Examiners' Report/
Principal Examiner Feedback

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GCE Decision D2 (6690) Paper 01

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Introduction

The paper proved accessible to most candidates, who demonstrated good knowledge and understanding, and most had sufficient time to complete the paper, although some blank responses were seen to questions 4 and 8.

There seemed to be sufficient marks available to E grade candidates and for A grade candidates to demonstrate their quality.

The large majority of candidates continue to use clear and efficient styles of presentation and most made good use of the tables and diagrams given in the answer book.

Weaker candidates tend to self-penalise using poor styles of presentation, making it difficult for them to self-check and by forming their digits carelessly making it more likely that they misread their own figures.

Candidates are reminded that they should not use methods of presentation that depend on colour. Candidates are advised to complete diagrams in (dark) pencil.

Report on individual questions

Question 1

This was a good starter, the modal score was full marks gained by 66% of the candidates and only 9% of the candidates gained 4 or fewer marks. Errors mostly arose from arithmetic slips, some caused by poorly written numbers. Candidates should be encouraged to take great care with their arithmetic since this can affect the structure of the solution and therefore can lead to a significant number of marks being withheld. A minority of candidates turned this into a maximising problem. Others only reduced rows, and then attempted to apply the algorithm immediately, without reducing columns. Some candidates drew more zero-cover lines than necessary. For the second application of the algorithm, some candidates used $e=1$ twice, rather than $e=2$, once, which makes a significant impact on the efficiency of the algorithm. Some candidates did not state their final allocation.

Question 2

This proved a good source of marks for most candidates. The modal mark was full marks, gained by 61% of the candidates, 8% of the candidates gained 2 or fewer marks. Most candidates answered part (a) correctly. Some did not list their route and some routes did not return to A. A small number of candidates incorrectly doubled the length of their nearest neighbour route to create their upper bound. Most found the correct residual minimum spanning tree in part (b), Kruskal's algorithm was sometimes seen, but the large majority sensibly chose to use Prim's algorithm, unfortunately some used the nearest neighbour algorithm (again) instead of Prim's algorithm. Most used the two shortest arcs from A though some used AB instead of either AF or AE.

Question 3

This question proved challenging for some, the modal mark was still full marks gained by 36% of the candidates, but 8% scored zero marks. There were some very messy solutions, from a surprisingly large number of candidates, which were difficult to follow/read. Despite the many blank tables drawn for the candidates, some try to cram everything into just one table, which often leads to mistakes. Many candidates ignored the information provided in the question, that AG is the entering cell, and so wasted time initially, unnecessarily calculating shadow costs and improvement indices. Some candidates re-used the same shadow costs, throughout the question, without recalculating them for each improved solution. Many candidates did not follow the instruction to state the exiting cells they used. Many placed a zero in the exiting cell in their improved solution leading to serious method errors, with candidates calculating too few improvement indices in subsequent iterations. Some candidates muddled the figures for costs and tonnes sent, leading to incorrect shadow costs. Most were able to find two valid stepping stone routes, but some had two entering cells, a serious method error. The majority of candidates indicated that they understood the implication of a negative improvement index, and were able to comment on the optimality of their solution. Some went on to apply the algorithm a third time, to find an optimal solution, which was not required, on this occasion. Of these some incorrectly argued that their improvement indices were all positive, rather than non-negative.

Question 4

This proved the first of the more discriminating questions leading to a good spread of marks, and challenging for many. A significant minority did not attempt this question, but some very confident accurate solutions were seen too. The modal mark was 7 gained by 32% of the candidates, 41.3% gained 7 or more marks and 15% scored zero marks. Most chose the correct pivot in part (a) and went on to use the correct row operations. A few forgot to change the basic variable and inevitably arithmetic errors were also seen. A significant number of candidates had difficulty in writing their profit equation in part (b). Common errors were sign errors, having two equal signs and omitting the value. Only the better students gained credit in part (c), very few answered the question asked and many answered the more routinely asked question and said it was optimal because there were no negative values in the profit row.

Question 5

This proved a good discriminator. The modal mark was 8/9 (often due to an incomplete final strategy statement), with 30% of candidates scoring this, 50% gained 8 or more marks and 10% scored zero marks. Most were able to clearly express the correct dominance argument, and reduce to a 2x3 table. The correct three probability expressions were frequently seen, with only some slips, mostly due to wrong signs, or occasionally the use of (p-1) rather than (1-p). The most common error was 6p-1, instead of 4p+1, which fortunately did not affect later parts of the solution. Graphs were often well drawn, but some incorrectly allowed their lines to extend beyond p=0 and p=1. Candidates would be well advised to use a ruler, show a clear scale and construct both vertical axes, (the 'rugby post' style) as the omission of the vertical line at p=1 often led to inaccurate graphs. The vertical axis intercepts were sometimes wrongly calculated, for example 7p-3 was quite often drawn with end points at -3 (correctly) and 7 (incorrectly). Generally the optimum point was correctly identified, and algebraic errors were rare when solving their simultaneous equations. Many candidates omitted the "never play land" part of their final strategy. The value of the game was usually correct, though some substituted their correct probability, into the third probability expression, which did not contribute to the optimal point.

Question 6

This proved a good discriminator and challenging for many. The modal mark was full marks with 28% gaining this, 10% of the candidates gained 3 or fewer marks. Parts (a) and (b) were completed correctly by almost all the candidates. Most went on to find at least one correct flow augmenting route in part (c), often SBDET. Part (d) proved more challenging. Candidates must make their flow clear, some over-cluttered their diagram and got confused and ended up with an inconsistent flow pattern. Some candidates try to show both the final flow and the maximum capacity on each arc, but this often leads to flow conservation errors at vertices and also does not give a clear unambiguous diagram for the examiners to confidently mark. Candidates are strongly advised to use one number (only) per arc showing the final flow along that arc. The flow into each vertex should equal the flow out of the vertex, this was often not the case at B. Most were able to reference the max flow-min cut theorem in (d) but many did not find the correct cut.

Question 7

This proved to be a challenging, discriminating, question. The modal mark was full marks with 36% gaining this and 7% scoring zero marks. A pleasing proportion of candidates were able to produce model answers. Many others lost the first mark due to incomplete definitions or poor notation, or for not then using their defined variables, for example, changing to numerical subscripts rather than the letters in the question, or reversing subscripts. It was encouraging to see that many were able to write down the correct objective function, and only a few omitted to state that it required minimising. The constraints proved more challenging to candidates. Most correctly attempted to produce eight equations, in sixteen variables, but non-unitary coefficients were sometimes seen, along with inequality signs, and occasionally slack variables, or

even "V". Those who used sigma notation correctly were able to score all four marks, save themselves time, and remove the possibility of a slip, when writing our all sixteen variables, with subscripts, twice. There were a number of blank responses seen.

Question 8

Once again the modal mark was full marks, gained by 28.7% of the candidates, however 15% scored zero marks here. There were many who could not start the question and many who misread the information given. Some did not include all the key elements in their working, omitting storage costs or overheads or extra worker costs. Candidates needed to make a decision about when to add in the storage costs and then do so consistently, some changed their mind midway through the question. A significant minority did not carry the values from their earlier stages into the later stages. As in past sessions some candidates incorrectly 'worked forwards', starting with January. There were there usual arithmetic slips seen. On the positive side most candidates wisely showed the working used to find the value for each action, making it easier for them to calculate these values accurately. There were far fewer candidates who reversed their states this year. Some excellent solutions were also seen.

Grade Boundaries

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