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Mathematics MD02

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Decision 2

Report on the Examination

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General

The general performance of candidates was very encouraging and, on the whole, solutions were presented clearly and legibly; this is essential when examiners have to check each step of the various algorithms. Basic algorithms from topics such as Critical Path Analysis, the Simplex Method, Game Theory and the Hungarian Algorithm appeared to be well understood by most candidates.

However, regarding the Hungarian algorithm, it is not acceptable to use the tables provided in the question paper, simply crossing out various numbers and replacing them with new values; examiners cannot be expected to give credit for such unclear procedures, where it is almost impossible to trace the sequence of tableaus required to check that the algorithm has been applied correctly.

It was again encouraging to see the improved performance by candidates in the Dynamic Programming question and no doubt the partially completed table helped. There has been a tremendous improvement since candidates have abandoned methods based on tracing paths on a network and marks have increased accordingly.

The labelling procedure in Network Flows is also becoming more familiar to candidates and most are now indicating potential increases and decreases on their network diagrams; backward arrows to show existing flows and forward arrows to indicate potential flows is the preferred convention, although some display the technique quite well using duplicated edges but with forward and backward arrows on the twin edges to show potential increases and decreases. However, some persist in using an unconventional notation so that, without a suitable key, candidates cannot expect to score full marks.

Question 1

Part (a) Almost every candidate calculated the earliest start times and latest finish times correctly.

Part (b)(i) The single critical path was again found correctly by almost everyone.

Part (b)(ii) A few candidates did not know how to calculate the float for activity *D*, but the majority were able to do so by finding 13–2–7.

Part (c) The histogram was usually constructed correctly but a few candidates left gaps or "cantilevers" in their blocks and others made slips having certain blocks with an incorrect height or width. It was pleasing to see most candidates indicating clearly which activities were taking place at any given time.

Part (d) The resource levelling caused a few problems; some could not deal correctly with the activity F which needed to be fitted in before G started. A number of alternatives were possible with the events following G, but the common mistake was trying to start K before H had finished. Those with a correct second histogram had no trouble in stating the correct minimum extra time required.

Question 2

Most candidates were able to apply the Hungarian algorithm correctly. There are still, however, a few candidates who insist on crossing out values in a single table rather than producing a new matrix for each stage of the algorithm. This should be discouraged since it makes the examiner's task almost impossible and candidates are unlikely to score many marks for this approach. Despite comments in previous reports this message does not seem to have been relayed to teachers and their candidates. This problem required at least two applications of augmentation and it was good to see better candidates explaining that the zeros could be covered with just four lines before a second or even third augmentation in some cases.

It was necessary for the explanation to mention three things in order to score full marks; the number of rows and columns were now equal; the Hungarian algorithm minimises the **total** score; an expression such as $20-x$ gives an indication of the points not scored for **each entry** in the table. However, the value 20 is somewhat irrelevant and many candidates did not seem to realise that. Although some guessed the actual matching and corresponding total score, it was pleasing to see the majority using the algorithm with good understanding.

Question 3

Part (a)(i) The entry "x" caused problems to several candidates. Credit was generously given to those who wrote the correct three minima at the ends of the rows in the pay-off matrix, when they were perhaps unaware of what was required in the request made in this part.

Part (a)(ii) Explanations rarely scored full marks. In order to show that the game did not have a stable solution, it was expected that the maximum values in the columns would be indicated before finding the minimum value of these maxima. The maximum of the row minima from part (a)(i) also needed to be found. Some statement should then have been made indicating that these two values were not equal and hence that the game did not have a stable solution.

Part (b)(i) Most candidates were able to find the optimal mixed strategy for Rhona. Some lost marks for not drawing accurate graphs of expected values for $0 \leqslant p \leqslant 1$. Although it is acceptable to use the horizontal lines printed in the answer booklet, at least one of these vertical lines should have a clear scale so that the accuracy of the process of finding the highest point in the region can be checked by the examiner.

Part (b)(ii) Those finding the correct optimal strategy in part (b)(i) were usually able to find the correct value of the game.

Question 4

Part (a)(i) The pivot was usually identified correctly but the explanation was often inadequate for full marks. Some indication needed to be made as to why the negative quotient had been rejected; the calculations 10/2 and 21/4 needed to be shown with a statement that 5 was the smallest positive ratio.

Part (a)(ii)The row operations were usually carried out accurately and most candidates made a suitable comment about the negative value in the objective row implying that the optimal value had not yet been reached.

Part (b)(i) Those candidates who found the next correct pivot were usually successful in performing a correct second iteration, although some arithmetical slips did occur.

Part (b)(ii) Finding the value of P earned most candidates a mark, even from an incorrect tableau. Part of the interpretation was to say that the maximum value of P had now been reached, provided there were still no negative values in the top row of their matrix. The values of x, y and z needed to be stated but some neglected to state that $z = 0$, even when their previous tableau was correct. Several candidates wrote down the value of the slack variable, u, instead of writing down the actual inequality that still had slack.

Question 5

Part (a) Good use was made of the table and, apart from a few arithmetic slips, most candidates scored full marks for completing the table of values, thus indicating a good understanding of dynamic programming in this context.

Part (b) The minimum value of a ticket was usually found correctly and at least one of the two correct paths was usually found correctly.

Question 6

Part (a) Most candidates understood how to add a super source and super sink to the network and inserted correct weights on the edges.

Part (b) Again, few candidates had trouble in finding the maximum flows along the given edges. It was not clear whether some had misread the second route when they gave the flow as 9 instead of 8. For this reason, this error was not penalised heavily in the subsequent work if they eventually found the correct maximum flow through the network.

Part (c) It was good to see candidates trying to set out their solution in a logical manner and once again the diagram and table clearly helped. Only a few candidates failed to show potential forward **and** backward flows on their network. Candidates are advised to use the table to show what new flows have been introduced and to modify both the forward and backward flows in their network. The previous values should be clear to the examiner when such modification is made. Marks are awarded for the initial flow and it is very difficult to credit candidates for their original values if they have been obliterated during augmentation.

Part (d)Those who had a correct maximum flow in part (c) were usually able to find the correct cut with value equal to the maximum flow.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results statistics page of the AQA Website.