Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
TOTAL	

General Certificate of Education
Advanced Level Examination
January 2013

Mathematics MD02

Unit Decision 2

Monday 28 January 2013 9.00 am to 10.30 am

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 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 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.
- 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.

Advice
- You do not necessarily need to use all the space provided.

Answer **all** questions.

Answer each question in the space provided for that question.

1 **Figure 1** below shows an activity diagram for a project. Each activity requires one worker. The duration required for each activity is given in hours.

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

(b) On **Figure 2** opposite, complete the precedence table. *(2 marks)*

(c) Find the critical path. *(1 mark)*

(d) Find the float time of activity *E*. *(1 mark)*

(e) Using **Figure 3** on page 5, draw a resource histogram to illustrate how the project can be completed in the minimum time, assuming that each activity is to start as early as possible. *(3 marks)*

(f) Given that there are two workers available for the project, find the minimum completion time for the project. *(1 mark)*

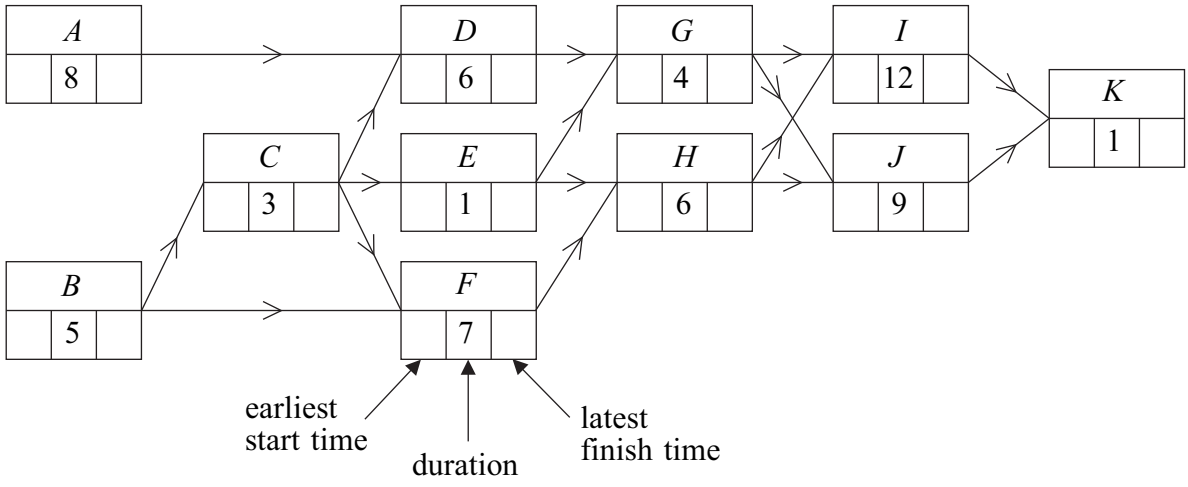
(g) Given that there is only one worker available for the project, find the minimum completion time for the project. *(1 mark)*

QUESTION PART REFERENCE

(a)

Answer space for question 1

Figure 1



QUESTION PART REFERENCE

Answer space for question 1

(b)

