

**CS-121**  
**DATA STRUCTURES**  
*(Attempt 2 questions out of 3)*

**Question 1**

Consider the following list of towns and cities:-

Llanelli, Pontypridd, Brecon, Cardiff, Portsmouth, Bridgend, Aberystwyth,  
Neath, Newport, Swansea

- a. Construct a binary search tree to store this list in ascending order **[5 marks]**
- b. What does it mean for a tree to have the AVL property, and does the tree you have constructed have this property? **[2 marks]**
- c. Construct the tree again but this time maintaining the AVL property at all stages of the construction. Carefully indicate when tree rotations have to be undertaken and why. **[5 marks]**
- d. Given an initial hash function defined by  
Hash value = number of consonants in name  
Show how the given towns and cities would be stored in a hash table of size 7 (indexed from 0) where collisions are resolved by chaining. **[5 marks]**
- e. Show how the given towns and cities would be stored in a hash table of size 17 (indexed from 0) where collisions are resolved using a second hash function defined by  
Second Hash Value = number of vowels in name **[5 marks]**
- f. Briefly comment on the advantages and disadvantages of the four methods of storing sorted data that you have used in this question **[3 marks]**

## Question 2

- a. What does it mean to say that a data structure can be defined by the operations that can be performed upon it? Once a data structure has been defined, what subsequent steps and design decisions need to be taken before that data structure can be used in a program? **[3 marks]**
- b. Define the concept of a **stack** in terms of the operations that can be performed on them. Include in your answer details of all the arguments required for each operation, and the results of each operation. **[5 marks]**
- c. Using a Java-like language which includes the concept of references, but not arrays, show how you could implement a stack. Discuss any alternative implementation strategies that might be available to you. **[6 marks]**
- d. Using a Java-like language which includes the concept of an array show how you could implement a stack. Discuss any alternative implementation strategies that might be available to you. **[6 marks]**
- e. Discuss the advantages and disadvantages of the two approaches you have used above. **[5 marks]**

## Question 3

- a. Explain the difference between Static and Dynamic data storage and outline how dynamic data storage can be managed. Your answer should include a brief description of how free-lists can be used and the implications of allocating memory blocks of different sizes. The following terms should be explained:
  - i) first-fit
  - ii) best-fit
  - iii) next-fit
  - iv) fragmentation
  - v) reference counting
  - vi) mark and release garbage collection
  - vii) buddy system
  - viii) on-the-fly garbage collection **[15 marks]**

- b. Given the following definition of a power relation which calculates  $x^n$  for positive integers  $x$  and  $n$ .

$$\text{power}(x, 0) = 1$$

$$\text{power}(x, n) = x * \text{power}(x, n-1) \quad \text{for } x > 0$$

write a recursive function to calculate  $\text{power}(x, n)$  and give a call trace for  $\text{power}(2, 4)$ .

Write an iterative function to perform the same task and comment on the efficiency of each function.

**[10 marks]**