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Examiners' Report
Principal Examiner Feedback

January 2022

Pearson Edexcel International Advanced Level In Decision Mathematics (WDM11/01)

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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; they are reminded that 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 2, 5 and 7(b).

Report on Individual Questions

Question 1

Overall, this question was accessible to all candidates with the majority able to access all parts. There were many perfect solutions seen.

Most candidates answered (a) very well, showing sufficient working. Very occasionally candidates forgot to round their answer up to 4. The odd rare case tried to explain using full bin method or divided by a number other that 40 e.g., 10.

Generally accurate well-presented solutions were seen in (b), with only a few errors seen when placing the values, most commonly the 5. Some candidates did not read the question carefully and either sorted the list first or used full bins. Some other candidates also decided a full bin was a number less than 40 and placed the 8 incorrectly.

There was a definite improvement in the quality of responses seen in (c) compared to previous years. Pivots were well chosen and clear, usually middle right. A minority of candidates did not sort into ascending order and instead sorted into descending. A few candidates are still unaware of how to end the algorithm; too many assumed that because the 5 and 9 were in their correct final positions, they did not need to give a ‘sort’ complete statement or show a fifth (final) pass.

Part (d) was also extremely well answered with only the clarity of how to clearly show that the 9 had been found being the main reason why some candidates did not score full marks. There were several candidates who used the unsorted list (which showed a lack of understanding of the what the algorithm is doing). Other common mistakes seen were in retaining a pivot value from one pass to the next (when the algorithm says that unless the pivot value is the value that is being searched for it should be discarded) and choosing middle left rather than middle right values.

Question 2

This question was found to be very accessible to most of the candidates although full marks was rare.

Part (a) was answered well, though without confidence by some candidates, who possibly hedged their bets on what a path was by finding one (e.g., ABCEGFHJ) that passed through all vertices. However, nearly all candidates scored this mark.

However, (b) discriminated extremely well with the vast majority stating (incorrectly) that as the given path passed through all the vertices it was therefore a tour, rather than understanding the requirement that a tour must return to the starting node.

In (c) most candidates were able to gain full marks for correctly applying Kruskal's algorithm. Those candidates who sorted the arcs in to order of size first were the most successful. Some candidates listed the accepted and rejected arcs separately and lost marks as the order of selection (and/or rejection) was therefore unclear. Most candidates were able to select the correct MST, with the most common errors being the omission or poor ordering of one or more of the rejections. There were some who incorrectly rejected EJ, or BC and then selected HJ or CE or other similar errors. Probably the most common way to score no marks in (c) was to not show any rejections.

Those who had the correct arcs in (c) almost always managed (d) with no problem. Mistakes from earlier were carried through into this part. Those that found the MST without rejections were also generally able to access this mark.

Candidates who gained the mark in (d), generally also gained the mark in (e) although there were some slips in addition (usually missing one of the values entirely).

Question 3

Compared to previous sessions, candidates appeared to be better prepared to approach the construction of an activity network as required in this question. The overwhelming majority made a good attempt at this question and most picked up at least three marks. It was less common than in previous sessions to see the previously frequent and persistent errors of arcs without arrows, dummies without arrows and non-unique activities. Only a handful of candidates attempted activity on node diagrams, and it was very rare for networks to have more than one start. More common errors this session included missing off an activity, often H, or leaving the network with multiple end points. For some candidates, there was a tendency to use either a dummy or an extra activity to connect the end of activity A with either the end of activity D (impacting on the immediate precedences of activities H, I and J) or to the end of H. Otherwise, extra unnecessary dummies were rare and provided they did not affect the immediate precedences of activities they were penalised with just the final accuracy mark.

Most candidates produced an activity diagram identical to the mark scheme version. Although an equivalent diagram with the dummy between A and B reversed and D and E coming off activity A was also seen a few times.

Most errors involved the third and fourth dummy either in their placement, omitting one of these two dummies, or failing to include the arrows on these dummies. This suggests that some candidates were not checking that the immediate precedences of activities I and J were properly met. Sometimes, extra but unlabelled activities were added to the end of activities. This was costly as it could impact heavily on precedences of later activities.