Figure 2

Activity	Immediate predecessor(s)
A	
B	
C	
D	
E	
F	
G	
H	
I	
J	
K	

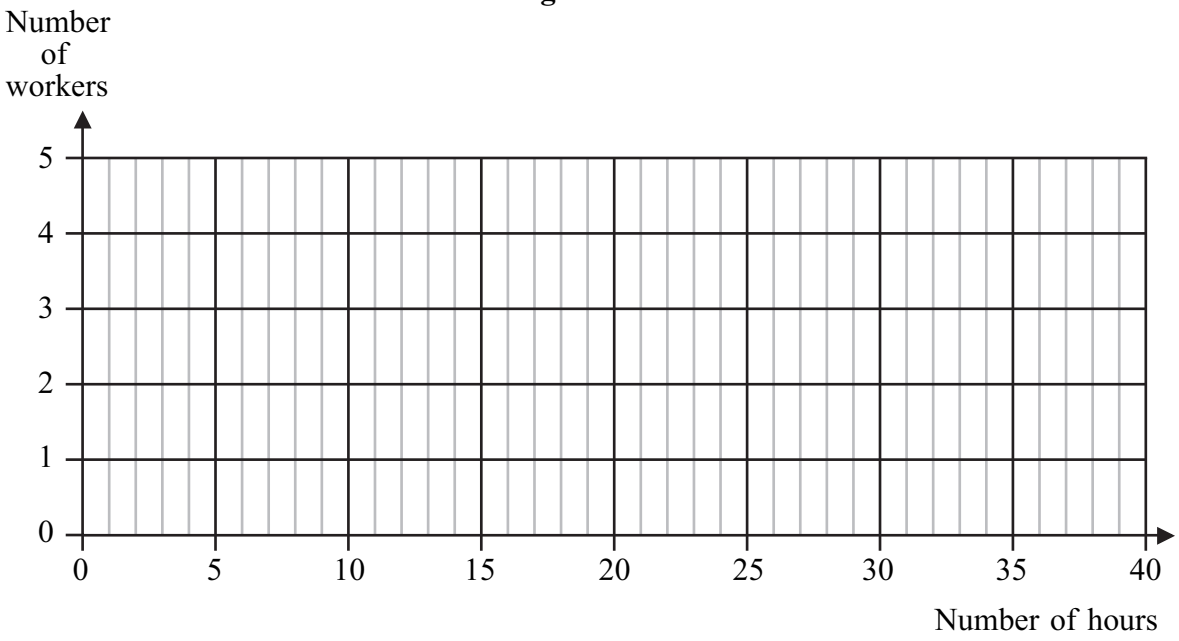
QUESTION PART REFERENCE

Answer space for question 1

QUESTION PART REFERENCE

Answer space for question 1

Figure 3



2 Harry and Will play a zero-sum game. The game is represented by the following pay-off matrix for Harry.

		Will			
	Strategy	***D***	***E***	***F***	***G***
Harry	***A***	4	−1	2	3
	B	4	6	3	7
	C	1	3	−2	4

(a) Show that this game has a stable solution and state the play-safe strategy for each player. *(4 marks)*

(b) List any saddle points. *(1 mark)*

QUESTION PART REFERENCE

Answer space for question 2

QUESTION PART REFERENCE

Answer space for question 2

3 Four pupils, Wendy, Xiong, Yasmin and Zaira, are each to be allocated a different memory coach from five available coaches: Asif, Bill, Connie, Deidre and Eric. Each pupil has an initial training session with each coach, and a test which scores their improvement in memory-recall produces the following results.

	Asif	**Bill**	**Connie**	**Deidre**	**Eric**
Wendy	35	38	43	34	37
Xiong	38	37	38	34	36
Yasmin	32	33	31	31	32
Zaira	34	38	35	31	34

(a) Modify the table of results by subtracting each value from 43. *(1 mark)*

(b) Use the Hungarian algorithm, reducing the **rows first**, to assign one coach to one pupil so that the total improvement of the four pupils is maximised.

State the total improvement of the four pupils. *(8 marks)*

QUESTION PART REFERENCE

Answer space for question 3

QUESTION PART REFERENCE

Answer space for question 3

4 (a) When investigating three network flow problems, a student finds:

(i) a flow of 50 and a cut with capacity 50;

(ii) a flow of 35 and a cut with capacity 50;

