Examiners' Report

Principal Examiner Feedback

January2020

Pearson Edexcel International GCE

In Decision Mathematics D1 New

(WDM11) Paper 01

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General

This was the second 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, and it should be noted 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(a).

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 ABFDECA (and corresponding length of 244 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 B to the weight of the residual MST and while many correctly showed the adding of 66 to their RMST weight many made errors in initially calculating the weight of the RMST.

Question 2

In (a)(i) many candidates lost this mark for not knowing the correct definition of a tree. Some had "connect" rather than "connected" and there were also many unacceptable words for "cycle(s)" including "circuit", "circle" and "loop". In (a)(ii) a good proportion of candidates scored one mark for the inclusion of 'all vertices' in their definition of a minimum spanning tree, but most lost the final mark for failing to mention edges/arcs in their definition.

In (b) many candidates were able to apply Kruskal's algorithm correctly. However common mistakes were either omitting the last arc, BE, or including an additional arc, usually AD. In some cases, a deliberate rejection of BE was seen. This mistake was costly leading to marks lost in (b) and consequently a loss of marks in (c). A minority of candidates correctly listed all eight arcs, in the correct order, but without any reference to rejections, resulting in scoring no marks as there was no clear indication of applying the algorithm correctly. Those that completed (b) successfully generally

gained full marks in (c), for the correct tree and weight. It is worth advising candidates on efficient presentation of their answer to Kruskal. For example, some unnecessarily write 'reject because cycle formed' next to each rejection, where 'not' would suffice.

Question 3

This question was a good source of marks for most candidates but also provided a good opportunity for differentiation between candidates.

Most candidates were able to state three values for x, y and z but it was common to see one value incorrect. The value for x was probably the most commonly incorrect value given (sometimes stated as $x = 20$ a result of subtracting 4 from 24) but $y = 7$ and $z = 12$ were other commonly incorrect values. Errors in (a) led to corresponding errors on the cascade chart in (b).

Most candidates were well-versed in how to construct a cascade chart and examiners saw very few scheduling diagrams. Most floats were drawn in the standard way (as shown in previous mark schemes) and critical activities were almost always seen drawn along the top of the cascade chart although this was not always the case.

Cascade charts were usually completed accurately and neatly with most errors occurring following through from errors in (a). Errors at B and D were the most common as a result of errors in (a). From time to time activities were mis-plotted – for example, sometimes at the start of K, L and/or M. Examiners noted that some responses had missing activities. Critical activities were rarely incorrect, but a few candidates drew activity G as critical.

Part (c) was challenging for some candidates. Some of whom mistakenly believed that a lower bound calculation using the total activity length was required, so stated '101/33 = 3.06 therefore 4 workers required' which (on its own) gained no marks in this part. Often, responses that were creditworthy for one mark did not include enough detailed information to be worthy of both marks. The question asked candidates to make specific reference to time and activities, but candidates frequently stated only activities or time and as a result, were unable to earn both marks. Furthermore, precision in the specification of time was important and some candidates lost a mark for stating times that included $t = 24$ or $t = 26$ or for stating answers were ambiguous about whether these end points were included. Some candidates incorrectly considered activities in time period 10 - 11 not recognising that due to floats, activities D and F did not have to be completed at this time. It was pleasing however, to see that some candidates had drawn a vertical line on the charts so they could identify the relevant activities. In a small number of cases candidates could not earn any marks in (c) for a correct consideration of time and activities as they had not stated that the lower bound for the number of workers was 4.

Question 4

Examiners reported that a significant number of candidates struggled in applying the first-fit bin packing algorithm in (a). 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 7 in the second bin (and not the first bin).

Many correct solutions were seen in (b), 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 41 and 29 being interchanged in the first pass and/or the 29 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 (c) 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 17 in the fourth rather than the first bin (and some placed the 23 in the fourth bin so failing to apply the algorithm at its first real test and therefore scored no marks). 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 (d) many candidates realised that $8 < x < 12$ but very few correctly realised that $y > x$ only. Several candidates gave only the constraint that $y > 8$ (which while necessary was not a sufficient condition on the value of y) and many candidates managed to give other spurious constraints on the value of y.

