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Examiners' Report

Summer 2015

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 are reminded that they should not use methods of presentation that depend on colour, but are advised to complete diagrams in (dark) pencil.

Students are also reminded that this is a 'methods' paper. They need to make their method clear, 'spotting' the correct answer, with no working, rarely gains any credit.

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

Most students were well prepared for the exam and there were very few blank pages.

It was evident though that in the final question some students ran out of time, a few made no attempt and many more stopped mid-solution.

Report on Individual Questions

Question 1

This question on the simplex algorithm was well answered by the majority of students. The overwhelming majority chose both the correct column and indeed the correct row to pivot on. Examiners commented on seeing very few students who either pivoted on an incorrect column or an incorrect row within the *x*-column. The majority of students changed the basic variable correctly and almost every student gave the correct row operations. The source of most errors appeared to be numerical inaccuracy which led to either the loss of one or sometimes two marks in part (a).

Part (b) was more challenging for some students, although the majority scored both marks. It is surprising that a significant number of students are still unable to write down the profit equation correctly. There were ‘equations’ with two equals signs, the coefficients of y and z and s were of the incorrect sign and sometimes the 15 was omitted. It was clear that some students were unsure what was being asked when asked to write down the value of the slack variables and some students only gave two of the three variables (usually $s = 0$ was absent). Some students gave the values of all the variables including P and some incorrectly read off from the bottom row of the table.

Question 2

Many students over complicated their answer to part (a); a simple statement indicating that one player's gains were equal to the other player's losses was all that was required. Students need to be aware that for 1 mark they are not going to be required to write half a page. A few students confused this with saddle points and discussed stable solutions or stated that each player would eventually win/lose zero.

Part (b) was very well done with the vast majority giving the correct answer of 5, unsurprisingly, the most common incorrect answer was –5.

Part (c) on the whole was answered very well – with only a minority of students incorrectly stating the row maximums and column minimums. Students need to be made aware that this is a ‘methods’ paper; a number of students simply stated that the row maximin was 0 and the column minimax was 2 with no method or working to back up this claim. A number of students who did find these values did not indicate that these two values were not equal and so therefore there was no stable solution.

The most common error in part (d) was when the wrong dominance was stated (usually that column 2 dominated column 1) and then used (so therefore column 1 was deleted). Many students did not write down the reduced pay-off matrix for Greg, as specifically asked for in the question.

In part (e) the majority of students set up the three probability expressions correctly (though some had errors when simplifying these expressions) and then subsequently went on to draw a graph with 3 lines; a few students attempted to just solve three 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 Greg although a number did not state that Greg should never play his option 2. The value of the game to Greg was often stated correctly.

Question 3

This question seem to differentiate nicely between students. It was surprising that even some of the more standard and straightforward parts of the question caused difficulty for some students.

Part (a) was usually done correctly although a minority of students used the nearest neighbour algorithm rather than Prim's as evidenced by a return to vertex A. Some students tried to involve x despite x being within a range that made it irrelevant in this part. A small minority of students did not use Prim and other students did not show any obvious method but simply drew a MST. Some students who clearly were using Prim lost marks for only listing the nodes in order rather than listing the arcs as requested.

Part (b) was usually done correctly by those students who had obtained the correct minimum spanning tree in part (a) although some stated the weight of the tree plus the weight of arc AG.

Part (c) was completed correctly by the majority of students who gave their nearest neighbour route either as a list of nodes or arcs. The most common error was to omit the return to vertex A. Often these students were able to recover in the calculation for the upper bound by adding in the weight of the extra arc at this point.

Part (d) was less standard but nonetheless it was relatively well attempted and most students produced a good numerical reason together with a clear conclusion. The approaches taken by students seemed fairly evenly split between those who considered $x + 153$ together with the minimum value of x and those who considered the range of values that the nearest neighbour route from F could take. It is worth noting however that a surprising number of students were unable to accurately sum the arcs for the nearest neighbour route from F. Examiners noted that only a handful of students thought that the better upper bound was the larger of the two numbers.

A large proportion of students answered part (e) well and many provided clear diagrams alongside their work to illustrate the addition of the two least arcs incident to A. It was clear however that a minority of students were unsure what to do here. Some students made errors in their RMST and others added $2x$ to their RMST rather than 21 and x.

