



A level

Further Mathematics

7367/3D

Report on the examination

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Question 1

The vast majority of students were awarded the single mark available in this question.

Question 2

Over three-quarters of the students were awarded the single mark available in this question.

Question 3

Nearly all students were awarded the single mark available in this question.

Question 4

Just under two-thirds of the students received all three marks in part (a). Some students did not include units in their answer. Some students selected incorrect arcs for the minimum spanning tree, and some students used an incorrect procedure such as finding a Hamiltonian cycle.

In part (b), over two-thirds of the students were awarded both marks, as most could correctly identify that Hoole and Upton were not directly connected to each other in the minimum spanning tree of part (a), so had no effect on the minimum possible total length. The main reason why marks were not awarded was the use of imprecise language.

Question 5

Nearly 90% of students were awarded both marks in part (a)(i), with nearly all students receiving at least one mark. If both marks were not awarded, it was often for misapplication of the forward and reverse algorithms associated with determining the earliest start times and latest finish times.

The vast majority of students received the single mark in part (a)(ii). No unit was required for the mark in this series, but it is always good practice for students to include units with their numerical values.

In part (b) just over half of the students produced a fully correct cascade diagram and were awarded all three marks. Nearly 90% of the students received at least two marks. The most common reason for three marks not being awarded was for producing a resource histogram type diagram instead of a cascade diagram, so not showing any floats for the activities.

Question 6

In part (a) over 90% of students were awarded the two marks available. Where two marks were not awarded, it was often for identifying incorrect nodes, such as A and B for the super source and I and J for the super sink.

Over three-quarters of the students received the single mark available in part (b), where the common mistakes were not taking into account the direction of the flow across the arcs involved in the cut and whether that implies using the lower or upper capacity for individual arcs.

Part (c)(i) was found challenging. Most students could relate the value of the cut found in part (b) to the stated value of the flow, but few could correctly use the maximum flow-minimum cut theorem to correctly state that if a cut and a feasible flow are found to have the same value, then this cut is the minimum cut and this feasible flow is the maximum flow. Lots of students incorrectly reasoned that there may be a cut with a lower value and they would have to perform further checks to rule this out.

Students fared slightly better in part (c)(ii), with most correct answers reasoning that adding a super source or super sink into the network wouldn't change the value of the minimum cut, and so wouldn't change the value of the maximum flow.

Question 7

The vast majority of students receiving the single marks in part (a)(i) and part (a)(ii).

In part (b)(i), over three-quarters of the students identified the correct number of each loaf the bakery should make each day. The most common method for doing this was to construct an objective line to identify the optimal vertex of the feasible region.

Over 90% of the students were awarded the sole mark available in part (b)(ii).

Just under half of the students gave a plausible reason for part (b)(iii) and so were awarded the single mark.

Question 8

Just over half the students received all three marks in part (a)(i). Most students could correctly recall Euler's formula for connected planar graphs, and most of these students could go on to form a three-term quadratic equation. However, fewer students gave correct reasoning as to why only one of the solutions for the quadratic equation was viable. The correct reasonings were always based on testing the solutions and arguing that the number of edges cannot be negative or that the number of faces must be greater than or equal to one. Some students incorrectly reasoned that the vertices must also not be negative, but the vertices were given by n^2 and so would always be non-negative.

Nearly all students received the one mark available in part (a)(ii).

Over 95% of the students were able to produce a correct graph to represent G when G was Eulerian in part (b)(i). Some students did not draw any vertices on their graph and therefore were not awarded this mark.

In part (b)(ii) just over one-third of the students were awarded both marks. They correctly redraw the graph in a form where its bipartite property is more easily seen, or stated that G is isomorphic to $K_{2,2}$ and then related this back to the claim in the question.

In part (c)(i), just under 90% of students received the single mark available. Some students produced a graph with only three edges and so were not awarded the mark. Some students produced a graph which did have four vertices, four edges and two faces, but was not semi-Eulerian as all four of its vertices had odd degrees.

Part (c)(ii) was found challenging. Over half of the students received at least one mark, but just over a quarter of the students were awarded both marks. Most students could identify that G contained a cycle or had two faces, but didn't provide enough reasoning to explain why this resulted in G not being a tree; for instance, most students didn't say a tree cannot contain any cycles, or a tree has exactly one face.

Question 9

The vast majority of students received the single mark in part (a)(i), for correctly identifying that strategy **C** should never be played and for the reasoning that strategy **C** was dominated by strategy **B**.

Part (a)(ii) produced a spread of marks. Most students explicitly defined a probability variable and could produce three expressions for John's gain based upon each of Elizabeth's possible strategies. There was mixed quality for the graphs drawn in order to determine the optimal vertex and therefore the value of the probability variable – some students graphs lead them to make mistakes in which two of the three gains led to the correct optimal mixed strategy. Some students did not remove strategy **C** from the analysis which often lead to mistakes. Some students tried to apply the Simplex algorithm to this question, which often lead to errors.

In part (b), just under half of the students could produce all three correct inequalities. The most common mistakes included getting the orientation of the inequality sign the wrong way around, or to use the transpose of the entries in the pay-off matrix.

Question 10

Just under a quarter of the students were awarded both marks in part (a), but close to three-quarters received at least one mark. Most students could show that $(0, 1)$ was a left identity or a right identity, but fewer students showed it was both a left and right identity, and so be an identity, and then provide a correct conclusion.

Most students could form a correct relationship for the general element (a, b) and its inverse with $(0, 1)$, and over half of the students could work towards finding the entries of the ordered pair inverse in terms of a and b . However, only just over one quarter of the students found the correct inverse, with most errors being made in the algebra.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the [Results Statistics](#) page of the AQA Website.