Question 5

This question involved constructing an activity network that was perhaps a little more complex than those seen in recent sessions. Nonetheless, many candidates did very well in (a) and a good number of candidates were able to demonstrate good understanding and interpretation of the precedence table and earn full or near to full marks. This perhaps represents something of an overall 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, B and C. The first two dummies and activities D and E were also usually correctly dealt with in terms of immediately preceding activities. Where errors occurred, it was usually associated

with the two dummies later in the activity network. In general, candidates who drew F, G, and I in order tended to end up with less confusing networks than those who drew these activities in a different order. In such cases, it proved challenging for candidates to join D, F and G into an event node as well as D, F, G, I, and E into another event node. Sometimes, to combat this, extra dummies were added but provided that precedences were upheld, this usually only lost the final accuracy mark. It was not uncommon though to see D, F, G, I and E meeting at a node but without an additional node where only D, F and G met. This meant that precedences for H and J could not be upheld and so at least two marks were lost in this case. Sometimes a more costly error was the addition of extra unlabelled activity arcs. Candidates should be advised that dummies must be distinct from activities: either labelled as dummies or dashed.

Almost all networks were drawn with a single start node but there were a few networks which appeared to have multiple end nodes. Most candidates recognised the importance of arrows on dummy activities and examiners saw very few responses with no arrows on dummies whatsoever. A small number of candidates missed arrows on one dummy.

In part (b) many candidates correctly stated at least two of the four correct activities but only the most able got all four (and only those four) correct.

Question 6

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 G, H and/or J). The route 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 route. 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.

In (b), 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 that arose in at least one of the two pairings AH + DJ and AJ + DH was where candidates obtained a value of 52 (for at least one of these two pairings) instead of the correct answers of 51. 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 AD + HJ. Some candidates were clearly on 'autopilot' and stated the length of the route even though it was not required.

Part (c) was answered extremely well with many candidates correctly giving an answer of 4 and 3 for the number of times that vertices C and D respectively would appear in the corresponding inspection route.

Part (d) discriminated as even though many candidates understood what was required very few, as requested, explained their reasoning or showed all their working. To obtain both marks in this part

candidates had to make it clear that travelling from H to H required the consideration of the shortest path from A to J only (as these were the only two odd nodes) and therefore it would be quicker to start at H and finish at D. Furthermore, a correct numerical comparison (either 314 with 309 or 45 with 40) had to be given.

Question 7

This question proved to be quite challenging for candidates and while full marks was very rare, so was zero marks. There was some evidence that some candidates ran out of time but most candidates were able to make at least some progress with this question with only the strongest candidates combining the accuracy and the range of skills necessary to both set up and then correctly approach the graphical solution of the LP problem.

Surprisingly, it was common to see the objective stated in (a) with no 'minimise' or equivalent despite the question clearly stating that this was a minimisation problem. 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 training days. More common were errors in the other two constraints. The second constraint for the relationship between new teachers and the total days of training for middle and senior leaders was frequently seen with either the incorrect direction for the inequality sign or with the multiplier of '2' on the wrong side of the inequality. Sometimes both errors were made. For the third inequality, for the senior leaders, 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.

In (b), the ratio of 5:3 was quite often incorrectly expressed as $5y = 3z$ which caused errors later in the question. However, there were many successful substitutions of the correct ratio to achieve the required objective and constraint in terms of x and y only although some candidates did not substitute into both constraint and objective and so lost at least one mark here. Candidates were once again asked to give the resulting constraint in a simplified form with integer coefficients which was sometimes overlooked. Of course, errors in (a) often led to an incorrect objective and constraint in (b) but method marks were available to candidates who correctly undertook substitutions into their equations from (a).

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.

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 (d), 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.

Part (e) discriminated well with very few candidates inferring correctly that the required number of training days for senior leaders was 3 and that this would lead to a cost of £9800.

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