

Please write clearly, in block capitals.

Centre number

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Candidate number

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Surname

Forename(s)

Candidate signature

A-level FURTHER MATHEMATICS

Paper 3 - Discrete

Exam Date

Morning

Time allowed: 2 hours

Materials

For this paper you must have:

- You must ensure you have the other optional question paper/answer booklet for which you are entered (**either** Mechanics **or** Statistics). You will have 2 hours to complete both papers.
- The AQA booklet of formulae and statistical tables.
- You may use a graphics calculator.

Instructions

- Use black ink or black ball-point pen. Pencil should be used for drawing.
- Answer **all** questions.
- You must answer each question in the space provided for that question. If you require extra space, use an AQA supplementary answer book; do **not** use the space provided for a different question.
- Do not write outside the box around each page.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work that you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 50.

Advice

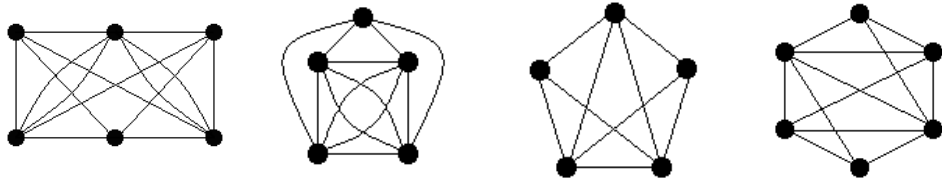
Unless stated otherwise, you may quote formulae, without proof, from the booklet.
You do not necessarily need to use all the space provided.

Answer **all** questions in the spaces provided.

1 Which of the following graphs is **not** planar?

Circle your answer.

[1 mark]



- 2** The set $\{1, 2, 4, 8, 9, 13, 15, 16\}$ forms a group under the operation of multiplication modulo 17.

Which of the following is a generator of the group?

Circle your answer.

[1 mark]

4

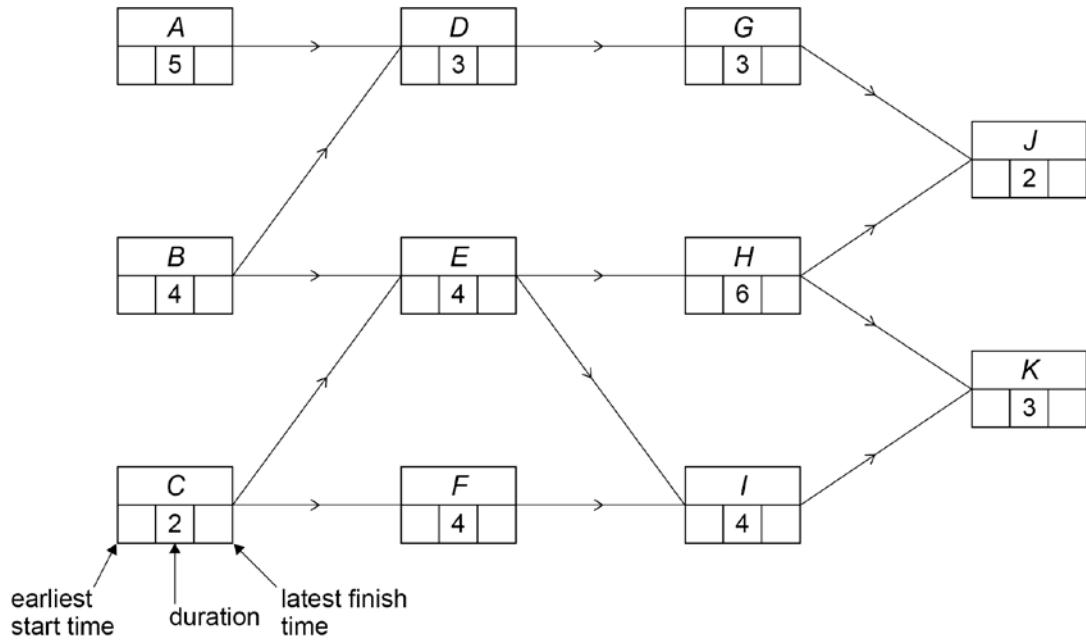
9

13

16

- 3 Deva Construction Ltd undertakes a small building project. The activity network for this project is shown below in **Figure 1**, where each activity's duration is given in hours.

Figure 1



- 3 (a) Complete the activity network for the building project.

[2 marks]

3 (b) Deva Construction Ltd is able to reduce the duration of a single activity to 1 hour by using specialist equipment.

State, with a reason, which activity should have its duration reduced to 1 hour in order to minimise the completion time for the building project.

