

General Certificate of Education
June 2004
Advanced Level Examination



MATHEMATICS (SPECIFICATION A)
Unit Discrete 2

MAD2

Wednesday 23 June 2004 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);
- one sheet of graph paper for use in Question 3;
- 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.
- Additional 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 [Table 1, printed on the insert, is provided for use in answering this question.]

Three pop groups, Alfa (A), Beata (B) and Cappa (C), are going to perform consecutively at a concert. The order in which they perform is to be determined. The time taken for each group to set up their equipment on stage depends on which, if any, of the other groups have already performed.

These times, in minutes, are given in the table.

Order	Previous group(s)	Time A	Time B	Time C
1	—	12	18	15
2	A	—	21	17
	B	14	—	17
	C	15	22	—
3	A and B	—	—	18
	A and C	—	19	—
	B and C	23	—	—

By completing **Table 1**, or otherwise, use dynamic programming to determine the order in which the groups should perform to minimise the total time for setting up their equipment. State this minimum time. (9 marks)

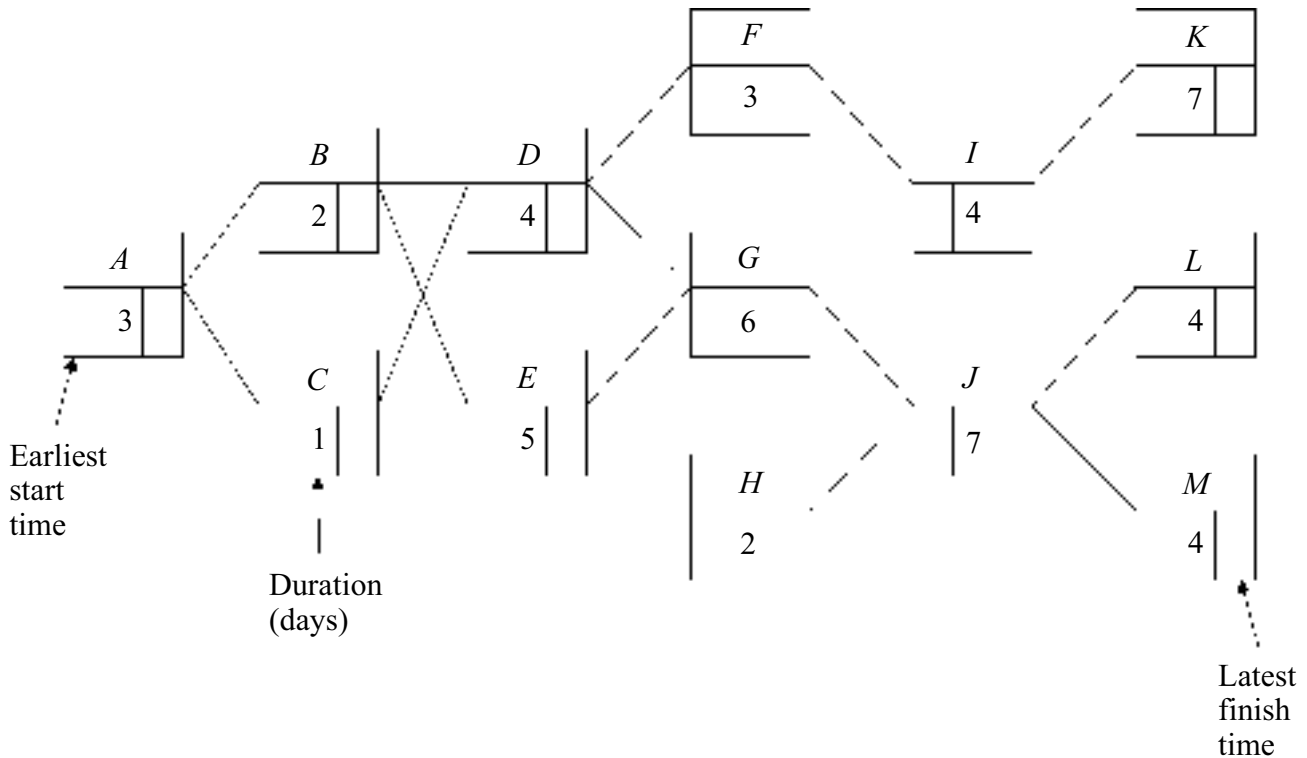
2 Four neighbours, Audrey (A), Blanche (B), Curly (C) and Dev (D), form a team to take part in a quiz. Each person is to be chosen to answer questions on one of the following subjects: Geography (G), History (H), Literature (L) and Sport (S). The questions on each subject must be answered by a different member of the team. The score that each member of the team would be expected to gain on each subject is given in the table.

