General Certificate of Education
June 2005
Advanced Level Examination

MATHEMATICS (SPECIFICATION A) **MAD2**
Unit Discrete 2

Wednesday 22 June 2005 Afternoon Session

In addition to this paper you will require:
- an 8-page answer book;
- an insert for use in Questions 1, 3 and 4 (enclosed);
- the AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed: 1 hour 20 minutes

Instructions
- Use blue or black ink or ball-point pen. 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 MAD2.
- Answer **all** questions.
- All necessary working should be shown; otherwise marks for method may be lost.
- The **final** answer to questions requiring the use of tables or calculators should normally be given to three significant figures.
- Tie loosely any additional sheets you have used, including the insert for use in Questions 1, 3 and 4, to the back of your answer book before handing it to the invigilator.

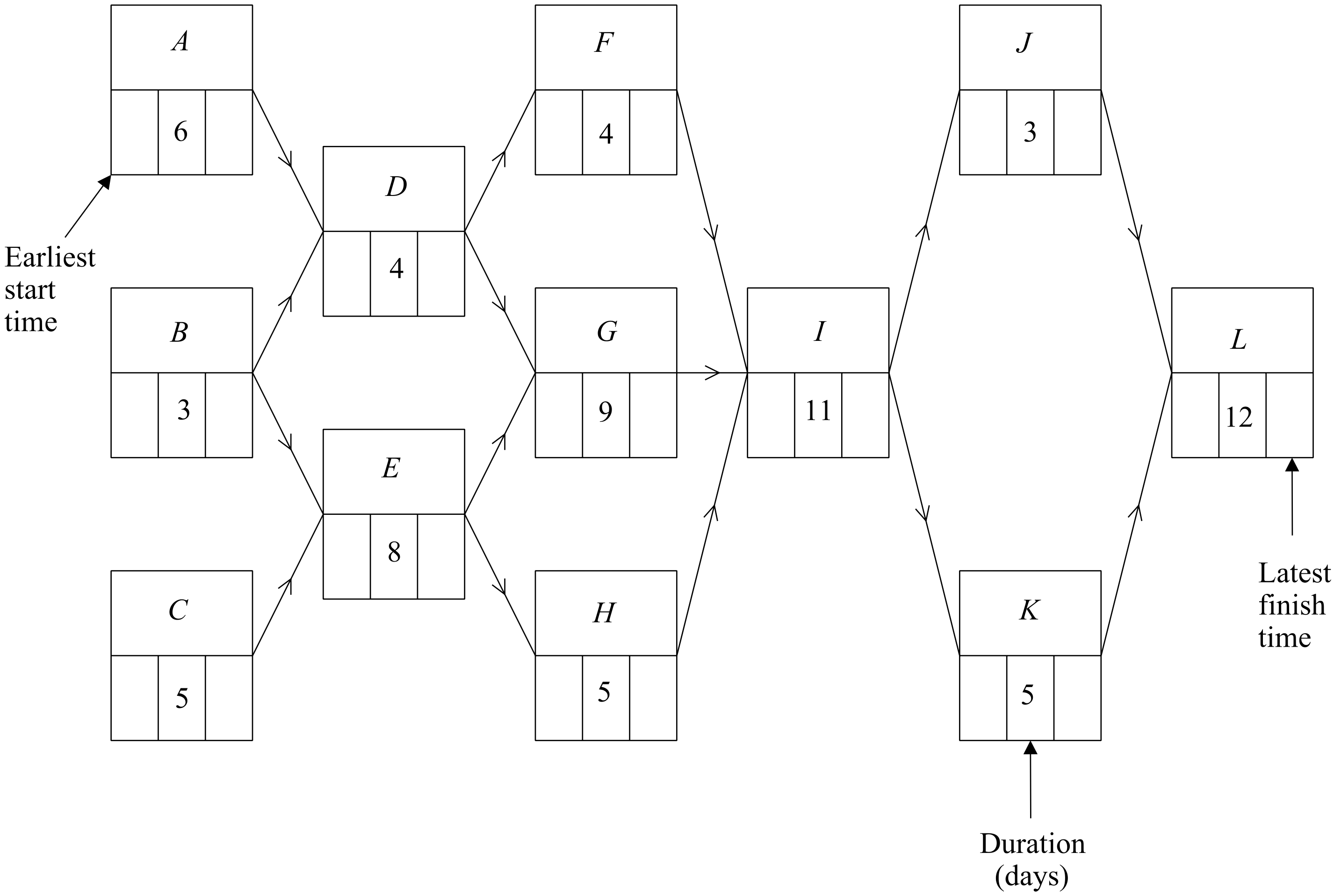
Information
- The maximum mark for this paper is 60.
- Mark allocations are shown in brackets.
- Further copies of the insert for use in Questions 1, 3 and 4 are available on request.
- Sheets of graph paper are available on request.