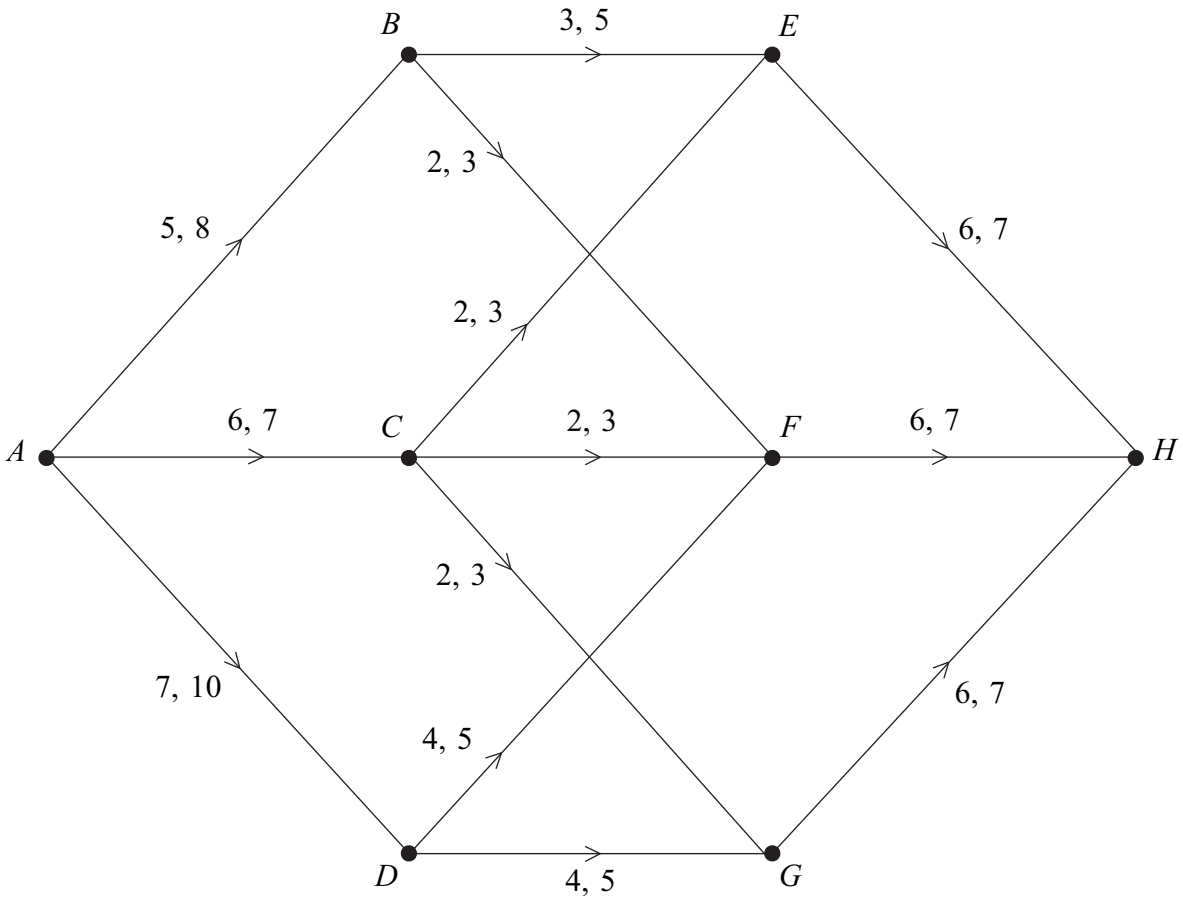
(iii) a flow of 50 and a cut with capacity 35.

In each case, write down what the student can deduce about the maximum flow.

(4 marks)

(b) The diagram below shows a network. The numbers on the arcs represent the minimum and maximum flow along each arc respectively.

By considering the flow at an appropriate vertex, explain why a flow is not possible through this network.



(2 marks)

QUESTION PART REFERENCE

Answer space for question 4

5 (a) Display the following linear programming problem in a Simplex tableau.

Maximise $P = x - 2y + 3z$

subject to
$$x + y + z \leqslant 16$$
$$x - 2y + 2z \leqslant 17$$
$$2x - y + 2z \leqslant 19$$

and $x \geqslant 0$, $y \geqslant 0$, $z \geqslant 0$. *(2 marks)*

(b) (i) The first pivot to be chosen is from the z-column. Identify the pivot and explain why this particular value is chosen. *(2 marks)*

(ii) Perform one iteration of the Simplex method. *(3 marks)*

(c) (i) Perform one further iteration. *(3 marks)*

(ii) Interpret the tableau that you obtained in part **(c)(i)** and state the values of your slack variables. *(3 marks)*

QUESTION PART REFERENCE

Answer space for question 5

QUESTION PART REFERENCE

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Answer space for question 5

6 Kate and Pippa play a zero-sum game. The game is represented by the following pay-off matrix for Kate.

		Pippa		
	Strategy	***D***	***E***	***F***
Kate	***A***	−2	0	3
	B	3	−2	−2
	C	4	1	−1

(a) Explain why Kate should not adopt strategy *B*. *(1 mark)*

(b) Find the optimal mixed strategy for Kate and find the value of the game. *(7 marks)*

