Examiners' Report/
Principal Examiner Feedback

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GCE Decision D1 (6689) Paper 01

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General 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.

Candidates should ensure that they use technical terms correctly. This was a particular problem in Q4(a).

Report on individual questions

Question 1

This first question proved to be a good discriminator and gave rise to a good spread of marks. The mode was full marks gained by 23.8% of the candidates, 22.2% of the candidates scored 2 or fewer marks. Q1(a) was completed with varying degrees of success. Most candidates could make a start on following the flow chart and usually had the first two rows of the table completed correctly. The main issue was the inability of candidates to tell whether the difference in the values of R and E fell between the two boundaries of 10^{-6} and -10^{-6} and therefore many stopped the algorithm in the wrong place (usually on the third row) or continued for many more rows than required.

Common errors in this part were not giving answers to a sufficient number of decimal places (7 were asked for in the question) or truncating their answers rather than rounding (it was popular to see 8.485281374 become 8.4852813). The majority of candidates were aware that they needed to state their final output once they had achieved a ‘yes’ in the last column although many did not use the pre-printed line below the table; many opted for putting their output value under their final R value or on the next page of the answer booklet. A number of candidates instead of outputting the final value for R instead gave the value of R – E as the final output. Many candidates had the ‘correct’ final output of $\sqrt{72}$ even though this did not follow from their working. For the final mark in this part, examiners could only follow through from the candidates working as the nature of the algorithm (for finding the square root of a number) was described in the question.

In Q1(b) all that was required in this part was to state that the output would now be negative (or the more complete answer that the algorithm would now find the negative square root). Some candidates were convinced that there would be no affect on the output and some described what would happen at each stage of the algorithm rather than at the final output stage.

Q1(c) was very well answered with the majority of candidates giving the correct answer that E could not be zero. A number of candidates went on to explain why E could not be zero and it was also common to see answers which implied that E could not be negative or take the value of 72.

Question 2

This question, especially Q2 (b), proved to be an excellent discriminator with the modal mark being 4 (out of 6) and only 8.8% of candidates scoring full marks.

The format of this question differed from previous sorting questions in that candidates were asked to work from a list which was not given in the question. This particular sort required the candidates to know, and write down, the letters of the alphabet, which the vast majority of candidates did without any problems. However, there were a number of candidates who thought that the alphabet had 24, 25 or 27 letters and others who had an 'incorrect' list (for example, it was common to see letters M and N the wrong way round). Some candidates neglected to write down the alphabet at all, which in a number of cases led to subsequent errors in the identification of pivots and also made it difficult to verify that the candidate was using the correct ordered list.

Q2(a) was undertaken well by nearly all candidates and a large proportion scored full marks in this part. The vast majority of candidates were able to carry out the identification of middle right pivots correctly and very few selected middle left pivots. Most were then able to reject the correct sublist (including the pivot).In some cases, candidate wrote 'reject A – N' in the first pass but then had, in the second pass, a list which included N. Many candidates, throughout this part, did set out their work in a very logical manner by adopting one (or more) of the following approaches:

- explicitly writing out, at each stage, their calculation for the pivot and circling or making their pivot clear;
- writing out their reduced list after each pass;
- renumbering their reduced list (from 1) before each new pass.

It is advised that in this type of problem it is essential that the choice of pivot is made clear at each stage as should the new sublist which is to be used in the next pass.

Finally, when the search is complete it is important that the candidate provides a clear statement to the effect that the letter being searched for has been found. Many candidates did not differentiate that P was the letter they were searching for and in many cases it seemed to be stated as a pivot and not the target value. It was sometimes unclear if at the end of the search that P had been found or was, in fact, a letter in a sublist with only one value.

