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Examiners' Report/
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Pearson Edexcel International A Level
Decision Mathematics D1 (WDM01/01)

Paper 01

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Report on IAL Decision Maths 1

(WDM01/01)

January 2016

General introduction

The paper proved accessible to the majority of candidates and there was little evidence of students running out of time. 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 also. Students are advised to make their method clear; 'spotting' the correct answer, with no working, rarely gains any credit. Students are further reminded that they should not use methods of presentation that depend on colour or highlighters, but are advised to complete diagrams in pencil. Candidates should ensure that they use technical terms correctly. This was a particular problem in question 2 part (a) and question 6 part (a).

Report on individual questions

Question 1

In part (a), the majority of students could identify the correct alternating path from D to 6 (or vice-versa) and this was then usually followed by a correct alternating path from B to 5 (or vice-versa) in part (d). There was nonetheless the usual loss of marks for some students due to a lack of the change of status being either stated or shown in both parts and/or failing to state the improved matching in part (a) or the complete matching in part (d). In some cases, students may have drawn the improved matching on diagrams which were not clear due to multiple arcs being drawn from individual vertices. If students are going to show these matchings on a diagram (rather than simply stating them) then only clean diagrams with the exact number of arcs will be accepted. Omission of the change of status and lack of stating the improved/complete matchings seem to be occurring less with each session but are unfortunately still evident.

Parts (b) and (c) represented a challenge to many students. In part (b), the vast majority provided an explanation about A and about tasks 4 and 5. It was common to see 'only A can do 4 and 5" although it was interesting to note that it was fairly common for candidates to cover every eventuality and write "only A can do 4 and 5" followed by "4 and 5 can only be done by A". Far less common, but equally valid were the longer, more elaborate arguments involving more than one worker, for example, an argument based on workers B, E and F and tasks 2 and 3. A minority of students did not realise what was required in this part and argued along the lines of "because C can only do 6" or similar. In part (c), the majority correctly selected E for training. Although most struggled to provide a fully acceptable reason or indeed in some cases any reason at all. Often candidates argued that E should be chosen because 4 can only be completed by one worker.

Question 2

The definitions in part (a) challenged many, particularly that of a 'connected graph' which challenged even the more able students, with some defining a complete graph and others being unclear about the nature of the connection between nodes. There were the usual confusions of technical terms, 'nodes connected by vertices' etc. Part (b) was often correct, some incorrect answers were seen, such as: $n, \frac{n}{2}$ and equations similar in nature to $n = n - 1$ or $n = V - 1$, where V was the number of vertices. In part (c), nearly all network diagrams were correct and included the correct weights. Some diagrams surprisingly contained only three or four arcs, but the majority of these students clearly did not go on to use this diagram to answer part (d). The arcs most often

missing from the diagram were either CE or the pair of arcs BC and CD. Occasionally, weights were missed out or incorrect. Most students applied Kruskal's algorithm correctly in part (d), but some did not demonstrate the correct handling of rejected arcs, which is essential for this algorithm. A number of students incorrectly rejected arc CF and instead included arc EF even though the rest of the arcs were selected or rejected correctly. Most students employed the recommended style of listing the arcs in order of increasing weight and then used ticks or crosses to indicate their inclusion or rejection, which made it straightforward to see when the arcs were rejected as well as which ones were being rejected. A number of students wasted time here by writing multiple lists or giving lengthy reasons for accepting or rejecting arcs. Nearly all students calculated the weight correctly in part (e). However, some added up all the arcs (even the rejected ones) and others omitted an arc from their calculation or simply made an arithmetic slip.

Question 3

It was evident that a significant number of students struggled to apply the first-fit bin packing algorithm in part (a). This was mainly down to not applying the algorithm correctly. First fit is just that; students must decide if the current item under consideration will fit in their first bin rather than the most recent bin used. In this part, a number of students placed the 10.9 in the second bin and not the first.

The majority of students were able to complete the first two passes of the bubble sort in part (b)(i), however many took several lines to do so and a significant number carried out the full bubble sort when only the first two passes were required. The vast majority started on the left-hand end of the list and sorted into descending order. There were very few errors in this part. However, there were mixed responses to part (b)(ii), in which students were asked to state the total number of comparisons and swaps performed during the first two passes. Some students missed out this part completely, either not understanding what was being asked or just forgetting to answer this part. Others gave completely incorrect answers. In between these two extremes there were those students who painstakingly listed each comparison and whether the result was a swap or not but then failed to state how many comparisons and swaps there had been in total. While a number of students gave the correct number of swaps as 12, it was surprising that the majority thought that the total number of comparisons was 18 rather than the correct 17. It can only be assumed that these candidates failed to realise that after the first pass of a bubble sort the smallest value is guaranteed to be in the correct position and so is therefore not compared during the second pass. Many correct solutions were seen in part (c), but a number of students did not choose their pivots consistently, switching between middle-left and middle-right pivots during the course of the quick sort algorithm. A number of students either lost an item or changed an item during the sort, and in a small number of cases, only one pivot was chosen per iteration. Some students did not indicate that their sort was complete. This could have been achieved either by having at the end a 'list sorted' statement, or every item in the original list being used as a pivot or the final list being rewritten at the end. Common errors included the 12.1, 15.7 and 14.0 being interchanged in the third pass or not choosing the 8.1 as a pivot for the fifth pass; students should be reminded that items should remain in the order from the previous pass as they move into sub-lists.

