General Certificate of Education
January 2006
Advanced Subsidiary Examination

MATHEMATICS **MD01**
Unit Decision 1

Wednesday 18 January 2006 1.30 pm to 3.00 pm

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 Question 5 (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 MD01.
- 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 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.

Answer **all** questions.

1 (a) Draw a bipartite graph representing the following adjacency matrix. *(2 marks)*

	U	***V***	***W***	***X***	***Y***	***Z***
A	1	0	1	0	1	0
B	0	1	0	1	0	0
C	0	1	0	0	0	1
D	0	0	0	1	0	0
E	0	0	1	0	1	1
F	0	0	0	1	1	0

(b) Given that initially A is matched to W, B is matched to X, C is matched to V, and E is matched to Y, use the alternating path algorithm, from this initial matching, to find a complete matching. List your complete matching. *(5 marks)*

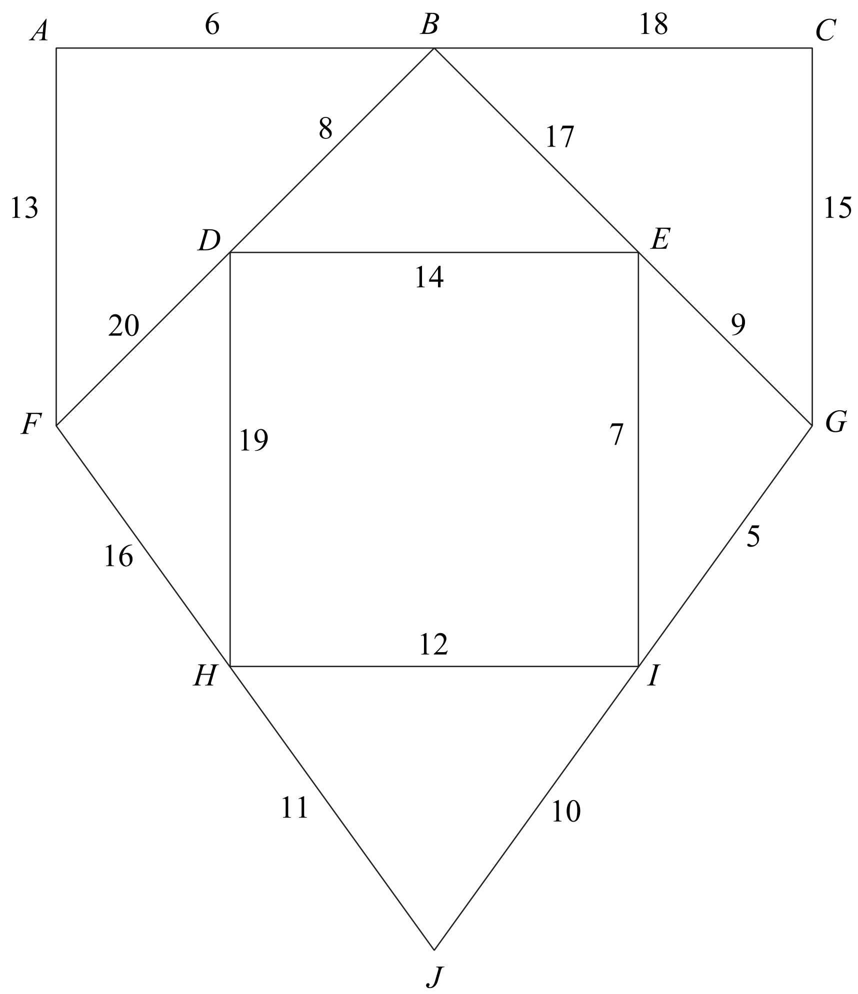
2 Use the quicksort algorithm to rearrange the following numbers into ascending order. Indicate clearly the pivots that you use.

18 23 12 7 26 19 16 24 *(5 marks)*

3 (a) (i) State the number of edges in a minimum spanning tree of a network with 10 vertices. *(1 mark)*

(ii) State the number of edges in a minimum spanning tree of a network with n vertices. *(1 mark)*

(b) The following network has 10 vertices: A, B, …, J. The numbers on each edge represent the distances, in miles, between pairs of vertices.