	Geography (G)	History (H)	Literature (L)	Sport (S)
Audrey (A)	15	14	12	15
Blanche (B)	14	15	13	14
Curly (C)	12	16	9	12
Dev (D)	17	19	18	17

Use the Hungarian algorithm, reducing the columns before the rows, to decide how the team should allocate each person to a topic so as to **maximise** the team's expected score. State the team's maximum expected score. (8 marks)

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

A major construction project is to be undertaken and the project has been divided into 13 activities. The following diagram shows the activity network for the project.



(a) On **Figure 1**:

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

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

(b) List the non-critical activities. (1 mark)

(c) Draw a Gantt (cascade) diagram for the project. (3 marks)

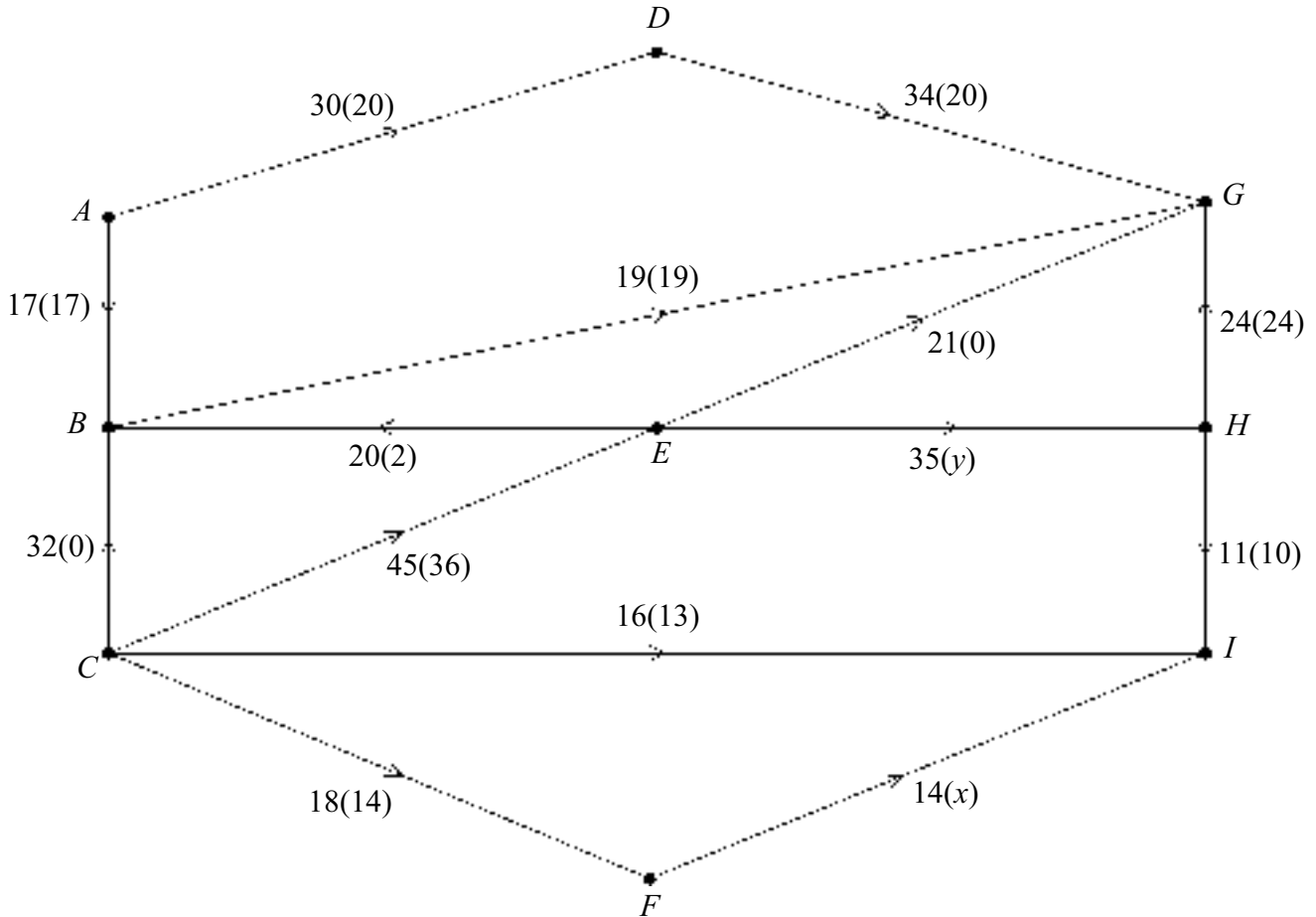
(d) There are only two workers available, each able to complete any of the activities in the stated time.

(i) Find the new minimum completion time for the whole project. (2 marks)

(ii) Allocate the activities to the two workers so that this new minimum time can be achieved. (2 marks)

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

The following diagram shows a capacitated directed network. The number on each arc is the capacity of that arc. The numbers in brackets represent an initial feasible flow through the network.



