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Examiners' Report

Summer 2015

Pearson Edexcel GCE in Decision Mathematics D1 (6689/01)

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General 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 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.

Some students are using methods of presentation that are too time-consuming, this was particularly true in question 2(b), the bubble sort, where many students ran out of space (and possibly time) unnecessarily showing each comparison. 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 3(b) and 4(a).

Report on Individual Questions

Question 1

A significant number of students in part (a) struggled to explain why the maximum matching algorithm needed to be used twice to find a complete matching. Incorrect or incomplete arguments usually focused on the fact that vans B and D could each match with only one delivery or that one alternating path would not produce a complete matching so two were required. Students who appreciated that there were two unmatched vertices in each set usually went on to score the mark.

In part (b) most students found at least one of the two alternating paths and many correctly stated both. A few students repeated the one that had been given in the question, either in addition to the two required or as one of the two 'new' ones. A number of students in this part changed the status of their paths and stated the corresponding improved matching even though the question only asked for the two possible alternating paths to be given.

Most students in part (c) were able to either state or draw the improved matching correctly. Some students failed to include the unchanged C = 4 in the new matching, while others used the alternating path from D to 1 that they had just found rather than the one from D to 5 as given in the question.

Part (d) was answered extremely well but there was nonetheless the usual loss of marks due to the change of status either not being stated or shown and/or failing to list or draw the complete matching. Allowing change of status to be either stated or shown benefitted many, particularly those who used incorrect terms such as 'flip' or 'change' or 'change state' (the only acceptable term is 'change (of) status'), as well as those who seem to think that the change of status can be shown without all the connected symbols being interchanged. There were, however, many students who both stated and demonstrated the change of status clearly and correctly. Some students simply stated the complete matching and showed no appropriate method, thus failing to score any marks.

It is worth noting that both improved and complete matchings can be drawn rather than stated, but these diagrams must be clear with no additional arcs. In a number of previous examiners' reports it has been made clear that examiners cannot accept diagrams with arcs which appear to be crossed out, so if any mistakes are made it is advisable to either draw the diagram out again or to list the (complete or improved) matching.

Question 2

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 first (and subsequent) passes. The most common occurrence of this tended to be that the 48 and 42 were interchanged after the first pass. Other errors included failing to select the 27 as a pivot for the fourth pass and a number of students failed to acknowledge that the sort was complete. As stated in previous examiners' reports students can make it clear that the sort is complete by either explicitly stating that the sort is complete or by choosing each item as a pivot or by re-writing the final list. Very occasionally, students selected only one pivot for each iteration or failed to sort the list into (values less than the pivot), (the pivot), (values greater 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 descending order usually remembered to reverse their list at the end to gain full credit although a number of students left their list in descending order.

In part (b) the majority of students knew how to carry out a bubble sort and nearly all did so correctly. Unfortunately, many students did not read the question carefully and either showed each comparison and swap during the first pass or during all subsequent passes. There were occasional errors including the loss of one item and many examiners commented on the frequency that students had the 77 before the 75 in the final 'sorted' list. A minority of students did not work consistently through the list of numbers. Finally, in this part, it was common for students to stop after a fifth pass due to the list appearing to be in the 'correct order'. With the bubble sort algorithm if the list finds itself ordered before the final two items in the list have been considered then either a suitable conclusion (that the list is sorted) or an additional pass is required.

Part (c) was undertaken well by nearly all students and a large proportion scored all three marks in this part. The vast majority of students were able to carry out the identification of middle right pivots correctly and very few selected middle left pivots. Most were then able to reject the correct sublist (including the pivot). In some cases, students wrote 'reject 1 – 11' in the first pass but then had, in the second pass, a list which included the 53. Many students, throughout this part, did set out their work in a very logical manner by adopting one (or more) of the following approaches:

- explicitly writing out, at each stage, their calculation for the pivot and circling or making their pivot clear;
- writing out their reduced list after each pass;
- renumbering their reduced list (from 1) before each new pass.

It is advised that in this type of problem it is essential that the choice of pivot is made clear at each stage as should the new sublist which is to be used in the next pass. Finally, when the search is complete it is important that the student provides a clear statement to the effect that the number being searched for has been found. Many students did not differentiate that the 68 was the number they were searching for and in many cases it seemed to be stated as a pivot and not the target value. It was sometimes unclear if at the end of the search that the 68 had been found or was, in fact, a number in a sublist with only one value.

Question 3

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 C, E and/or J). The route was usually given correctly and most students realised that whatever their final value was at J 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.

Most students attempted an explanation in part (b) and most were at least partially correct and scored at least one mark for an indication of 'working backwards' through the network. For both marks the explanation had to include (as a minimum) the idea of working backwards from the final vertex J and including an arc if the difference in final values was equal to the weight of the arc. Those students who listed their arc calculations were usually more successful than those who attempted a general explanation, though even here some simply listed their calculations without linking them to the corresponding arcs or vertices.

Part (c) differentiated well and very few students scored any of the two marks in this part. Only a minority showed an understanding that once Dijkstra's algorithm had been applied from a given node, in this case A, the final values for all other nodes show the length of the shortest route from A to each of these other nodes. Therefore the shortest route to E from A could be found by working backwards as described in part (b). Most students who did successfully navigated as far as E then failed to discover the shortest route from E to J which involved returning to node G.