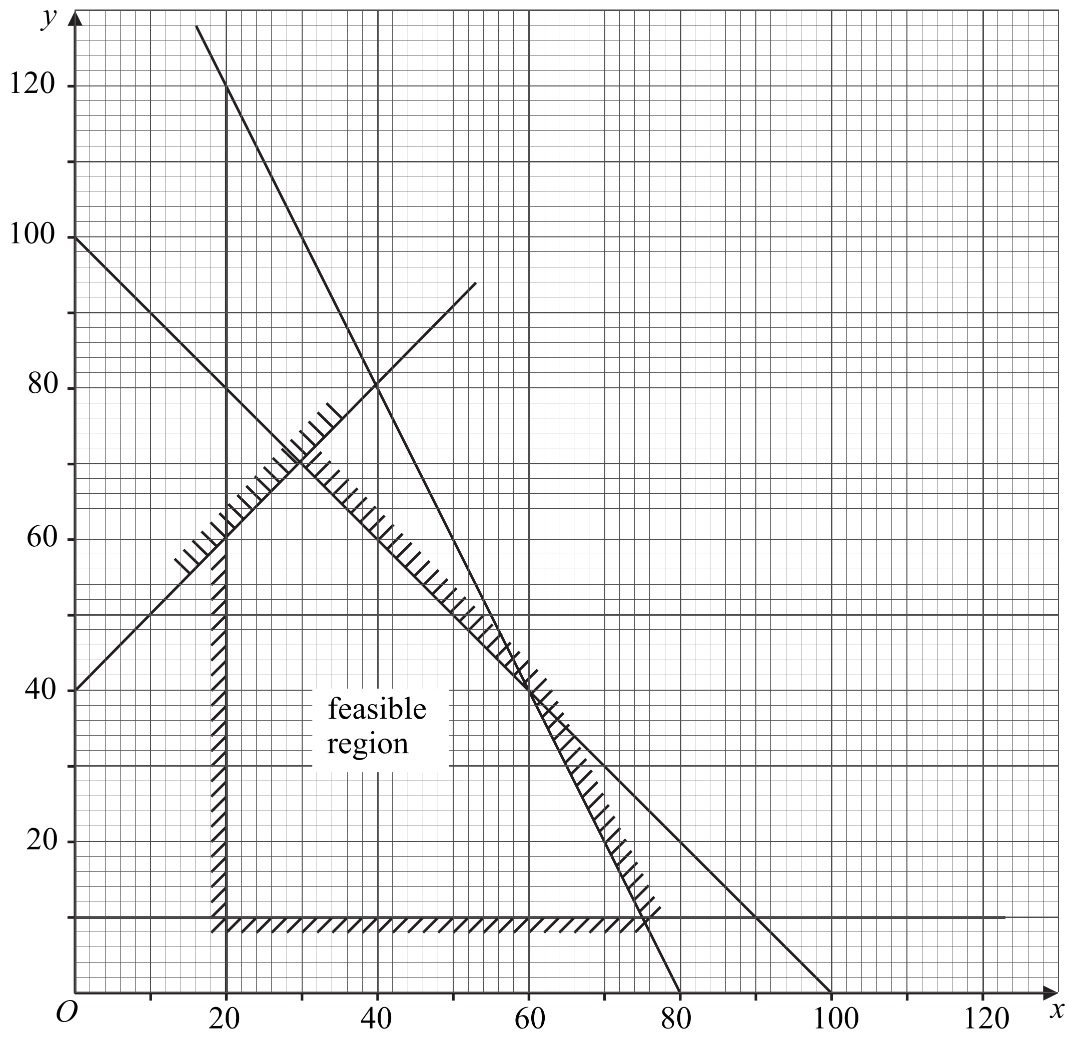
(i) Use Kruskal's algorithm to find the minimum spanning tree for the network. *(5 marks)*

(ii) State the length of your spanning tree. *(1 mark)*

(iii) Draw your spanning tree. *(2 marks)*

Turn over ▶

4 The diagram shows the feasible region of a linear programming problem.



(a) On the feasible region, find:

