

**ADVANCED SUBSIDIARY GCE**  
**MATHEMATICS (MEI)**  
Decision Mathematics 1

**4771**

**QUESTION PAPER**

Candidates answer on the Printed Answer Book

**OCR Supplied Materials:**

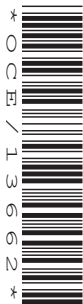
- Printed Answer Book 4771
- MEI Examination Formulae and Tables (MF2)

**Other Materials Required:**

- Scientific or graphical calculator

**Tuesday 22 June 2010**  
**Afternoon**

**Duration: 1 hour 30 minutes**



**INSTRUCTIONS TO CANDIDATES**

These instructions are the same on the Printed Answer Book and the Question Paper.

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the spaces provided on the Printed Answer Book.
- **The questions are on the inserted Question Paper.**
- **Write your answer to each question in the space provided in the Printed Answer Book.** Additional paper may be used if necessary but you must clearly show your Candidate Number, Centre Number and question number(s).
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- You are permitted to use a graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.

**INFORMATION FOR CANDIDATES**

This information is the same on the Printed Answer Book and the Question Paper.

- The number of marks is given in brackets [ ] at the end of each question or part question on the Question Paper.
- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is being used.
- The total number of marks for this paper is **72**.
- The Printed Answer Book consists of **12** pages. The Question Paper consists of **8** pages. Any blank pages are indicated.

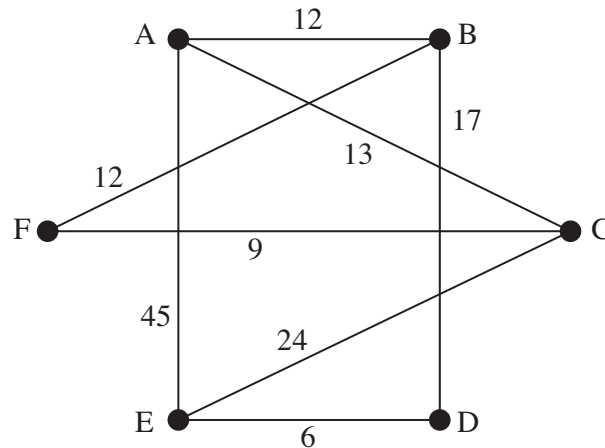
**INSTRUCTIONS TO EXAMS OFFICER/INVIGILATOR**

- Do not send this Question Paper for marking; it should be retained in the centre or destroyed.

Answer all questions on the Printed Answer Book provided.

Section A (24 marks)

- 1 (i) Use Dijkstra's algorithm to find the shortest distances and corresponding routes from A to each of the other vertices in the given network. [7]



- (ii) If the shortest distances and routes between every pair of vertices are required how many applications of Dijkstra will be needed? [1]

- 2 The following steps define an algorithm which acts on two numbers.

STEP 1 Write down the two numbers side by side on the same row.

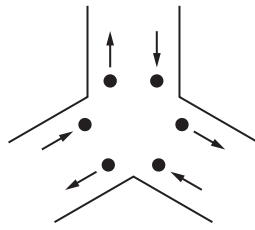
STEP 2 Beneath the left-hand number write down double that number. Beneath the right-hand number write down half of that number, ignoring any remainder.

STEP 3 Repeat STEP 2 until the right-hand number is 1.

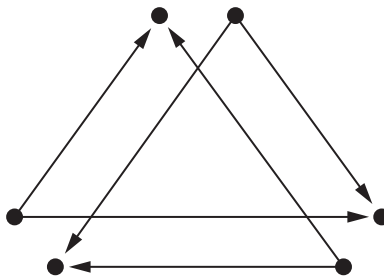
STEP 4 Delete those rows where the right-hand number is even. Add up the remaining left-hand numbers. This is the result.

- (i) Apply the algorithm to the left-hand number 3 and the right-hand number 8. [3]
- (ii) Apply the algorithm to the left-hand number 26 and the right-hand number 42. [4]
- (iii) Use your results from parts (i) and (ii), together with any other examples you may choose, to write down what the algorithm achieves. [1]

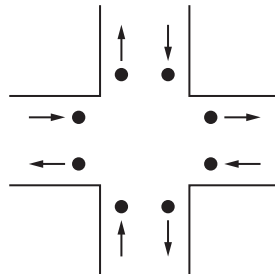
- 3 Traffic flows in and out of a junction of three roads as shown in the diagram.



Assuming that no traffic leaves the junction by the same road as it entered, then the digraph shows traffic flows across the junction.



