Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
TOTAL	

General Certificate of Education
Advanced Level Examination
June 2010

Mathematics MD02

Unit Decision 2

Friday 18 June 2010 1.30 pm to 3.00 pm

For this paper you must have:
- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed
- 1 hour 30 minutes

Instructions
- Use black ink or black ball-point pen. Pencil or coloured pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Write the question part reference (eg (a), (b)(i) etc) in the left-hand margin.
- You must answer the questions in the spaces provided. 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.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.

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

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

1 **Figure 1** below shows an activity diagram for a construction project. The time needed for each activity is given in days.

(a) Find the earliest start time and latest finish time for each activity and insert their values on **Figure 1**. *(4 marks)*

(b) Find the critical paths and state the minimum time for completion of the project. *(3 marks)*

(c) On **Figure 2** opposite, draw a cascade diagram (Gantt chart) for the project, assuming that each activity starts as early as possible. *(3 marks)*

(d) A delay in supplies means that Activity I takes 9 days instead of 2.

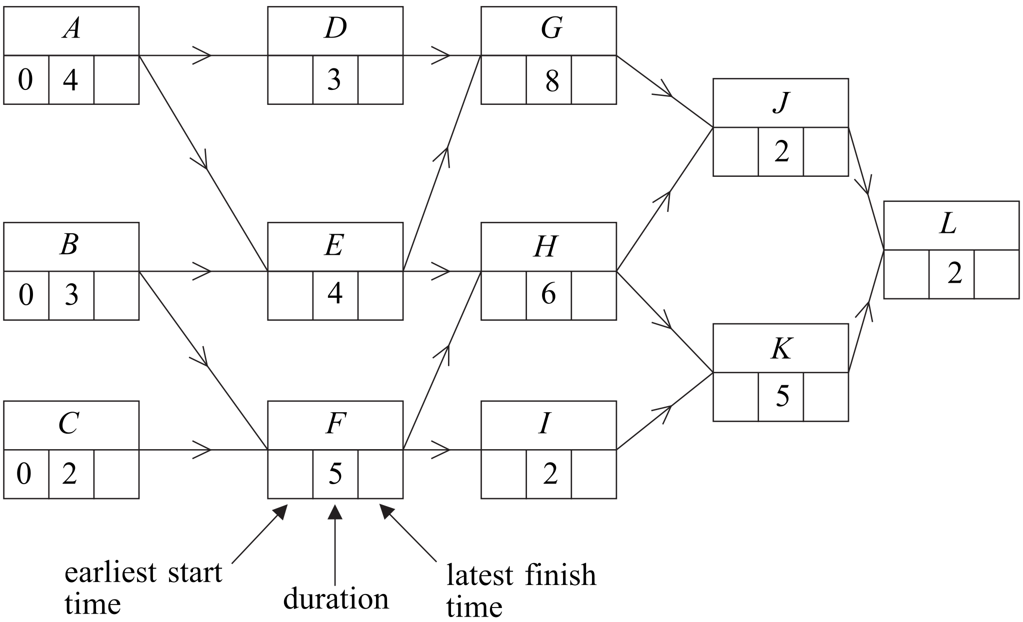
(i) Determine the effect on the **earliest** possible starting times for activities K and L. *(2 marks)*

(ii) State the number of days by which the completion of the project is now delayed. *(1 mark)*

QUESTION PART REFERENCE

(a)

Figure 1



(b) Critical paths are ....

....

Minimum completion time is .... days.

