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General Certificate of Education

Mathematics 6360

MD02 Decision 2

Report on the Examination

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General

The general performance of candidates was quite pleasing. Some topics such as Critical Path Analysis, the Simplex Method and Game Theory appeared to be well understood, although occasionally non-orthodox methods were used. However, a large number of candidates seemed to be unprepared for the maximin aspect of Dynamic Programming and once again the labelling procedure in Network Flows seemed unfamiliar to many candidates who did not indicate potential increases and decreases on their network diagrams.

Candidates need to distinguish between critical activities and critical paths and to be aware that there may sometimes be more than one critical path for a project.

When using the Hungarian algorithm, separate matrices should be used at each stage rather than crossing numbers out and replacing their values in a single tableau. 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 had been achieved by trial and error rather than by using the Hungarian algorithm.

Candidates would do well 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. In a minimax or maximin situation it should be clear to the examiner which numbers have been compared and selected at each vertex.

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

This was meant to be a confidence boosting first question and it proved to be the case. The network diagram was usually correct and almost all candidates calculated the earliest start times and latest finish times correctly. The minimum completion time was usually correct also. However, even some very able candidates failed to realise that there were three critical paths.

Question 2

In part (a), candidates could not always articulate their thoughts coherently. The Hungarian algorithm is used to **minimise** the total, and by subtracting the values in the table from 15 a measure of points **not** scored is obtained. In part (b), once again, many performed the column and row reductions, but then made no attempt at the adjustment process, thus omitting an essential part of the Hungarian algorithm. Those who merely guessed at an appropriate matching were given some credit but may not always do so in future examinations. In order to score full marks in part (c) it was necessary to delete the relevant row and column from the reduced matrix obtained in part (b) or to rework the reduced matrix so as to obtain the new matching.

Question 3

In part (a), most candidates were able to form the initial tableau, but a few neglected to introduce slack variables and scored no marks. Explanations in part (b)(i) were often poor. Some comparison of $\frac{16}{4}$ with $\frac{12}{2}$ was expected, with the smaller of these quotients determining that the pivot was 4. The mark scheme for part (b)(ii) gives an indication of the preferred layout of the tableaux. Those candidates who reduced the pivot to 1 and who worked with fractions were usually more successful than those who chose not to use elementary row operations. In part (b)(iii), most candidates were able to find the value of P at the maximum point. Several omitted to say that $z = 0$, and, although many realised that the entries in the objective row were non-negative, they sometimes failed to state that this implied the maximum had been reached and therefore had not answered the question.

Question 4

In part (a), in order to show that the game has a stable solution, it was expected that the minimum values in the rows and 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. To find the optimal mixed strategy in part (b), when a letter such as p is introduced, there should be an indication that this is the probability that Ros 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 5

Part (a) was intended to give help in how to find a maximin route and was often answered correctly. There were some, however, who simply added values together and considered totals. Those who used stages and states working backwards from T were most successful. Candidates could benefit from studying the model solution in the mark scheme and should be discouraged from simply scribbling a few numbers on a network diagram. There should be clear evidence that the minimum value from a pair of numbers is being considered at the various stages and that the maximum value from groups of minima is being selected, thus identifying the maximin route.

Question 6

In part (a), a number of candidates made errors in calculating the value of the cut; a common wrong answer was 39. Several incorrectly thought that the maximum flow was equal to the value of this cut. In part (b), the values of the initial maximum flows were usually correct, and in part (c), it was pleasing to see candidates trying to set out their solution in a logical manner. Some 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 and the final backward flows should be the values transferred onto Figure 3 to give a possible maximum flow. Although quite a few were successful in finding a cut of the same value as the maximum flow, they failed to convince examiners that they had proved that the flow must be a maximum.

Mark Ranges and Award of Grades

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