- (i) Redraw the digraph to show that it is planar. [3]
- (ii) Draw a digraph to show the traffic flow across the junction of 4 roads, assuming that no traffic leaves the junction by the same road as it entered.



[4]

(Note that the resulting digraph is also planar, but you are not required to show this.)

- (iii) The digraphs showing flows across the junctions omit an important aspect in their modelling of the road junctions. What is it that they omit? [1]

**Section B** (48 marks)

4 A wall 4 metres long and 3 metres high is to be tiled. Two sizes of tile are available, 10 cm by 10 cm and 30 cm by 30 cm.

- (i) If  $x$  is the number of boxes of **ten** small tiles used, and  $y$  is the number of large tiles used, explain why  $10x + 9y \geq 1200$ . [3]

There are only 100 of the large tiles available.

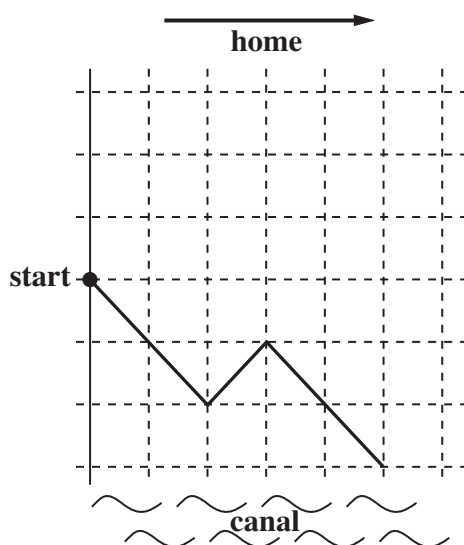
The tiler advises that the area tiled with the small tiles should not exceed the area tiled with the large tiles.

- (ii) Express these two constraints in terms of  $x$  and  $y$ . [3]

The smaller tiles cost 15p each and the larger tiles cost £2 each.

- (iii) Given that the objective is to minimise the cost of tiling the wall, state the objective function. Use the graphical approach to solve the problem. [8]
- (iv) Give **two** other factors which would have to be taken into account in deciding how many of each tile to purchase. [2]

- 5 The diagram shows the progress of a drunkard towards his home on one particular night. For every step which he takes towards his home, he staggers one step diagonally to his left or one step diagonally to his right, randomly and with equal probability. There is a canal three steps to the right of his starting point, and no constraint to the left. On this particular occasion he falls into the canal after 5 steps.



- (i) Explain how you would simulate the drunkard's walk, making efficient use of one-digit random numbers. [3]
- (ii) Using the random digits in the Printed Answer Book simulate the drunkard's walk and show his progress on the grid. Stop your simulation either when he falls into the canal or when he has staggered 6 steps, whichever happens first. [2]
- (iii) How could you estimate the probability of him falling into the canal within 6 steps? [2]

On another occasion the drunkard sets off carrying a briefcase in his right hand. This changes the probabilities of him staggering to the right to  $\frac{2}{3}$ , and to the left to  $\frac{1}{3}$ .

- (iv) Explain how you would now simulate this situation. [3]
- (v) Simulate the drunkard's walk (with briefcase) 10 times, and hence estimate the probability of him falling into the canal within 6 steps. (In your simulations you are not required to show his progress on a grid. You only need to record his steps to the right or left.) [6]

**Question 6 is printed overleaf.**

- 6 The table shows the tasks that have to be completed in building a stadium for a sporting event, their durations and their precedences. The stadium has to be ready within two years.

Task	Duration (months)	Immediate predecessors
A	4	–
B	2	–
C	7	–
D	12	A
E	5	A
F	7	A, B
G	6	D, J
H	3	C
I	12	E, F, H
J	7	E, F, H
K	12	C

- (i) Draw an activity on arc network for these activities. [5]
- (ii) Mark on your diagram the early time and the late time for each event. Give the project duration and the critical activities. [6]

In the later stages of planning the project it is discovered that task J will actually take 9 months to complete. However, other tasks can have their durations shortened by employing extra resources. The costs of “crashing” tasks (i.e. the costs of employing extra resources to complete them more quickly) are given in the table.

Tasks which can be completed more quickly by employing extra resources	Number of months which can be saved	Cost per month of employing extra resources (£m)
A	2	3
D	1	1
C	3	3
F	2	2
G	2	4

- (iii) Find the cheapest way of completing the project within two years. [3]
- (iv) If the delay in completing task J is not discovered until it is started, how can the project be completed in time, and how much extra will it cost? [2]

**Mathematics (MEI)**

Advanced Subsidiary GCE 4771

Decision Mathematics 1

**Mark Scheme for June 2010**

---

1.