Q2(b) provided to be an excellent discriminator. Many candidates did not generalise their answer and it was clear that a significant number of candidates did not know what to do in this part, which was evident in the number of candidates who left this part blank. Common incorrect answers included:

- stating a number of required iterations without any justification;
- incorrect calculations such as $\frac{26}{2}$ = 13 (therefore 13 iterations) or $\sqrt{26}$ = 5.1 (so 6 iterations);
- a continuation of their answer to part (a) based on the evidence that part (a) required 4 iterations and if one of either O or Q were required then 5 would be necessary so 5 was the maximum.

Common incomplete answers included:

- a statement that the letter A would require the maximum number of iterations, often without any justification of why A requires the most or even a demonstration of the number of iterations required to find this particular letter;
- arguments based on halving 26 five times without sufficient demonstration or justification (and in many cases it wasn't clear what the value was being compared to) or incomplete arguments based on powers of 2 without explicit calculations being seen or even a comparison being made to the value of 26.

The most succinct responses were those based on the use of logarithms although these were relatively rare. It was also pleasing to see that a number of candidates considered the maximum number of letters that would remain at either the start or the end of each iteration. It was, however, common to see errors in this latter approach as many candidates failed to engage with the requirement of the maximum number of letters remaining after each iteration and so it was all too common for candidates to retain their pivots when moving from one pass to the next. While many candidates who adopted this approach were able to recognise that after the first iteration there would be 13 letters remaining, the next iteration caused problems as many stated that 7 letters would remain rather than the correct answer of 6.

Question 3

This question proved to be a good source of marks for nearly all candidates. The mode was full marks, gained by 50.5% of the candidates, only 19.7% of candidates scored 5 marks or fewer.

In Q3(a) the majority of candidates were able to find one of the two possible alternating paths, between either C or O and 2 and then correctly indicate the change of status. It is important that examiners can clearly identify the alternating path so it 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 has the additional advantage of making the path very clear to examiners. A lack of change of status was penalised twice, both in Q3(a) and in Q3(c). Most candidates were able to give an improved matching in Q3(a), either as a list or on a clear diagram, with just five arcs. If candidates are going to display their improved matching (or later their complete matching in Q3(c)) 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.

Q3(b) proved to be a good discriminator, with strong candidates giving a concise, fully correct reason why a complete matching was not possible. Clarity of expression, probably caused the loss of marks for a number of candidates in this part as many could see why a complete matching was not possible, but many answers were marred by a lack of precision. 'Task 1 and 5 can only be done by George' was the most common correct answer. Of those candidates who used the alternative argument involving N, O and C many did not achieve both marks due to incomplete statements like 'Nurry can do tasks 4 and 6' instead of the accurate statement that 'Nurry can **only** do tasks 4 and 6'. Some candidates lost marks in this part for failing to name the relevant nodes, so a comment such as 'there are two tasks that can only be done by one worker' gained no marks.

In Q3(c) almost all candidates who gave a correct path in Q3(a) followed with the correct corresponding second path between either O or C and 1 and nearly all candidates went on to give the correct complete matching.

Question 4

This question proved to be a good source of marks for many candidates with 80.8% scoring 7 marks or more, and only 3.0% scored 3 marks or fewer but (due to Q4(a)) this question still discriminated well with only 6.1% scoring full marks.

In Q4 (a) A number of candidates had learnt the definition for a path and gave a concise answer that contained all three key points. However, many gave a vague account of a path being 'a route from one vertex to another'; the fact that a path is a **finite** sequence of **edges** was rarely seen by examiners. A significant number of candidates wrote that arcs should not be repeated, or that there should be no cycles, rather than the correct statement that no vertex should be repeated. Candidates demonstrated insufficient knowledge and understanding of the correct technical terms in decision mathematics; line and point were often seen instead of the correct arc (edge) and vertex (node).

