

# Examiners' Report

Summer 2014

Pearson Edexcel GCE in Decision Mathematics D2  
(6690/01)

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## **Mathematics Unit Decision Mathematics 2**

### **Specification 6690/01**

#### **General Introduction**

The majority of students demonstrated sound knowledge of all topics, and were able to produce well-presented solutions, making good use of the tables and diagrams, printed in the answer book.

Students should be advised to read questions carefully and answer as required. For example, marks were lost in question 1, by students minimising rather than the required maximisation.

Poor quality of handwriting causes a minority of students to lose many marks, particularly in misreading their own written numbers and capital letters.

## Question 1

This question was accessible to the majority of students. Unfortunately however, a smaller yet still significant proportion of students were confused by the combination of a maximisation problem with empty cells. There was evidence of confusion in approach and some students entered large values in the empty cells before minimising, replaced the empty cells with zeros after converting to a minimisation problem, or dealt with them midway through their solutions (usually after row/column reduction). Some students did not fully undertake row and column reduction, in some cases prematurely augmenting their tables. There were many students who began their solution as a minimisation problem and then realised their mistake and restarted. The number of arithmetic errors was small but significant, sometimes caused by students misreading their own handwritten numbers. Despite the issues apparent for some students, this was in general a well attempted question and many students were able to apply the algorithm correctly.

## Question 2

Most students found both nearest neighbour routes in Q02(a) but some failed to return to A, or made arithmetic errors in calculating the lengths of these two routes and some incorrectly doubled the length of their routes to obtain an upper bound.

In Q02(b) most found a residual spanning tree, but unfortunately lost marks in this part as they did not use the correct two least lengths incident to F. A number of students incorrectly used both arcs of 88. A common mistake for the RST was to include arc CD. Some students calculated a nearest neighbour route for the vertices A to E rather than finding a minimum spanning tree.

In Q02(c) most students, who had obtained upper and lower bounds earlier, wrote down an interval containing these two values, although a significant number lost marks through poor notation, including writing  $< 471$ . Those students with incorrect bounds became creative with their interval, particularly when their lower bound was greater than their upper bound.

### Question 3

In Q03(a) the majority of students correctly identified the correct pivot and went on to divide the pivot row by 2. However a number incorrectly used the 3 in the top row as the pivot and some used the -1 in the third row. A small number of students decided to pivot on the  $x$  column or the  $z$  column instead of  $y$  despite the question stating that the most negative number in the profit row should be used. A small number failed to change the basic variable in the pivot row. Having divided through, most students stated the correct row operations and applied them successfully to the table, although some numerical errors crept in. Most then went on to correctly identify the second pivot and to divide through again. Those that had a correct or virtually correct first iteration generally went on to state and apply the correct second set of row operations, ending with a correct optimal solution. However those that had made more significant errors in their first iteration often did not have the correct second set of row operations.

From time to time it was difficult to read students' work due to crossings out/corrections and students should be reminded to make sure their work is clearly set out. Many students made use of only two tables, however, a significant number of students used several tables, often writing and rewriting elements within the table a number of times.

Q03(b) was generally less successfully attempted. Of those students who provided an answer to this part many were able to correctly write down at least some of the values from the value column rather than from the profit row of the table. However a significant number lost marks because they did not write down all of the variables (often giving only the basic variables) or they did not write down  $P$  explicitly.

Surprisingly there was a significant number who did not attempt this part of the question or who wrote down only  $P + 43x + 27s + 4t = 47750$ .

#### Question 4

In Q04(a) students found the correct row minimums and column maximums and then deduced that the row maximin (-3) was not equal to the column minimax (1), though a few had 2 for the latter.

