Examiners' Report/
Principal Examiner Feedback

Summer 2013

GCE Decision D1 (6689)
Paper 01

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Summer 2013
Publications Code UA035684

Decision Mathematics D1 (6689)

Introduction

The paper proved accessible to the majority of candidates and there was little evidence of there not being enough time to complete the paper. The questions differentiated well, with most giving rise to a good spread of marks. All questions contained marks available to the E grade candidate and there also seemed to be sufficient material to challenge the A grade candidates also.

Candidates are advised to make their method clear; 'spotting' the correct answer, with no working, rarely gains any credit.

Report on individual questions

Question 1

This first question proved to be a good source of marks for many candidates with the mode being full marks obtained by 59.2% of candidates and only 17% scored 4 marks or fewer. In part (a) the majority of candidates gave a phonetically close response to the correct answer of 'bipartite'. Common incorrect answers included 'matching algorithm', 'complete matching', 'alternating path' and 'tree diagram'.

In part (b) it was clear that the majority of candidates were very well prepared for this question and knew the required components for a correct and complete answer. It is important that examiners can clearly identify the alternating paths so they should be listed (rather than drawn) separately (rather than left as part of a 'decision tree' of potential paths). A number of candidates are still not making the change status step clear. This can be done either by writing 'change status' or, more popularly, by relisting the path with the alternating connective symbols swapped over, this latter approach has the additional advantage of making the path very clear to examiners. A lack of change of status was penalised twice. In some cases, candidates appeared to be performing a change of status but in fact gave part of the improved matching e.g. B = 4 L = 3 H = 2.
A small minority of candidates stopped after one iteration and it was unclear whether they believed they had finished or were unsure how to proceed. A significant number of candidates did not state the improved matching after the first alternating path and some appeared to be doing both parts simultaneously. If candidates are going to display their improved matching (or later their complete matching) on a diagram then it must be made clear that only a diagram with the exact number of required arcs going from one set to the other will be accepted; examiners cannot accept diagrams with additional arcs even if they 'appear' to be crossed out.

Question 2

This question proved to be a good source of marks for many candidates with the mode being full marks obtained by 36.4% of candidates and only 20.1% scored 7 marks or fewer.

It was noted by examiners that for both the bin-packing and quick-sort algorithms, a number of candidates lost marks by placing numbers in incorrect places if they ran out of room in the answer book. Candidates should be encouraged to set out their work clearly so that the method is clear. As noted in General Introduction this is a methods paper and candidates' working must clearly show that they have followed the algorithm correctly.

Part (a) was answered well with many fully correct solutions seen. Most candidates placed the first four items correctly. However, quite a common mistake was to put the 0.1 in the wrong bin, usually in bin 2. A number of candidates put 0.7 and 0.9 in separate bins and so used 5 bins rather than 4. Simple arithmetic errors were quite common. This was less common where candidates kept a list of 'space available' in each bin when items were placed in them, or in cases where candidates had used a vertical scale and a visual representation of items in bins.

Many correct solutions were seen to part (b), but a minority produced an ascending list and failed to reverse it, leading to marks being lost later in the question. A number of candidates did not choose their pivots consistently, switching between middle-left and middle-right pivots during the course of the quick sort algorithm. A very small number of candidates lost an item or changed one, and very few cases were seen where only one pivot was chosen per iteration. Some candidates did not indicate that their sort was complete. This could have been achieved either by having at the end a "list sorted" statement, or every item in the original list been used as a pivot or the final list being rewritten at the end. A common error was 0.2 and 0.3 being interchanged in the 3rd pass; candidates should be reminded that items should remain in the order from the previous pass as they move into sub-lists. Quite a few candidates made more than one attempt at this part of the question, often because they initially sorted into ascending order; candidates should be reminded that they can still obtain full marks by reversing their ascending list at the end. A few students multiplied everything by 10 then sorted a list of integers before then converting back. Finally, a small number of bubble sorts were seen even though quick sort was specifically asked for in the question.

In part (c) in which candidates now had to apply the first-fit decreasing algorithm to their ordered list from part (b) a significant number, who had sorted the numbers into ascending order earlier, then proceeded to attempt a "first fit increasing" method in this part. Otherwise, the most common errors seen were putting 0.1 in bin 4 or putting 0.3 in bin 4 (or both).

Part (d) was generally answered very well. Most candidates worked out the lower bound correctly but some did not then relate their answer to part (c) or say "yes". A few others simply stated "yes" with no justification, again this gained no credit. A small number of candidates correctly argued that their solution was optimal because 3 bins were full and a fourth was needed for the other items.