Advice
- Unless stated otherwise, formulae may be quoted, without proof, from the booklet.

Answer **all** questions.

1 [**Figure 1**, printed on the insert, is provided for use in answering this question.]

The following diagram shows an activity network for a major building project.



(a) On **Figure 1** find:

(i) the earliest start time for each activity; *(2 marks)*

(ii) the latest finish time for each activity. *(2 marks)*

(b) Identify the critical path. *(1 mark)*

(c) State the activity with the greatest float time. *(1 mark)*

(d) Construct a Gantt (cascade) diagram for the project. *(3 marks)*

(e) Activities *D* and *J* overrun by 5 days each. Find:

(i) the new minimum completion time for the project; *(3 marks)*

(ii) the new critical path. *(1 mark)*

2 A computer repair company has five workers, *A*, *B*, *C*, *D* and *E*. The company carries out four types of repair, 1, 2, 3 and 4. The times, in minutes, taken by each of the workers to carry out each type of repair are given in the following table.

	Repair 1	**Repair 2**	**Repair 3**	**Repair 4**
A	18	24	26	22
B	17	25	23	19
C	19	26	24	23
D	16	22	28	20
E	20	23	22	21

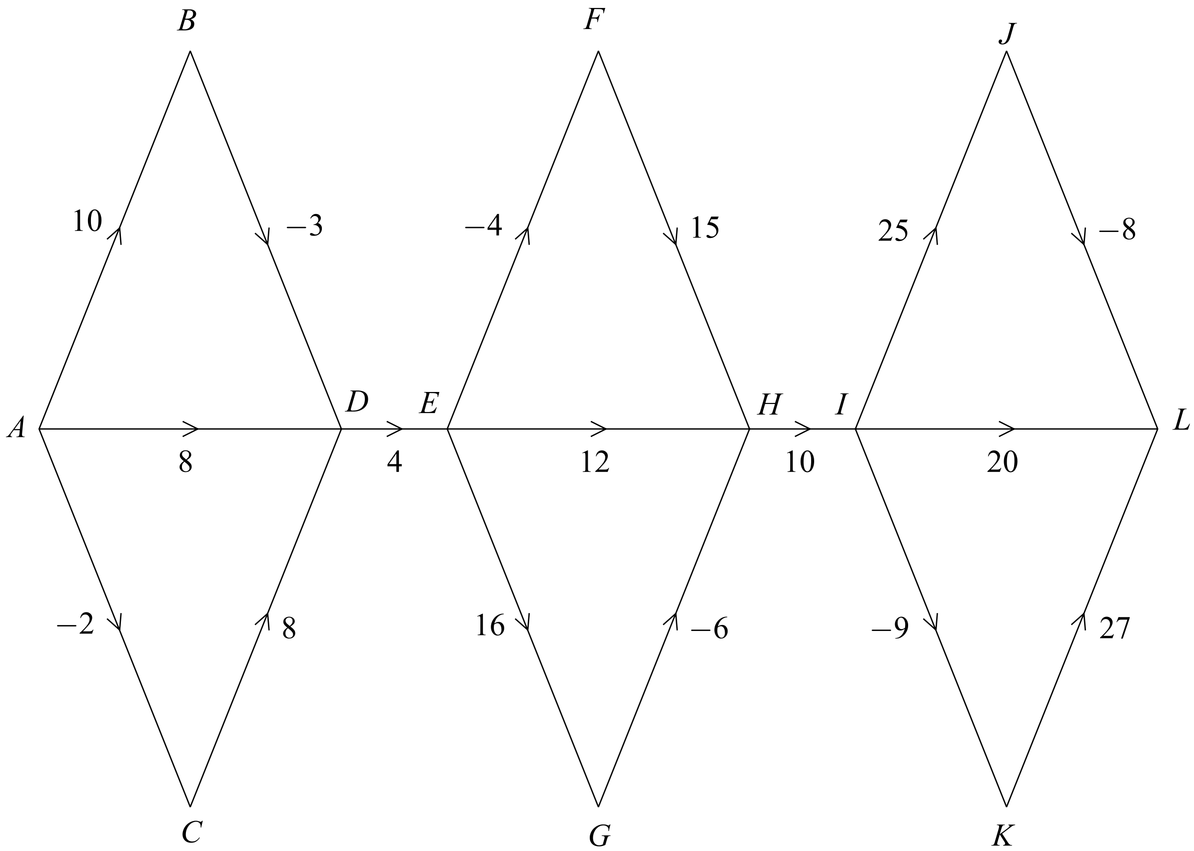
On a certain day, the company needs to carry out one of each type of repair and each repair is to be carried out by a different worker.

