

General Certificate of Education  
June 2006  
Advanced Level Examination



**MATHEMATICS**  
**Unit Decision 2**

**MD02**

Thursday 8 June 2006 9.00 am to 10.30 am

**For this paper you must have:**

- an 8-page answer book
- the **blue** AQA booklet of formulae and statistical tables
- an insert for use in Questions 1, 3 and 4 (enclosed)

You may use a graphics calculator.

Time allowed: 1 hour 30 minutes

**Instructions**

- Use blue or black ink or ball-point pen. Pencil or coloured pencil should only be used for drawing.
- Write the information required on the front of your answer book. The *Examining Body* for this paper is AQA. The *Paper Reference* is MD02.
- Answer **all** questions.
- Show all necessary working; otherwise marks for method may be lost.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Fill in the boxes at the top of the insert.

**Information**

- The maximum mark for this paper is 75.
- The marks for questions are shown in brackets.

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Answer **all** questions.

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**1** [Figures 1 and 2, printed on the insert, are provided for use in this question.]

A construction project is to be undertaken. The table shows the activities involved.

Activity	Immediate Predecessors	Duration (days)
<i>A</i>	–	2
<i>B</i>	<i>A</i>	5
<i>C</i>	<i>A</i>	8
<i>D</i>	<i>B</i>	8
<i>E</i>	<i>B</i>	10
<i>F</i>	<i>B</i>	4
<i>G</i>	<i>C, F</i>	7
<i>H</i>	<i>D, E</i>	4
<i>I</i>	<i>G, H</i>	3

- Complete the activity network for the project on **Figure 1**. (3 marks)
- Find the earliest start time for each activity. (2 marks)
- Find the latest finish time for each activity. (2 marks)
- Find the critical path. (1 mark)
- State the float time for each non-critical activity. (2 marks)
- On **Figure 2**, draw a cascade diagram (Gantt chart) for the project, assuming each activity starts as **late** as possible. (4 marks)

- 2 Four of the five students Phil, Quin, Ros, Sue and Tim are to be chosen to make up a team for a mathematical relay race. The team will be asked four questions, one each on the topics A, B, C and D. A different member of the team will answer each question. Each member has to give the correct answer to the question before the next question is asked. The team with the least overall time wins.

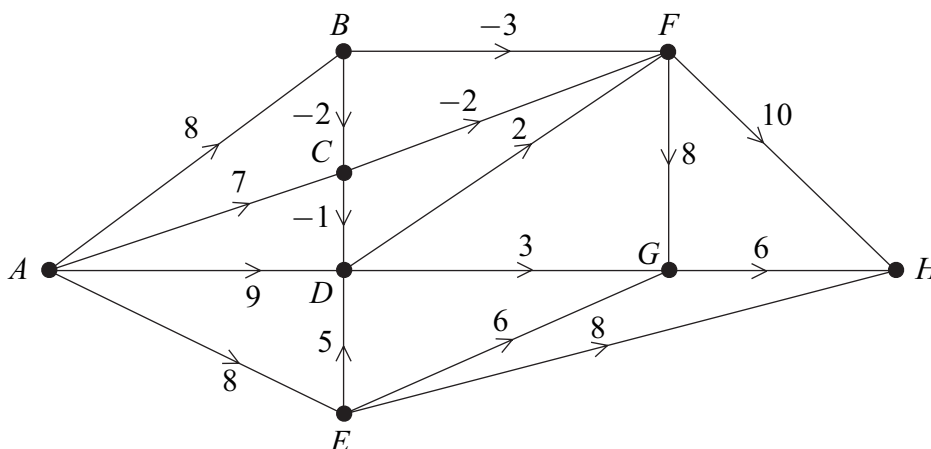
The average times, in seconds, for each student in some practice questions are given below.

	Phil	Quin	Ros	Sue	Tim
<b>Topic A</b>	18	15	19	20	17
<b>Topic B</b>	23	24	22	25	23
<b>Topic C</b>	20	16	18	22	19
<b>Topic D</b>	21	17	18	23	20

- (a) Modify the table of values by adding an extra row of values so that the Hungarian algorithm can be applied. (1 mark)
- (b) Use the Hungarian algorithm, reducing **columns first**, then rows, to decide which four students should be chosen for the team. State which student should be allocated to each topic and state the total time for the four students on the practice questions using this matching. (8 marks)

- 3 [Figure 3, printed on the insert, is provided for use in this question.]