(i) the maximum value of $2x + 3y$; *(2 marks)*

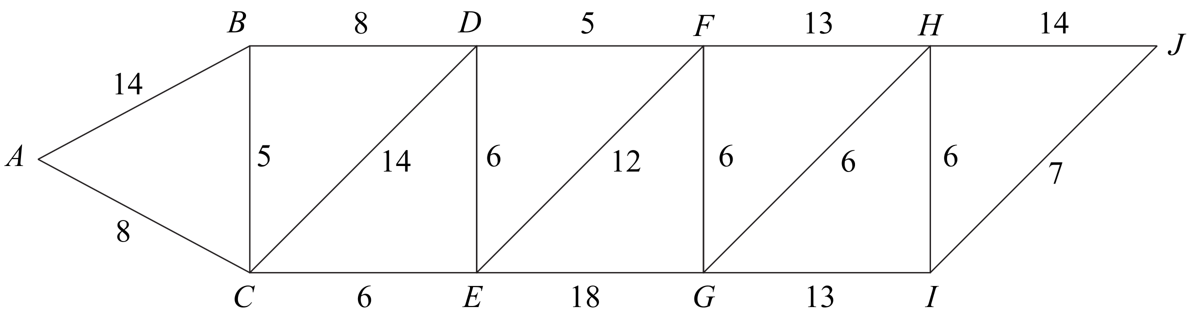
(ii) the maximum value of $3x + 2y$; *(2 marks)*

(iii) the minimum value of $-2x + y$. *(2 marks)*

(b) Find the 5 inequalities that define the feasible region. *(6 marks)*

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

The network shows the times, in minutes, to travel between 10 towns.



(a) Use Dijkstra's algorithm on **Figure 1** to find the minimum time to travel from A to J. *(6 marks)*

(b) State the corresponding route. *(1 mark)*

6 Two algorithms are shown.

Algorithm 1

Line 10	Input P
Line 20	Input R
Line 30	Input T
Line 40	Let $I = (P * R * T)/100$
Line 50	Let $A = P + I$
Line 60	Let $M = A/(12 * T)$
Line 70	Print M
Line 80	Stop

Algorithm 2

Line 10	Input P
Line 20	Input R
Line 30	Input T
Line 40	Let $A = P$
Line 50	$K = 0$
Line 60	Let $K = K + 1$
Line 70	Let $I = (A * R)/100$
Line 80	Let $A = A + I$
Line 90	If $K < T$ then goto Line 60
Line 100	Let $M = A/(12 * T)$
Line 110	Print M
Line 120	Stop

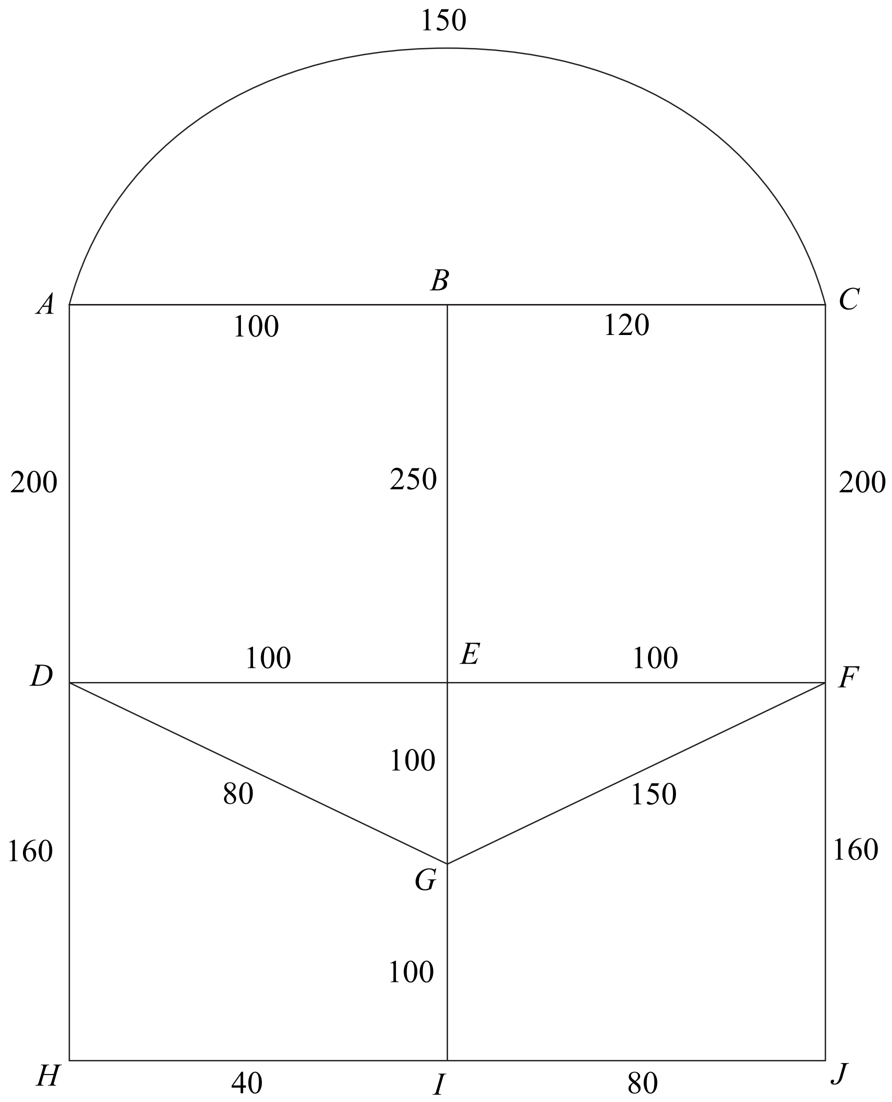
In the case where the input values are $P = 400$, $R = 5$ and $T = 3$:

