**Pearson**
**Edexcel GCE**

# Decision Mathematics D2

**Advanced/Advanced Subsidiary**

Wednesday 29 June 2016 – Morning
**Time: 1 hour 30 minutes**

Paper Reference
**6690/01**

**You must have:**
D2 Answer Book

**Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.**

## Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B). Coloured pencils and highlighter pens must not be used.
- **Fill in the boxes** on the top of the answer book with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the D2 answer book provided – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- When a calculator is used, the answer should be given to an appropriate degree of accuracy.
- Do not return the question paper with the answer book.

## Information

- The total mark for this paper is 75.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*

## Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

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*Turn over*

PEARSON

**Write your answers in the D2 answer book for this paper.**

**1.** (a) Explain the difference between the classical travelling salesperson problem and the practical travelling salesperson problem.

**(2)**

| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| A | – | 31 | 15 | 12 | 24 | 17 | 22 |
| B | 31 | – | 20 | 25 | 14 | 25 | 50 |
| C | 15 | 20 | – | 16 | 24 | 19 | 21 |
| D | 12 | 25 | 16 | – | 21 | 32 | 17 |
| E | 24 | 14 | 24 | 21 | – | 28 | 41 |
| F | 17 | 25 | 19 | 32 | 28 | – | 25 |
| G | 22 | 50 | 21 | 17 | 41 | 25 | – |

The table above shows the least direct distances, in miles, between seven towns, A, B, C, D, E, F and G. Yiyi needs to visit each town, starting and finishing at A, and wishes to minimise the total distance she will travel.

(b) Show that there are two nearest neighbour routes that start from A. State these routes and their lengths.

**(3)**

(c) Starting by deleting A, and all of its arcs, find a lower bound for the length of Yiyi's route.

**(3)**

(d) Use your results to write down the smallest interval which you can be confident contains the optimal length of Yiyi's route.

**(2)**

**(Total 10 marks)**

**2.**

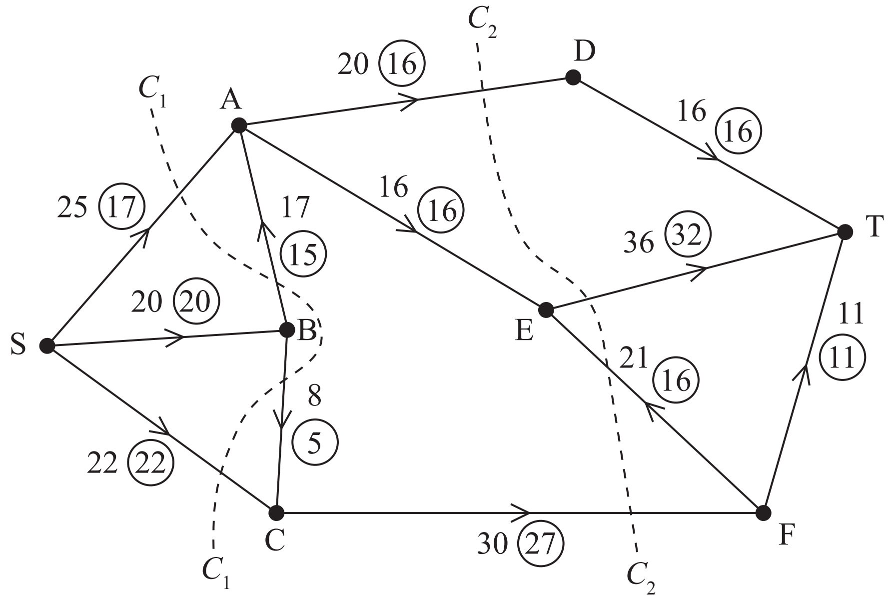


**Figure 1**

Figure 1 shows a capacitated, directed network of pipes. The number on each arc represents the capacity of the corresponding pipe. The numbers in circles represent an initial flow.

(a) List the saturated arcs.

**(2)**

(b) State the value of the initial flow.

**(1)**

(c) State the capacities of the cuts $C_1$ and $C_2$

**(2)**

(d) By inspection, find a flow-augmenting route to increase the flow by three units. You must state your route.

**(1)**

(e) Prove that the new flow is maximal.

**(2)**

**(Total 8 marks)**

**3.** Four pupils, Alexa, Ewan, Faith and Zak, are to be allocated to four rounds, 1, 2, 3 and 4, in a mathematics competition. Each pupil is to be allocated to exactly one round and each round must be allocated to exactly one pupil.

Each pupil has been given a score, based on previous performance, to show how suitable they are for each round. The higher the score the more suitable the pupil is for that round. The scores for each pupil are shown in the table below.