Question 3

This question proved to be an excellent source of marks for many candidates with the mode again being full marks obtained by 60.0% of candidates and only 10.9% scored 5 marks or fewer.

In part (a) many fully correct answers were seen although a significant number of candidates listing nodes rather than the required arcs and so scored two of the three marks available. A common error was to number the columns correctly across the top of the matrix but then choose arc DE instead of arc CE when listing the arcs. The correct numbering across the top of the matrix saved many candidates who had made a slip with their final list of arcs, as this also gained them two out of the three marks available.

Most candidates drew the minimum connector correctly in part (b) if they had the correct answer in part (a).

In part (c) nearly all network diagrams were correct and included the correct weights. Some diagrams surprisingly contained only three arcs, but the majority of these candidates clearly did not go on to use this diagram for answering part (d) as they recovered later. Arcs most often missing from the diagram were either DE or the pair of arcs AD and BE. Occasionally weights were missed out or incorrect.

Most candidates applied Kruskal’s algorithm correctly in part (d), more so than Prim’s in part (a), but some did not demonstrate the correct handling of rejected arcs, which is essential for Kruskal’s algorithm. Some missed out arc DE completely even though the rest of the arcs were selected or rejected correctly. This was sometimes as a result of DE missing in part (c).

Most candidates employed the recommended style of listing the arcs in order of increasing weight and then used ticks or crosses to indicate their inclusion or rejection, which made it straightforward to see when the arcs were rejected as well as which ones were being rejected. A number of candidates wasted time here by writing multiple lists or lengthy reasons for accepting or rejecting arcs and they should be encouraged to use simpler notation.

Nearly all candidates calculated the minimum time correctly in part (e). However, some added up all the arcs (even the rejected ones) and others omitted an arc from their calculation or simply made an arithmetic slip.

Question 4

This question proved to be a good source of marks for most candidates with the mode being full marks obtained by 40.1% of candidates and only 15.2% scored 4 marks or fewer.

Part (a) was usually very well done with most candidates applying Dijkstra's algorithm correctly. Some candidates made minor errors, omitting either one of the working values or labelling the vertices in the incorrect order, the most common error being the omission of 25 at E. This omission usually led to 31 as the final value at T. This error seemingly arose because candidates had not considered going ('backwards') from G to E which gives the smaller value of 25 at E.

Those candidates who found the correct value of 30 invariably stated the correct route. The order of labelling was only occasionally incorrect, as was a label of 1 in A where candidates had failed to notice that there was already a 1 in S.

It is worth noting that because the working values are so important in judging the candidate's proficiency at applying the algorithm it would be wise to avoid methods of presentation that require values to be crossed out.

The majority of candidates also found the correct shortest route through F in part (b), even when not gaining full marks in part (a). Candidates were clearly aware that they were able to access the marks for part (b) without having gained full marks in part (a).

Question 5

This question gave rise to a good spread of marks and proved a good discriminator. The mode was full marks gained by 20.6% of the candidates, 61.5% of the candidates scored 7 or more marks.

Part (a) required candidates to recognise A, B, D, and E as the odd vertices and once this was achieved they then needed to write down the three pairings of these four odd nodes which nearly all candidates did. Most candidates are now aware of the need for the totals of these three pairings to be given although errors in these totals did occur. The pairing of AE with BD (with a total of 77) was the one pairing that was most consistently found correctly while the most common errors being the pairing of AD and BE being given as 95 and AB and DE being stated incorrectly as 77. Candidates once again are losing unnecessary marks by not stating the **edges** they need to repeat but instead just writing in this case AB and DE instead of AC, CB and DE or even ACB and DE.

Most candidates in part (b) had spotted that the total weight of the network had been given under the network in the question and successfully added on their least from part (a). There were very few instances of the route not starting and ending at A. Those candidates who correctly identified AC, CB and DE as repeated arcs usually went on to identify a correct route. Unfortunately some candidates did not answer this part.

Candidates found part (c) to be the most challenging part of the question and so it proved to be a good discriminator. Nearly all candidates who attempted this part understood that there was a need to repeat an arc but the arc stated by the candidate was not always correct. Some candidates decided to repeat DE as it was the smallest of all the pairings, unfortunately this was incorrect as the question stated that the route was going to start at E. Those that understood the need to repeat an arc that excluded E, usually chose the correct arc BD but did not explain why they were choosing BD. Many candidates who gained the method mark also went on to gain the final accuracy mark as they stated that the route would finish at A and have a length of 382. Some candidates, however, forgot to state the length of the route, only saying that it would end at A. Candidates need to make sure that they return to the question to ensure that they have answered it fully.