Part (f) was generally done well by most students. Many obtained both marks or scored one mark on the follow through from an earlier stated upper bound in part (d). Others lost the final mark for use of a strict inequality for the upper limit. It was rare but nonetheless worrying to see statements along the lines of $178 < x < 166$.

Question 4

This question was quite straightforward and a high proportion of students earned full marks.

For part (a) the majority gave the correct answers for the two cuts with the answer for second cut being the more popular incorrect answer.

The vast majority obtained the mark for part (b) either with the correct answer of 45 or on the follow through from the two answers to part (a). The most common incorrect answer was choosing the biggest number from part (a) and not the smallest. It was surprising how many students could not correctly select the lesser of their answers to (a) even though some clearly stated they were looking for the max flow (= min cut).

There were many correct answers for part (c) but some overcomplicated what was necessary for this mark.

Part (d) proved more challenging. Most students understood what was being asked but had difficulty putting it into words. A numerical solution was required, showing that the total capacity into G was less than the total capacity out of G i.e. 21 < 26 therefore GF and GT cannot both be saturated. Many students gave non numerical answers which discussed conservation of flow. Some students talked about 21 flowing in without reference to it being the maximum flow or the capacity of the arc flowing in.

Students have become too familiar with the ‘standard’ way of finding a maximum flow pattern through a network and so were unable to apply their knowledge when the question is approached in a slightly different way as was the case in part (e). For those that did attempt this question, the common errors were students missing a number on an arc, having more than one number on an arc or having nodes that had inconsistent flow patterns. Students would benefit from methodically checking every node for ‘flow in = flow out’. The other main cause of lost marks involved a flow pattern in which one (or more) arc was over capacitated.

Question 5

Almost all students in part (a) found the correct stepping stone route, though some had an extra theta in cell BP, not understanding the requirement for balance both across rows, and down columns. Many went on to give the correct improved solution in this part, although some had an additional zero in CQ, the exiting cell, and typically lost a later mark for the same transgression, in their second improved solution. Some wasted time calculating initial shadow costs and improvement indices, only to confirm that AQ was to be the entering cell (this was given to students in the question).

Most students attempted to calculate shadow costs and improvement indices from their improved solution in part (b), although a number made errors in their calculations or used the supply pattern instead of the costs, as the basis for their calculations. The most negative improvement index was generally chosen to start a new stepping stone route and many found the correct route and improved solution, though some lost a mark for failing to state either the correct entering cell (DP) or exiting cell (DQ).

The majority of students who found the second improved solution, went on to calculate new shadow costs and improvement indices in part (c), although occasionally these contained errors, and they then made the correct conclusion of an optimum solution. As in previous sessions, a minority of students made the costly mistake, once or even twice, of finding only 5 improvement indices.

Many students, in part (d), correctly stated the cost of the solution found in part (b) although this was sometimes left blank.

In part (e) the majority of students failed to make a clear definition of their x_{ij} and then use it consistently throughout this part. 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 issues included errors with suffices or values and a mixture of equations and inequalities. A small number of students incorrectly wrote all their constraints as $\geq$. Furthermore, some students incorrectly equated them to 1 (possibly mistaking this for an allocation formulation). Some students changed their notation between the objective function and constraints, for example using x_{AP} in the objective function and x_{PA} in the constraints.

Question 6

Part (a) usually had the correct answer of maximin although many left it blank or had minimax, or maximise.

Part (b) was generally well attempted with the main issue for students being the type of dynamic programming problem to use. Students tended to complete the table for their chosen problem correctly. The most common wrong types were minimax and maximising. There were very few * errors and students usually had the stage, state, action and destination columns completed correctly. A number of students had 'reversed states' or 'worked forwards' and so lost the majority of the corresponding accuracy marks. Students should be aware that in both these cases these are critical errors in the process of dynamic programming; in the case of 'reversed states' it means that the states are not grouped together meaningfully to select an optimal solution. Of those that correctly used a maximin route the most common error was a value of 6 for action FJ rather than 5.

In parts (c) and (d) students generally demonstrated that they knew how to read off the maximum weight and route from their table.

Most gained the mark for part (e) (i) although some stated that H should be increased to 10 rather than HT.
Part (e)(ii) was also well answered although some students did not state both a new maximum weight for the truck and a new route.

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

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