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Alexa | 61 | 50 | 47 | 23 |
| Ewan | 71 | 62 | 20 | 61 |
| Faith | 70 | 49 | 48 | 49 |
| Zak | 72 | 68 | 67 | 67 |

(a) **Reducing rows first**, use the Hungarian algorithm to obtain an allocation that **maximises** the total score. You must make your method clear and show the table after each stage.

**(8)**

(b) State the maximum total score.

**(1)**

**(Total 9 marks)**

**4.** A three-variable linear programming problem in $x$, $y$ and $z$ is to be solved. The objective is to maximise the profit, $P$. The following tableau is obtained after the first iteration.

| Basic Variable | $x$ | $y$ | $z$ | $r$ | $s$ | $t$ | Value |
|---|---|---|---|---|---|---|---|
| $r$ | 0 | 5 | 2 | 1 | –3 | 0 | 10 |
| $x$ | 1 | 2 | 3 | 0 | 1 | 0 | 18 |
| $t$ | 0 | 1 | –1 | 0 | 4 | 1 | 3 |
| $P$ | 0 | 3 | –4 | 0 | 1 | 0 | 7 |

(a) State which variable was increased first, giving a reason for your answer.

**(1)**

(b) Perform **one** complete iteration of the simplex algorithm, to obtain a new tableau, T. Make your method clear by stating the row operations you use.

**(5)**

(c) Write down the profit equation given by T.

**(1)**

(d) State whether T is optimal. You must use your answer to (c) to justify your answer.

**(2)**

**(Total 9 marks)**

**5.** The table below shows the cost of transporting one unit of stock from each of four supply points, 1, 2, 3 and 4, to each of three demand points, A, B and C. It also shows the stock held at each supply point and the stock required at each demand point. A minimal cost solution is required.

| | A | B | C | Supply |
|---|---|---|---|---|
| 1 | 18 | 23 | 20 | 15 |
| 2 | 22 | 17 | 25 | 36 |
| 3 | 24 | 21 | 19 | 28 |
| 4 | 21 | 22 | 17 | 20 |
| Demand | 40 | 20 | 25 | |

(a) Explain why it is necessary to add a dummy demand point.

**(1)**

(b) Add a dummy demand point and appropriate values to Table 1 in the answer book.

**(1)**

(c) Use the north-west corner method to obtain a possible solution.

**(1)**

After one iteration of the stepping-stone method the table becomes

| | A | B | C | D |
|---|---|---|---|---|
| 1 | 15 | | | |
| 2 | 19 | 17 | | |
| 3 | | 3 | 25 | |
| 4 | 6 | | | 14 |

(d) Taking D3 as the entering cell, use the stepping-stone method twice to obtain an improved solution. You must make your method clear by stating your shadow costs, improvement indices, routes, entering cells and exiting cells.

**(6)**

(e) Determine whether your solution from (d) is optimal. Justify your answer.

**(3)**

**(Total 12 marks)**

**6.** A two-person zero-sum game is represented by the following pay-off matrix for player A.

| | B plays 1 | B plays 2 | B plays 3 |
|---|---|---|---|
| A plays 1 | 5 | –3 | 1 |
| A plays 2 | 2 | 5 | 0 |
| A plays 3 | –4 | –1 | 4 |

(a) Verify that there is no stable solution to this game.

**(2)**

(b) Formulate the game as a linear programming problem for player A. Define your variables clearly. Write the constraints as equations.

**(7)**

(c) Write down an initial simplex tableau, making your variables clear.

**(3)**

**(Total 12 marks)**

**7.** Remy builds canoes.

He can build up to five canoes each month, but if he wishes to build more than three canoes in any one month he has to hire an additional worker at a cost of £400 for that month.

In any month when canoes are built, the overhead costs are £150

A maximum of three canoes can be held in stock in any one month, at a cost of £25 per canoe per month.

Canoes must be delivered at the end of the month.

The order book for canoes is

| Month | January | February | March | April | May |
|---|---|---|---|---|---|
| Number ordered | 2 | 2 | 5 | 6 | 4 |

There is no stock at the beginning of January and Remy plans to have no stock after the May delivery.

(a) Use dynamic programming to determine the production schedule that minimises the costs given above. Show your working in the table provided in the answer book and state the minimum cost.

**(13)**

The cost of materials is £200 per canoe and the cost of Remy’s time is £450 per month. Remy sells the canoes for £700 each.

(b) Determine Remy’s total profit for the five-month period.

**(2)**

**(Total 15 marks)**

**TOTAL FOR PAPER: 75 MARKS**

**END**