Examiners' Report

Principal Examiner Feedback

October 2020

Pearson Edexcel International A Level

In Decision Mathematics 1 (WDM11)

Paper: 01 Decision Mathematics 1

General

This paper proved accessible to the candidates. The questions differentiated well, mostly producing a good spread of marks. There were marks available to grade E candidates in all questions and there appeared to be sufficient challenging material for A grade candidates too. It was very rare for a candidate to make no attempt at a question, leaving just blank pages.

As has been stated before, Decision Mathematics examinations are methods-based; consequently, candidates should be reminded that it is vital to display their method clearly. A correct numerical answer, without supporting working demonstrating their method, rarely scores any marks.

Some candidates waste valuable time producing unnecessarily long solutions, for example in the Bubble Sort and Kruskal's algorithm.

Some very clear well-structured solutions were seen by examiners. Handwriting was generally better than sometimes seen in past sessions, so that it was rare for examiners to struggle to understand what was written by candidates.

Report on individual questions

Question 1

This question was well attempted by the majority of candidates.

Most gained both marks in 1(a), although a small number did not add weights to their network. There were a few candidates who omitted an arc (such as DB or DF) or misplaced one arc (e.g. EF instead of EA). Where candidates scored no marks in this part, they appeared not to have read the question fully and were using the diagram to answer part (b).

In (b) many were able to apply Kruskal's algorithm correctly, with very few cases of Prim's or Nearest Neighbour algorithm being seen. However, common mistakes which lost both A marks included adding AB and rejecting AF in favour of BC. Another typical error was omitting one of the rejected arcs from their list, which lost the last A mark only. Some of these errors were the result of a missing arc in (a) or apparently misreading numbers from their own diagram. Among those candidates scoring no marks in (b), the most common errors were only showing the five arcs chosen, with no reference to rejections, or omitting one of the first three arcs to be chosen.

In (c) almost all candidates who had completed (b) correctly went on to gain both marks for the Minimum Spanning Tree and its weight. Similarly, errors in (a) and (b) generally led an incorrect MST and weight. A few who had gained no marks in (b) were able to score both marks in (c).

Question 2

In (a)(i) many candidates were able to correctly state that the bubble sort started by comparing the first and second numbers in the list and making a swap if the first was larger than the second. However, some failed to clearly show the comparison was a matter of size, or showed the swap the wrong way round (descending). Whilst a number of complete answers were seen, many lost the A mark, not stating that the second comparison was between the (new) second and third numbers in the list or that the comparisons continued in this way until the end of the list was reached.

Part (a)(ii) was not generally well answered, with many candidates giving minimal answers or no answers at all. The most common answer to gain one mark was that the sort ended when no further swaps were made in a pass. Equally, many lost this mark for stating the obvious, that the sort ended when the list was in order. Very few gave the other answer, that the sort stops when a list of length 1 is reached. Those that did, often referred to $n - 1$ pass having been done, which was also acceptable. It was surprising how many candidates gave only one answer for this part, when two marks were available.

Part (b) was also not well answered. Those candidates who correctly stated 3 passes often lost the second mark because they did not explain that only the 3 largest numbers were correctly positioned. These included those who mentioned the 3 values, but not their significance as the largest. The most common incorrect answers seen were ‘9 (or 10) passes’, referring to a complete sort, ‘6 passes’, again in relation to completing the sort, and 45, with calculations indicating candidates were thinking of comparisons rather than passes.

In (c), the most common marks awarded were M1A1A1A0, as candidates completed the first five passes correctly but failed to include a sixth pass to show that no more swaps would take place. A few failed to complete the sort, leaving the 0.9 and 0.7 in the wrong order. There were a few instances of candidates sorting the list into descending order or attempting a Quick Sort. These received no marks. It is worth noting again that, despite the question asking for the state of the list at the end of each pass only, some candidates are still using a lot of time unnecessarily writing each pass in full.

In (d) the majority completed the bin packing successfully. The most common errors involved misplacing 1.7 and 1.5, losing all three marks, or failing to place 0.7 in the first bin, losing the final mark. A significant minority of candidates used their list in ascending order from (c), inevitably gaining no marks.

Question 3

The travelling salesman problem was introduced in the new specification and first examined last year. Questions on recent exam papers involved finding an upper bound, using the nearest neighbour algorithm, and finding a lower bound, from a reduced minimum spanning tree, each examined again here in (b) and (c). However, this is the first time, in (a), that the short cut method for finding an upper bound has been tested. Many candidates either did not attempt this part of the question or were unable to score any marks. As the starting point, a diagram of the minimum spanning tree, with weighted arcs, was printed in the answer book, along with its total weight. Few candidates recognised that the method starts by doubling that weight, and then reducing that figure using shortcuts, with the resulting graph connected and Eulerian. Almost all those who did make a correct start, failed to clearly specify their shortcut(s), by naming both the arc(s) to be added and those no longer to be repeated. Attempting to draw and delete arcs on the diagram scored no marks. Candidates should be advised to name all arcs involved, both added and removed, and show their calculations in full. A handful of candidates did indeed do this.

