

# Examiners' Report

Summer 2014

Pearson Edexcel GCE in Decision Mathematics D1  
(6689/01)

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# Mathematics Unit Decision Mathematics 1

## Specification 6689/ 01

### **General Introduction**

The paper proved accessible to the majority of students. The questions differentiated well, with most giving rise to a good spread of marks.

## Report on Individual Questions

### Question 1

A number of students who used the matrix form of Prim's algorithm lost marks by listing the arcs in the wrong order although the correct arcs had been selected in the table. Students would be advised to scan all labelled columns, circle the smallest value and then write down the corresponding arc immediately before going on to label the next column. Trying to write down the arcs selected in order after completing the algorithm is far more demanding. A common error was in the selection of the final two nodes or arcs with CD selected before BG, and only a few students lost marks by listing only the vertices in order instead of the required arcs. It was pleasing to note that only a small minority of students started from a different vertex than the required A, although some began at D, possibly due to arc DG being the shortest arc in the network. Finally, very few students appeared to reject arcs when applying Prim's algorithm. If the student answered Q01(a) successfully then they typically answered Q01(b) and Q01(c) correctly. A number of students were able to recover from mistakes in Q01(a) to draw the correct minimum spanning tree and state a correct total.

### Question 2

Students generally showed a good understanding of the process of constructing an activity network from a precedence table, 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 students were unsure about the placement of their dummies, putting them in 'anywhere' so that they had two dummies included. Some also had three dummies even though the question clearly stated that they were to use exactly two. A very small number of students put activity on node, and some failed to check that they had all activities present, with K being the activity that was missing most often.

A minority of students were able to give a competent description of why the first dummy was needed (to enable activities to be described uniquely in terms of their end events). Many students used the word "unique", but gave an incorrect or incomplete explanation of what this meant. Common explanations were that, "D, F and G depend on A and B, and these start from the same place". A significant number of students got the explanation for the second dummy correct by referring directly to the correct activities in the context of dependence. Some students used the word precedence to describe this dummy – and while some were confident with the terminology and were able to use this term accurately, more often than not students were confusing this word with dependence. A small number of students gave one vague general explanation for the two dummies, without reference to specific activities or they omitted to say that I depended solely on D.

### Question 3

Q03(a) was generally answered well by most students with the vast majority stating the correct three distinct pairings of the correct four odd nodes. There were a few students who only gave two pairings of the four odd nodes or who gave several pairings but not three distinct pairings. There were however many instances where the totals were incorrect. The majority of such mistakes occurred for the pairing of D with F. There were also some instances where no totals were given which lost students a significant number of marks. Students should be advised to be thorough when checking the shortest route between each odd pairing. Many students did not explicitly state the arcs that should be repeated instead stating that DE and FK should be repeated instead of the correct arcs DA, AE, FJ, JK. Furthermore, a number of students did not state the length of a shortest inspection route.

Only a minority of students were able to answer Q03(b) correctly with the majority stating that J would appear 6 times (6 was the order of vertex J once the two additional arcs were added) rather than the correct answer of 3 times.

In Q03(c) many students identified DE, DF and EF as the paths that needed to be considered, although they often missed stating the fact that DF was the shortest path that did not include vertex K. Many students, even with the correct selection of arcs, either did not state a route or gave an incorrect route. Some students misunderstood the reasoning altogether and focused on the fact that DK had the greatest weight of the previous pairings and therefore should be avoided and so EF should be repeated. Others still said that 'FK is the least therefore start and end at F and K'. Those that did state DF usually went on to score the mark for stating the length of a shortest inspection route.

#### Question 4

The majority of students were able to successfully complete the bipartite graphs in Q04(a) and Q04(b) although there were a notable number of students who added arcs from F to G and from P to D to their bipartite graph in Q04(a).

Q04(c) was well attempted and most students were able to write down an alternating path from N or P to D. 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). 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 lack of change of status was penalised twice both in this part and in Q04(e). A significant number of students did not state the improved matching after stating their alternating path. If students are going to display their improved matching (or later their complete matching) 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.

The responses seen in Q04(d) were mixed. Students are clearly familiar with the type of explanation that is required and most are giving explanations which refer to all of the relevant nodes. However, some students provided an explanation which despite appearing to be true did not provide the required reasoning for why a complete matching was not possible. For example, the most common incorrect answer was 'R is the only one who can play G and K'. Although this initially seems like a correct response, this is incomplete as it does not preclude others from either playing G or K. Others failed to home in on the relevant nodes stating for example, "D can only be done by J" or "because we can't get to K".

Q04(e) was well done although less so than Q04(c) probably due to some students not updating their bipartite graph with the addition of the two further preferences given before the stem to Q04(e). Students that drew the new bipartite graph tended to do well in this part. Although those students who failed to state/draw an improved matching in Q04(c) usually did provide the complete matching in Q04(e).

## Question 5

Q05(a) was usually very well done with most students applying Dijkstra's algorithm correctly. The boxes at each node in Q05(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 S, L and/or Y). The route was usually given correctly and most students realised that whatever their final value was at Y this was therefore the value that they should give for their route.