(c) Find the optimal mixed strategy for Pippa. *(4 marks)*

QUESTION PART REFERENCE

Answer space for question 6

QUESTION PART REFERENCE

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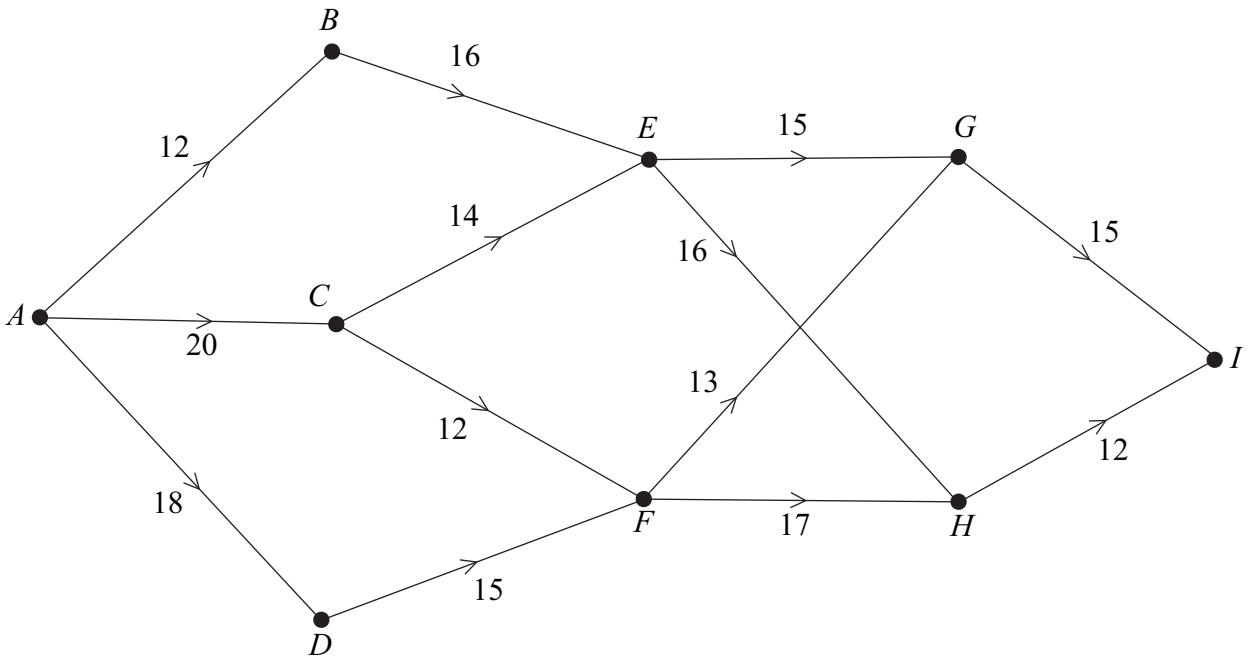
Answer space for question 6

7 The network below shows a system of one-way roads. The number on each edge represents the number of bags for recycling that can be collected by driving along that road.

A collector is to drive from A to I.



(a) **Working backwards from *I***, use dynamic programming to find the maximum number of bags that can be collected when driving from A to I.

You must complete the table opposite as your solution. *(7 marks)*

(b) State the route that the collector should take in order to collect the maximum number of bags. *(1 mark)*

QUESTION PART REFERENCE

Answer space for question 7

QUESTION PART REFERENCE

Answer space for question 7

(a)

Stage	State	From	Value
1	*G*	*I*	
	H	*I*	
2			

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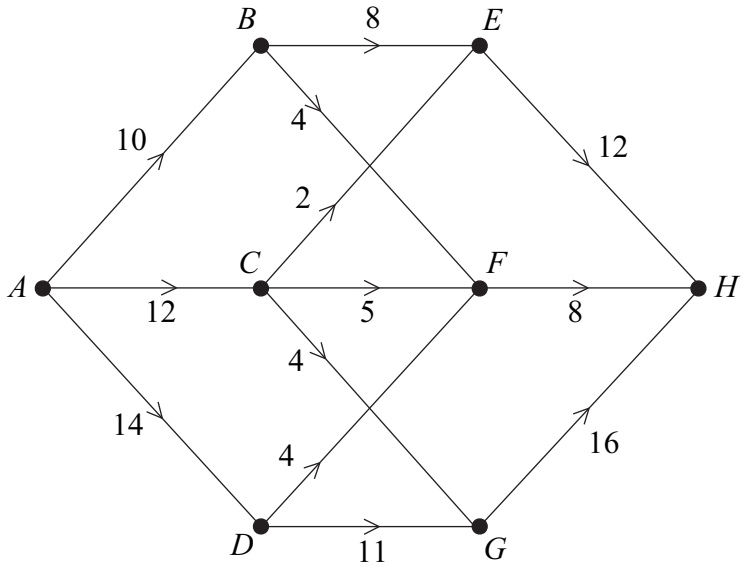
8 The network below represents a system of pipes. The capacity of each pipe, in litres per second, is indicated on the corresponding edge.