In Q04(b) the majority of students correctly defined  $p$  and then used a dominance argument to eliminate one of the options for player B but a significant number deleted column 4 instead of column 2. Those that did not use a dominance argument usually went on to correctly form expressions for A's expected winnings if B played each of its four options. In this second part most went on to set up their three probability expressions correctly (though some had errors when simplifying these expressions) and they then went on to draw a graph with 3 lines; a few students just attempted to solve 3 pairs of simultaneous equations, scoring no marks. It was noted that many graphs

- were poorly drawn without rulers,
- went beyond the axes at  $p = 0$  and  $p = 1$ ,
- had uneven or missing scales on the vertical axes,
- were so cramped that it was difficult to identify the correct optimum point.

Most students then attempted to solve the pair of equations for which they considered to be their optimal point. Those that solved the correct pair usually went on to list the correct options for player A. Many students also stated the value of the game to A at the end of the solution despite this not being required.

## Question 5

The vast majority of students stated the correct initial flow and completed the flow diagram in Q05(a) and Q05(b). Most then went on to find one or more flow augmenting routes, although a significant number failed to obtain the maximum flow of 70. A small number tried to increase the flow by more than 8, generally not realising that only 2 units could flow along BA. A number of students incorrectly tried to find flow augmenting routes starting SA... or made statements about decreasing the flow in particular arcs.

Most students went on to attempt the final flow diagram in Q05(d), although a significant number of students did not gain full marks as they did not have a flow of 70. A number of errors were often present such as two numbers on some (or all) of the arcs and a significant number either left one arc blank or had an inconsistent flow pattern, most notably at nodes A or B.

In Q05(e) many gained the method mark, for a cut, but some students, who had been successful up to this point, attempted a cut not equal to 70, or they failed to quote the 'maximum flow – minimum cut' theorem. It is also advisable for students to draw the cut on the diagram showing their maximal flow pattern rather than stating the arcs that the cut passes through. Those that quoted the theorem without a cut lost both marks. Students should be reminded to refer to the original diagram containing the flow capacities, when considering possible cuts, rather than their optimal solution.

## Question 6

The majority of students failed to make a clear definition of their  $x_{ij}$  and then use it consistently throughout the question. Common errors included omitting the word "number" or using P, Q, R in the definition and 1, 2, 3 elsewhere. Some students defined  $x_{ij}$  as being equal to 1 or 0 as in an allocation formulation. Most students correctly stated the objective function and "minimise", although a small number stated "maximise" and there were some slips, either with the coefficients or suffices. There were a variety of errors made with the constraints, with some not having unit coefficients and commonly the non-negativity constraint for  $x_{ij}$  was absent. Other errors included errors with suffices or values and a mixture of equations and inequalities. A small number of students incorrectly wrote all their constraints as  $\geq$  and some equated them to one like in an allocation formulation. Some students changed their notation between the objective function and constraints, for example using PA in the objective function and  $x_{pA}$  in the constraints.

## Question 7

A number of students showed a clear grasp of how to use the given information to work backwards through their table, from one stage to the next using the correct relevant values at each stage to find a correct final solution. There were a number of errors made when choosing the correct elements to include in calculations or in the arithmetic.

Nearly all correctly started backwards from July and most were able to obtain values for July, either opting to add storage costs in the current month or the next. A number of students forgot to carry forward previous optimal values but most were able to continue correctly. Very few extra rows were seen but a significant number of students lost marks for deleting or omitting state 2 (equivalent to having two aircrafts in stock at the beginning of the month) in the stages for May and/or April. Students who omitted these states appeared to be considering the demand required in an earlier month, and they therefore concluded that it would not be possible to have two aircrafts in storage at these stages.

In essence these students were working forwards and not backwards; this is a common error when applying the principles of dynamic programming. Students should be advised that in Decision Mathematics they must rigorously apply the algorithm, rather than introduce their own logic or common sense. Most students did show the necessary working as requested. A small minority of students started from March, attempting to apply the algorithm going forwards.

## **Grade Boundaries**

Grade boundaries for this, and all other papers, can be found on the website on this link:

<http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx>