Use the Hungarian algorithm to allocate workers to repairs to minimise the total repair time. State this minimum time. *(9 marks)*

TURN OVER FOR THE NEXT QUESTION

3 [**Figure 2**, printed on the insert, is provided for use in answering this question.]

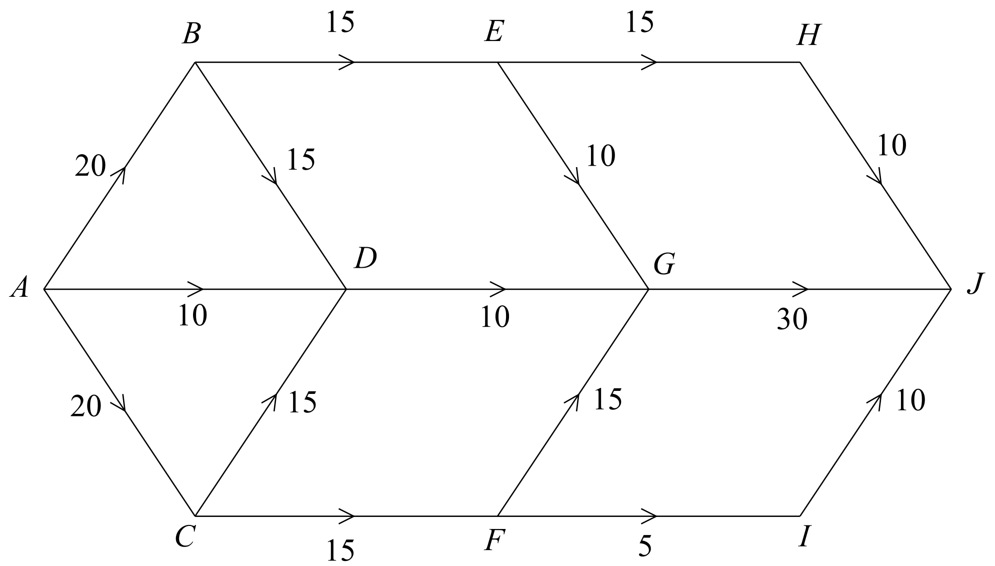
The following network shows 12 vertices. The number on each arc is the cost of a journey between a pair of vertices.



On **Figure 2**, or otherwise, use dynamic programming to find the minimum cost of a route from *A* to *L*. State the route corresponding to this minimum cost. *(8 marks)*

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

The following diagram shows the maximum number of cars that can travel along each section of a one-way system in a 5 minute interval.



