

UNIVERSITY OF LONDON

GOLDSMITHS COLLEGE

Department of Computing

B. Sc. Examination 2014

IS50001B

**FOUNDATIONS OF PROBLEM SOLVING AND
PROGRAMMING**

Duration: 2 hours 15 minutes

Date and time:

There are five questions in this paper. You should answer no more than THREE questions. Full marks will be awarded for complete answers to a total of THREE questions. Each question carries 25 marks. The marks for each part of a question are indicated at the end of the part in [.] brackets.

There are 75 marks available on this paper.

**THIS PAPER MUST NOT BE REMOVED
FROM THE EXAMINATION ROOM**

Question 1

(a) i. Given the following array of integers:

24 8 21 25 50 40 65 73 81

- (1) What is the maximum number of comparisons it will take the linear search algorithm to find a value in this array?
- (2) Write down the complexity of the linear search algorithm.
- (3) Can a binary search algorithm be used to search for data in this array? Explain your answer.

ii. Write a pseudo-code for the binary search algorithm.

[13]

(b) Given the following array of integers:

1 10 25 33 45 56 65 84 91

- i. Using the binary search algorithm, describe the sequence of steps it would take to find the number 56.
- ii. What is the maximum number of comparisons it will take the binary search to find data in this array?
- iii. What is the maximum number of comparisons it will take the binary search to find a value in an array of n elements?

[12]

Question 2

- (a) i. Use `bubble_sort` algorithm to rearrange the following numbers into ascending order, showing the list of numbers after each pass.

5 1 2 6 9 4 3

- ii. Write down the number of comparisons and swaps on each pass.
- iii. Find the maximum number of comparisons and the maximum number of swaps that might be needed in a `bubble_sort` to rearrange seven numbers into ascending order.

[13]

- (b) i. Describe how the `selection_sort` algorithm works.
- ii. Use the `selection_sort` algorithm to rearrange the following number into ascending order, showing the list of numbers.

35 65 30 60 20

- iii. Using the `selection_sort` algorithm, find the maximum number of comparisons needed to sort a list of five elements into ascending order. Can you generalise this for a list of n elements?

[12]

Question 3

- (a) The following list represents the lengths in minutes of nine radio programmes. They are to be recorded onto tapes. Each tape stores up to 100 minutes of programmes.

29, 52, 73, 87, 74, 47, 38, 61, 41

- i. Find the lower bound for the number of tapes needed to store all the above nine programmes.
- ii. Use the `first_fit` bin packing algorithm to fit the programmes onto tapes.
- iii. Use the `first_fit_decreasing` algorithm to fit the nine programmes.

[12]

- (b) Five tour guides, Adam, Emiley, Gareth, Rob and Wendy need to be assigned five coach trips, 1, 2, 3, 4, and 5. Preferences of each tour guides is shown by a bipartite graph in Figure 1.

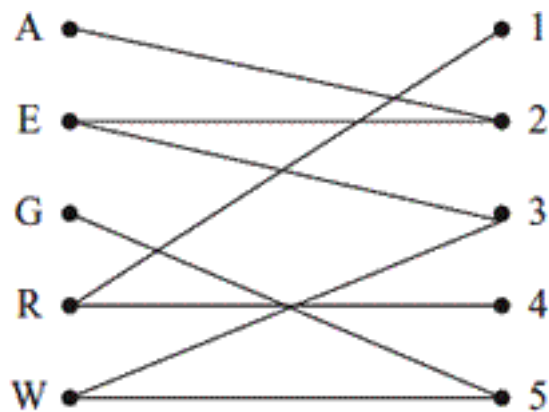


Figure 1

- i. Starting with the initial state given in Figure 2, use the maximum matching algorithm to increase to number of matching. State the alternative path you used.