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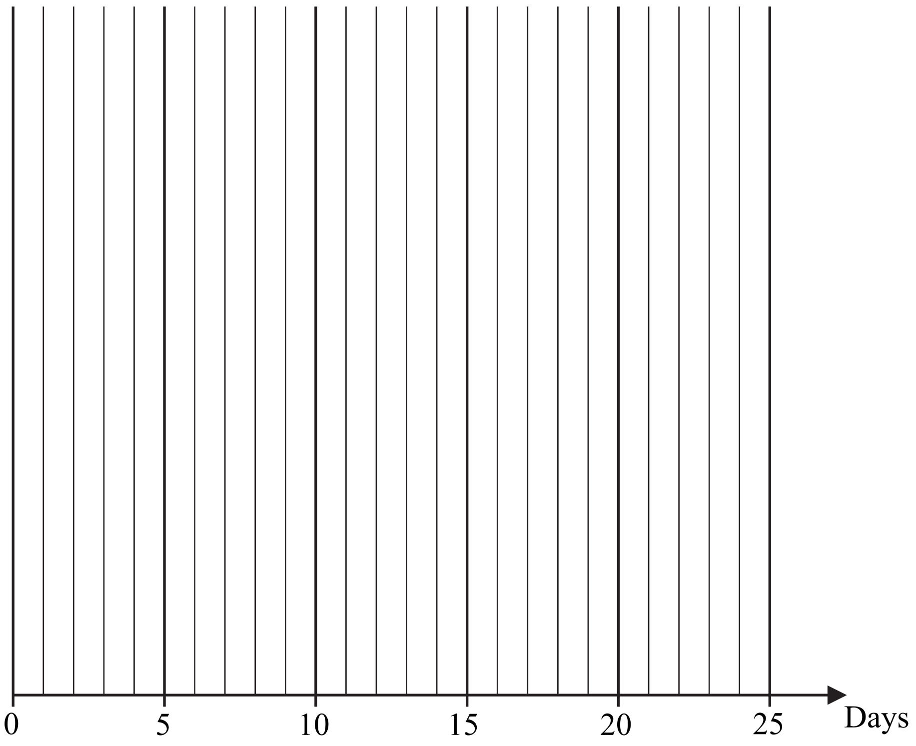
QUESTION PART REFERENCE

(c)

Figure 2



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2 Five students attempted five different games, and penalty points were given for any mistakes that they made. The table shows the penalty points incurred by the students.

	Game 1	Game 2	Game 3	Game 4	Game 5
Ali	5	7	3	8	8
Beth	8	6	4	8	7
Cat	6	1	2	10	3
Di	4	4	3	10	7
Ell	4	6	4	7	9

Using the Hungarian algorithm, each of the five students is to be allocated to a different game so that the total number of penalty points is minimised.

(a) By reducing the **rows first** and then the columns, show that the new table of values is

2	4	0	2	3
4	2	0	1	1
5	0	1	k	0
1	1	0	4	2
0	2	0	0	3

and state the value of the constant k. *(3 marks)*

(b) Show that the zeros in the table in part **(a)** can be covered with three lines, and use augmentation to produce a table where five lines are required to cover the zeros. *(3 marks)*

(c) Hence find the possible ways of allocating the five students to the five games with the minimum total of penalty points. *(3 marks)*

(d) Find the minimum possible total of penalty points. *(1 mark)*

QUESTION PART REFERENCE

QUESTION PART REFERENCE

3 (a) Given that k is a constant, display the following linear programming problem in a Simplex tableau.

Maximise $P = 6x + 5y + 3z$

subject to $x + 2y + kz \leqslant 8$

$2x + 10y + z \leqslant 17$

$x \geqslant 0,\ y \geqslant 0,\ z \geqslant 0$ *(3 marks)*

(b) (i) Use the Simplex method to perform **one** iteration of your tableau for part **(a)**, choosing a value in the x-column as pivot. *(4 marks)*

(ii) Given that the maximum value of P has not been achieved after this first iteration, find the range of possible values of k. *(2 marks)*

(c) In the case where $k = -1$, perform one further iteration and interpret your final tableau. *(6 marks)*

QUESTION PART REFERENCE

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QUESTION PART REFERENCE

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4 Two people, Roger and Corrie, play a zero-sum game.

The game is represented by the following pay-off matrix for Roger.

