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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 good and it was encouraging to see that, 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 needed to solve problems in Critical Path Analysis, the Hungarian Algorithm, the Simplex Method and Game Theory appeared to be well understood by most candidates.

It was again encouraging to see the improved performance by candidates when tackling the Dynamic Programming question and no doubt the partially completed table helped. Since candidates have not pursued methods based on tracing paths on a network, marks have increased accordingly.

The labelling procedure in Network Flows is now becoming much 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. Those who use an unconventional notation, without a suitable key, cannot expect to score full marks.

Question 1

Part (a) Almost every candidate found the correct values of the constants x, y and z.

Part (b) The two critical paths were found correctly by most candidates, but several candidates wrote down extra paths that were not critical paths.

Part (c) Most candidates identified the correct activity with the largest float and calculated the float correctly.

Part (d) The histogram was usually constructed correctly but a few candidates left “holes” in their blocks and others made slips having certain blocks with an incorrect height or width. It was necessary to indicate clearly which activities were taking place at any given time; those who had the correct histogram profile, but without the activities indicated, did not score full marks.

Part (e) The resource levelling caused difficulties for many, with only the best candidates finding the correct minimum extra time required and the new start time for activity J.

Question 2

It was necessary for the explanation to mention two things in order to score full marks; the Hungarian algorithm minimises the **total** score; **each new entry** in the table gives an indication of the points not scored. The value 35 in the substitution $35 - x$ was somewhat irrelevant and many candidates did not seem to realise that.

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 likely to lose marks for this approach. Despite comments in previous reports, this message does not seem to have been relayed to some teachers and their candidates. The augmentation was usually done well but some only identified one possible allocation of topics to the five team members. Although some guessed at least one of the actual allocations and the corresponding total score, it was pleasing to see the majority using the correct algorithm with good understanding.

Question 3

Part (a) In most cases the explanation of a "zero-sum game" was inadequate for full marks; most candidates scored a single mark for a statement such as "one player's gain is the other one's loss".

Part (b) The values of Colum's column maxima needed to be calculated along with a statement that the minimum of these maxima was -2 in order to give an adequate reason for C_1 being Colum's play safe strategy.

Part (c)(i) Most candidates gave a suitable reason based on domination as to why row 2 needed to be deleted; it was not enough to say that "other strategies are better than R_2". Some deleted a column and were unable to make much progress with the rest of the question.

Part (c)(ii) Most candidates were able to find the optimal mixed strategy for Roz. Some lost marks for not drawing accurate lines showing expected gains for $0 \leqslant p \leqslant 1$; the intersection points of the three lines were very close together and so an accurate graph was essential here. Although it was acceptable to use the horizontal lines printed in the answer booklet, at least one of these vertical lines needed to have a clear scale so that the accuracy of the process of finding the highest point in the region could be checked by the examiner. Some omitted to say that Roz should play R_3 with probability 0.4 when stating the optimal strategy.

Question 4

Part (a)(i) The column and pivot for the next iteration were usually identified correctly but the explanation was often inadequate for full marks. Some indication had to be made as to why the negative quotient had been rejected; the calculations $2/2$ and $3/6$ needed to be shown with a statement that 0.5 was the smallest **positive** ratio. Some who did this calculation omitted to say that 6 was the pivot; simply drawing an arrow pointing to the corresponding row was insufficient.

Part (a)(ii)The row operations were usually carried out accurately and most candidates obtained the correct tableau for the next iteration.

Part (b)(i) Most made a suitable comment about there being no negative values in the objective row and therefore the optimal value had not yet been reached; it was incorrect to say that "the values in the top row were all positive".

Part (b)(ii) The number of incorrect answers suggested that many were "guessing" the number of inequalities that still had slack.

Part (c)(i) Finding the value of P, even from an incorrect tableau, earned most candidates a mark. The values of x, y and z needed to be clearly stated but some neglected to include $y = 0$, even when their previous tableau was correct.

Part (c)(ii) The values for P, x, y and z from part (c)(i) needed to be substituted into the given expression in order to find the value of k. Consequently most scored a method mark here even if their values were incorrect.

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 demonstrating a good understanding of dynamic programming in this context.

Part (b) The maximum profit was usually found correctly and at least one of the two correct paths was usually found correctly.

Question 6

Part (a) It was surprising to see a large number of able candidates being unable to calculate the correct value of the cut, with many confusing upper and lower capacities in their calculation.

Part (b)(i) Few candidates had trouble in finding the flows along DE and FG.

Part (b)(ii) It was pleasing to see that many more candidates this year were aware of how to show the potential increases and decreases along each edge. Those who did not do this lost both marks here and two marks in the next part of the question.

Part (b)(iii) 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. These candidates used the table effectively to show what new flows had been introduced and modified both the forward and backward flows on their network. Marks were awarded for the initial flow and it is very difficult to credit candidates for their original values if they have been obliterated during augmentation; candidates are advised to show the initial flow in ink and then to augment their flow using pencil.

Part (c)Those who stated that the maximum flow was 36 were given some credit for illustrating a flow of 36 on Figure 4. Those with the correct maximum flow were usually able to show a correct flow on the network; those who made a couple of slips were again given some credit for their work.

Part (d) Many candidates were able to find the correct cut with capacity 37, but quite a few who had the correct maximum flow were deceived into using their Figure 4 on which every cut had value 37, rather than looking at the initial network with upper and lower capacities.

Mark Ranges and Award of Grades

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