Examiners’ Report
Principal Examiner Feedback

Summer 2017

Pearson Edexcel GCE Mathematics

Decision Mathematics D1 (6689)

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications are awarded by Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk. Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

Summer 2017
Publications Code 6689_01_1706_ER

Decision Mathematics 1 (6689) – Principal Examiner's report

General introduction

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

Students are reminded that they should not use methods of presentation that depend on colour, but are advised to complete diagrams in (dark) pencil. Furthermore, a number of students are using highlighter pens even though the front cover of the examination paper specifically mentions that this type of pen should not be used.
Students should be reminded of the importance of displaying their method clearly. Decision Mathematics is a methods-based paper and spotting the correct answer, with no working, rarely gains any credit. Some students are using methods of presentation that are very time-consuming, this was particularly true in question 2(a), the application of Prim's algorithm, where a number of students ran out of space (and possibly time) unnecessarily completing the algorithm on a matrix. The space provided in the answer book and the marks allotted to each section should assist students 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. Students should ensure that they use technical language correctly. This was a particular problem in questions 1(a) and 6(d).

Question 1

Part (a)(i) 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. Students need to use the correct technical language such as 'nodes' or 'vertices', rather than points, dots, people, data etc. Some students were thrown by the diagram and had explanations referring to columns of nodes. A lot of students 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 (a)(ii), in which students were asked to define term 'alternating path' discriminated well with the majority of students failing to include the two key points that an alternating path starts at an unmatched vertex (in one set) and finishes at an unmatched vertex (in the other set) **and** alternately uses arcs not in/in the matching.

Parts (b) and (c) were well attempted and most students were able to write down an alternating path from F to 5 in (b) and then successfully found an alternating path from C to 2 in (c). It is important that examiners can clearly identify the alternating path so it should be listed (rather than drawn) separately, rather than left as part of a 'decision tree' of potential paths. A number of students 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 students did not state the improved matching in (b) or the final complete matching in (c). If students 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, it is extremely important that students read the question carefully as part (b) explicitly asked for an alternating path from F to 5. Many students in (b) either found an alternating path from F to 2 or from C to either 2 or 5 and so therefore could only access three of the six marks available in the latter two parts of this question.

Question 2

Part (a) was generally well answered with the majority of students applying Prim's algorithm correctly starting from vertex B. A few students attempted to construct a table to perform Prim, clearly believing that Prim can only be performed when expressed in matrix form. Finally, there is still a small minority of students who appear to be rejecting arcs when applying Prim's algorithm so scoring only one of the three possible marks in this part.

Those students who found the correct minimum spanning tree in (a) usually went on to state the minimum cost in (b).

Most students 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. Students 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 students 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. It was pleasing to note that the vast majority of students correctly dealt the fact the arcs BD and FJ had to be included in the spanning tree.

Question 3

Examiners reported that a significant number of students struggled in applying the first-fit bin packing algorithm in part (a). This was mainly down to not applying the algorithm correctly. First fit is just that; students must decide if the current item under consideration will fit in the first bin rather than the most recent bin used. In this part a number of students placed the 10 in the third bin (and not the second bin) and others did not place the 27 in the third bin.

Many correct solutions were seen in part (b), but a number of students did not choose their pivots consistently, switching between middle-left and middle-right pivots during the course of the quick sort algorithm. A number of students 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, students 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 42 and 39 being interchanged in the second pass and/or the 27 and 21 not being interchanged in the fifth pass; students 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 students 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 students over complicated the process by insisting on using a different 'symbol' to indicate the pivots for each pass. Those students who sorted into ascending order usually remembered to reverse their list at the end to gain full credit although a number of students 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 a large number of wholly correct answers. A small number performed first-fit increasing therefore scoring no marks. A small minority of students lost all three marks by placing the 27 in the 4th rather than 3^{rd} bin (so failing to apply the algorithm at its first real test). Some students 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.

Part (d) discriminated well with many students correctly determining that $14 < x < 17$. However, a number of students gave an answer which included the value of 17 even though the question clearly said that the numbers in the list were distinct or incorrectly assumed that x must be an integer.