Q4(b) was usually very well done with most candidates applying Dijkstra's algorithm correctly. Labelling and the order of working values were much more accurate than in previous sessions. Common errors were the addition of an extra working value at B, the absence of the working value 27 at D or having the working values at T appearing in the wrong order. The ordering of labelling was generally very good with the most common mistakes being node A being labelled before C and E being labelled before F. 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 examiners gave follow through marks on the length of the route and those who obtained the correct length of 40 almost always gave the correct route.

In Q4(c) the question clearly asked for the length of the shortest path from S to F so it was surprising the number of candidates who gave a path from S to F and not the distance between these two nodes. In Q4(d) the majority of candidates scored full marks and those that didn't tended to find a path via F rather than via E.

Question 5

This question gave rise to a good spread of marks and proved a good discriminator. The mode was full marks gained by 14.7% of the candidates, 11.1% of the candidates scored 5 or fewer marks.

In Q5 (a) candidates had to apply Prim's algorithm to find the minimum connector for the given network. The vast majority of candidates started at the correct node A although node G (possibly because this node was at one end of the shortest arc GJ) was often seen. Common errors were with the placement of arc DH, with this arc either appearing as the fourth arc or appearing after arc FI. Most candidates took notice of the instruction to state the order in which they included the arcs as only a few candidates left their answer as a list of nodes. It was pleasing to see very few candidates using Kruskal's algorithm however it is worth noting that with Prim there should be no rejections of arcs seen during the selection process. Candidates would benefit from stating their final list of arcs in the correct order as some candidates opted to show all the possible arcs from a particular node. In some of these cases candidates appeared to be rejecting arcs whereas many were just showing their thought process as they consider each node in turn.

Q5 (b) was the most successfully attempted part of the question, with most candidates gaining the first method mark as they recognised the need to multiply the value of 80 with the weight of their minimum spanning tree from Q5(a). The main errors seen for the second accuracy mark were either due to an earlier error in Q5(a) or the inability to add up the length of the arcs in their MST correctly. Some candidates incorrectly multiplied the total weight of the original network by 80.

Q5(c) required candidates to recognise that nodes B, F, G and H were the four odd nodes, which nearly all candidates did. While most candidates showed the correct three distinct pairings of the correct four odd nodes many candidates did not show the total for each pairing. These totals need to be given as evidence that the correct arcs, which need to be traversed twice, have been chosen. There were many completely correct solutions to this part but even more where errors were made in the calculation of the shortest route between two nodes. BH and FG (with a correct shortest route of 94) was often given incorrectly as 95 (GI being used instead of GJI) or 100 (BFH instead of BEFH) or 101 (both of these errors being made). A significant minority of candidates did not give the correct repeated arcs as BE, EG and FH, instead giving the answer of BG with no evidence to imply a route via node E.

Q5(d) was answered well as most candidates had an answer of 64 as their least from Q5(c) and used the information given in the question that the total weight of the network was 379.

In Q5 (e) candidates were specifically asked to give a reason for their answer and many candidates failed to do so making this part a good discriminator. It needed to be clear to examiners that candidates appreciated the need to repeat FH because it was the **least** of the six individual pairings given in Q5(c). Some candidates decided to subtract the largest arc from their value of 443 rather than selecting the smallest to add on to 379. Some candidates thought that because FH was the least this meant that F and H should be the start and finishing nodes. Another common response was to give the correct start and finish nodes and a correct reason for repeating only FH but did not give the length of the route. It was also common in this part for stronger candidates to leave this part blank after scoring highly in the earlier parts of this question.

Question 6

This question also gave rise to a good spread of marks and proved a good discriminator. The mode was again full marks gained by 17.8% of the candidates, 43.1% of the candidates scored 8 or fewer marks.