Corrie

	Strategy	**C_1**	**C_2**	**C_3**
Roger	**R_1**	7	3	-5
	R_2	-2	-1	4

(a) (i) Find the optimal mixed strategy for Roger. *(7 marks)*

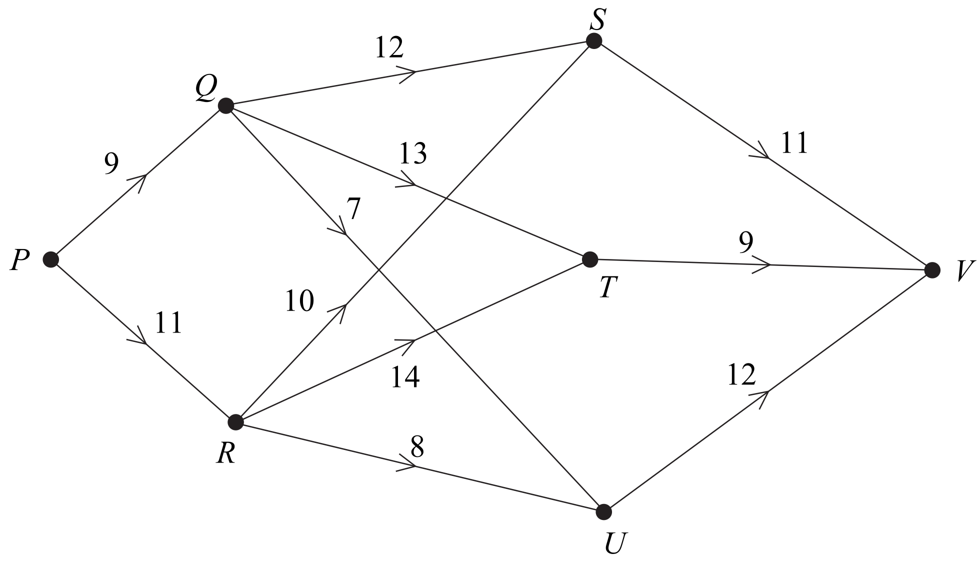
(ii) Show that the value of the game is $\frac{7}{13}$. *(1 mark)*

(b) Given that the value of the game is $\frac{7}{13}$, find the optimal mixed strategy for Corrie. *(5 marks)*

QUESTION PART REFERENCE

QUESTION PART REFERENCE

5 A three-day journey is to be made from P to V, with overnight stops at the end of the first day at one of the locations Q or R, and at the end of the second day at S, T or U. The network shows the journey times, in hours, for each day of the journey.



The optimal route, known as the minimax route, is that in which the longest day's journey is as small as possible.

(a) Explain why the route $PQSV$ is better than the route $PQTV$. *(2 marks)*

(b) By completing the table opposite, or otherwise, use dynamic programming, **working backwards from V**, to find the optimal (minimax) route from P to V.

You should indicate the calculations as well as the values at stages 2 and 3. *(8 marks)*

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(b)

Stage	State	Action	Calculation	Value
1	S	SV	–	
	T	TV	–	
	U	UV	–	
2	Q	QS		

Minimax route from P to V is ....

Turn over ▶

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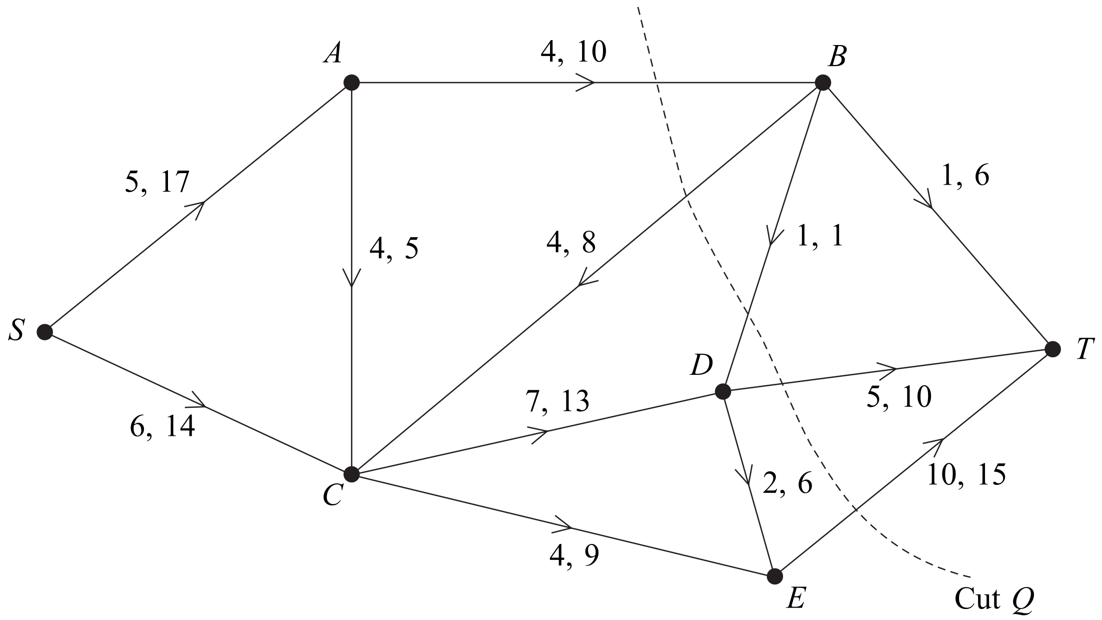
6 The network shows a system of pipes with the lower and upper capacities for each pipe in litres per minute.



