Examiners' Report/
Principal Examiner Feedback

Summer 2016

Pearson Edexcel GCE
Decision Mathematics 1
(6689/01)

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Principal Examiner's Report

GCE Mathematics

Decision Mathematics 1 (6689/01)

Introduction

This paper proved accessible to the students. The questions differentiated well, with most giving rise to a good spread of marks. All questions contained marks available to the E grade students and there also seemed to be sufficient material to challenge the A grade students.

Students should be reminded of the importance of displaying their method clearly. Decision Mathematics is a methods-based paper and spotting the correct answer, with no working, rarely gains any credit. Some students are using methods of presentation that are very time-consuming, this was particularly true in question 4(c), the application of Prim's algorithm, where a number of students ran out of space (and possibly time) unnecessarily completing the algorithm on a matrix. It was also evident in 5(b) when students traced through the flow chart a second time.

The space provided in the answer book and the marks allotted to each section should assist students in determining the amount of working they need to show. Some very poorly presented work was seen and some of the writing, particularly numbers, was very difficult to decipher. Students should ensure that they use technical terms correctly. This was a particular problem in questions 1(a), 6(b) and 6(c).

Report on Individual Questions

Question 1

Part (a) had a variety of responses – the best responses contained the key ideas that a bipartite graph consists of two sets of vertices X and Y in which edges only join vertices in X to vertices in Y and do not join vertices within a set. Students need to use the correct technical language such as 'nodes' or 'vertices', rather than points, dots, people, data etc. Some students were thrown by the diagram and had explanations referring to columns of nodes. A lot of students who correctly wrote 'two sets of vertices' went on to say that arcs cannot connect vertices in the same set but did not explicitly state that arcs connect vertices from one set to the other.

Part (b) was well attempted and most students were able to write down an alternating path from P to B. It is important that examiners can clearly identify the alternating path so it should be listed (rather than drawn) separately, rather than left as part of a 'decision tree' of potential paths. A number of students are still not making the change status step clear. This can be done either by writing 'change status' or, more popularly, by relisting the path with the alternating connective symbols swapped over, this latter approach has the additional advantage of making the path very clear to examiners. A significant number of students did not state the complete matching after stating their alternating path. If students are going to display their complete matching on a diagram then it must be made clear that only a diagram with the exact number of required arcs going from one set to the other set will be accepted.

Question 2

Students generally showed a good understanding of the process of constructing an activity network from a precedence table, using arcs drawn with arrows and labelled for activities. Some responses lacked a sink node at the end and a small number did not have a single source node. Some of the diagrams and labels were challenging to read, especially when they were very small and/or drawn with lines that crossed over. Some students were unsure about the placement of their dummies, putting them in 'anywhere' so that they had three dummies included. Some also had four or more dummies even though the question clearly stated that they were to use exactly three. A very small number of students put activity on node, and some failed to check that they had all activities present, with activity K being the activity that was missing most often.

Question 3

In part (a), most students selected middle-right pivots and many were able to carry out the sort correctly. Errors cropped up in the ordering of the sublists after the second (and subsequent) passes. The most common occurrence of this tended to be that the '55' and '63' were interchanged after the second pass. Other errors included failing to select the '42' as a pivot for the fifth pass. As stated in previous examiners' reports even though after the fourth pass the list 'appears' to be in order, as demanded by the algorithm, a final pass through the list is required. Very occasionally, students selected only one pivot for each iteration or failed to sort the list into (values greater than the pivot), (the pivot), (values less than the pivot) after the first iteration. There were only a few instances where students selected the first or last items as the pivot. Pivots were usually chosen consistently although the spacing and notation on some solutions made these difficult for examiners to follow. Some students over-complicated the process by insisting on using a different 'symbol' to indicate the pivots for each pass. Those students who sorted into ascending order usually remembered to reverse their list at the end to gain full credit, although a number of students left their list in ascending order.

The first-fit decreasing in part (b) was well carried out with only a small minority failing to attempt this part. There were a large number of fully correct answers. A small number performed first-fit increasing therefore scoring no marks. A small minority of students lost all the marks by placing the '45' in the 4^{th} rather than 3^{rd} bin (so failing to apply the algorithm at its first real test). Some students wrote totals in the bin rather than the next value. A variety of different layouts were used but in nearly all cases were easy to read and decipher.

Part (c) was answered very well by the majority of students. Most errors that were made were avoidable – arithmetic errors or failing to answer the question in stating that their solution was optimal. A minority of students attempted an alternative to finding the lower bound, most of these referred to the total wastage relative to the bin size, and these approaches were rarely successful. Students need to make sure their answers are clear – some lost a mark in part (c) as, although they correctly found that the lower bound was 4, they did not explicitly refer to their solution in part (b) as therefore being optimal.

Question 4

Part (a) was usually very well done with most students applying Dijkstra's algorithm correctly. The boxes at each node in part (a) were usually completed correctly. When errors were made it was either an order of labelling error (some students repeated the same labelling at two different nodes) or working values were either missing, not in the correct order or simply incorrect (usually these errors occurred at nodes D, G and/or F). The route was usually given correctly and most students realised that whatever their final value was at F, this was therefore the value that they should give for their route. As noted in previous reports because the working values are so important in judging the student's proficiency at applying the algorithm it would be wise to avoid methods of presentation that require values to be crossed out.

Part (b) was answered well with the vast majority of students correctly stating the shortest path and corresponding length from A to F via J.

Part (c) was generally well answered with the majority of students applying Prim's algorithm correctly starting from vertex G. A few students attempted to construct a table to perform Prim, clearly believing that this algorithm can only be performed when expressed in matrix form. Finally, there is still a small minority of students who appear to be rejecting arcs when applying Prim's algorithm so scoring only one of the three possible marks in this part.