<p>(i)</p> <p style="margin-top: 20px;">             AB 12 AB              AC 13 AC              AD 29 ABD              AE 35 ABDE              AF 22 ACF         </p> <p>(ii) 5</p>	<p>M1 Dijkstra              A1 working values              B1 order of labelling              B1 labels</p> <p style="margin-top: 20px;">             B1 AB and AC              B1 AD and AF              B1 AE</p> <p style="margin-top: 20px;">B1</p>
--	---

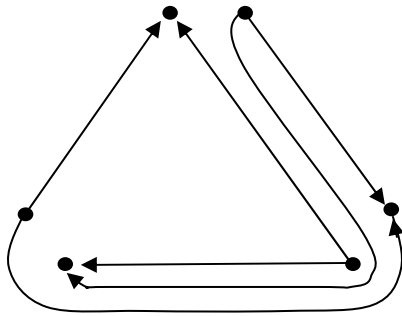
2.

<p>(i)</p> $  \begin{array}{r}  \begin{array}{r}  \text{---} 3 \text{---} 8 \text{---} \\  \text{---} 6 \text{---} 4 \text{---} \\  \text{---} 12 \text{---} 2 \text{---} \\  24 \quad 1 \\  \mathbf{24}  \end{array} \\  \\  \begin{array}{r}  \text{---} 26 \text{---} 42 \\  52 \quad 21 \\  \text{---} 104 \text{---} 10 \\  208 \quad 5 \\  \text{---} 416 \text{---} 2 \\  832 \quad 1 \\  \mathbf{1092}  \end{array}  \end{array}  $ <p>(ii)</p> <p>(iii) multiplication</p>	<p>M1 doubling and halving              M1 deleting and summing              A1 cao</p> <p style="margin-top: 20px;">             M1 doubling and halving              M1 deleting              DM summing              A1 cao</p> <p style="margin-top: 20px;">B1</p>
---	--



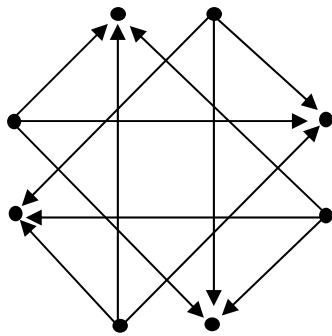
3.

(i)



B1  
B1  
B1

(ii)



B1 12 arcs  
B1 connectivity  
B1 3 out of each in vertex  
B1 3 into each out vertex

(iii) The graphs represent traffic flows within the junctions.  
They do not take account of flows approaching or  
leaving the junctions.  
(Graphs are not planar if these flows are added, so  
traffic flows have to cross.)

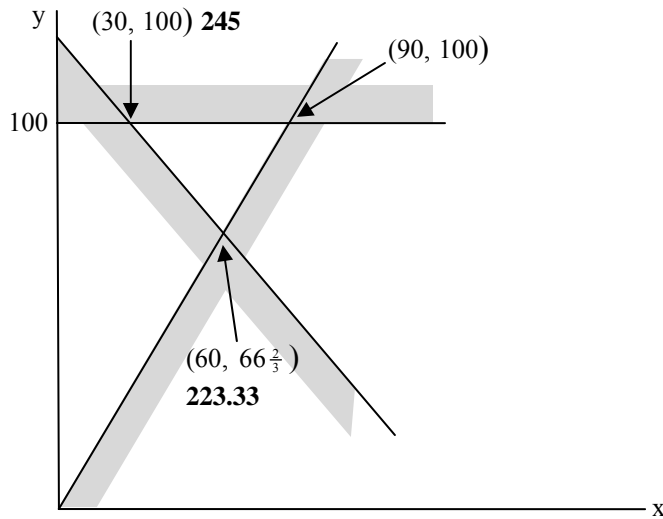
B1

4.

