Examiners' Report

Principal Examiner Feedback

Summer 2019

Pearson Edexcel International A Level

In Decision Mathematics D1 (WMA01/01)

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Summer 2019
Publications Code WDM11_01_1906_ER

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Decision Mathematics 1 (WDM11/01)

Introduction

This was the first series that the new IAL Decision Mathematics 1 unit was offered to candidates. The content difference from the previous D1 unit (WDM01/01) is in the removal of the topic of Matchings and the inclusion of The Travelling Salesman problem.

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

Candidates are reminded that they should not use methods of presentation that depend on colour but are advised to complete diagrams in (dark) pencil. Furthermore, several candidates are using highlighter pens even though the front cover of the examination paper specifically mentions that this type of pen should not be used.

Candidates should be reminded of the importance of displaying their method clearly. Decision Mathematics is a methods-based examination and spotting the correct answer, with no working, rarely gains any credit. Some candidates are using methods of presentation that are very time-consuming, this was particularly true in Q2(b), the application of Prim's algorithm, where several candidates ran out of space (and possibly time) unnecessarily completing the algorithm in tabular form. The space provided in the answer book and the marks allotted to each section should assist candidates 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. Candidates should ensure that they use technical language correctly. This was a problem in Q4 (a) and Q5(b).

Report on Individual Questions

Question 1

It was pleasing to see that most candidates were well prepared for this question on the new topic of The Travelling Salesman problem and there was little evidence of candidates being unfamiliar with the demands of this question. Part (a) was usually answered correctly with many giving the correct nearest neighbour route as ADEFBCA (and corresponding length of 221 km) with the most common error being a failure to return to A. In part (b) many candidates understood the need to add the two smallest weighted arcs incident to A to the weight of the residual MST and while many correctly showed the adding of 55 to their RMST weight many made errors in initially calculating the weight of the RMST. In part (c) most candidates correctly gave their interval as an inequality and many gave an answer of either $183 \leq \text{length} \leq 221$ or $183 < \text{length} \leq 221$. A number of candidates incorrectly gave a strict inequality for the upper bound and so failed to realise that as the nearest neighbour algorithm had earlier found a Hamiltonian cycle for the network this therefore guaranteed that a route of length 221 existed.

Question 2

Part (a) was usually very well done with most candidates 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 candidates 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 E, J and/or K). The path was usually stated correctly, and most candidates realised that whatever their final value was at J, this was therefore the value that they should give for the length of their path. As noted in previous reports because the working values are so important in judging the candidate'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 generally well answered with most candidates applying Prim's algorithm correctly starting from vertex A. A few candidates attempted to construct a table to perform Prim, clearly believing that Prim can only be performed when expressed in matrix form. There is still a small minority of candidates who appear to be rejecting arcs when applying Prim's algorithm so scoring only one of the three possible marks in this part. Finally, some candidates did not read the question carefully and applied Prim to the entire network and not just for nodes A to E.

Most candidates applied Kruskal's algorithm correctly in part (c), but some did not demonstrate the correct handling of rejected arcs, which is essential for Kruskal's algorithm. Candidates 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 candidates lost the final mark by omitting one or more rejected arcs while a small minority scored no marks in this part as they then failed to record any rejections. Finally, some candidates applied Kruskal to the entire network and not just on nodes F to K and therefore scored no marks in this part.

The most common incorrect answer to part (d) was 64 which came from forgetting to add the length of the arc EF to the length of the two spanning trees found in parts (b) and (c).

Question 3

Part (a) was generally very successfully attempted. Most candidates carried out a correct calculation and rounded their value up to give the correct lower bound. It was rare to see '1785' (the total of all the numbers) divided by 10 (the number of schools).

Examiners reported that a significant number of candidates struggled in applying the first-fit bin packing algorithm in part (b). This was mainly down to not applying the algorithm correctly. First fit is just that; candidates must decide if the current item under consideration will fit in the first bin rather than the most recent bin used. In this part several candidates placed the 10 in the fourth bin (and not the second bin) and others did not place the 7 in the first bin.

Many correct solutions were seen in part (c), but several candidates did not choose their pivots consistently, switching between middle-left and middle-right pivots during the quick sort algorithm. A few candidates 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. As stated in previous examiners' reports candidates must 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 rewriting the final list. Common errors included the items 8 and 9 being interchanged in the second pass and/or the 7 (or 15) not being used as a pivot for the fourth

pass; candidates should be reminded that items should remain in the order from the previous pass as they move into sub-lists. There were only a few instances where candidates 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 candidates over complicated the process by insisting on using a different 'symbol' to indicate the pivots for each pass. Those candidates who sorted into ascending order usually remembered to reverse their list at the end to gain full credit although several candidates left their list in ascending order.