Question 6

This question also gave rise to a good spread of marks and proved a good discriminator. The mode was 11 marks gained by 15.4% of the candidates, 12.4% scored full marks and 19.8% of the candidates scored 4 or fewer marks.

In part (a) most candidates tried to describe in context the inequality $x + y \geq 90$ but a surprisingly large number failed to make clear they were referring to the *total* number of boats. Some failed to describe the inequality correctly and a few did not mention the **number** of boats at all but talked about the number of seats, the cost or even length of the boat(s).

Part (b) proved to be an excellent discriminator with very few scoring both marks although many candidates scored at least one mark in this part. Many adopted an approach along the lines of: *for every two 2-seater boats there must be at least three 4-seater boats* which although was incorrect scored one of the two marks. The candidates who used the language of 'number of' were generally much more successful. Some responses suggested completely incorrect coefficients and in many cases this was probably due more to poor sentence construction rather than understanding.

There were many correct solutions but it was surprising to see a fair number of errors drawing the lines correctly in part (c). The line $x + y = 90$ was nearly always drawn correctly but a significant minority of candidates had $3x = 2y$ instead of the correct $2x = 3y$. A few candidates ignored the request to label the feasible region R and a surprising number of candidates selected the wrong region having drawn all three lines correctly, possibly expecting one that was bounded on all sides.

Part (d) was the most successfully completed part of the question. Some candidates wrote the objective function as $100x + 400y$, others simplified it before writing it down. A very few had coefficients the wrong way round.

Of the two possible methods that could be adopted in part (e) the objective line method was predominant the one seen. Reciprocal gradient were shown by a significant number, which of course usually meant choosing the wrong vertex. Where point testing was used there were a surprisingly large number of calculation errors. Many failed to give the minimum cost even when the correct point(s) were found, especially among those using an objective line. When vertices were read off the graph they were rarely checked algebraically to confirm they had correct coordinates. If using point testing it would be advisable (in most cases) to find the intersection points using simultaneous equations rather than reading off the graph. Some candidates who made errors with the method in this part, or did not show a method at all, were still able to pick up the two final marks for identifying the x, y values and the correct cost.

Question 7

This proved to be a challenging and lengthy question for the candidates with only 2.6% scoring full marks. The modal mark was 11 and 23.5% of candidates scored 6 marks or fewer. In part (a), usually the forward pass was carried out correctly. The backward pass was far less successful however, with candidates failing to carry out the pass correctly through the dummies. A high proportion of candidates wrote 9 as the late time at the end of C, 43 at the end of M, 9 or 13 at the end of A and/or 19 at the end of D.
In part (b), the majority of candidates knew the method for the float calculation and showed it clearly. Unfortunately, due to an error in part (a), many lost the second accuracy mark.

The delay on activities P & Q were well understood and a lot of correct answers were given in part (c). Some candidates' responses were more succinct than others and a significant number of candidates described the effect these delays would have on the activity which followed or on the float time and did not as requested, comment on the effect on the project completion date.

In part (d), nearly all candidates gave the correct answer of 4 for the lower bound. A common incorrect answer was 10 arising from dividing by the total number of activities. The cascade chart was relatively challenging to complete in part (e). Adding 11 activities with floats was clearly daunting for weaker candidates who were perhaps running short of time by this stage of the paper. Furthermore the 'odd' times were not marked by vertical lines which added an extra challenge for some. However, most candidates made a very good attempt at this part. Follow through errors from (a) cost accuracy marks and a few omitted one (or more) activities, others who had part (a) correct made minor slips when drawing their activities. A small number ignored the given activities and duplicated them, getting them wrong in some cases. Despite the examples given for A and B there was a variety of different ways of representing activities and floats seen by examiners. A few students had multiple entries on each line and a small number of scheduling diagrams were still seen.

In part (f), there were few completely correct responses. Most candidates opted for an argument involving activities H, I, J, K and L and to score any marks in this part a time had to be provided and for both marks this had to be correct. Several responses failed to score any marks because no time was mentioned at all. Very few candidates gave reasons associated with D, E, F, G and H and those that attempted to do so rarely scored any marks as this was the more challenging of the two options. Many candidates gave arguments based on scheduling which scored no marks.

In part (g) there were very few completely correct responses to this question and it was clear that most candidates were not familiar with the significance of different lower bounds. A significant proportion chose the smaller lower bound "because it is cheaper" or "uses less workers". Of those who selected the higher bound, very few gave the correct reason for doing so. Many candidates misunderstood the question and gave reasons for why the cascade bound was more *reliable*, arguing for example: "because it takes account of when activities must be taking place" or "because it takes account of precedences". Many more, however, gave incorrect and irrelevant reasoning such as "because it is more practical".

Grade Boundaries

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