Oxford Cambridge and RSA

Tuesday 3 June 2025 – Afternoon

AS Level Further Mathematics A

Y534/01 Discrete Mathematics

Time allowed: 1 hour 15 minutes

You must have:
- the Printed Answer Booklet
- the Formulae Booklet for AS Level Further Mathematics A
- a scientific or graphical calculator

QP

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INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided in the **Printed Answer Booklet**. If you need extra space use the lined pages at the end of the Printed Answer Booklet. The question numbers must be clearly shown.
- Fill in the boxes on the front of the Printed Answer Booklet.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.
- Give non-exact numerical answers correct to **3** significant figures unless a different degree of accuracy is specified in the question.
- The acceleration due to gravity is denoted by $g\,\mathrm{m\,s^{-2}}$. When a numerical value is needed use $g = 9.8$ unless a different value is specified in the question.
- Do **not** send this Question Paper for marking. Keep it in the centre or recycle it.

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **8** pages.

ADVICE
- Read each question carefully before you start your answer.

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1 A builder has some pieces of wood that are 6 m in length. The builder needs to cut smaller pieces to use in a project. The lengths of the smaller pieces required are shown below.

2.5 m 2 m 4.5 m 3 m 1.5 m 3.5 m 2 m

(a) Use the first-fit **decreasing** algorithm to determine the smallest number of 6 m lengths of wood needed to cut the seven smaller pieces. **[3]**

(b) First-fit decreasing is a **heuristic** algorithm. Explain what this means. **[1]**

The first-fit decreasing algorithm is order $O(n^2)$.

(c) It takes a computer 3.2 seconds to solve an allocation problem involving 200 items of data using the first-fit decreasing algorithm. Calculate approximately how long it would take to solve an allocation problem involving 1000 items of data. **[2]**

2 A student has six cards numbered from 1–6. The cards are shown below.

1	2	3	4	5	6

(a) The student chooses four cards at random.

Use the Pigeonhole Principle to explain why they must have at least two cards whose numbers add to seven. **[2]**

(b) The student now chooses two cards and places them side by side to form a two-digit number.

(i) Determine the number of different two-digit numbers that the student can make. **[2]**

(ii) Determine the number of different **even** two-digit numbers that the student can make. **[2]**

3 The table shows the lengths in km of footpaths between six places, A to F, in a town.

	A	B	C	D	E	F
A	–	5	3	5	8	10
B	5	–	6	2	7	5
C	3	6	–	1	10	8
D	5	2	1	–	9	4
E	8	7	10	9	–	3
F	10	5	8	4	3	–

(a) Apply the tabular form of Prim's algorithm, starting at A, to the copy of the table in the **Printed Answer Booklet** to construct a minimum spanning tree for the six places in the town. You should state the order in which the arcs are added to the tree.

Draw the minimum spanning tree and find its weight. **[4]**

(b) Sam needs to walk from A to F.

Give an example of a question Sam could ask which leads to an enumeration problem. **[1]**

(c) Use an appropriate algorithm to find the shortest route from A to F. You must state its length. **[4]**

4 Ryan and Casey play a game.
They can each choose to play one of three options.
Ryan can play options A, B and C and Casey can play options X, Y and Z.

The scores for each player for each combination of choices are shown in the pay-off matrices below:

Scores for Ryan

Casey's Options

Ryan's Options		**X**	**Y**	**Z**
	A	1	4	3
	B	5	3	4
	C	3	1	3

Scores for Casey

Casey's Options

Ryan's Options		**X**	**Y**	**Z**
	A	5	2	3
	B	1	3	2
	C	3	5	3

(a) Explain how the game between Ryan and Casey can be expressed as the zero-sum game with the pay-off matrix below (the entries represent pay-offs for Ryan). **[1]**

Casey's Options

Ryan's Options

	X	**Y**	**Z**
A	–2	1	0
B	2	0	1
C	0	–2	0

(b) If Casey knows that Ryan will play option A, state the option that Casey should play. **[1]**