The first-fit decreasing in part (d) was well carried out with only a small minority failing to attempt this part. There were many wholly correct answers. A small number performed first-fit increasing therefore scoring no marks. A small minority of candidates lost the second mark by placing the 10 in the third rather than second bin (so failing to apply the algorithm at its first real test). Some candidates 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.

In part (e), most candidates were able to identify the correct four odd nodes and most paired them correctly. There were thankfully few candidates who made the error of considering less than the three pairings. There were however, perhaps surprisingly, frequent errors in the pairing totals. A common error arose in the pairing BH + CG. However, errors in the totals often did not affect the choice of repeated arcs which were usually stated correctly. Candidates should however note the requirement for repeated *arcs* rather than repeated *pairings* as there were several candidates who lost a mark for stating simply BC + GH. Some candidates were clearly on 'autopilot' and stated the length of the route here rather than (or as well as) in part (f).

Parts (f) and (g) proved to be good discriminators with many stating a correct route in part (f). Part (g) was often left blank but for those that attempted it many correctly stated that C would be the finishing vertex for Sally's route and that the difference in lengths of the routes would be 25.7 m.

Question 4

More able candidates were able to use terminology correctly to accurately describe why both dummy activities were needed in part (a), with the precedence argument for the dummy from event 2 to event 3 being described most accurately. Whilst many candidates knew what they wanted to say for the dummy between event 6 and event 7, 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 candidates must mention the need to describe activities uniquely in terms of the events at each end.

Part (b), in which candidates had to complete the early event times and late event times, was often done extremely well. Errors occasionally occurred in the early event time at the beginning of L or with one or two of the late event times (most notable at the end of G and/or at the end of B). However, either full marks or three marks out of four were common in this part.

Part (c) was answered well with many correctly stating the minimum completion time as 26 hours and the critical activities as A, D, I and M.

Part (d) discriminated well with many candidates correctly determining that $9 + x$ was a possible early and late event time at event 7 but very few candidates also realised that 12 was a possible early event time and 15 was a possible late event time too.

In part (e) many correctly determined that the value of x was 10 but it was also common to see an incorrect value of 11.

Question 5

This was probably the most challenging question on the paper for most candidates, with very few scoring full marks. In part (a) candidates had to write down an inequality to represent the constraint that for every 3 medium shirts ordered the manager would also order at least 5 large shirts. While many correctly stated the constraint as $5y \leq 3z$ a number either incorrectly used a strict inequality or gave the answer as $3y \leq 5z$.

Part (b) was answered extremely well with many candidates correctly writing down statement in context that described the given constraints; where issues occurred was either in implying equality (e.g. the total number of shirts must be 250) or a strict inequality (e.g. less than 20% of all the shirts should be small).

Nearly all candidates who attempted part (c) correctly wrote down the objective as $6x + 10y + 15z$.

In part (d)(i) most candidates correctly substituted $z = 150$ into their inequalities to form inequalities in terms of x and y only, however, some failed to simplify or did not realise that the question required that the coefficients be given as integers.

Most candidates were able to draw the required lines correctly in part (d)(ii) although some were unable to draw lines sufficiently accurately (some drew lines without a ruler) or sufficiently long enough. As stated in previous reports 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 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 candidates 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. Furthermore, a significant number of candidates were unable to select (or even label) the correct feasible region.

In part (e), most candidates drew the correct objective line, however, a line with reciprocal gradient was sometimes seen or, in several cases, no objective line was drawn (and therefore no marks could be awarded in this or the next part). Some used obscure constant values to plot the objective line and some candidates did not label the optimal vertex clearly.

Most candidates in part (f) correctly stated the correct cost but did not state the number of each type of bookcase the company should make and simply stated that $x = 50$ and $y = 50$.

Part (g) discriminated well with very few candidates infer that the minimum number of large shirts was 125 and that this would lead to a cost of £2925 (which was £125 less than the amount found in part (f)).

Question 6

Candidates generally showed a good understanding of the process of constructing an activity network from a precedence table in part (a), using arcs drawn with arrows and labelled for activities. Some scripts 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 candidates were unsure about the placement of their dummies, putting them in 'anywhere' so that they had more than the minimum (of four). A very small number of candidates put activity on node, and some failed to check that they had all activities present, with either activity J or K being the activities that were missing most often.

In part (b) many candidates correctly stated the critical path as AEK

In part (c) only the most able candidates realised that there were only two possible critical paths (CHIM and CHIL). Many candidates either randomly wrote down a string of activities or wrote down more than two possible critical paths.

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