Q05(b) was done well although many students failed to read the question carefully and simply calculated the length of the new shortest route without stating the increase in the distance travelled. Some failed to realise that the final value at vertex M added to the length of the arcs ML and LY would give them the required length of the new shortest route, instead many added up the length of each arc from scratch.

## Question 6

The inclusion of  $x$  as an unknown value was seen as a challenge for a number of students. A few chose a value for  $x$  at the beginning (usually 23) and then forgot it was a variable, using the same value throughout. One or two left out  $x$  completely or felt it needed to be isolated in a bin of its own.

Q06(a) was answered well with many correct responses seen. A common error was to put the 6 in the wrong bin. Only a few students just worked with  $x$  as a chosen value within the range at this stage.

In Q06(b) most students' selected middle-right pivots and many were able to carry out the sort correctly. Errors cropped up in the ordering of the sublists after the first (and subsequent) iterations. The most common occurrence of this tended to be that  $x$  and 25 were interchanged after the first pass. Other errors included failing to select the 9 as a pivot for the fifth pass probably because the sublist of length two after the fourth pass appeared to already be in order. Very occasionally, students selected only one pivot for each iteration or failed to sort the list into (values greater than the pivot), (the pivot), (values less than the pivot) after the first iteration. There were only a few cases 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 and then went on to apply first-fit increasing in Q06(c).

Q06(c) challenged many students with most only stating one correct allocation. Often students did not even seem to consider a second possible allocation despite the question clearly saying there were two. Some students did not know how to handle the value of  $x$  in this part and used a value instead. A common error was omitting the values of 8 or 9 from bin 2 and putting in the value of 6 instead.

Many students could only score one mark in Q06(d) due to the lack of two correct allocations stated in Q06(c). Of those that did have two correct allocations and both answers for  $x$ , most also supported their answers with relevant calculations, and so were able to gain full credit.



## Question 7

Q07(a) was challenging to most students. Many definitions of total float muddled the terms 'events' and 'activities'. A large majority of students gave incomplete answers, for example, not clearly stating earliest start time or latest finish time (either saying start and finish time or early and late times). Some students tried to state the mathematical formula but did not fully explain all the symbols they used. The majority of students understood the idea that it was the time an activity could be delayed for but in many cases, students thought it was the total of the floats for all activities in a network.

In Q07(b) the dummy between events 6 and 7 caused the most difficulty, with a number of students going via K and getting a late event time of 25 rather than the correct value of 21. Most could gain the first mark by having only one rogue value and the early event times were largely correct. In general more mistakes were seen in the bottom half of the boxes. Students should be advised to take time checking their values as a significant number of subsequent marks can be lost if errors are made in this part. The majority of students successfully identified the correct critical activities in Q07(c) and Q07(d) the majority of students knew the method for the float calculation and showed it clearly. Others just gave the calculation of  $21 - 14$  which could have been the latest finish time – the earliest start time for the event between G and L rather than the correct calculation  $21 - 11 - 3$ .

Finding the lower bound in Q07(e) had more variable success; some did not do a calculation and tried to argue for a lower bound based on scheduling despite the question asking for a calculation. Others made either arithmetical errors or conceptual errors (the most common being calculating the ratio of the earliest possible finish time (30) to the number of activities (13) ) in their calculation.

For Q07(f) quite a few students drew a Gantt chart instead of a scheduling diagram, and so scored no marks. There were also quite a few instances where this part was left blank. Those that did schedule tended to make errors on activity H, which needed to take place after activity D. There were also minor errors in duration lengths seen meaning few scored full marks in this part. It would be advisable for students to check their working carefully to ensure that preceding activities are completed and that activities do not start before their earliest start time or continue beyond their latest finish time. Also it was common for at least one activity to be missing from the scheduling diagram.

## Question 8

Q08(a) was generally well attempted and most students were able to obtain at least one mark in this part. Some students incorrectly used strict inequalities and there were also errors in the directions of the inequalities.

Students that attempted Q08(b) usually began by stating or calculating the exact coordinates of vertex D. However, many did not find the exact coordinates for vertex A, and instead either rounded their answers or read them directly from the graph. The majority of students then (incorrectly) went on to compare the expressions representing the value of the objective function, in terms of  $k$ , at these two vertices. As a result, many scored only 1 or 2 marks in Q08(b). Even students who successfully found all 4 coordinates often compared vertices incorrectly and unnecessarily. Some compared the values from each pair of vertices in turn, achieving the method mark almost by 'trial and error'. Other methods, based on an objective line approach, were rarely seen. When they were, students were often successful, although some struggled to use 'steeper' and 'shallower' in the context of negative gradients. Others could 'see' the solutions but omitted to show how the gradients of the lines and the objective function were related to  $k$ . Furthermore, the negative values and the negative reciprocal of  $k$  in the inequalities caused some difficulties and some used incorrect algebra to obtain an answer that looked reasonable and it was not uncommon to see the correct final answer following incorrect working.

## Grade Boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

<http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx>

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