The vast majority of students correctly stated the length of the minimum spanning tree in part (d).

Question 5

The majority of students showed a sound understanding of applying the given flow chart, scoring 3 or full marks in part (a). However a few lost all marks in part (a) for failing to fill in the first row and instead starting with the second row. Arithmetic errors were surprisingly rare. Extra "yes" and "no" entries were quite common in the fourth and fifth columns and were penalised with the final mark in this part.

Many scored the first B1 mark in part (b) for identifying that x should be 122, but then lost the next mark struggling to correctly explain why. The simplest explanation that x must be an integer, was spotted by some, as was "$\frac{1}{2}$ is neither odd nor even". However many simply focused on the $\frac{1}{2}$ stating that the algorithm would not terminate, or x would never $= 0,$ but failing to explain why.

The correct answer of 61 was often seen for the final mark in part (b). Many realised that it was simply the product of the two inputs, but some wasted time working through the algorithm for a second time with the two values of 122 and $\frac{1}{2}$.

Question 6

Part (a) was generally answered well by most students with the vast majority stating the correct three distinct pairings of the correct four odd nodes. There were a few students who only gave two pairings of the four odd nodes or who gave several pairings but not three distinct pairings. There were however many instances where the totals were incorrect. The majority of such mistakes occurred for the two pairings of BF with EH and BH with EF. There were also some instances where no totals were given which lost students a significant number of marks. Students should be advised to be thorough when checking the shortest route between each odd pairing. Many students did not explicitly state the arcs that should be repeated instead stating that BE and FH should be repeated instead of the correct arcs BA, AD, DE, FJ and JH.

Part (b) was challenging for most students and it was rare to see both marks awarded. The majority of students obtained no marks here due to arguments along the lines of "because that is the method that gives the shortest route" or fairly long-winded arguments to do with the order of nodes and the number of times a node can be entered/left without ever reaching the crux of the correct explanation. Of the two marks available a small minority scored a mark for conveying at least the idea of finishing at an odd vertex.

In part (c), many students identified BE, EH and BH as the paths that needed to be considered, although they often missed stating the fact that EH was the shortest path that did not including vertex F. Many students, even with the correct selection of arcs, either did not state a route or gave an incorrect route in part (d). Some students misunderstood the reasoning altogether and focused on the fact that EF had the greatest weight of the previous pairings and therefore should be avoided and so BH should be repeated. Those that did state EH usually went on to score the mark in part (d) for stating the length of a shortest inspection route.

Question 7

Most students correctly identified at least two of the four unknowns in part (a), with $w = 12$ being the most common incorrect answer.

Part (b) was generally well answered by students with many successfully drawing a correct Gantt chart. Most errors in this question occurred because students had failed to answer part (a) correctly. Common errors included identifying D as a critical activity (from an incorrect w), in spite of the float of one stated in the question, and incorrectly identifying the float of C (from an incorrect z). Students would be well advised to check they have included all 14 activities, as a minority lost marks due to omitting one (or sometimes more) activities.

It was rare for students to score both marks in part (c). Some disregarded the instruction to "use your cascade chart", and attempted a calculation instead, dividing the total number of days by the critical path length. Those who scored one mark correctly identified the 5 activities, but then struggled to express the time correctly. "On day 12" or "between 12 and 13" were common incorrect answers.

Part (d) discriminated well. Of those students who attempted this part, most failed to utilise the additional 6 days available for the completion of the activities and consequently needed to use four or five workers. In the relatively rare instances where 36 days and 3 workers were used, failure to check precedences accounted for the majority of lost marks, especially on activities G, H and I, which all had to follow activities B, E and F, and also on activity K, which had to follow activities D, G and H.

Question 8

The majority of students answered part (a) correctly. A very small number used the wrong inequality sign or wrote $x + y \leq 520$.

Most students were able to draw the required lines correctly in part (b) although some were unable to draw lines sufficiently accurately (some drew lines without a ruler) or sufficiently long enough. The following general principle should always be adopted by students:

- lines should always be drawn which cover the entire graph paper supplied in the answer book and therefore,
- lines with negative gradient should always be drawn from axis to axis.

The rationale behind this is that until all the lines are drawn (and shaded accordingly) it is unclear which lines (or parts of lines) will define the boundary of the feasible region. If students only draw the line segments that they believe define the boundary of the feasible region then examiners are unaware of the order in which the lines were drawn and therefore it is unclear to examiners why some parts of the lines have been omitted. In general, the lines $x = 2, 7x + 8y = 112$ and $20x + 65y = 520$ were correctly drawn. The most common error when drawing the line $-x + 24y = 24$ was drawing this line with a negative rather than a positive gradient.

In part (c), only a minority of students were able to state a correct objective function. Some transposed the coefficients, and many had the ratio of coefficients as 1: 2. A common error was $P = x + 2y$ but other functions stated were $3y = 2x, P = 2x + y$ and $y = 2x$.

In part (d), the majority of students drew the correct objective line, however, a line with reciprocal gradient was often seen or, in a number of cases, no objective line was drawn (and therefore no marks could be awarded in this part). Some used obscure constant values to plot the objective line.

In part (e), some students gave an estimate of the optimal vertex using a reading from their graph, rather than solving the relevant equations simultaneously.

Only a few students attempted part (f). Few students tested at least two valid integer points, either in a correct pair of constraint inequalities or in a correct objective function. Simply stating "in region" or "not in region" therefore gaining no marks. Some students just stated one pair of integer coordinates despite being asked to "make your method clear". The final mark was independent of all others, so a handful of students scored the mark for correctly stating the cost as £480.

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

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