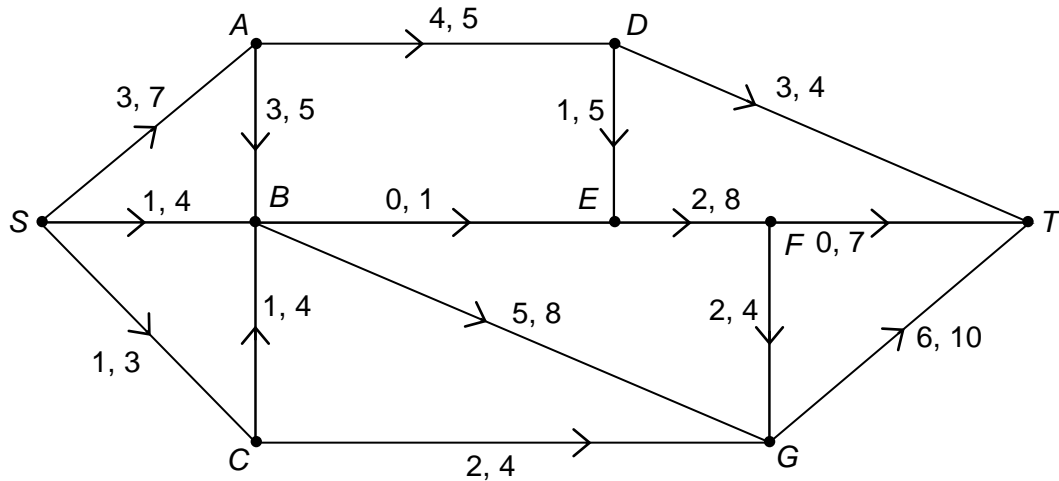
[3 marks]

3 (c) State one limitation in the building project used by Deva Construction Ltd.

Explain how this limitation affects the project.

[2 marks]

- 6 The network shows a system of pipes, where S is the source and T is the sink.
- The lower and upper capacities, in litres per second, of each pipe are shown on each arc.



- 6 (a) There is a feasible flow from S to T .

- 6 (a) (i) Explain why arc AD must be at its lower capacity.

[1 mark]

- 6 (a) (ii) Explain why arc BE must be at its upper capacity.

[1 mark]

- 6 (b) Explain why a flow of 11 litres per second through the network is impossible.

[1 mark]

- 6 (c) The network in **Figure 2** shows a second system of pipes, where S is the source and T is the sink.

The lower and upper capacities, in litres per second, of each pipe are shown on each edge.

Figure 2

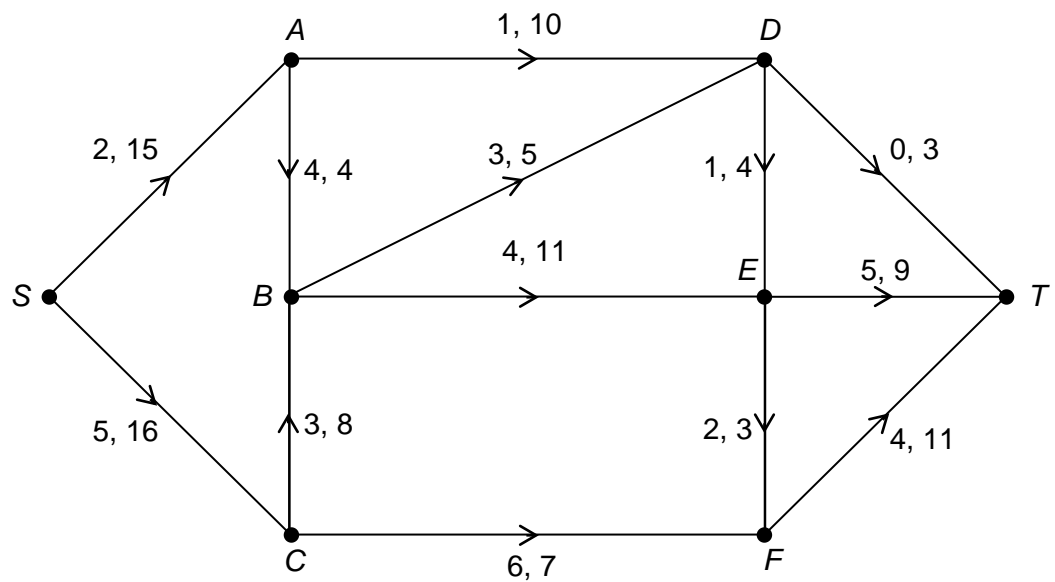
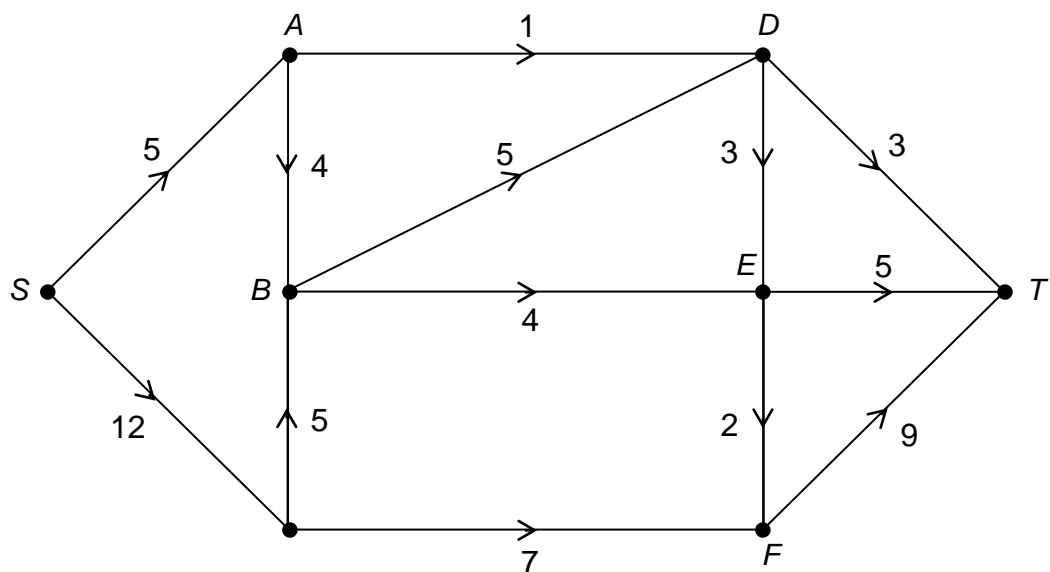