Question 4

Part (a) was found to be particularly demanding and very many students seem to suggest erroneous arguments along the lines of:

- ‘an extra odd node would have no other node to pair with’: These students often stated that an even number of vertices of odd degree were required in order to use the route inspection algorithm
- Many students stated that ‘an odd number of odd degrees would make it impossible to traverse the graph’: These students often also stated that the graph would not be semi-Eulerian and sometimes argued that there would be half an arc with no end point
- Many students stated simply ‘handshaking lemma’ but usually with little success as it was often accompanied by little or no supporting comment or argument
- Some students attempted an induction based argument stating that if there are only even degreed vertices then every arc added must create two vertices of odd degree

Stronger students were able to score one of two marks – usually the first mark for stating a relationship between the number of arcs and the sum of the order of the vertices. There were also a significant minority of students who were able to provide clear and precise arguments and gain both marks.

Part (b) was mostly answered correctly, however, an answer of nodes A and H, appeared on more than one occasion.

Part (c) 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 AB with DE and AD with BE. 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 AE and BD should be repeated instead of the correct arcs AC, CE, BD.

Surprisingly, part (d) was rarely correct with the majority of students forgetting to add the 130 (from the additional arc AB) to the length of their shortest inspection route and so the incorrect answer of 2410 (rather than the correct answer of 2540) was often seen.

There were many excellent responses to part (e) with the majority of students realised that BE had to be repeated giving a difference in route lengths of 190. Some students found the right arc, BE, to repeat but then said B or E. Some students decided on E without considering the other options, having limited themselves to the route they picked in part (c) with an additional 320. A number of students worked out the new route length but then failed to answer the question which explicitly asked for the difference.

Question 5

Most students applied Kruskal's algorithm correctly in part (a), but some did not demonstrate the correct handling of rejected arcs, which is essential in this algorithm. Students would be advised to list all the arcs (from the network) in ascending order and then state 'add' or 'reject' next to each arc (or some other clear indication of which arcs are being included/not included in the MST). Some students lost the final mark by omitting one or more rejected arcs (usually BD) while a small minority scored no marks in this part as they failed to record any rejections.

Part (b) 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.

Most students could correctly work out the weight of the minimum spanning tree in part (c), with mistakes at this point usually following on from earlier mistakes when applying either Prim's and/or Kruskal's algorithm. Some students did not seem to be aware that the weight of the minimum spanning tree should be the same irrespective of the algorithm used. This should have provided evidence to the student that either part (a) and/or part (b) was incorrect if two different weights/trees were found in the first two parts.

Part (d) was often not attempted, and those that did usually failed to gain much credit. Very few students in part (i) showed an understanding that the sum of the order of nodes is equal to twice the number of arcs (giving an answer of $m/2$). Part (ii) was handled better as more students appreciated that the number of arcs in a minimum spanning tree is one less than the number of nodes (therefore giving an answer of $n – 1$). When parts (i) and (ii) were answered correctly it was common to see a strict inequality incorrectly used to link these two answers in part (iii).

Question 6

This was the most challenging question on the paper for many students, with very few scoring full marks. Most students were able to draw the required lines correctly in part (a) 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 $x + y = 8$ and $3y = 9 + 2x$ were correctly drawn. One of the most common errors was with the line $4y = x$ (many students drew $y = 4x$), the second most common error was not showing the line $x = 8$ as distinct from the other three in anyway (many students either ignored or did not notice the strict inequality constraint $x < 8$). In part (b) a significant number of students were unable to select the correct feasible region.

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

The majority of students who correctly answered part (c) usually went on to score the mark in part (d).

Parts (e) and (f) were often not attempted and many who did attempt part (e) identified the maximum point as (8, 8) (even though this was not in the feasible region) or gave a point with non-integer values despite the question explicitly asking for integer values. A minority of students identified the point (7,7) but failed to substitute the values into the objective function.

Part (f) differentiated well between students. Once again the management of the inequality provided a source of errors for those who had an understanding of what was required in this part but gave the incorrect answer of $k = 1/4$.

Question 7

In part (a) the majority of students were able to add the remaining three activities and the dummy successfully to their diagram. Some students placed the dummy correctly, but added extra event boxes to the network along with the additional activities. Some students drew the arcs for activities E, F and I as finishing at activity L. Arrows were usually placed correctly on the arcs, but sometimes one or more would be missing.

For part (b) the forward pass was generally completed correctly with the most common error being a value of 7 instead of 8 at the end of activity B. The backward pass was less successful with the dummies causing most of the errors, again particularly at the end of activity B, a value of 8 instead of 13 was relatively common. Students are advised to take time checking their values as a significant number of subsequent marks can be lost if errors are made at this stage.

Finding the lower bound in part (c) had more variable success; some did not do a calculation and tried to argue for a lower bound based on scheduling the workers despite the question asking for a calculation. Others made either arithmetical errors or conceptual errors (the most common being calculating the ratio of the earliest possible finish time (39) to the number of activities (12)) in their calculation.

For part (d) quite a few students drew a Gantt chart instead of a scheduling diagram, and so scored no marks. There were also quite a few instances where this part was left blank. Those that did schedule tended to make errors on activity G, which needed to take place after activities B and C. There were also errors in the duration of a number of activities meaning few scored full marks in this part. It would be advisable for students to check their working carefully to ensure that preceding activities are completed and that activities do not start before their earliest start time or continue beyond their latest finish time. Also it was common for at least one activity to be missing from the scheduling diagram.

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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