(c) Find the play-safe strategies for both players. **[3]**

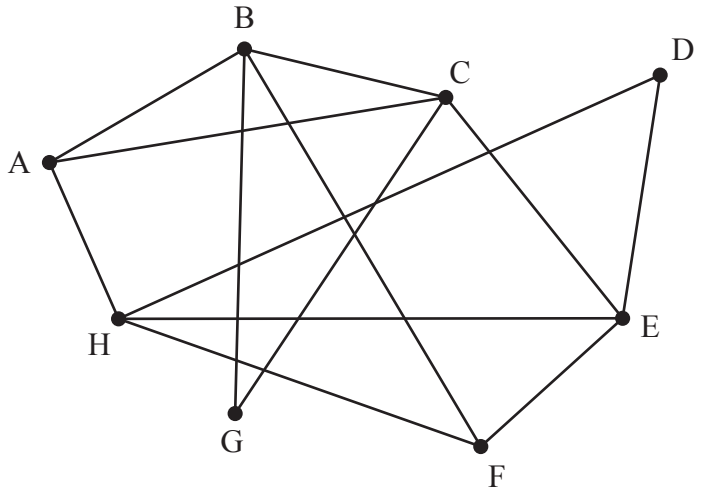
(d) Determine whether or not the game is stable. **[1]**

(e) Use a dominance argument to reduce the zero-sum game to a 2×3 game. **[1]**

(f) Let p be the probability that Ryan plays option A on the reduced game from part **(e)**.

Use a graphical method to determine the optimal mixed strategy for Ryan. **[4]**

5 Graph X is shown below.



(a) Explain whether graph X is Eulerian, semi-Eulerian or neither. **[1]**

(b) Give an example of a cycle on the graph above. **[1]**

The adjacency matrix for a graph Y is shown below.

	I	**J**	**K**	**L**	**M**	**N**	**O**	**P**
I	0	1	1	1	0	0	0	1
J	1	0	1	1	1	0	0	0
K	1	1	0	1	0	0	0	0
L	1	1	1	0	1	0	0	0
M	0	1	0	1	0	0	0	1
N	0	0	0	0	0	0	1	1
O	0	0	0	0	0	1	0	1
P	1	0	0	0	1	1	1	0

(c) Show that X and Y are **not** isomorphic. **[3]**

6 The table shows the activities involved in a project, together with their immediate predecessors and the duration of each activity in hours.

Activity	**Duration (Hours)**	**Immediate Predecessors**
A	3	–
B	1	–
C	2	A
D	2	A, B
E	5	C
F	2	C, D
G	4	E, F

(a) Model the project using an activity network. **[3]**

(b) **(i)** Carry out a forward pass to find the early event times and a backward pass to find the late event times. **[3]**

(ii) Write down the critical activities. **[1]**

(c) Determine the effect on the minimum project completion time if the duration of activity F is 4 hours longer than planned. **[2]**

Turn over for question 7

7 A shop sells three different arrangements of flowers, X, Y and Z. The number of roses, lilies and carnations in each arrangement are shown in the table below.
The shop will sell all of the arrangements that they make.

Arrangement	Roses	Lilies	Carnations
X	5	3	5
Y	4	7	2
Z	9	6	7

Arrangement X sells for £20, arrangement Y sells for £15 and arrangement Z sells for £24.

The shopkeeper has a maximum of 40 roses, 80 lilies and 30 carnations that they can use to make the flower arrangements.

The shopkeeper wants to make as much money as possible from selling the flower arrangements.

The shopkeeper decides that **no more** than 50% of the total number of arrangements can be arrangement Y.

(a) Formulate a linear programming problem to represent the problem. You should define the variables that you are using in your formulation. **[5]**

The shopkeeper decides to make the same number of arrangement Z as arrangement X.

(b) (i) Use a graphical method to determine how many of each arrangement should be made. **[6]**

(ii) State the maximum amount of money that the shopkeeper can make. **[1]**

The maximum number of lilies available changes from 80 to k. The number of arrangement Z is still the same as the number of arrangement X.

(c) Determine the range of values of k for which the new optimal solution is the same as in part **(b)(i)**. **[2]**

END OF QUESTION PAPER

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