(a) List:

(i) the source vertices;

(1 mark)

(ii) the sink vertices.

(1 mark)

(b) Find the value of:

(i) the initial flow;

(1 mark)

(ii) x ;

(1 mark)

(iii) y .

(1 mark)

(c) On **Figure 2**, starting from the given initial flow, use flow augmentation to find a flow of 122. (6 marks)

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

$$\begin{array}{ll}
 \text{Maximise} & 3x + 6y + 2z \\
 \text{subject to} & x + 3y + 2z \leq 11 \\
 & 3x + 4y + 2z \leq 21 \\
 \text{and} & x \geq 0, y \geq 0, z \geq 0.
 \end{array}
 \quad (2 \text{ marks})$$

- (b) Solve the problem using the Simplex algorithm. (8 marks)

- 6 Two people, Ann and Bev, play a zero sum game. The game is represented by the following pay-off matrix for Ann.

		Bev		
		I	II	III
Ann	Strategy I	1	3	6
	II	6	1	1
	III	7	4	2

- (a) Show that there is no stable solution. (3 marks)
- (b) Explain why it will never be optimal for Ann to adopt **Strategy II** and write down the reduced pay-off matrix for Ann. (2 marks)
- (c) Hence, given that the value of the game is $3\frac{3}{5}$, find the optimal mixed strategy for **Bev**.
 (You are **not** required to find the optimal mixed strategy for Ann.) (5 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 ►

Stage	State	Action	Value
1			
2			
3			

Table 1 (for Question 1)