The following network shows eight vertices. The number on each edge is the cost of travelling between the corresponding vertices. A negative number indicates a reduction by the amount shown.

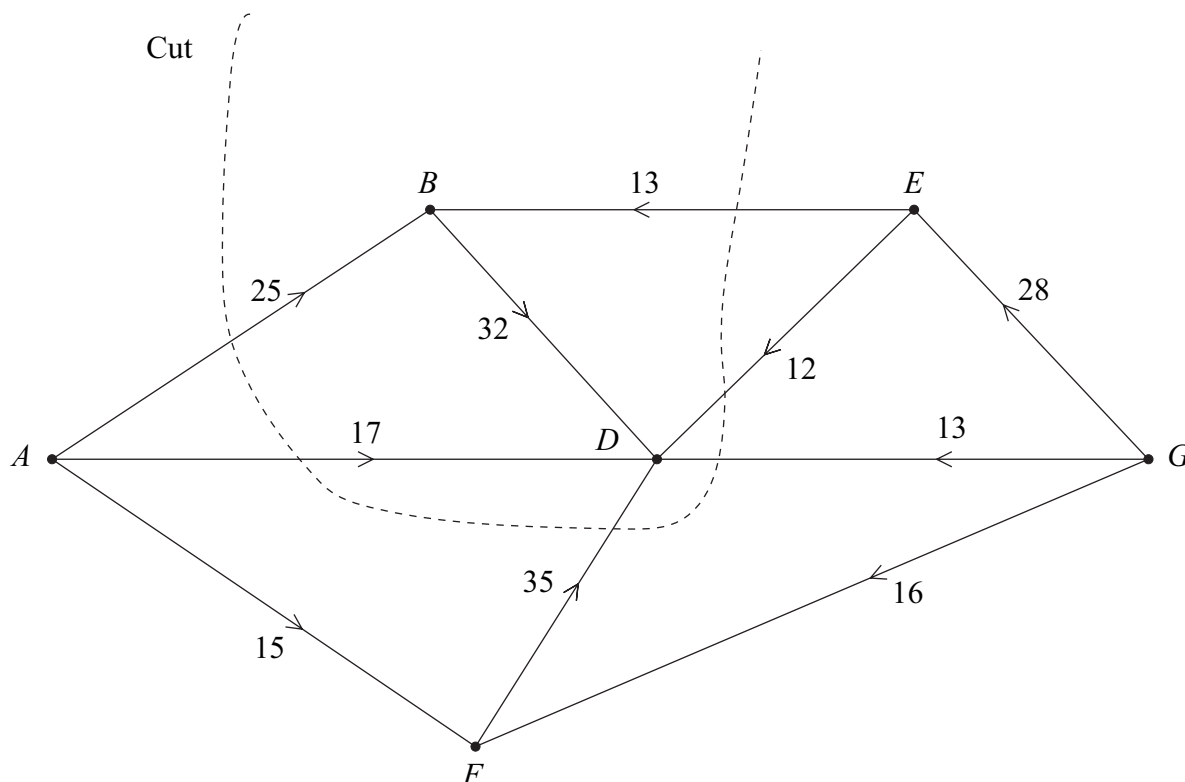


- (a) Use dynamic programming to find the minimum cost of travelling from A to H. You may use **Figure 3** for your working. (6 marks)
- (b) State the minimum cost and the possible routes corresponding to this minimum cost. (3 marks)

Turn over ►

4 [Figures 4 and 5, printed on the insert, are provided for use in this question.]

The network shows the routes along corridors from the playgrounds  $A$  and  $G$  to the assembly hall in a school. The number on each edge represents the maximum number of pupils that can travel along the corridor in one minute.