(a) Find the value of the cut Q. *(2 marks)*

(b) **Figure 3** opposite shows a partially completed diagram for a feasible flow of 24 litres per minute from S to T. Indicate, on **Figure 3**, the flows along the edges BT, DE and ET. *(2 marks)*

(c) (i) Taking your answer from part **(b)** as an initial flow, indicate potential increases and decreases of the flow along each edge on **Figure 4** opposite. *(2 marks)*

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

You should indicate any flow augmenting paths in the table and modify the potential increases and decreases of the flow on the network. *(5 marks)*

(iii) Illustrate the maximum flow on **Figure 5** opposite. *(2 marks)*

(d) Find a cut with value equal to that of the maximum flow.

You may wish to show the cut on the network above. *(1 mark)*

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Figure 3

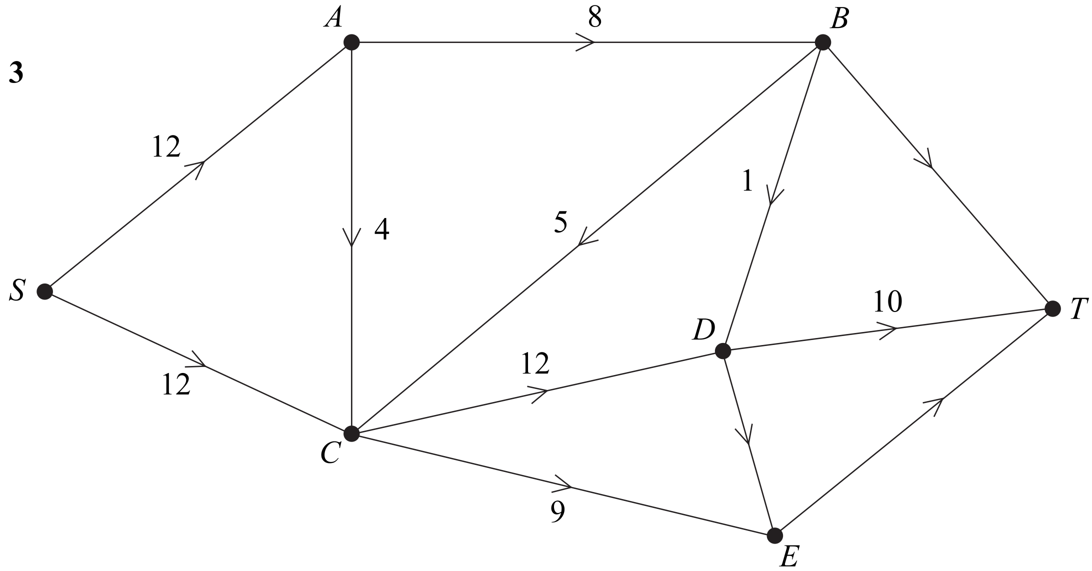
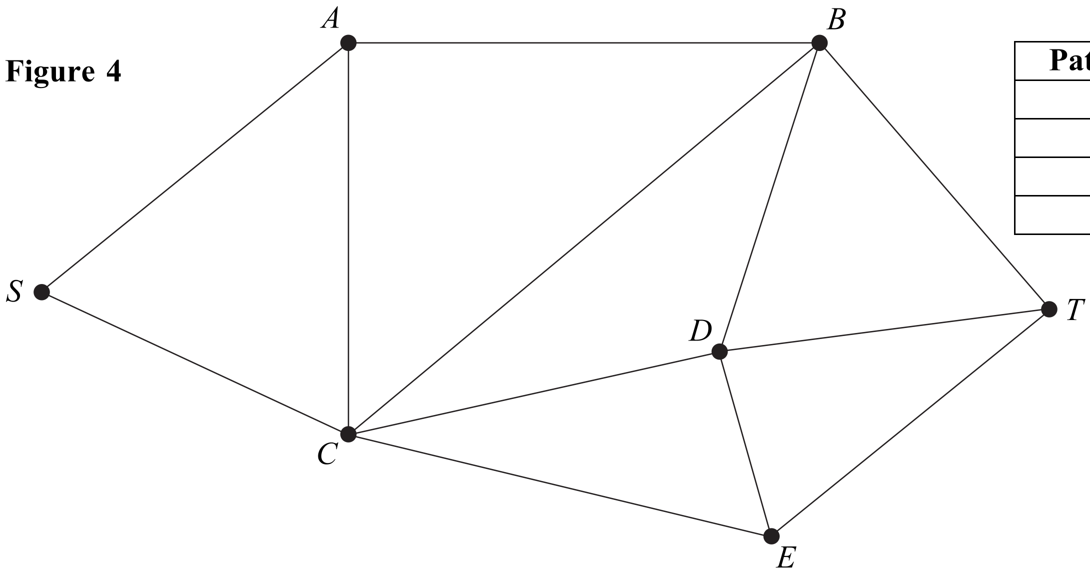
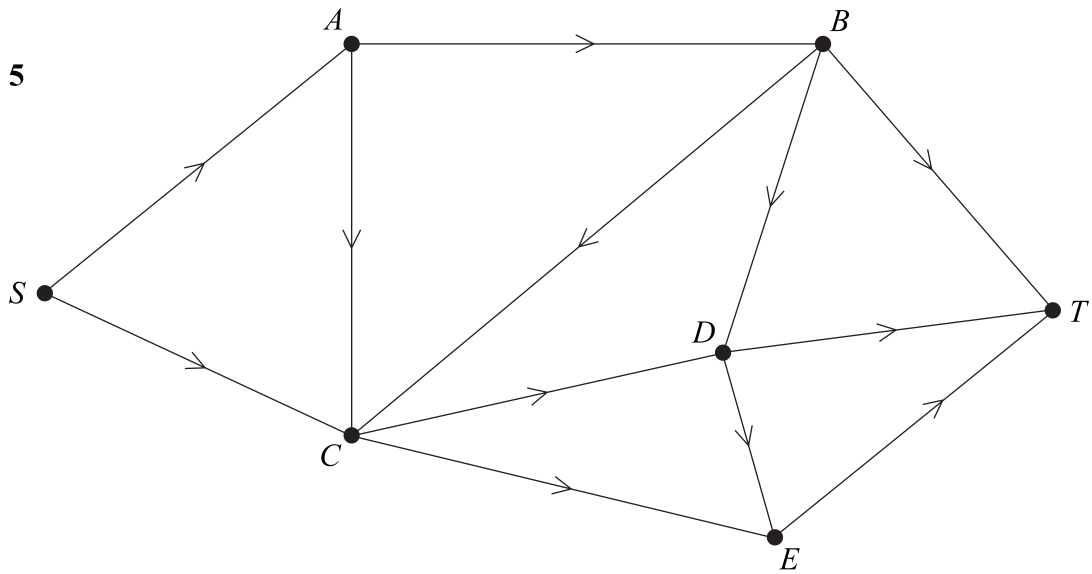


Figure 4



Path	Flow

Figure 5



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END OF QUESTIONS

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