Question 4

Part (a) was usually very well done with most students 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 students 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 B, G and/or H). The path was usually given correctly and most students realised that whatever their final value was at H, 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.

The vast majority of students did not realise the connection between part (a), in which the shortest distances from vertex A to any other vertex had been found and part (b). Therefore many students went on to make at least one error in the totals for the pairings in part (b). Most students stated the repeated arcs correctly although there were a few who simply stated “AD, EG”. Very few students failed to give three distinct pairings and corresponding totals in this part.

Part (c)(i) was well answered with the majority of students correctly stating that arcs AD, CD, BC and BG needed to be repeated. Both the route and its corresponding length in part (c)(ii) were answered well (although in a number of cases the route was left blank). Most of the students remembering to subtract the weight of the arcs BD and BE from their total.

Question 5

In part (a) the vast majority of students correctly stated the three inequalities but some opted for incorrect strict inequalities.

In part (b) a small minority failed to state the exact coordinates of all the vertices of the feasible region with a number incorrectly stating either (2, 4) or (10, 0) as one of the two integer coordinates. The non-integer vertex was often given exactly but a minority opted to either read this point off the graph or, after solving the simultaneous equations correctly, only give an answer correct to either 1 or 2 decimal places.

In part (c), many students did not do as requested which was to apply the method of point testing with many instead using the objective line method and so scored no marks in this part. Of those that did attempt point testing, many only tested one or two of the three vertices of the feasible region; students are again reminded that this is a methods paper and therefore they must apply all stages of the corresponding algorithm. Even in cases when it is clear that a given vertex, in this case (4, 2), could not possibly be the optimal vertex students must still test all vertices of the feasible region.

Part (d) proved to be extremely discriminating with many students either leaving this part blank or simply guessed the range of possible values for lambda. It was expected that students would either consider

- $2\left(\frac{100}{9}\right)+\lambda\left(\frac{50}{9}\right)>2(0)+\lambda(10)$ **and** $2\left(\frac{100}{9}\right)+\lambda\left(\frac{50}{9}\right)>2(4)+\lambda(2)$ (point-testing)

Or

- $-\frac{2}{\lambda}<-\frac{2}{5}$ and $-\frac{2}{\lambda}>\frac{1}{2}$ (objective line)

While many students did correctly use one of these two methods many, surprisingly, struggled with the corresponding algebra or, in respect to the case of point-testing, many did not use the exact coordinates so did not achieve the correct answer of $-4<\lambda<5$.

Question 6

Part (a), in which students 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 well with many fully correct diagrams seen following correct answers in part (a). Very few students 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 six non-critical activities correct and so could score at least three marks in this part.

Part (c) was answered well with many correctly stating that activities J and L must both be happening at time 18.5.

In part (d), students were required to consider if the revised project could be completed in the same time as the original project if the duration of the additional activity P was either 10 or 17 days. It was noted by examiners that this part discriminated across the entire range of students. The most coherent and succinct answers considered the earliest possible finish time of activity P based on the latest possible finish time of activity D. Students need to understand that questions of this type (especially on an A Level Mathematics paper) require a mathematical argument and not just an answer of 'yes' or 'no'.

Question 7

Whilst the objective function was found correctly on many occasions, the absence of the word 'maximise' meant that the first mark could not be awarded. The first constraint (based on the caterer making at least 280 salads) was usually correct. The constraint which required 'at least 35% of the salads to be small and no more than 20% to be large' was either dealt with very well by students or not attempted at all. However, a simplified inequality was not always achieved and, on occasion, coefficients were left as fractions rather than integers. The final constraint which required '400 small salads **or** 300 medium salads **or** 200 large salads' was rarely dealt with correctly as many students incorrectly read this as 'at most 400 small salads **and** 300 medium salads **and** 200 large salads' and so gave incorrect answers of $x \leq 400, y \leq 300$ and $z \leq 200$ instead of the correct $3x + 4y + 6z \leq 1200$.

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London, WC2R 0RL, United Kingdom