A greater proportion of candidates were able to score both marks in (b) using the nearest neighbour algorithm to find an upper bound. However, some omitted the return to vertex A, having found the correct path from A to C, in which case their length was also usually incorrect, so both marks were lost. In some cases, candidates doubled their correct length, losing the second mark.

Candidates were most successful finding the lower bound in (c), and a majority scored all 3 marks. But a surprising number of attempted reduced spanning trees, whilst correctly omitting vertex E, had five arcs so losing all 3 marks. Almost all spotted the correct two arcs BE and EF to connect to their RMST.

Question 4

This question required the construction of a network involving four dummies, which is more than seen in recent sessions. Many candidates scored well in (a) with a good number of candidates demonstrating their understanding and correct interpretation of the precedence table, earning full or near to full marks. This perhaps represents something of an ongoing improvement in the standard of responses for this part of the specification.

Almost all candidates were able to start their activity network with one start node leading into activities A and B, correctly placing the first dummy (leading from the end of activity A to the end of activity B) and correctly placing activities C and D to earn the first two marks. The most common mistake was for the second accuracy mark, which was awarded for correctly placing the second and third dummies, and for activities E, F and G being dealt with correctly. Where errors occurred, candidates omitted one of these dummies and placed a single dummy from the end of activity C to the end of activity D. In general, candidates who did this were then able to pick up the next accuracy mark for then correctly placing the fourth dummy (leading from the end of activity F to the end of activity E) and for dealing with activities H, I, J and K correctly.

Very few candidates had multiple end nodes or wrote their activities on nodes – common errors in previous sessions. Most candidates recognised the importance of arrows on all activities, but in some cases the final mark was lost for one missing activity arrow. At least two marks were lost for the omission of arrows on one or more dummy activities.

In part (b) many candidates incorrectly stated activities 'B, D and F' as critical, with fewer earning the mark for correctly stating only D and F. The correct critical path (ACGIJ) was identified by some candidates, the most common error was including activity H.

Question 5

This question proved to be a good source of marks for many candidates whilst also providing opportunities for differentiation. Well-prepared candidates should have experienced few issues with parts (a) to (c) but were likely to find that part (d) was far less familiar. In fact, full marks were rarely awarded due to the challenge provided in part (d).

Part (a) was a very standard question and as a result, almost all candidates were able to make a reasonable attempt. It was rare to see boxes left empty and extremely rare to see a completely blank attempt. Most candidates completed the top boxes correctly and errors most commonly arose in the bottom boxes. Such errors perhaps occurred more often than has been seen in previous exam series. Nonetheless, the two method marks were usually awarded as a minimum.

Candidates seemed to fare less well in part (b). Whilst many fully correct answers were seen, the number of candidates who made errors here was surprising. For example, in summing the total activity length to obtain values other than 87, in calculating the finish time divided by number of activities (33/15) or in attempting to argue a lower bound via scheduling rather than via a calculation as was requested. A minority of candidates simply stated '3', which gained no marks, as the question states 'You must show your working'. In some cases, this part of the question was left unanswered, surprisingly, given the presence of similar questions in many past exam series.

When a scheduling solution was attempted, part (c) was often well answered. Unfortunately, though, a significant number of candidates were ineligible for marks here as they incorrectly attempted a cascade chart instead. Furthermore, although the question asked for a schedule using the 'minimum number of workers', some candidates attempted schedules with four or more workers which greatly limited the number of marks available to them. Likewise, those candidates who missed out one or more activities or indeed those that repeated one or more activities in their schedules were also limited to one mark only here. Despite being only question five on the paper, a number of candidates appeared to run out of steam after plotting only a handful of activities on their schedule. Conversely, some candidates wasted valuable time completing a cascade diagram prior to completing a schedule. To avoid the inevitable time cost associated with such an approach, candidates should be encouraged to draw schedules directly, without the need to rely on a cascade chart. Whilst schedules were, on the whole, completed accurately, errors did arise, some due to errors in part (a). Otherwise, errors occurred for a range of reasons: sometimes precedence relationships were violated, for example at H, I or K. Sometimes durations were incorrect where an activity was drawn with length equal to its duration plus its float and less commonly, activities were drawn outside their correct time interval.

Part (d) provided much more of a challenge, with only a few of the most able candidates able to gain both marks, by identifying the correct reasoning. Indeed, it was fairly rare to award even one mark out of two. Many candidates did mention the fact that D was a critical activity but failed to mention that P was also a critical activity. Fewer candidates mentioned that G was not a critical activity. The question was successful in uncovering a number of misconceptions, for example, "G should be shortened as it has a float", "P should be shortened as it is the longest activity", "D should be shortened because P depends on D". Most candidates seemed to be lost here and were unable to isolate the key reasons for shortening D and instead gave a range of erroneous suggestions.

Question 6

This question was a less familiar style of linear programming question than those seen in some previous exam sessions. Nonetheless, most candidates were able to pick up some of the marks in both parts.