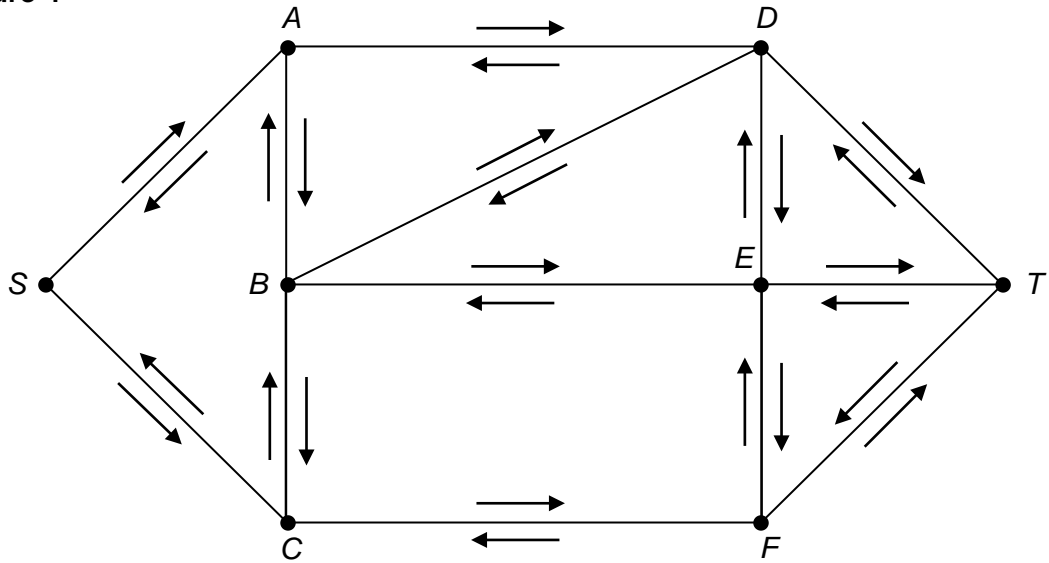
Figure 3 shows a feasible flow of 17 litres per second through the system of pipes.

Figure 3



6 (c) (i) Using **Figures 2** and **3**, indicate on **Figure 4** potential increases and decreases in the flow along each arc. [2 marks]

Figure 4



6 (c) (ii) Use flow augmentation on **Figure 4** to find the maximum flow from S to T.

You should indicate any flow augmenting paths clearly in the table below and modify the potential increases and decreases of the flow on **Figure 4**.

[3 marks]

Augmenting Path	Flow

6 (c) (iii) Prove the flow found in part (d) (ii) is maximum.

[1 mark]

6 (c) (iv) Due to maintenance work, the flow through node E is restricted to 9 litres per second.

Interpret the impact of this restriction on the maximum flow through the system of pipes.

[2 marks]

Turn over for the next question