- (a) State the vertex that represents the assembly hall. (1 mark)
- (b) Find the value of the cut shown on the diagram. (1 mark)
- (c) State the maximum flow along the routes  $ABD$  and  $GED$ . (2 marks)
- (d)
  - (i) Taking your answers to part (c) as the initial flow, use a labelling procedure on **Figure 4** to find the maximum flow through the network. (6 marks)
  - (ii) State the value of the maximum flow and, on **Figure 5**, illustrate a possible flow along each edge corresponding to this maximum flow. (2 marks)
  - (iii) Verify that your flow is a maximum flow by finding a cut of the same value. (2 marks)
- (e) On a particular day, there is an obstruction allowing no more than 15 pupils per minute to pass through vertex  $E$ . State the maximum number of pupils that can move through the network per minute on this particular day. (2 marks)

- 5 A linear programming problem involving variables  $x$  and  $y$  is to be solved. The objective function to be maximised is  $P = 4x + 9y$ . The initial Simplex tableau is given below.

$P$	$x$	$y$	$r$	$s$	$t$	<i>value</i>
1	-4	-9	0	0	0	0
0	3	7	1	0	0	33
0	1	2	0	1	0	10
0	2	7	0	0	1	26

- (a) Write down the **three** inequalities in  $x$  and  $y$  represented by this tableau. (2 marks)
- (b) The Simplex method is to be used to solve this linear programming problem by initially choosing a value in the  $x$ -column as the pivot.
- (i) Explain why the initial pivot has value 1. (2 marks)
- (ii) Perform **two** iterations using the Simplex method. (7 marks)
- (iii) Comment on how you know that the optimum solution has been achieved and state your final values of  $P$ ,  $x$  and  $y$ . (3 marks)
- 6 Two people, Rowan and Colleen, play a zero-sum game. The game is represented by the following pay-off matrix for Rowan.

		Colleen		
Rowan	<i>Strategy</i>	<b>C<sub>1</sub></b>	<b>C<sub>2</sub></b>	<b>C<sub>3</sub></b>
	<b>R<sub>1</sub></b>	−3	−4	1
	<b>R<sub>2</sub></b>	1	5	−1
	<b>R<sub>3</sub></b>	−2	−3	4

- (a) Explain the meaning of the term 'zero-sum game'. (1 mark)
- (b) Show that this game has no stable solution. (3 marks)
- (c) Explain why Rowan should never play strategy  $R_1$ . (1 mark)
- (d) (i) Find the optimal mixed strategy for Rowan. (7 marks)
- (ii) Find the value of the game. (1 mark)

**END OF QUESTIONS**

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Surname						Other Names					
Centre Number						Candidate Number					
Candidate Signature											

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# Insert

Thursday 8 June 2006      9.00 am to 10.30 am

Insert for use in **Questions 1, 3 and 4.**

Fill in the boxes at the top of this page.

Fasten this insert securely to your answer book.

**Turn over for Figure 1**

**Turn over ►**

For use in Question 1

Figure 1 (for use in parts (a), (b) and (c))

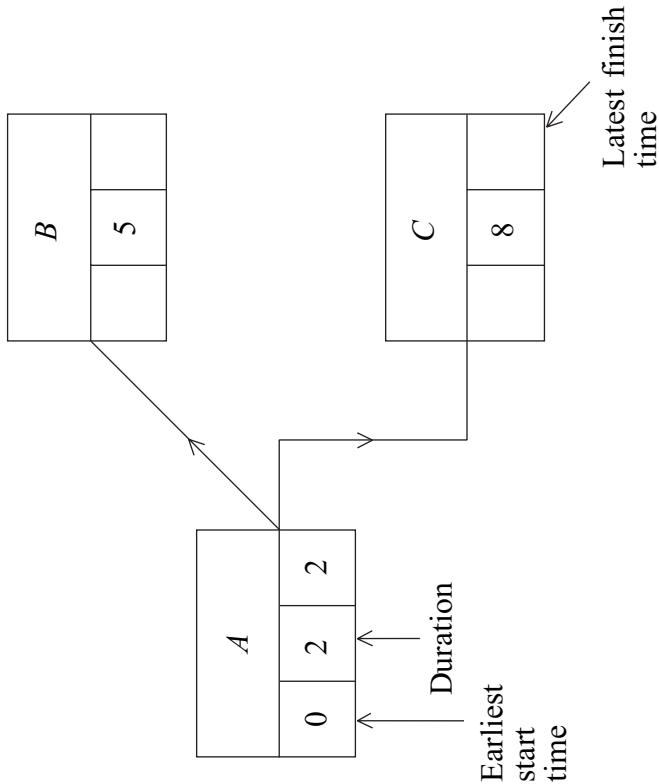


Figure 2 (for use in part (f))