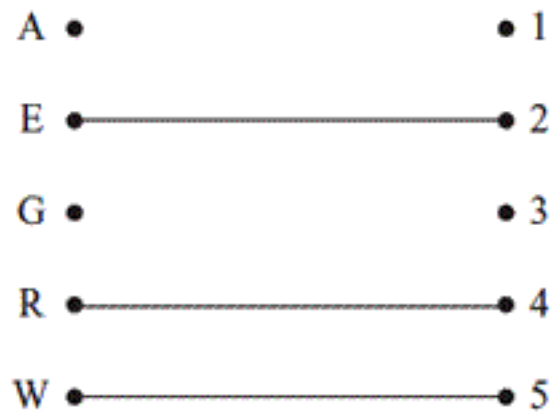


Figure 2

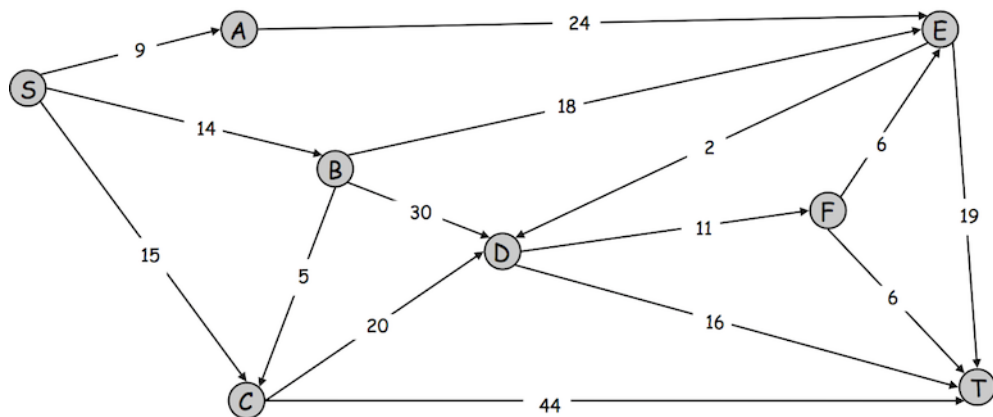
- ii. List the improved matching found in (i).
- iii. A complete matching in this case is not possible. Explain why?
- iv. Suppose Wendy agrees to be assigned to coach trip 3, 4 or 5. Starting with your current maximal matching, use the maximum matching algorithm to obtain a complete matching.

[13]

Question 4

(a) i. Explain how Dijkstra's algorithm works.

ii. Given the following directed graph:



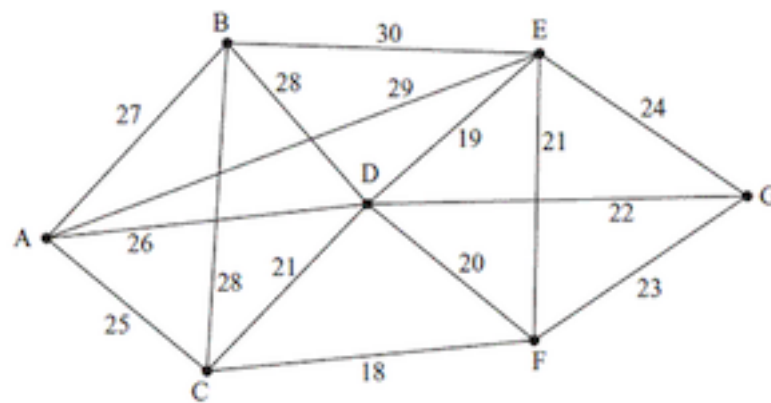
Use Dijkstra's algorithm to find the shortest route from S to T. Explain your answer.

[13]

(b) i. Explain how Kruskal's algorithm works.

ii. Using Kruskal's algorithm, find a minimum spanning tree (MST) of the following weighted graph.

iii. What is the difference between Kruskal's and Prim's algorithm?



[12]

Question 5

(a) Given the following system of linear equations:

$$\begin{aligned}x - 2y + z &= 1 \\x + y + z &= 10 \\3x + 2y - 2z &= 2\end{aligned}$$

- i. Write down the augmented matrix.
- ii. Use Gaussian elimination to solve this system.

[10]

(b) Consider the following linear programming problem. The objective is to maximise the value of the variable $p = 6x + 2y$.

$$\text{Subject to } \begin{cases} 2x + y \leq 10 \\ x + y \leq 8 \\ x \geq 0 \\ y \geq 0 \end{cases}$$

- i. Graph the feasible region for the problem.
- ii. Find the optimal solution.

[15]