(a) On **Figure 3**, starting from a position of no flow of cars along the one-way system, use flow augmentation to find the maximum flow. *(4 marks)*

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

(c) A new road is to be added to the system. Determine which two vertices this new road should connect in order to make a flow of more than 50 cars, in a 5 minute interval, possible. *(2 marks)*

TURN OVER FOR THE NEXT QUESTION

5 Arnie (A) and Ben (B) play a zero-sum game. The game is represented by the following pay-off matrix for Arnie (A).

		Ben (B)		
		I	II	III
Arnie (A)	I	1	2	2
	II	3	1	7
	III	2	3	6

(a) Explain why the matrix can be reduced to

3	1
2	3

(2 marks)

(b) Find the optimal mixed strategy for each player and the value of the game. *(9 marks)*

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

Maximise

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

subject to

$$3x + 6y + z \leqslant 72$$
$$4x + 2y + z \leqslant 48$$
$$x - y + z \leqslant 36.$$

(2 marks)

(b) Solve the problem using the Simplex algorithm, stating the values of P, x, y, z and the slack variables. *(10 marks)*

END OF QUESTIONS

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Surname		Other Names							
Centre Number						Candidate Number			
Candidate Signature									

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Insert for use in answering 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 ▶

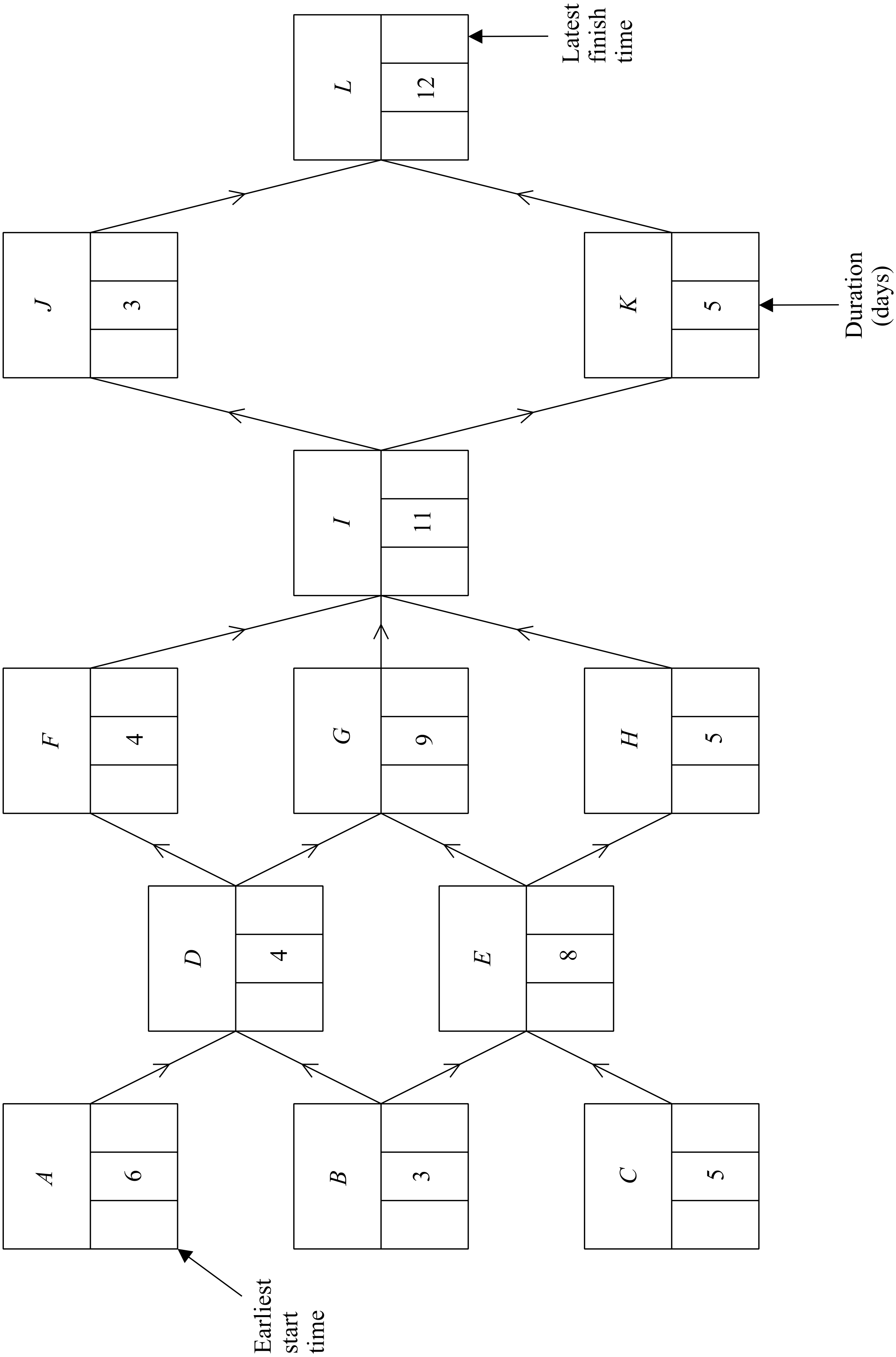

Figure 1 (for Question 1)