The first two parts of this question involved identifying inequalities for given constraints. It was Q6(a), in which the constraint was given graphically, that proved to be the most difficult with many candidates needing to resort to using the formula $y - y_1 = m(x - x_1)$ instead of obtaining the equation of the line by inspection of the graph. Many candidates failed to identify the gradient of the line or, having found the gradient, were unable to convert this into the correct inequality, giving either the incorrect coefficients or the incorrect direction of the inequality. Q6(b), in which the information was given in the form of a statement, was much better answered, although a number of candidates had the inequality signs the wrong way round or tried, unsuccessfully, to redefine the x, y variables using w and r to represent the colours of the roses. Most candidates who had the correct equations in Q6(b) went on successfully to draw the two additional lines in Q6 (c) but many did not gain the mark in Q6(d) for identifying the correct feasible region due possibly in some part to earlier errors in Q6(b).

The vast majority of candidates scored the mark in Q6(e) for writing down the correct objective function and for some candidates it was the only mark that they earned in this question. A few candidates 'simplified' their objective function which led to incorrect production times in Q6(f).

Q6(f) asked for candidates to use the method of point testing to find the optimal number of each type that should be produced. Having stated the objective function in Q6(e) many candidates found the optimal solution using the objective line method and thus scored no marks in this part. Those candidates who did use point testing often only tested the three vertices nearest the origin. Whilst it may have been obvious to candidates that the other two vertices would give larger values for the objective function the algorithm requires that all vertices of the feasible region are tested and this was required to gain full marks. A number of candidates spent a large amount of time solving five pairs of simultaneous equations to find all five vertices (which, in this case, could have been read directly from their graph) and then did not test any of their points with their objective function. A number of candidates treated this as a maximisation rather than a minimisation problem and gave an answer of 720. Also a number of candidates were perhaps confused by the instruction to use point testing and after finding their optimal point (usually by the objective line method) began to test other integer solutions around their optimal point.

Question 7

This question discriminated well leading to a good spread of marks. The modal mark was 12, 6.5% of the candidates scored full marks, 50.8% gained 11 or more marks and 14.3% gained 6 or fewer marks.

While many completely correct answers were seen in Q7(a) a considerable number of candidates showed little understanding of why a specific dummy is needed in an activity network (in this case because of precedence of activities in the network). Some candidates referred to either activity K or activity I in their argument but not both. Some candidates referred to events rather than activities. It was clear that a number of candidates understood the need for each activity in a network to be uniquely identified in terms of its start and end events but this was not the reason for this particular dummy. A few candidates tried to explain the dummy between events 5 and 8.

Q7(b) and Q7(c) were generally answered extremely well with many candidates scoring at least the first 3 marks in Q7 (b) with the most common error in this part being the late event time at event 3 being given as 10 instead of the correct 9.

Most candidates knew how to calculate the float for activity G however a few candidates did not notice the wording of the question which explicitly asked for all the numbers in their calculation to be made clear. This was seen when a number of candidates simply showed the calculation 15 – 12 = 3 so it was unclear if this came from the correct calculation of 15 – 6 – 6 or from incorrectly subtracting the early event time from the late event time at event 5. While many excellent responses were seen for Q7(e) a number of Gantt charts were extremely difficult to read i.e. the line between the activity and its float was not always clear and many floats were frequently very faint. It is worth noting that it would be advisable for candidates to check to see if their diagrams include all the activities (a number missed off activity M) as incomplete diagrams were penalised with the loss of the final two marks in this part. Very few scheduling diagrams were seen and the most common errors were the length of the floats on activities C, D and E or not having floats on all 9 non-critical activities.

Q7(f) was not answered well with many candidates believing that activity B needed to be happening at time 5.5 (activity B could start as late as time 6) and so activities A, B, C and D were given as the answer to Q7(f) instead of the correct answer of A, C and D. Q7(g) was only answered correctly by a relatively small number of candidates. Most candidates either used a lower bound calculation, or tried to argue using a scheduling approach. Some candidates simply repeated their incorrect answer from Q7(f) of activities A, B, C and D needing to take place at time 5.5, and some candidates had arguments that began with ‘at time 10 or time 11’ which failed to take into account activities that could have ended at these times or activities that did not need to have started at these times.

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