Examiners' Report
Principal Examiner Feedback

Summer 2019

Pearson Edexcel GCE AS Mathematics
In Decision Mathematics 1 (9FM0/3D)

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 2019
Publications Code 9FM0_3D_1906_ER

Introduction

This paper proved accessible to most candidates although examiners noted that a significant number of candidates struggled to cope with the new content not previous seen in the legacy modules 6689/01 and 6690/01, and some had difficulty with the problem-solving nature of some of the questions (which forms part of the assessment objectives for this qualification). However, 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 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. 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(d), 3(c), 4(a), 6(a) and 6(d).

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.

Report on Individual Questions

Question 1

Examiners reported that a significant number of candidates 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; 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 1.2 in the third bin (and not the first bin) and others did not place the 0.2 in the third bin.

Many correct solutions were seen in part (b), 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. A common error included the 1.5 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.

In part (c) many candidates scored both marks for showing correct working (for example, $\frac{2.32(11250\log 11250)}{450\log 450}$ or starting with an equation of the form $t = k(n\log n)$ with $t = 2.32$ and $n = 450$ to find *k*) followed by a final answer of 88.6. A sizeable minority did not score the accuracy mark for giving an answer of 88.56 or 90, as the question required an answer to the nearest tenth of a second. Those candidates with a correct answer, but no supporting working, scored one mark only, as the question explicitly stated that both method and working needed to be shown.

Question 2

This question was generally well attempted. Most candidates were clearly well prepared for Dijkstra's algorithm with most errors in part (a) arising from slips rather than lack of understanding. Values at nodes A, B, F, E and G were generally correct with errors most commonly occurring at C and/or H. Most candidates were able to correctly state the path from A to D and the corresponding length. There were the standard errors in order of working values and/or extra or missing working values and examiners saw several cases where there was no replacement of working values whatsoever. As is often the case, handwriting presented something of a challenge when deciphering working values. Candidates should be reminded of the importance of working values in judging the application of the method by examiners and so candidates should ensure their presentation is clear and it cannot be stressed enough that working values should **NOT** be crossed out.

In part (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 (or more) than the three pairings. There were however, perhaps surprisingly, frequent errors in the pairing totals. A common error arose in the pairing AH + CE. 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 AE + CH. Some candidates were clearly on 'autopilot' and stated the length of the route here rather than (or as well as) in part (c).

Part (d) was the most testing part of the question for a lot of candidates, with some making no attempt. Of those that did many were limited to the mark for identifying which nodes were now odd, and some candidates got stuck after "finding" there were three or five odd nodes. Some candidates who had identified the four odd nodes seemed unsure how to proceed, giving unjustified start and finish points and ignoring the arc that needed to be repeated. Other candidates were meticulous in their working listing every possible pairing with their length, then picking the shortest CG and identifying D and H as the start/finish points. Some candidates lost the accuracy mark by selecting a shortest pairing before homing in on CG. A small but worrying number of candidates persist in using the "avoid the longest of the repeats" misconception. In the final part of (d), of those who got here successfully, not all removed the three arcs from B not currently available before adding on the repeated arc CG.

Question 3

Many candidates seemed to find the first part of this question on Floyd's algorithm relatively straight forward, even though it is a newly examined topic, with many scoring a significant number of marks. The route table in part (a) was almost unanimously done correctly, and most of the distance tables were too. A small number had one or two incorrect values in the distance table, and a very small number of candidates confused the rows and columns in the distance table.

It was clear that most candidates were using the method displayed in the new Pearson textbook to complete the iterations of the distance and route tables, though of course those using alternative approaches were given equal credit for their responses. A significant number of candidates made one or two errors causing them to drop the final accuracy mark in part (b), but a mark of 5 or 6 out of total of 7 (for parts (a) and (b)) was very common. Only a very small proportion of candidates lost method marks for changing entries in rows/columns that they should have been leaving unchanged for that iteration.

It was part (c) and (d) that caused most problems for candidates. In part (c) several candidates were able to score full marks for a near full (but not totally complete) response, due to the varying nature of the different methods. Many lost marks though as they were not clear about how to use the tables, many did not mention rows and columns specifically, which lost the first two marks in this part. Also, the second (dependent) B mark was especially rarely scored as many candidates did not fully consider the route from D to A. Meanwhile many candidates who lost these first two B marks still earnt the third for a correct route EDCA. Candidates should be aware of the level of detail required for a question that requires them to explain a method.

In part (d), many candidates failed to appreciate that the standard method of applying the nearest neighbour method on a table with undirected arcs would not apply in the same way with directed arcs, so incorrectly stated the nearest neighbour route. In nearly all cases this therefore led to the rest of part (d) being incorrect so unfortunately no marks in this part was not an uncommon score. Parts (d)(iii) and (iv) proved particularly challenging with very few candidates realising that (iii) was requesting the actual route used and that (iv) required candidates to find a shorter cycle. In general, proof that a solution to any Decision Mathematics problem is non-optimal only requires a counter-example i.e. a better solution.

Question 4

In part (a) very few candidates explained, with detailed reasoning, why $x = 11$. For the first mark candidates had to give a correct reason why the total float on activity H was given by $25 – 7 – x$ (e.g. mention that the early event time at the end of activity C is 7) and for the second mark (which was dependent on the first) a reason why the expression $25 – 7 – x$ leads to the given answer. Far too many candidates gave no reasoning at all and simply wrote down the equation $25 – 7 – x = 7$ and then stated that $x = 11$.

Part (b) was answered extremely well with many candidates correctly complete the diagram with the early event times and late event times. When errors did occur, they mostly occurred at the ends of activities B, F and/or H.