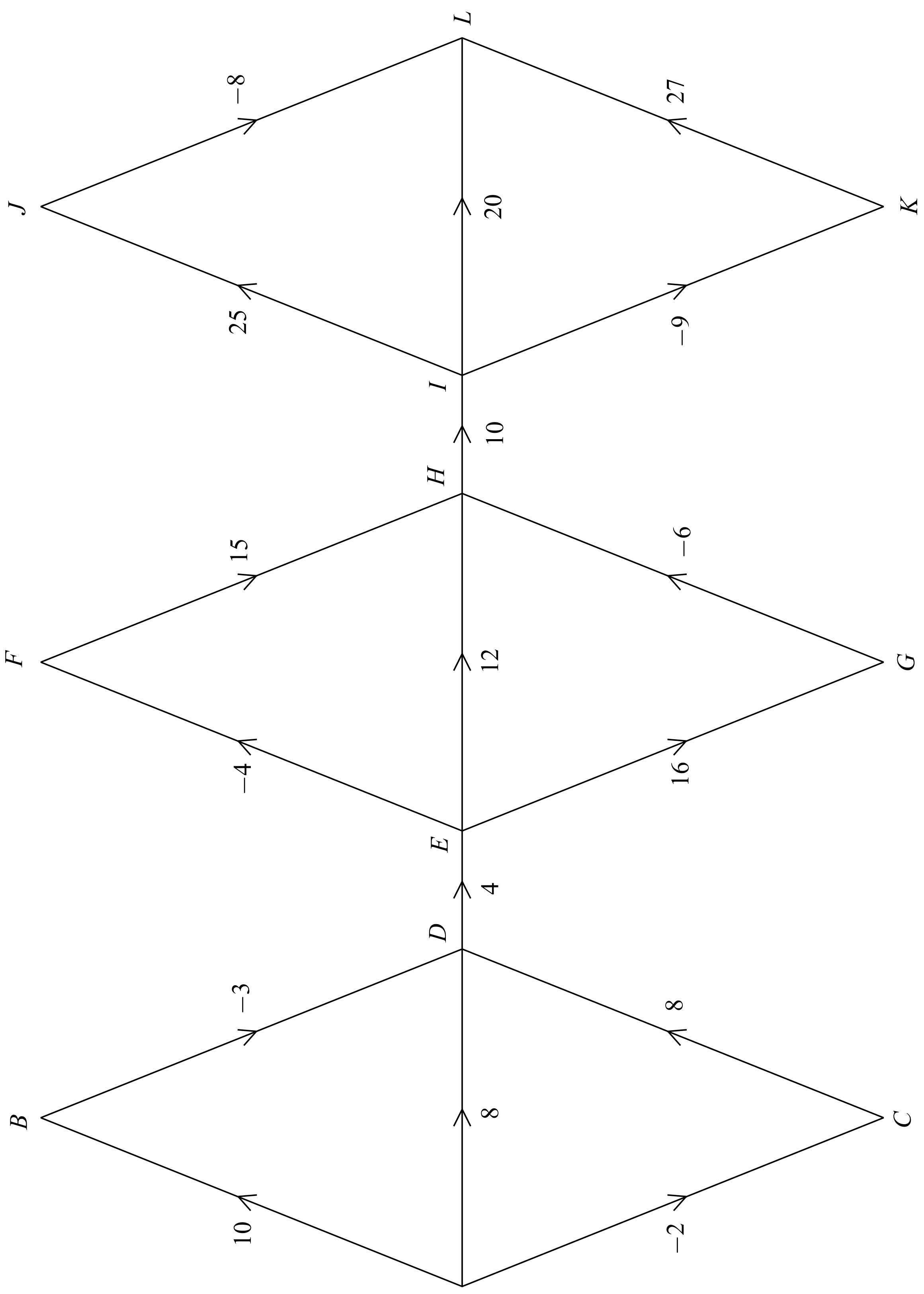

Figure 2 (for Question 3)