It was surprising that in part (a), a number of candidates were confused by the statement "determine the inequalities that define R" such candidates gave a general explanation of what a feasible region is rather than simply defining the particular region given in the question in terms of inequalities. A minority of candidates wasted time here re-establishing the equations of the three lines that border R and some unfortunately gave strict inequalities. Others unnecessarily rearranged the inequalities to make y the subject which had not been requested in the question. Most candidates, however, were successful in obtaining both marks.

Part (b) provided more of a challenge to many candidates. There were two main approaches here, a vertex approach, and a gradient approach. The former was the most common, but it seemed that the majority of candidates employing this strategy were unable to produce a complete method. Having been told in the question that the maximum value of P occurred at C, most candidates began by finding the coordinates of C, which on its own was not creditworthy. A significant number of candidates made no further progress here. Many of those candidates that did continue did not recognise that the minimum value of P must occur at vertex A and so were unable to see that $b = 4$. Instead, many persevered with general statements for P involving a and b. As the question had not directly mentioned vertex B, many candidates did not realise the need to find the coordinates of B and to compare the value of P at B with the value of P at C. Instead, some candidates compared the expression for P at C with 8, obtaining $a > -1$ or even $a < 1$. Other candidates, who had failed to determine b, either came up with 'creative' ways to remove b from their calculations or ground to a halt unable to make progress with an inequality in two unknowns. Often the gradient approach was more successful. Although, it was still necessary for candidates to engage with vertex A to determine the value of b and sometimes this proved to be a stumbling block in this approach as was the case for the vertex approach. Often candidates employing a gradient approach did so with minimal working which, given the potential for error with inequalities and minus signs, was risky and sometimes led to few marks being awarded. Nevertheless, it was pleasing to see some succinct and confident solutions which demonstrated secure understanding of linear programming.

Question 7

Attempts at this question generally started well, in (a), with many candidates demonstrating their knowledge and skills when applying Dijkstra's algorithm, resulting in scoring the first four marks. However, examiners once again saw some cases of no replacement of working values at all, which lost the initial method mark and therefore ruled out the following 6 accuracy marks, even when almost all final values were correct. It is worth emphasising to candidates that this is a methods paper, and, as such, methods must invariably be fully demonstrated. As usual there were some arithmetic slips, and one relatively common error was omission of the third working value, 20, at vertex C, causing incorrect final values at both C and F, losing two marks. In spite of the unknown 'x' in two arc lengths it was good to see that many candidates wrote down the three correct working values, 70, $37 + 2x$ and $51 + x$, in order, at H. However, it was disappointing that the majority then lost marks due to failing to follow this up by stating the three routes and their respective lengths.

Part (b) proved to be a challenge with some candidates giving up here and others failing to recognise that this was a route inspection problem, utilising an answer from (a). A good number of candidates did spot that A and H were the two odd nodes so that a path between them should be repeated. Muddled thinking was then often evident here. The correct working was $(3x + 205) + (37 + 2x) = 307$. Variations often seen were $3x + 205 = 307$, $(3x + 205) + 2(37 + 2x) = 307$ and just $2(37 + 2x) = 307$.

Question 8

This question proved to be quite challenging for candidates and while full marks was very rare, so was zero. There was evidence that some candidates ran out of time (only attempting part (a)), but most candidates were able to make at least some progress with this question with only the strongest candidates finding a correct solution of the Linear Programming problem.

It was less common than previous sessions to see the objective with 'minimise' missing. In setting up the constraints, there was a reasonable amount of work to be undertaken. Almost all candidates were able to correctly write down the constraint for the total number of doughnuts made. More common were errors in the other three constraints. The second constraint, for the relationship between ring doughnuts and jam doughnuts, was frequently seen with either the incorrect direction for the inequality sign or with the coefficient '3' on the wrong side of the inequality. Sometimes both errors were made. For the third and fourth inequalities, 'at most 70% of doughnuts must be ring doughnuts' and 'at least a fifth of the doughnuts must be jam doughnuts', marks were lost, again when the direction of the inequality sign was incorrect or when a candidate had not given the inequality with simplified integer coefficients. Strangely a common mistake was attempting to find 15%, rather than finding 1/5, often costing the candidate more marks in part (b). Few candidates did not attempt this part of the question and less than in previous sessions incurred a penalty for leaving their answer in percentage form. The requirements to simplify and have integer coefficients were mostly recognised by candidates.

Candidates attempting an answer in (b) were generally successful in correctly calculating either the value for x or the value for y. For the second M mark, candidates were expected to use their least value of y and their greatest value of x to calculate z. Some candidates then lost several marks when incorrectly attempting to use the inequality $3y \leq x$. Candidates who successfully found a value for z, using the correct constraints, were then able to state the correct values for x, y and z, but many lost one mark for failing to give their answers in context. However, they still managed to use their values to obtain the correct cost of 1800p. Unusually, a very small number of candidates, who showed no algebraic working in (b), were treated as a 'Special Case', and gained some marks for obtaining the correct values for x, y and z with the correct cost. They were awarded either three or four marks out of six, with the rationale that their correct answers must imply the correct underlying method, though it was not shown. However, one small slip would have been enough to lose all marks, so this is not an approach to be recommended.