Candidates should be advised to draw their activity networks large enough to enable them to complete their diagram accurately. Some candidates' diagrams were incredibly small and therefore undoubtably difficult to construct and certainly difficult to follow.

Question 4

In (a) most candidates formed equations using the floats for activities D and F, with most creating correct equations and going on to solve to find the correct values for x and y. Some candidates confused the float relationship, stating that $y = 2x$, but they were still able to use the second equation and gain the method mark for an attempt at solving their equations. Some errors occurred in multiplying out $2(8 – 3 – x)$ incorrectly to $10 – x$, and in rearranging positive and negative terms. Some candidates guessed unsuccessfully at values for x and y with $x = 5$ and $y = 14$ frequently seen. A few candidates found fractional values for the duration of activities D and F.

Part (b) was generally completed well, with few scheduling diagrams seen. Errors were usually seen following through from incorrect algebra seen in (a) and there were some errors in the drawing of activities J, K and M.

Those candidates who had found x and y correctly, usually picked up at least one mark in (c) by correctly stating the activities and number of workers. Some lost both marks by not stating the number of workers even though they had correctly identified the activities and the time. Many candidates stated the number of workers with no reasoning or tried to create a mini schedule of activities to support their answer. Some candidates tried to calculate the minimum number using the total duration and critical path length, ignoring the fact that the question asked for times and activities. A significant number of candidates made no attempt in (c) at all.

Question 5

Many candidates identified that additional arcs were required between C and D in (a) but did not state why or take the time to look for the shortest route, opting for the obvious direct path CD (8). Those that did check the network carefully found the additional arcs required and stated the correct total weight and a correct route.

In (b) most candidates identified the correct four nodes and created the required three pairings. The pairing BC and DG was usually correct although some errors were seen in the totals for the other two. Those that got this far generally identified the correct three repeated arcs.

Gaining marks in (c) was dependent on correctly identifying the correct arcs required in (a) and (b) although they did not have to be stated explicitly. Many lost marks from not being clear which route was the shortest with ‘ending at G’ being a common response. Those candidates who had identified and used the correct arcs generally gave a suitable numerical comparison of the routes.

Question 6

Dijkstra was a very comfortable start to this question and most candidates were very well prepared here. The errors in working values are becoming fewer with each session and generally errors are slips rather than incorrect application of the algorithm. Although there was the occasional costly error when no replacement of working values whatsoever was demonstrated. Sometimes candidates made mistakes with the order of labelling with repeated labels, for example B and C both labelled “2”. The most common error in working values was the omission of 11 at vertex E possibly due to a reluctance to move ‘backwards’ through the network to calculate the working value from D. Candidates should be reminded that examiners are checking working values and their order and so the order in which they are written into the working value box should be clear and unambiguous. Furthermore, working values should not be crossed out unless they are incorrect.

Usually, the table of least distances was filled out correctly although a small number of candidates clearly did not know what was being asked of them here and left the table blank. It should be noted that candidates were asked and expected to complete the table and so filling in just the column or just the row could not earn full marks.

Part (b) was more problematic for some candidates, and it was surprising the number who were unable to apply the Nearest Neighbour Algorithm correctly. A common error here was to omit the return to the start vertex when stating the nodes of the route, even though the length of CA was then often correctly added into the length of the route to give the upper bound. Weaker candidates sometimes thought they were being asked to find a spanning tree at this point perhaps confusing Nearest Neighbour with Prim's. Others incorrectly doubled the length of their route. Some candidates misread the question and did not realise they had been asked to state the route as well as value of the upper bound.