(a) trace **Algorithm 1**; *(3 marks)*

(b) trace **Algorithm 2**. *(4 marks)*

Turn over ▶

7 Stella is visiting Tijuana on a day trip. The diagram shows the lengths, in metres, of the roads near the bus station.



Total = 2090

Stella leaves the bus station at A. She decides to walk along all of the roads at least once before returning to A.

(a) Explain why it is not possible to start from A, travel along each road only once and return to A. *(1 mark)*

(b) Find the length of an optimal 'Chinese postman' route around the network, starting and finishing at A. *(5 marks)*

(c) At each of the 9 places B, C, . . ., J, there is a statue. Find the number of times that Stella will pass a statue if she follows her optimal route. *(2 marks)*

8 Salvadore is visiting six famous places in Barcelona: La Pedrera (L), Nou Camp (N), Olympic Village (O), Park Guell (P), Ramblas (R) and Sagrada Familia (S). Owing to the traffic system the time taken to travel between two places may vary according to the direction of travel.

The table shows the times, in minutes, that it will take to travel between the six places.

From \ To	**La Pedrera** (L)	**Nou Camp** (N)	**Olympic Village** (O)	**Park Guell** (P)	**Ramblas** (R)	**Sagrada Familia** (S)
La Pedrera (L)	—	35	30	30	37	35
Nou Camp (N)	25	—	20	21	25	40
Olympic Village (O)	15	40	—	25	30	29
Park Guell (P)	30	35	25	—	35	20
Ramblas (R)	20	30	17	25	—	25
Sagrada Familia (S)	25	35	29	20	30	—

(a) Find the total travelling time for:

(i) the route $LNOL$; *(1 mark)*

(ii) the route $LONL$. *(1 mark)*

(b) Give an example of a Hamiltonian cycle in the context of the above situation. *(1 mark)*

(c) Salvadore intends to travel from one place to another until he has visited all of the places before returning to his starting place.

(i) Show that, using the nearest neighbour algorithm starting from Sagrada Familia (S), the total travelling time for Salvadore is 145 minutes. *(3 marks)*

(ii) Explain why your answer to part (c)(i) is an upper bound for the minimum travelling time for Salvadore. *(2 marks)*

(iii) Salvadore starts from Sagrada Familia (S) and then visits Ramblas (R). Given that he visits Nou Camp (N) before Park Guell (P), find an improved upper bound for the total travelling time for Salvadore. *(3 marks)*

Turn over for the next question

9 A factory makes three different types of widget: plain, bland and ordinary. Each widget is made using three different machines: A, B and C.

Each plain widget needs 5 minutes on machine A, 12 minutes on machine B and 24 minutes on machine C.

Each bland widget needs 4 minutes on machine A, 8 minutes on machine B and 12 minutes on machine C.

Each ordinary widget needs 3 minutes on machine A, 10 minutes on machine B and 18 minutes on machine C.

Machine A is available for 3 hours a day, machine B for 4 hours a day and machine C for 9 hours a day.

The factory must make:

more plain widgets than bland widgets;

more bland widgets than ordinary widgets.

At least 40% of the total production must be plain widgets.

Each day, the factory makes x plain, y bland and z ordinary widgets.

Formulate the above situation as 6 inequalities, in addition to $x \geqslant 0$, $y \geqslant 0$ and $z \geqslant 0$, writing your answers with simplified integer coefficients. *(8 marks)*

END OF QUESTIONS

Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

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Insert

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Insert for use in **Question 5**.

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 ▶

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Figure 1 (for Question 5)