This question also proved to be a good source of marks for many candidates with the mode again being full marks obtained by 39.0% of candidates and only 18.9% scored 4 marks or fewer. Almost all candidates gave the correct initial supply pattern and most found the correct stepping stone route, though some had an extra theta in cell A1, not understanding the requirement for balance both across rows, and down columns. Many went on to give the correct improved solution in part (b), although some had an additional zero in B1, the exiting cell, and typically lost a later mark for the same transgression, in their second improved solution. Some wasted time calculating initial shadow costs and improvement indices, only to confirm that D1 was to be the entering cell (this was given to candidates in the question). Most candidates attempted to calculate shadow costs and improvement indices from their improved solution in part (c), although a number made errors in their calculations or used the supply pattern instead of the costs, as the basis for their calculations. The most negative improvement index was generally chosen to start a new stepping stone route and many found the correct route and improved solution, though some lost a mark for failing to state the correct exiting cell (D3). The majority of candidates who found the second improved solution, went on to calculate new shadow costs and improvement indices in part (d), although occasionally these contained errors, and they then made the correct conclusion of an optimum solution. As in previous sessions, a minority of candidates made the costly mistake, once or even twice, of finding only 5 improvement indices.

Question 3

This question was generally answered well by most candidates. The mode was full marks obtained by 22.3% of candidates and 77.9% scored 6 marks or more. Part (a) was almost always correct but many errors were seen in part (b) where candidates either included the flow on arcs rather than the capacity or included capacities of arcs crossing from sink to source. Most candidates found valid flow augmenting paths in part (c) to increase the flow to at least 51, but a minority did not find all paths to give a correct flow of 53. It was surprising how many candidates found their correct routes but with no evidence of using the network provided in diagram 1. In part (d), candidates were penalised for writing two flow figures on each arc, and other common errors in this part were a non-zero flow value on DE (where 'backflow' was not fully understood) or at least one of DF/GI/FH left blank. Candidates would benefit from methodically check every node for 'flow in = flow out'. In part (e), many gained the method mark, for a cut, but some candidates, who had been successful up to this point, attempted a cut not equal to 53, or they failed to quote the 'max – flow = min – cut' theorem. Those that quoted the theorem without a cut lost both marks. Candidates should be reminded to refer to the original diagram for flow capacities, for cuts, rather than their optimal solution.

Question 4

This question also gave rise to a good spread of marks and proved a good discriminator. The mode was again full marks gained by 29.5% of the candidates, 19.4% of the candidates scored 4 or fewer marks.

The majority of candidates realised that they needed to reduce the matrix using a dominance argument in part (a), but a significant number deleted column 2 instead of 1, losing at least 5 marks, and a small number deleted column 3, losing at least 8 marks.

Most candidates then attempted to modify their reduced matrix in part (b), either by just changing signs, or by transposing, or, correctly, both. In part (c) most went on to set up their three probability expressions correctly (though some had errors when simplifying these expressions) and they then went on to draw a graph with 3 lines; a few candidates just tried to solve 3 pairs of simultaneous questions, scoring no marks. It was noted that many graphs were poorly drawn, some without rulers, with uneven scales or so cramped that it was difficult for candidates and examiners to identify the correct optimum point. Most candidates then attempted to solve the pair of equations for what they considered to be their optimum point. Those that solved the correct pair went on to list the options for B, although a significant number failed to say “never play 1”. Most went on to correctly calculate the value of the game. A small minority of candidates did not transpose the matrix, but instead set up probability expressions from the 3 x 2 matrix and then looked down from the top of the graph to B’s optimum point, losing only the two marks in (b).

Question 5

This question proved to be a good discriminator and gave rise to a good spread of marks. There were two modes: 8 and 10 marks (out of 11) gained by 30.8% of the candidates, 66.9% of the candidates scored 7 or more marks.

Part (a) caused some problems here as many candidates assumed that they were being asked which variable should be increased next and stated y . Of those who read the question correctly most recognised that z had been increased first but many were unable to provide a correct (or complete) reasoning. A significant number stated that the z column had ones and zeros rather than specifying that the z entry alone was a one. Others reasoned that z had been increased because it was the only non slack variable missing from the profit row. There were some candidates who incorrectly stated that t had been increased because it was missing from the first column.

In part (b) many candidates were able to correctly identify the pivot row and divide and replace r with y as a basic variable. Most candidates defined row operations in terms of the new row 2. There were of course a number of candidates who made errors in the subsequent row operation calculations. Quite a significant number stopped after one iteration, in some cases stating that the solution was not optimal due to negative values in the profit row despite the fact that the question had asked for the problem to be solved. Of those who did proceed into the second iteration very few picked negative pivots and many were able to proceed correctly albeit with some errors in the pivot row calculations.

In part (c) most candidates gave values for $x, y, z,$ and P although many stated the objective function rather than giving P explicitly. Many others neglected to give values for the slack variables r, s and t . Very few candidates incorrectly read values from the bottom row of the table.

Question 6

Candidates answered this question well with 24.2% scoring full marks and 57.2% scoring 6 marks or more. In part (a), most did successfully modify the table to turn it into a minimising problem, with the majority choosing to subtract all elements from 257, though a few made all values negative. Some candidates apparently completely misunderstood the question, and set about using the Hungarian algorithm. A significant number of candidates made a confused attempt at defining their variables or defined them in a way that was inconsistent with their later work, where a minority lost the variable altogether, using the subscripts only. Those who modified the matrix, generally used these values in their objective function, although a number stated that they were maximising instead of minimising. Others used the original matrix when writing the objective function. A significant number of candidates made errors with their constraints, by writing them as inequalities or using coefficients other than 1 or with inconsistent notation.

Question 7

This question produced a variety of responses, from perfect “textbook” solutions (the mode was full marks gained by 21.2% of candidates) to minimal or blank attempts (12.1% scored no marks). A number of candidates showed a clear grasp of how to use the various values given to them in the tables in the question, using the scaffolding provided, and then went on to read back through their table, to use relevant values at each stage and find a final solution. A common error was to include extra incorrect states for ‘new’ in stages 4, 3, 2 and even 1. Many candidates crossed working out and then attempted to squeeze in alternative answers, making it very difficult for examiners to actually mark their work. There were a number of errors made when choosing the correct elements to include in calculations or in the arithmetic. Many candidates then went on to complete Stage 3, 2 and 1, although a small number failed to use the correct previous optimum values. There were again errors made in the choice of elements or arithmetic. Those who completed the table generally went on to correctly state their optimum actions and the value from their stage 1.

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