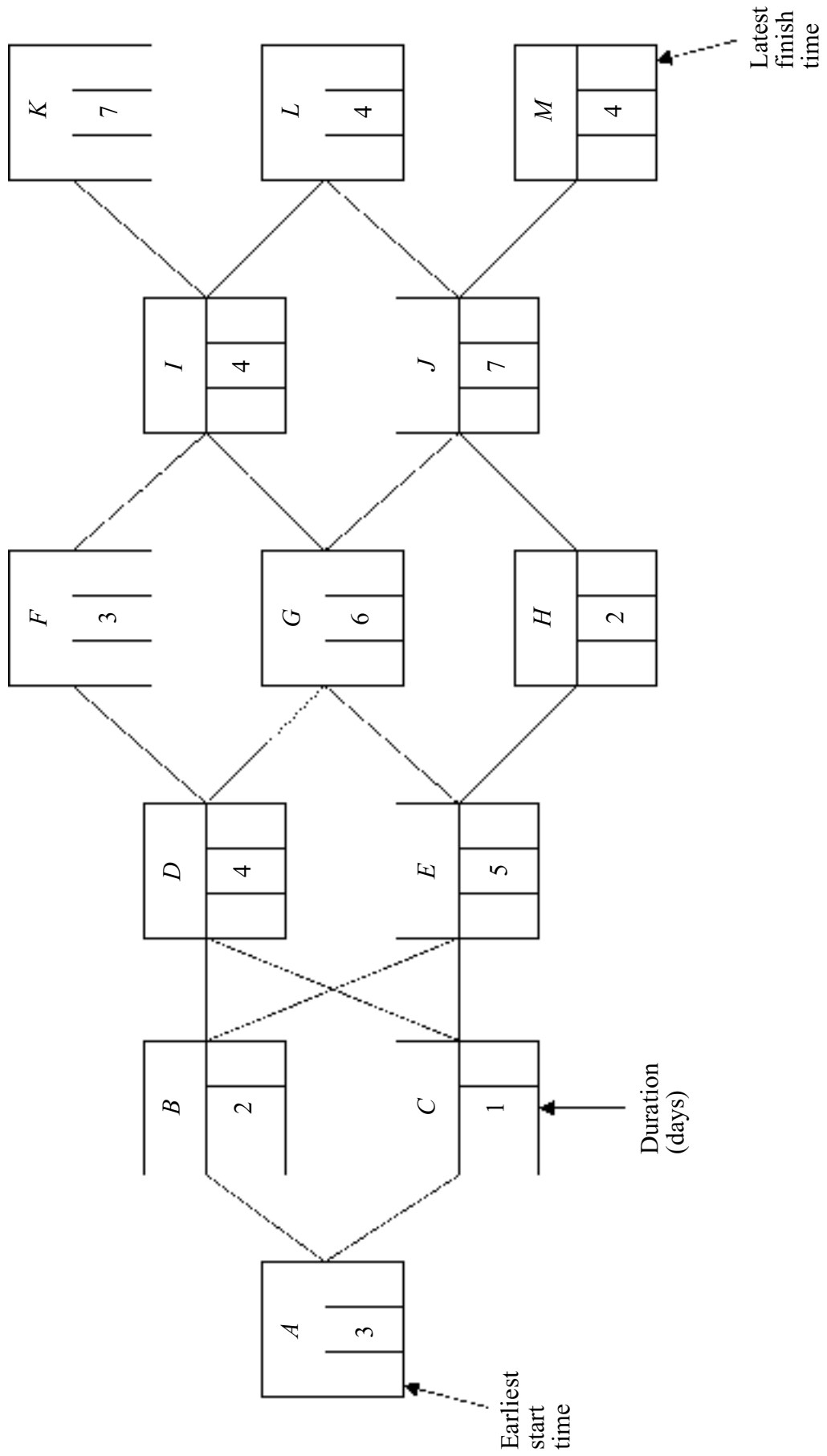


Figure 1 (for Question 3)

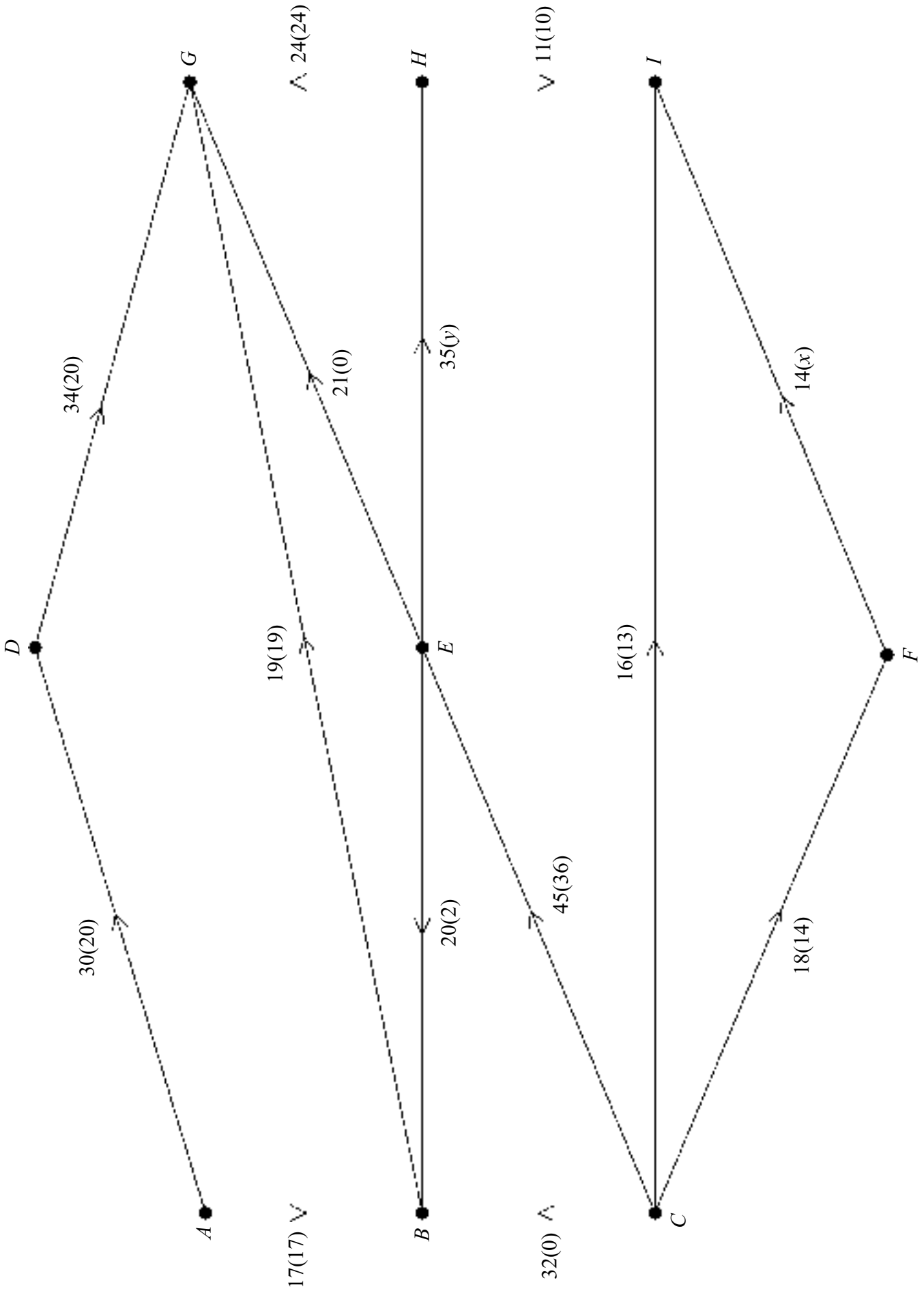


Figure 2 (for Question 4)