(a) Find the maximum flow along each of the routes *ABEH*, *ACFH* and *ADGH* and enter their values in the table on **Figure 4** opposite. *(1 mark)*

(b) (i) Taking your answers to part **(a)** as the initial flow, use the labelling procedure on **Figure 4** to find the maximum flow through the network. You should indicate any flow-augmenting routes in the table and modify the potential increases and decreases of the flow on the network. *(5 marks)*

(ii) State the value of the maximum flow and, on **Figure 5** opposite, illustrate a possible flow along each edge corresponding to this maximum flow. *(2 marks)*

(c) Confirm that you have a maximum flow by finding a cut of the same value. List the edges of your cut. *(1 mark)*

QUESTION PART REFERENCE

Answer space for question 8

QUESTION PART REFERENCE

Answer space for question 8

Figure 4

Route	Flow
ABEH	
ACFH	
ADGH	

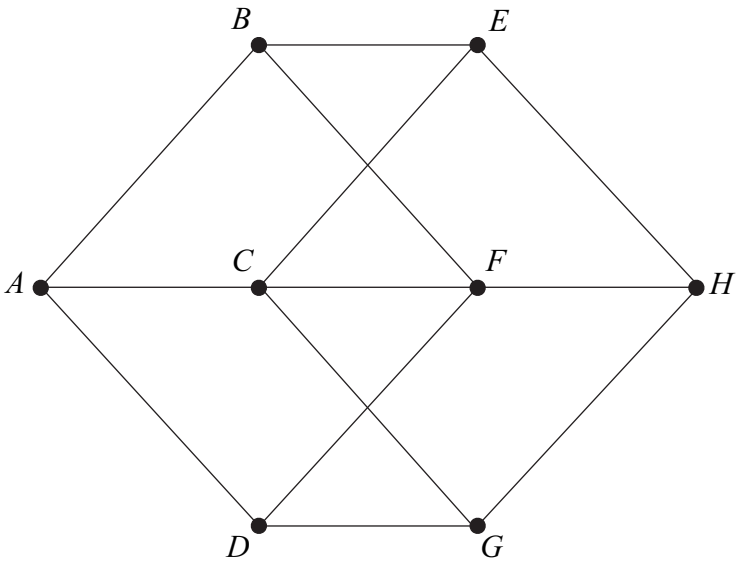
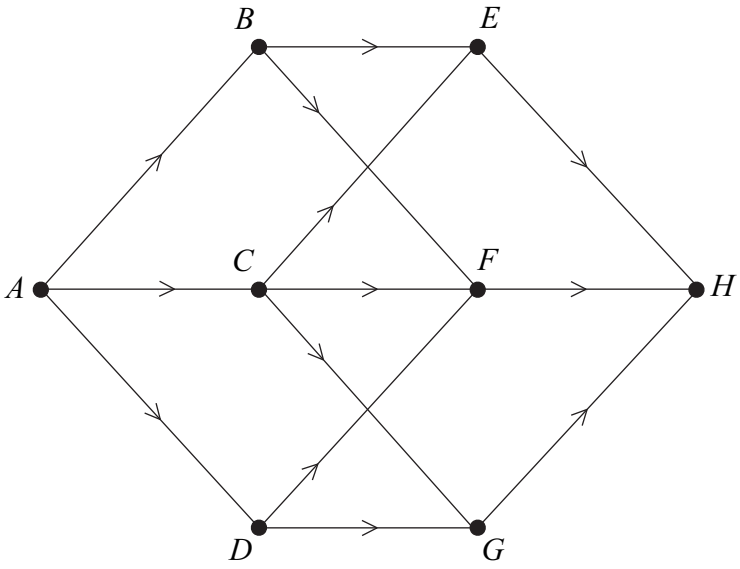


Figure 5



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Turn over ▶

QUESTION PART REFERENCE

Answer space for question 8

END OF QUESTIONS