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Examiners' Report
Principal Examiner Feedback

January 2019

Pearson Edexcel International Advanced Level In Decision Mathematics (WDM01/01)

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Introduction

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 question 6(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 questions 1(a), 2(b) and 6(a).

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. Candidates need to use the correct technical language such as 'nodes' or 'vertices', rather than points, dots, people, data, etc. Some candidates were thrown by the diagrams and had explanations referring to columns of nodes. A lot of candidates 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 almost always completed correctly with very few errors seen by examiners.

Part (c) was well attempted and most candidates were able to write down an alternating path from either D to 3 or from B to either 1 or 3 and then proceeded to find a corresponding second alternating path. It is important that examiners can clearly identify the alternating paths, so they should be listed (rather than drawn) separately, rather than left as part of a 'decision tree' of potential paths. Several candidates 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 candidates did not state the improved matching or the final complete matching. If candidates are going to display either their improved or complete matching (or both) 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.

Finally, some candidates stated D – 2 = A – 4 = C – 3 and B – 5 = E – 6 = F – 1 side by side, with no improved matching, so it wasn't clear to examiners if the algorithm was being applied correctly and hence only three of the six marks could be awarded in part (c).

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 J or K). The path was usually given correctly, and most candidates realised that whatever their final value was at L, 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.

Most candidates 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 L and including an arc if the difference in final values was equal to the weight of the arc. Those candidates 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), where attempted, was generally well done, although often it was not answered. In some cases, candidates wrote down the route but did not state the length. This part was often calculated from scratch with few candidates making effective use of (a).

Question 3

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

Part (b) was answered extremely well with most candidates correctly stating the three critical activities.

Part (c) was answered well with many fully correct diagrams seen following correct answers in part (a). Very few candidates failed to include all the activities. There were a few slips with lengths of activities and/or floats. Those with errors in part (a) were usually able to get at least seven non-critical activities correct and so could score at least three marks in this part.

Part (d) proved to be a good discriminator and it was rare for candidates to score both marks in this part. Many candidates either failed to list the activities or did not refer to time even though the question asked for a specific reference to both activities and time. Several candidates gave an answer based on scheduling the activities to workers even though the question said that their answer should relate to the cascade diagram. Finally, many candidates thought five workers and not four were required.

Question 4

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 11 (the number of boxes).

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 115 in the second bin (and not the first bin) and others did not place the 150 in the second bin. Many candidates did not read the question carefully and failed to state the number of times the van would be used.

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. Several 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 250 and 390 being interchanged in the first pass and/or the 105 not being used as a pivot for the fifth 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 all three marks by placing the 180 in the third rather than the 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.

Many candidates struggled with part (e) and very few came up with a solution that required only four vans, each containing three values which summed to 475 or less. The most common errors were solutions that involved five vans or more than three values in a van.

Question 5

Candidates generally showed a good understanding of the process of constructing an activity network from a precedence table in (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 three). A very small number of candidates 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.

In (b) only the most able candidates realised that if D was critical then B, E, H and K are guaranteed to be critical too. Many candidates either randomly wrote down a string of activities or wrote down one or more possible critical paths.

Question 6

Part (a) proved to be something of a differentiator. It was very rare for examiners to award both marks here. Indeed, earning one mark proved to be challenging for many as there was often appeared to be confusion between valency and vertices. Many candidates tried to explain that an edge has two ends but then many went on to infer that this meant that every edge added two vertices to the network rather than increasing the total valency by two. Worryingly, many candidates did not use technical language: using instead 'point' for vertex/node and 'line' for arc or indeed confusing the technical terms vertex, valency, arc, etc. Insufficient arguments often included explanations along the lines of:

- an edge has two ends so if there are an odd number of vertices of odd valency then one arc will have nowhere to finish.
- you would need to start at finish at an odd node and so there must be an even number of odd nodes.
- the odd vertices need to be in pairs so if there is an odd number of them then one will be left out

The most successful candidates, here, were those that were able to articulate that the total valency of the nodes is double the number of arcs although many who did manage this were then unable to be precise/thorough enough in their explanation to warrant both marks.

Part (b) was generally well done. Examiners noted that very few candidates gave explicit rejections although some did appear to apply Kruskal's in a fashion rather than Prim's (albeit without explicitly stating rejections). Occasionally HJ was omitted at the end of the selection and on a couple of occasions candidates had calculated the weights of the arcs given in terms of x incorrectly which lead to errors in their application of Prim's. The mark for the weight of the network was often awarded.

Part (c) was an excellent differentiator and provided an effective way of testing true understanding of route inspection. It was rare for examiners to award full marks with the modal mark here being three out of possible six. Almost all candidates who attempted this part (and most candidates did) were able to state or imply that 'BE' would need to be repeated and most were able to correctly work out the length of the three possible repeats and go on to set up and solve at least one of the corresponding equations in x. Occasionally errors cropped up – particularly in the BC CE pairing although sometimes this was due to candidates incorrectly reading their own handwriting. Very often $4x + 3$ was simply ignored without comment with candidates proceeding to consider the remaining two pairings and never analysing the circumstances for one pairing giving rise to a shorter route than the other. Quite a few candidates used the stated range for x ($x > 3$) to determine corresponding ranges for $4x + 2$ and $7x – 17$ but then were unable to progress further; failing to realise that they needed to consider the value of x at which $4x + 2$ would equal $7x – 17$. Of those that did find the critical value of $x = 19/3$ there was further differentiation between candidates as only a small proportion of candidates were able to go on to correctly demonstrate the inconsistency of the value of $x = 143/24$. For the most successful candidates, by far the most common approach was to consider the critical value of $x = 19/3$ and then verify the consistency of the values of x obtained directly. There were however, a handful of candidates who approached the problem in the alternative way by calculating the total length of the repeated arcs for each (of the 2 or 3) values of x and establishing consistency at this point.

Very occasionally, candidates did not understand that the value of x had changed since part (b) and so assumed that $x = 9$ still applied. They then simply worked out the time taken for the route repeating arc BE with $x = 9$.

Question 7

In (a) the objective function was often found correctly but the absence of the word 'maximise' meant that the first mark could not be awarded. Most candidates correctly stated the constraint $x + 4y \leq 30$ (and so scored the method mark) but then did not read the question carefully and gave the two remaining constraints as $1.5x + 4y \leq 35$ and $2.5x + 3y \leq 45$ even though the question asked for integer coefficients.

Most candidates were able to draw the required lines correctly in (b) 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 (c), 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 (d) correctly stated the correct profit but did not state the number of each type of bookcase the company should make and simply stated that $x = 10$ and $y = 5$.

Very few candidates correctly attempted part (e) and while some deduced that the packaging stage was the stage that needed less time many gave the difference in times as either 10 hours (or sometimes as 5 minutes) rather than the correct 5 hours.