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## General Certificate of Education

# Mathematics 6360

## MD02 Decision 2

# Report on the Examination

*2010 Examination – January series*

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## General

The general performance of candidates was quite pleasing. The paper had one or two unfamiliar parts of questions but candidates generally coped very well and indicated a good understanding of the underlying principles. Some topics such as Critical Path Analysis, the Hungarian Algorithm, the optimal mixed strategy in Game Theory and the Simplex Method appeared to be well understood. It was also particularly encouraging to see the improved performance in the project planning aspect of Dynamic Programming and no doubt the insert helped. 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.

This is the last examination in which a separate insert will be provided. In future, the corresponding figures will be printed alongside the respective questions in the combined question paper / answer book and this might prove more helpful to candidates.

## Question 1

Almost all candidates calculated the earliest start times and latest finish times in part (a) correctly.

In part (b), the float for activity *G* was calculated correctly by more than half the candidates and this was encouraging to see.

Most candidates found the two critical paths in part (c), but a surprising number omitted to state the minimum time for completion.

The histogram in part (d) was not always constructed correctly, with quite a few candidates leaving gaps in their blocks. It was pleasing to see most candidates indicating clearly which activities were taking place at any given time. Some candidates ignored the request to show the activities starting as **late** as possible, and others were obviously confusing their diagram with a Gantt chart and tried to indicate slack by extra dotted lines.

## Question 2

In part (a), those candidates who added a row of 12s seemed to be the most successful, but clearly it was possible to add any row of **equal non-zero** values to obtain a correct solution.

Most candidates were able to apply the Hungarian algorithm correctly in part (b), although a few made arithmetic slips in column and row reduction, and this caused a few difficulties when applying the algorithm; others neglected to adjust the entry involving $x$. Those who did the correct adjustment were usually able to allocate the four tasks correctly so that the total time was minimised. Careless arithmetic prevented some from obtaining the correct minimum time.

Some used the Hungarian algorithm once more for the final part of the question, but this was not expected. Most candidates found one of the additional allocations of tasks but usually only the better candidates managed to find both possible extra ways to allocate the tasks.

## Question 3

Some candidates argued correctly, in part (a), that row 2 dominated row 3 but then incorrectly that one column dominated another in an attempt to reduce the matrix to a 2 by 2. In order to show that the game had 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 were equal and hence that the game has a stable solution. The actual play-safe strategies for Ann and Bill were sometimes stated incorrectly even when the correct minimax and maximin values had been identified in the table.

The method of finding the optimal mixed strategy in part (b) seemed to have been clearly understood by most candidates. Sometimes the graphs were inaccurate and a mark was lost. Other good solutions were sometimes spoiled by not stating how often Russ should play each of the strategies $R_1$ and $R_2$. Those who found the correct probabilities in part (b)(i) were usually able to find the value of the game in part (b)(ii), but some substituted into the wrong expression for expected gain.

## Question 4

In part (a)(i), most candidates were familiar with the term “slack variables” but quite a few could not remember the correct word. In part (a)(ii), quite a few wrote down an inequality rather than an equation involving the given variables.

It was encouraging to see that most candidates were able to find the correct pivot in part (b)(i) and many were able to perform the first iteration without many errors. This was possibly due to the fact that the calculations only involved integers. In part (b)(ii), sometimes a statement such as “there are negative values” was given and scored no marks unless the first row, or objective row, was mentioned and actually contained a negative entry.

Those candidates who chose the correct pivot were usually successful in performing a second iteration in part (c)(i), although some arithmetical slips occurred. Part of the interpretation of the final tableau in part (c)(ii) should have included the fact that the optimum or maximum value of $P$ had now been achieved. Credit was given for stating the value of $P$ for their tableau, but only those with a correct final tableau were able to score the mark for the correct values of $x$, $y$ and $z$ which maximised $P$.

## Question 5

Those who used the insert provided were most successful. Those candidates who had only ever used a network approach for dynamic programming made little headway in this question. Usually the values for July were found correctly, with the occasional arithmetic slip. The idea of dynamic programming was to use various minimum values from July when performing the June calculations. It was, however, pleasing to see many completely correct solutions including the final schedule. Those who made a small slip in one of their calculations usually only lost a single mark in the question. Candidates need to be prepared for a stage and state approach in future, as it is likely that a similar table to that on the insert will be provided for candidates to show their calculations and values at each stage.

## Question 6

Usually after crossing out one or two additional figures, in part (a)(i), most candidates managed to show that the cut had value 97. This(ii) had been intended as a help to find the values of the other cuts in part (a)(ii), but only the best candidates managed to find the 4 correct values in the table. In part (a)(iii), many candidates made statements involving inequalities instead of saying that the maximum flow was equal to the minimum cut. The cut with value 53 had already been provided in the table but several candidates ignored this value.

In part (b)(i), it was good to see candidates trying to set out their solution in a logical manner and once again the insert clearly helped. Only a few candidates failed to show potential forward **and** backward flows on their network; however, some candidates started from a flow of zero rather than using their values on Figure 5. Candidates are advised to use the table to show what additional 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. In part (b)(ii), those who had the correct maximum flow and who had used the labelling procedure correctly usually had no trouble in showing this maximum flow on the final diagram.

## Mark Ranges and Award of Grades

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