- (i) Each small tile has area  $100 \text{ cm}^2$  so  $1000x$   
 Similarly  $900y$   
 So  $1000x + 900y \geq 400 \times 300 = 120000$

- (ii)  $y \leq 100$   
 $10x \leq 9y$

- (iii) e.g. minimise  $1.5x + 2y$



Integer solution required, so  $x=60$ ,  $y=67$ , cost = 224

- (iv) wastage or design

M1 areas  
 A1 tile areas  
 A1

B1  
 B1 B1

B1

B3 lines

B1 shading

M1 solving  
 A1  $x = 59-61$   $y = 66-68$   
 A1 220-228

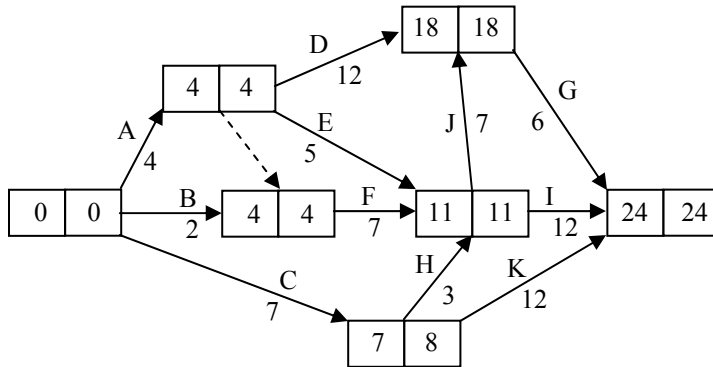
B2

5.

<p>(i) e.g. 0 to 4 → stagger left 5 to 9 → stagger right + accumulation</p> <p>(ii) probably one of:</p> <p>(iii) repeat relative frequency</p> <p>(iv) e.g. 0 to 2 → stagger left 3 to 8 → stagger right 9 reject and redraw</p>	<p>M1 A1 B1</p> <p>M1 A1</p> <p>B1 B1</p> <p>M1 reject some proportions A1 efficient A1</p>																																																																								
<p>(v) e.g.</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>run 1</td><td>R</td><td>L</td><td>R</td><td>L</td><td>L</td><td>R</td></tr> <tr><td>run 2</td><td>R</td><td></td><td>L</td><td></td><td>R</td><td>R</td><td>L</td><td>R</td></tr> <tr><td>run 3</td><td>R</td><td>R</td><td>L</td><td>L</td><td>L</td><td>L</td></tr> <tr><td>run 4</td><td>L</td><td>L</td><td>R</td><td>L</td><td>R</td><td>R</td></tr> <tr><td>run 5</td><td>R</td><td>R</td><td>R</td><td>*</td></tr> <tr><td>run 6</td><td>L</td><td>R</td><td>R</td><td></td><td>R</td><td></td><td>R</td><td>*</td></tr> <tr><td>run 7</td><td>R</td><td>R</td><td>L</td><td>R</td><td>R</td><td>*</td></tr> <tr><td>run 8</td><td>R</td><td>R</td><td>L</td><td>R</td><td>R</td><td>*</td></tr> <tr><td>run 9</td><td>R</td><td></td><td>R</td><td></td><td>R</td><td>*</td></tr> <tr><td>run 10</td><td>L</td><td>R</td><td>R</td><td>L</td><td>R</td><td>R</td></tr> </table> <p>Probability estimate = 0.5 (Theoretical = <math>0.7^3 + 5 \times 0.7^4 \times 0.3 = 0.70315</math>)</p>	run 1	R	L	R	L	L	R	run 2	R		L		R	R	L	R	run 3	R	R	L	L	L	L	run 4	L	L	R	L	R	R	run 5	R	R	R	*	run 6	L	R	R		R		R	*	run 7	R	R	L	R	R	*	run 8	R	R	L	R	R	*	run 9	R		R		R	*	run 10	L	R	R	L	R	R	<p>M1 A2 (-1 each wrong row)</p> <p>B1 falling in</p> <p>M1 probability A1</p>
run 1	R	L	R	L	L	R																																																																			
run 2	R		L		R	R	L	R																																																																	
run 3	R	R	L	L	L	L																																																																			
run 4	L	L	R	L	R	R																																																																			
run 5	R	R	R	*																																																																					
run 6	L	R	R		R		R	*																																																																	
run 7	R	R	L	R	R	*																																																																			
run 8	R	R	L	R	R	*																																																																			
run 9	R		R		R	*																																																																			
run 10	L	R	R	L	R	R																																																																			

6.

(i) & (ii)



Duration = 24 months

Critical : A; F; J; G

(iii) Crash F by 1 month and G by 1 month at a cost of £6m.

(iv) Crash G by 2 months at a cost of £8m.

M1 activity-on-arc  
 A1 D, E, H and K  
 A1 F  
 A1 I and J  
 A1 G

M1 forward pass  
 A1  
 M1 backward pass  
 A1

B1 cao

B1 cao

B1 F by 1 month  
 B1 G by 1 month  
 B1 £6m

M1 G only  
 A1 £8m