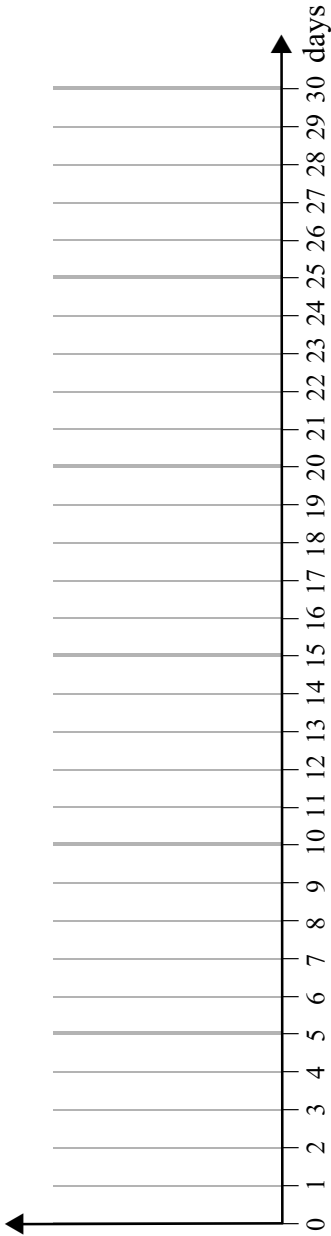
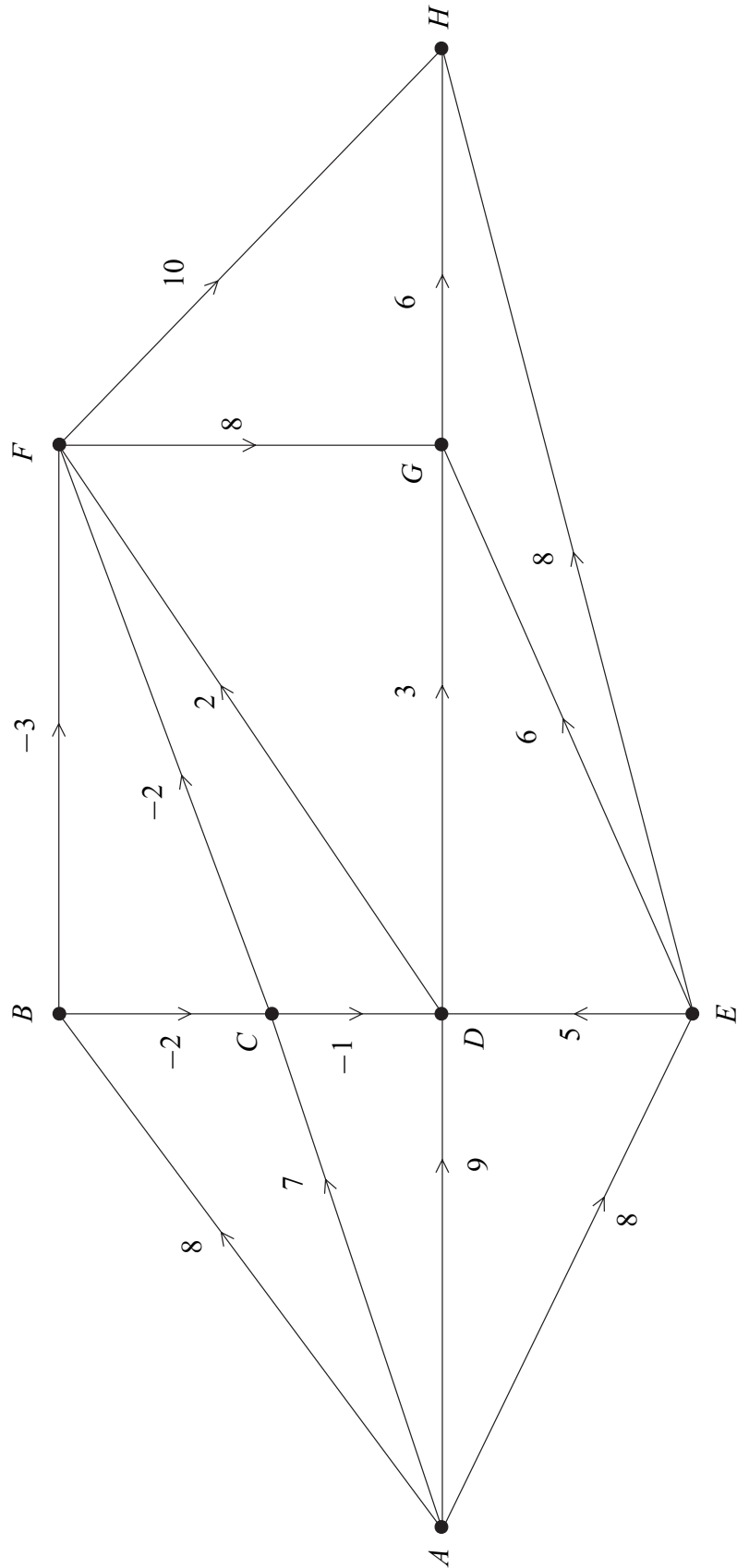
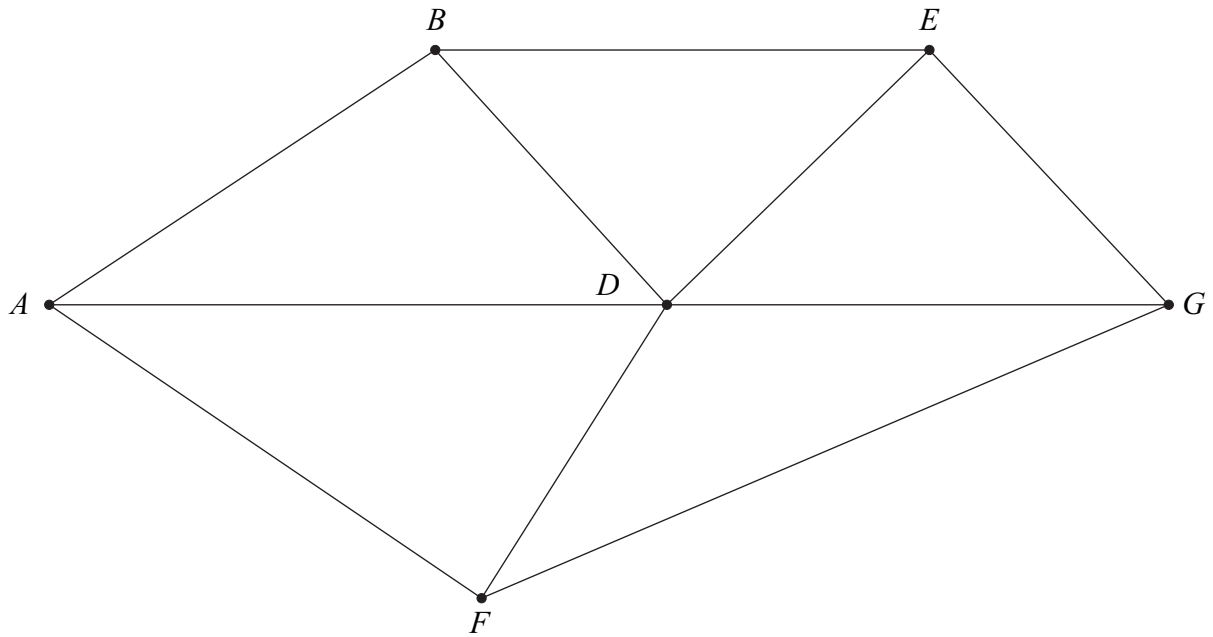


Figure 3 (for use in Question 3)



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Figure 4 (for use in Question 4 part (d)(i))



Route	Flow
<i>ABD</i>	
<i>GED</i>	

Figure 5 (for use in Question 4 part (d)(ii))