Examiners noted that part (c) was generally answered correctly with nearly all showing a correct calculation.

Most candidates did attempt to produce a schedule in part (d). However, a significant proportion of candidates tried to construct a schedule with only three workers (possibly due to their answer for part (c)), therefore scoring only one mark and completely disregarding the significance of the Immediately Preceding Activities (IPA). Of those candidates who did have four workers in their schedule, a pleasing number were correct, though errors were sometimes seen in either the duration, time interval or IPA for one or more activities. It was pleasing to note that cascade charts were rarely seen.

Question 5

Candidates generally showed a good understanding of the process of constructing an activity network from a precedence table in part (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 precedence was guaranteed. 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. Usually candidates were able to pick up the first two marks and errors usually arose either with the first two precedence dummies. Whilst most candidates now seem to be aware of the importance of arrows on dummies, there are still some candidates who make the costly mistake of not having arrows on their dummies. This makes it impossible to determine the preceding activities for F, H, I, J and K and ultimately lost three marks.

In part (b) only the most able candidates realised that if all the activities have the same duration then ADHK was the critical path.

Question 6

In part (a) many candidates gave a correct response, but these varied from statements such as "the problem contains ≥ constraints", to "simplex can only deal with ≤ constraints" through to a thorough explanation that "for this problem the origin is not in the feasible region as $x - y + z \geq 8$ and therefore the problem had to be modified to accommodate this". Incorrect responses included statements such as "the problem has three variables" or "it needs artificial variables".

In part (b) most candidates made a good attempt at setting up the initial tableau, generally converting the three constraints into equations of the correct form. Most used the notation provided in the question, although a small number used *r*, *s* and *t* instead of s_1, s_2 and s_3, although only some candidates changed the headings in their tableau. A small number made sign errors with the second and third constraints, adding surplus variables and subtracting artificial variables. A significant number of candidates made mistakes with their objective function, ranging from the basic form with errors such as $P - 2x - 2y + z - M(a_1 + a_2) = 0$ or $P = 2x + 2y - z + M(a_1 + a_2)$ seen or an expression with the equals sign omitted. Other errors followed when attempting to substitute for $a_1 + a_2$ or when simplifying the equation. There were some common errors seen in the three constraints when they were written in the tableau, such as 0 4 2 in the third row being entered as 4 2 0, the b.v. column being left empty or an *x*, *y* or *z* appearing in a cell. Some candidates left one or more cells blank. There were a significant number of errors made in the objective row, many of which came from simplification errors noted above. Common errors included 0 instead of $-23M$ in the value column and $-M$ instead of $+M$ in the s_2 and s_3 columns.

In part (c) most candidates stated the correct values for the three non-zero variables although a small number made errors here. Some failed to state the value of the five zero variables and a small number of candidates either omitted one of these or added an extra one, sometimes duplicating one of the non-zero variables.

In part (d) the majority of candidates failed to give a correct reason or explanation of why the solution was not feasible, with many stating that there were negative values in the objective row or making a general comment such as "not all the artificial variables are zero" or "the sum of the artificial variables is not zero". Other incorrect statements included "a_1 has a value". Correct answers included "a_1 is not zero" and "a_1 = 11.75" or even a full statement to explain that $x - y + z \geq 8$ is not satisfied with *x* = 0, *y* = 3.75 and *z* = 0 and therefore it is not a feasible solution.

In part (e) some candidates were unsure of the choice of pivot column with a significant number incorrectly choosing the *x* column. Some of those who chose the correct *z* column failed to state a reason for their choice. Of those who chose the *z* column and gave the correct reason, some then went on to simply stated that 0.5 had the smallest ratio value without showing the three calculations and others, who did show all their calculations correctly, stated that 7.5 was the next pivot.

Question 7

In part (a) the first constraint (based on the manager ordering at least 60 watches) was usually stated correctly. The constraint which required "at most 80% of the watches to be digital" was either dealt with very well by candidates or not attempted at all with only a minority giving either the inequality or the variables transposed.

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 on the legacy specification 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. In general, the lines $x + y = 60$ and $y = 4x$ were drawn correctly. Furthermore, a significant number of candidates were unable to select (or even label) the correct feasible region.

In part (c) of the two possible methods that could be adopted the objective line method was predominantly the one seen and it could be argued the more appropriate for this problem. Reciprocal gradient objective lines were shown by a significant number, which of course usually meant choosing the wrong vertex. Where point testing was used there were a surprisingly large number of calculation errors. When vertices were read off the graph, they were rarely checked algebraically to confirm if they were correct. If candidates are to use point testing it would be advisable (in most cases) to find the intersection points using simultaneous equations rather than reading off the graph. Some candidates did not show a method at all and hence gained no marks in this part. A small number of candidates stated the correct values for x and y but failed to give these in terms of the number of watches the manager should order and so failed to gain the final accuracy mark in part (c).

It was often the case that the final part of this question was left blank. Those candidates who did attempt this part usually scored at most two marks as they had failed to find the correct optimum point in part (c). Many candidates in part (d) attempted to combine the two relationships, which involved the total cost of the watches and the relative costs of the two types of watches, into one step. While many candidates completed this successfully, a significant number made errors confusing *analogue = 5(digital)* with *digital = 5(analogue)*. Several candidates in part (d) stated an incorrect equation that related their objective function with the total cost of the watches. This meant that the equation *analogue + 5(digital) = 4455* was often seen by examiners. Finally, several candidates made no use of the total cost of the watches in any part of their solution.

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