Part (c) was often more successfully attempted than part (b) and many candidates were able to pick up at least some marks here. The question asked for a minimum spanning tree for the reduced network by applying Prim's starting at C. Unfortunately, some candidates were on autopilot and so never stated the arcs in the minimum spanning tree in their hurry to find the lower bound. Instead, they completed the process by including the two least arcs from A. This of course, if done correctly, could earn 3 out of 4 marks in part (c) but candidates should be encouraged to check carefully what they are being asked to do. Rarely, candidates began from vertex B rather than vertex C as asked. A more common error was to double the weight of the RMST instead of (or sometimes as well as) adding the two least arcs from A. Candidates were asked to clearly state the order of the selection of arcs and therefore a list of nodes was insufficient for full marks. As has been seen in the previous series, a significant minority of candidates circled the correct weights in the table and then wrote the respective arcs in the order they appeared in the table, rather than in order of selection in the algorithm. This was also insufficient for full marks although the correct numbering across the top of the table earned the method mark.

For those candidates who had achieved success in either part (b) or part (c), with either a correct upper or lower bound, most were able to earn at least one mark in part (d) for stating the interval: lower bound < distance < upper bound. Unfortunately, when incorrect doubling had occurred in (c)(ii) candidates were tempted to write upper bound < distance < lower bound which was not credit worthy. Candidates should be encouraged to understand the meaning behind the bounds they calculate as well as the mathematical implications of the intervals they write down. Some candidates lost the final mark here for an interval with strict inequalities at both ends of the interval.

Question 7

Although this was the final question only a few candidates were unable to make any attempt. Apart from (b) the elements of this question have been seen on previous papers. Generally, candidates of all abilities were able to gain some marks in (a) and (c).

Most candidates were able to draw the required lines correctly in (c) 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.

In (a) the objective function was sometimes omitted. Of those who did write it correctly many failed to state 'minimise'. It should be emphasised to candidates that the formulation of a linear programming problem must involve either the word 'minimise' or 'maximise'. Most candidates wrote

the first two inequalities correctly, though some had $2z \geqslant y$ rather than $z \geqslant 2y$. To gain both marks,

for each of the next two inequalities, the answers need to have integer coefficients, but some candidates failed to realise this. Candidates gain no marks for simply writing an inequality involving a percentage. Development using a fraction or decimal is essential. It was common to see the time constraint expressed incorrectly as an equation or omitted altogether.

In (b) full marks here eluded almost all, due to the failure to reference the constant 720 in the final objective function. This part of the problem was essentially a conversion of minimising one function into maximising a different one. Candidates gained marks here for substituting for z into the objective function, using the rearrangement of $x + y + z = 45$, to give $720 - 7x - 4y$, followed by an explanation, in some form, that minimising $-7x - 4y$ is the same as maximising $7x + 4y$. Many candidates made no attempt here and others wasted time substituting for z into their inequalities from (a).

In (c) many perfect graphs were seen, gaining four marks for three accurate lines and the correct 'R' labelled with shading outside the feasible region. On this occasion the lack of shading beneath the x-axis was condoned. It should be noted that this would not generally be the case in problems of this type, where absence of shading would normally be penalised. It is acceptable to shade inside, rather than outside 'R', but this is not the standard convention, and probably best avoided. Excessive shading tends to confuse candidates and pose difficulties for examiners, where details are obliterated. As mentioned above, inaccurately drawn lines were often seen. These ranged from those that were sloppily drawn, or even without a ruler, to those who had mistaken the scale, for example on the y-axis so that their line did not contact at 37.5, but instead 35 or 38.75. It was also not uncommon to see the line $y = 27$ instead of $x = 27$.

In (d) many candidates omitted to draw the objective line. Those that did so successfully, generally drew their lines either between the points (4,0) and (0,7) or (8,0) and (0,14). Candidates should be advised not to draw very short lines close to the origin, or even through the origin, as these are likely to be penalised for inaccuracy. Lines drawn to pass through their 'V' were often inaccurate too. 'V' was quite often correctly labelled though a surprising number of incorrect labels were seen on otherwise correct graphs. It should be noted that this question specified use of the objective line, so the vertex method gained no marks.

The final two marks in (e) were only available to those who had drawn all four correct lines in (c) and (d). Of the relatively few candidates eligible for the marks here, most were able to calculate the correct optimal cost for the final mark, but many lost the first mark for simply stating 27, 6 and 12 without the context, each type of container, as required in the question.

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