A-LEVEL
FURTHER MATHEMATICS

7367/3D Paper 3: Discrete
Report on the Examination

7367/3D
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Question 1

Over 90% of students provided the correct option for this question.

Question 2

As with question 1, the vast majority of students provided the correct option for this question.

Question 3

Just over two-thirds of the students provided the correct option for this question, with the most common incorrect selection being *C*, perhaps as it is less common for the optimal vertex to lie on one of the coordinate axes.

Question 4

Just over three-quarters of the students were awarded both marks in part (a). The command sentence in the question included 'Using the language of networks' as a nudge towards using words like 'supersink' and 'sink' as part of the answer, and omission of these words was the most common reason for not awarding the marks available.

Approximately half of the students received the single mark available in part (b), where missing units was condoned. By far the most common reason for the mark not being awarded was for incorrectly dealing with the capacities on the arc *EF*.

Part (c) required the student to compare Tim's claim with the value of the cut found in part (b). Some students missed this, but instead carried out extra work and found the value of a different cut and compared this with Tim's value, and so provided clear evidence about the maximum flow through the network, meaning they were awarded the marks. The two marks were both follow through marks, meaning that if a value greater than 106 was (incorrectly) found in part (b), then so long as the reasoning was correct in part (c), both marks could still be awarded. Many students did not finish off the conclusion, with a short sentence like 'Therefore, Tim's claim is incorrect'.

Question 5

Part (a) was found challenging, with very few students noting that the simplex algorithm can only be used with linear programming problems that are seeking to 'maximise'.

In part (b)(i), over 90% of students received at least one mark, with over 80% of students receiving both marks. Where mistakes were made, it was typically for mixing up entries or for not including entries representing the slack variables.

Just over half of the students received both marks in part (b)(ii). By far the most common correct answer was for applying the simplex algorithm in its truest sense; by comparing ratios in the x-column, as this is the most negative entry in the objective row of the initial simplex tableau. However, students that did compare ratios for the y-column and subsequently used a different pivot row also received both marks, if done correctly. The most common mistakes were simple arithmetic errors.

In part (c)(i), just over half of the students were awarded the sole mark. The most common mistake was to state the objective row was 'positive', which is a subtle (but incorrect) difference to 'non-negative'.

Over 60% of students received both marks in part (c)(ii), with a clear statement of the value of Q being required for both marks. Where both marks were not awarded, this was typically for not stating –1986 was the value for Q, or for stating the optimal values for x and y, or P, but not going any further.

Question 6

Part (a) is a well-established question type, and as such nearly 40% of students received all 6 marks for providing solutions like that seen in the typical solution of the mark scheme. Two-thirds of students received at least 5 marks, with the most common reasons for not being awarded all the marks including omitting 'pm' on the final answer, or for not finding or stating all three correct pairs of shortest distances.

In part (b), just over a quarter of the students received both marks for a fully comprehensive account of why the refinement reduces the time taken. Noting the network can now be semi-Eulerian, or by stating two odd nodes to start and finish on, received the first mark, but a clear explanation of how this reduces the time taken was required for the second mark, with mentioning that the distance travelled would be less being crucial to complete the explanation.

Question 7

Part (a)(i) is a familiar question type, and as such nearly all students received at least one mark. By far the most common loss of marks was for incorrectly stating the latest finish time of activity A as 17, instead of the correct value of 18

As with part (a)(ii), nearly all students gave the correct critical path.

In part (b), nearly 90% of students were awarded the first two marks. By far the most common reason why all three marks were not awarded was for students not to include the float for each non-critical activity.

Over half of the students provided enough explanation for both marks in part (c), which typically stated that activity *G* was now critical and so the minimum completion time decreases by 2 weeks. If students did not provide a full enough explanation, but did state the minimum completion time decreases by 2 weeks or to 47 weeks, then they were still awarded one of the two marks.

Question 8

The majority of the students were able to give at least one reason why the graph *G* is simple in part (a)(i), but less than half of the students were able to give both reasons why *G* is simple and therefore conclude that *G* is a simple graph.

Nearly 90% of students were able to state that G only has vertices of even degree, but less than 10% of students also stated that G is connected, which is a subtle but important requirement for a graph to be Eulerian.

In part (b), just under three-quarters of the students realised that the two graphs had the same vertex degrees, but fewer than 25% of the students then realised that this does not necessarily mean that the two graphs are isomorphic. Hence, the most common reason for the second mark not being awarded was where the student gave a definite statement on whether or not *G* and *H* are isomorphic.

In part (c), approximately half of the students were awarded one or more marks. By far the most common reason for no marks being awarded was for an attempt at a numerical solution by trying to calculate the number of faces for *G* using the formula, and then comparing this to a number of faces that the student had counted for *G*. Those students who realised the formula can only be applied to connected planar graphs, and that *G* had a striking resemblance (and therefore subgraph) to $K_{3,3}$ realised this was a Kuratowski's theorem question and typically proceeded on to all three marks.

Question 9

Over half of the students received at least one mark in part (a)(i), typically for showing how one element could start to generate the other elements of the group. However, not all students proceeding in this direction gave a final conclusion about what they had done, such as 'as 1 is a generator of the group, therefore the group is cyclic'. Some students produced a full Cayley table for the group and stated this showed the group was cyclic, without any further analysis, and this was not awarded either of the marks available.

Just under a quarter of the students received the mark available in part (a)(ii), for a correct statement about the rotations of the square. The most common incorrect answer was 'the group of symmetries of the square', but this group includes reflections as well as rotations and so is a group of order 8 and not order 4.

Three-quarters of the students received at least one mark in part (b)(i), for correctly setting up the condition for the inverse element. The second mark was awarded to the vast majority who received the first mark, as they tended to go on and provide a fully complete solution. The most common error in this part was to set up the condition for the inverse element with an incorrect identity element.

Just under half of the students received both marks in part (b)(ii) for correctly stating a property of *V*, such as it only contains self-inverse elements or does not contain a generator, and then going on to state it is therefore not cyclic and so cannot be isomorphic to *C* which is cyclic. Where marks were not awarded, this was typically due to a student arguing that the two groups were isomorphic, often due to constructing an incorrect one-to-one mapping between the elements of *V* and *C*.

In part (c), just over half of the students spotted the flaw in Rachel's claim and so were awarded at least one of the two marks. However, a more distinct comment about the potential groups of order 2, 4 or 8 was required for the second mark, and less than a quarter of students gave this full solution. The most common reason for not awarding either mark here was for the student thinking Lagrange's theorem did give information on the number of subgroups at the potential orders, and therefore commenting that Rachel's claim is correct.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.