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Mathematics 6360

MD02 Decision 2

Report on the Examination

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General

The general performance of candidates was quite pleasing. The routine aspects when using algorithms for Critical Path Analysis, the Simplex Method and Game Theory appeared to be well rehearsed, although understanding was not always evident when explanations were required. It was very encouraging to see most candidates using the insert provided to solve the Dynamic Programming question. The labelling procedure in Network Flows seemed more in evidence this year with far more candidates indicating potential increases and decreases on their network diagrams.

Those who did not do quite so well might benefit from the following advice.

- Candidates need to realise what is meant by a resource histogram. There should be no gaps in the vertical blocks.

- The Hungarian algorithm involves more than reducing rows and columns when the zeros in the resulting n by n matrix cannot be covered by n lines; the adjustment process was not always in evidence. Often it appeared that the allocation has been achieved by trial and error rather than by using the positions of the zeros in the final table.

- Candidates are well advised to be familiar with the stage and state approach to dynamic programming working backwards through the network, rather than simply writing a few numbers on a network diagram.

- When using flow augmentation, the labelling procedure requires that both the potential increase and decrease of flow be indicated on each edge. This is best done using forward and backward arrows (or a repeated edge one showing forward potential increase and the other showing backward decrease). The individual routes augmenting the flow and the values of the extra flows should be recorded in the table provided.

Question 1

The network diagram was usually correct and almost all candidates calculated the earliest start times and latest finish times correctly and hence found the minimum completion time and critical path. Many candidates did not produce a correct resource histogram. The section between 10 and 12 days caused the biggest problem with many diagrams not having complete vertical blocks. It was good to see most candidates heeding the advice of previous reports in labelling their diagrams so that it was possible to see which activities were taking place on a particular day.

Question 2

Part (a) Some candidates added a row of *different* values and so made little progress on the question as a whole. It was good to see most tables modified with a row of sensible values such as 15 (rather than 100, for instance). Some chose to substitute a value for ** and, provided this was not less than 13, it was condoned.

Part (b) Once again many performed the column and row reductions, but then made no attempt to show that the zeros could be covered with four lines followed by the adjustment process, thus omitting an essential part of the Hungarian algorithm. Some omitted to state explicitly which person needed to be matched to a particular task.

Part (c) The better candidates realised that when ** was replaced by 12 the final matrix had a zero in this position, and hence it could be seen that no different matching was possible and therefore no improvement on the minimum total time could be made. Those who simply commented about Dan already doing a task taking 12 minutes did not score full marks.

Question 3

Part (a) The term “zero-sum” was generally understood, but candidates should have indicated that the sum of Rob’s winnings and Con’s winnings was equal to zero *for every pair of strategies*.

Part (b) In order to show that the game has a stable solution, it was expected that the minimum values in the rows and the maximum values in the columns would be indicated before finding the maximum of the minima and the minimum of the maxima. Some statement should then have been made indicating that these two values are equal and hence the game has a stable solution.

Part (c) Most candidates realised that R_1 dominated R_3 and hence Rob should never play R_3.

Part (d) To find the optimal mixed strategy, when a letter such as *p* is introduced, there should be an indication that this is the probability that Rob is choosing R_1, for example. Three expressions in *p* were often written down with no indication as to what they represented. Although three linear graphs were often drawn, many candidates chose the wrong pair to solve for the optimal strategy and seemed to be guessing rather than reasoning correctly which point to select. Those who obtained the correct optimal strategy were usually able to find the value of the game.

Question 4

Part (a) Most candidates were able to write down the correct inequalities, although some introduced the slack variables and others wrote equations or used “less than” rather than “less than or equal to”.

Part (b) The pivot was usually found correctly for the first iteration, although some used a value from the *x*-column, despite the clear instruction. Since this had value 1, the row operations were fairly easy and most candidates were successful in performing the first iteration.

Part (c) Those candidates who reduced the second pivot to 1 and who worked with fractions were usually more successful than those who chose not to use elementary row operations. Some caused problems for themselves by forming negative multiples of the rows. It was then common to see the incorrect pivot being used or the incorrect conclusion being made regarding optimality. Part of the interpretation was to state that the maximum value of *P* had been reached, but most candidates failed to make such a statement. Others found the values of the slack variables but failed to give the values for x, y and z when interpreting the final tableau.

Question 5

Most candidates scored full marks on this question and the insert probably contributed to this high success rate. Those who used a network diagram often failed to show the correct number of values at certain vertices and lost marks. Those who use an unusual notation that is not clear to examiners (such as 6^2_H) should provide a key to explain what their notation actually means or full credit cannot be given.

Question 6

Part (a) All candidates seemed familiar with the idea of a super-source, S, and super-sink, T. Although it was possible to assign equal values such as 100 to the capacity on each of the new edges, such a large value often caused problems with flow augmentation. Some incorrectly assigned equal values such as 20 to the new edges. Those using capacities of 22 on SP and 15 on SQ were usually the most successful.

Part (b) Quite a few candidates made errors in calculating the value of the cut with a common wrong answer being 36. Several incorrectly thought that the maximum flow was equal to the value of this cut.

Part (c) The values of the initial maximum flows along the given edges were usually correct.

Part (d) It was good to see candidates trying to set out their solution in a logical manner with most candidates showing 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, particularly the initial flow, should be clear to the examiner when such modification is made. It is not wise to totally obliterate previous values when adjustments are made.

Part (e) Some candidates misread this last part and stated the maximum flow through the network. Very few were able to use their final maximum flow diagram to interpret the correct flow from Y to X.

Mark Ranges and Award of Grades

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