Part (d) was, in general, more successfully attempted than part (a). Most students scored full marks although there were sometimes errors with the placement of the 14.0 and/or 6.4

The most common explanation provided in part (e) was to consider a lower bound calculation which many students did correctly. Some students failed to relate their argument or calculation back to part (d) and therefore lost this mark as a result.

Question 4

In part (a), most candidates seemed to be confident and accurate in applying Dijkstra's algorithm. The most common errors were:

- errors in labelling – the same repeated labels were seen a number of times, for example, A and J both labelled as '1'. On a number of occasions, vertex G was labelled before vertex B,
- a small minority of students omitted working values at vertices J, D and E,
- a small minority of students made errors in the order of working values – usually at vertices B and K.

Irrespective of earlier errors, most students were able to give the correct shortest time (sometimes by following through from previous working) and only in a few cases did students not state the correct shortest route.

Many correct answers were seen in part (b) for the route from B to K via A and its corresponding length. Though they had part (a) correct, some students then gave the route from B to A as BEA and/or the route from A to K as AJK. These students had therefore failed to use the final values from part (a) to work backwards from both B and K to obtain the required route via A.
The vast majority of students did not realise the connection between part (a), in which the shortest distances from vertex A to any other vertex had been found and part (c). Therefore, many students went on to make at least one error in the totals for the pairings in part (c). Even though part (c) explicitly told the candidates to use the route inspection algorithm, many students failed to state the three distinct pairings of the correct four odd nodes. Very few students stated all combinations of edges that Oliver could repeat (examiners had to explicitly see the arcs AF, BK, KH and AE, ED, DB, FG, GH stated) and a number did not calculate the shortest time needed.

Question 5

Most students were able to draw the required lines correctly in part (a) although some were unable to draw lines with sufficient accuracy (some drew lines without a ruler) or sufficient length. A number of students only drew lines in the first quadrant even though no explicit restriction was given for the value of y. On this point, the following general principle should always be adopted by candidates: lines should always be drawn which cover the entire graph paper supplied in the answer book.

In general, the lines $x = 3$ and $x + y = 9$ were correctly drawn and where errors did occur, they tended to be with the other two lines. Students are advised to calculate accurately both the x and y intercepts when they are required to draw lines with negative gradient. Furthermore, a significant number of students were unable to select the correct feasible region.
The drawing of an objective line in part (b) caused problems for a significant number of students. The most common errors included:

- the failure to draw an objective line,
- the drawing of an objective line that was too short to be of any practical use in finding the optimal vertex of the feasible region,
- the drawing of an objective line with reciprocal gradient or,
- the drawing of an objective line with an incorrect gradient.

Of those students who had both a correct feasible region and objective line, many did not label the optimal vertex on their graph as requested. In part (c), many students attempted to read the coordinates of V from their graph and it was rare to see students finding the coordinates of the optimal vertex using simultaneous equations. Students are reminded that the instruction on the front cover of the paper explicitly states that: '*You should show sufficient working to make your methods clear. Answers without working may not gain full credit*' and so students who failed to

show a method for solving their simultaneous equations did not score full marks in this part. While a number of students found the exact coordinates of vertex V they then failed to find the corresponding value of P at V which, by definition, also had to be given exactly. In part (d), many students failed to give both their x and y values as integers. Those who did, often gave the point incorrectly as $(3, -5)$ or failed to state the corresponding minimum value.

Question 6

This question was well attempted with no indication that time on the paper was an issue – most students attempted all parts of the question. More able students used terminology correctly to accurately describe why both dummies were needed, with the precedence argument for the dummy from event 5 to event 6 being described most accurately. Whilst many students knew what they wanted to say for the dummy between events 7 and 9, they were unable to express themselves clearly, instead trying to repeat verbatim a learnt phrase. It is insufficient to simply say something along the lines of, 'so that activities can be defined uniquely', instead students must mention the need to describe activities uniquely in terms of the events at each end.
For part (b) the forward pass was generally completed correctly with the most common error being a value of 11 (rather than 13) at the end of activity D (which therefore meant a value of 13 rather than 15 being given at the end of activity I). The backward pass was less successful with the dummies causing most of the errors, with a value of 14 (rather than 13) being given at the end of activity F and a value of 9 (rather than10) being given at the end of activity A. 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.

Part (c) was nearly always answered correctly. Finding the lower bound in part (d) had more variable success; some students 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 with the most common conceptual error being calculating the ratio of the earliest possible finish time (21) to the number of activities (11) required.
Part (e) was answered well with many fully correct diagrams seen following correct answers in part (b). Very few students failed to include all the activities. There were a few slips with lengths of activities and/or floats. Those with errors in part (b) were usually able to get at least four non-critical activities correct.

Part (f) discriminated well. Most students attempted a solution with three workers, however a significant number incorrectly used four. Many used a finishing time that was greater than their completion time + the additional one hour thus scoring a maximum of only one mark in this part. Many students omitted or 'shortened' an activity to ensure they finished by the required completion time. Of those students who used a finish time of 22, the only consistent error noted, apart from the lengths of certain activities, was the precedence of activities I and K.

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