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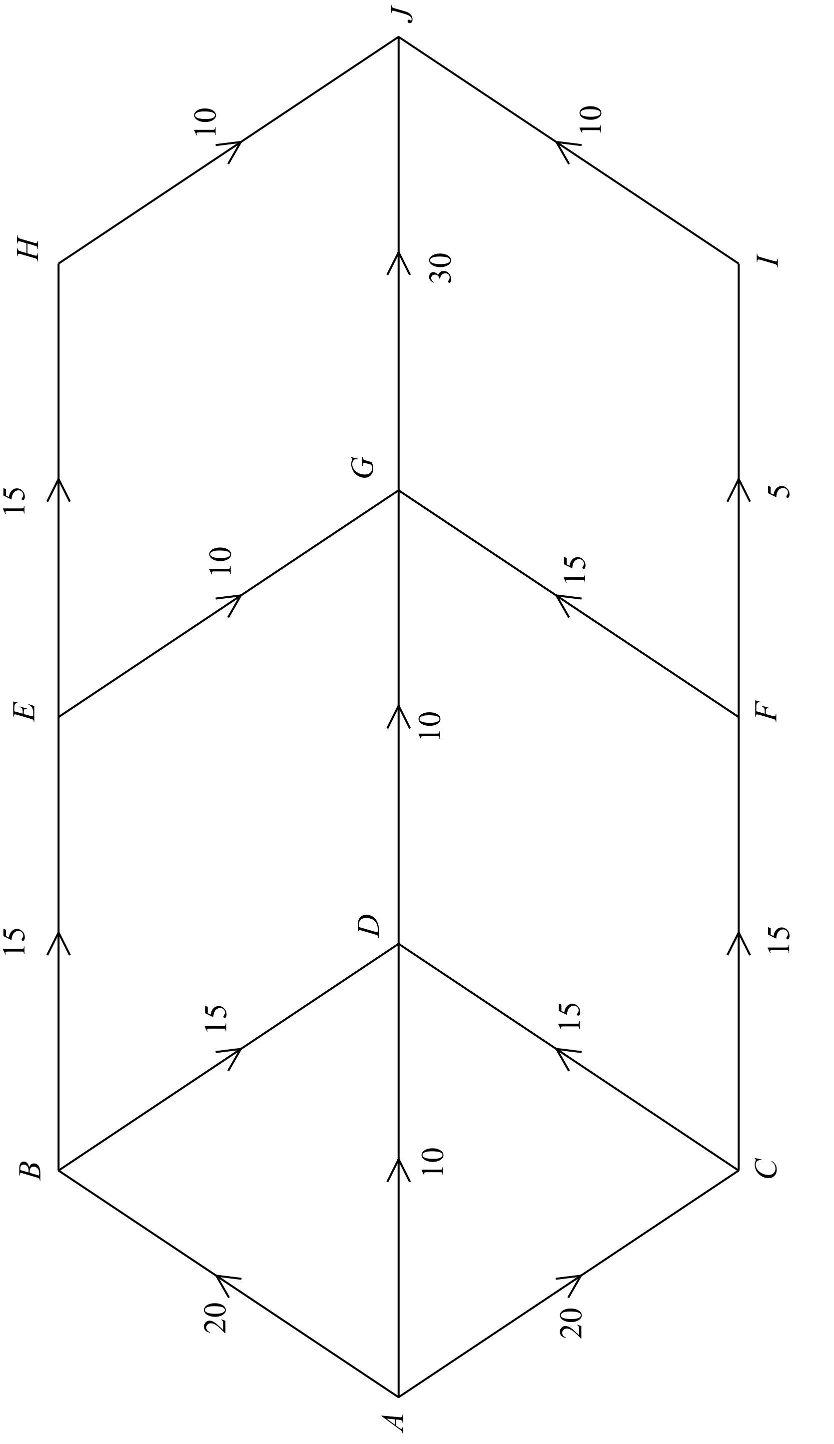

Figure 3 (for Question 4)