Sample Paper
FINALTERM EXAMINATION
Fall 2022
CS301 - Data Structures

Time: **90 min**
Total Marks: **60**
Section A: Objective (33 marks)
Section B: Subjective (27 marks)
Mandatory : **33 MCQs**, **4 Short** (3 marks each) , **3 Long** (5 marks each)

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Solved by Qalb-e-Momin

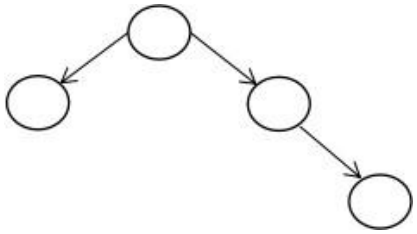
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Question No: 1 (Marks: 01) - Please choose the correct option

AVL Tree is invented in the year _____.

A. 1960
B. 1961
C. 1962
D. 1963

Question No: 2 (Marks: 01) - Please choose the correct option



Inserting a node at the right most place would make root's balance factor _____.

A. -1
B. -2
C. 1
D. 2

Question No: 3 (Marks: 01) - Please choose the correct option

As compared to BST, the root node in AVL tree is _____.

A. 0
B. Null
C. Constant
D. Changeable

Question No: 4 (Marks: 01) - Please choose the correct option

In AVL Tree, _____traversal gives sorted sequence in ascending order.

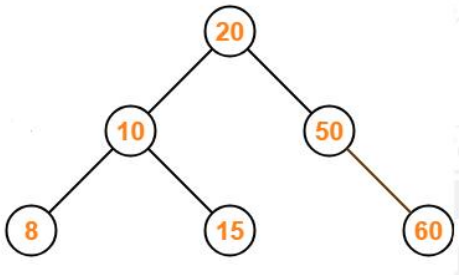
A. Inorder
B. Pre-order
C. Post-order
D. Level order Traversal

Question No: 5 (Marks: 01) - Please choose the correct option

_____converts assembly language code into machine code i.e. 0s & 1s.

A. Interpreter
B. Compiler
C. Converter
D. Assembler

Question No: 6 (Marks: 01) - Please choose the correct option



After deleting node 15 from above tree, how many rotations do we need to balance the AVL tree?

A. One Single Rotation
B. One Double Rotation
C. No Rotation
D. Two Single Rotations

Question No: 7 (Marks: 01) - Please choose the correct option

Compiler converts the C++ code into _____.

A. Assembly language
B. Visual Basic
C. Java
D. Bytecode

Question No: 8 (Marks: 01) - Please choose the correct option

Which one of the following is the application of an Expression Tree?

A. MS Word
B. 2D Paint
C. Spreadsheets
D. Outlook

Question No: 9 (Marks: 01) - Please choose the correct option

What is the height balancing factor in AVL tree?

A. Difference between left and right subtree heights
B. Sum of left and right subtree heights
C. Product of left and right subtree heights
D. Log of left and right subtree heights

Question No: 10 (Marks: 01) - Please choose the correct option

The technique of using binary trees in data compression is referred to as _____.

A. Huffman encoding
B. Heap
C. Graph
D. BST

Question No: 11 (Marks: 01) - Please choose the correct option

What will be the number of external nodes in a binary tree that has 31 internal nodes?

A. 30
B. 31
C. 32 // External node (leaf node) = Internal node (non-leaf node) + 1
D. 33

Question No: 12 (Marks: 01) - Please choose the correct option

What type of nodes are found in an expression tree?

A. Operators and operands
B. Functions and variables
C. Numbers and symbols
D. Numbers and operands

Question No: 13 (Marks: 01) - Please choose the correct option

What is the maximum number of nodes that a complete binary tree of height 'h' can have?

A. 2^h
B. 2^(h+1) - 1
C. 2^(h-1)
D. 2^h+1

Question No: 14 (Marks: 01) - Please choose the correct option

A max-heap is stored in an array as H = [49, 39, 36, 31, 27, 21, 35, 12].
What is the result of deleting 49 from this heap?

A. [39, 31, 36,12, 27, 21, 35]
B. [39, 36, 31, 27, 21, 35, 12]
C. [39, 36, 12, 31, 27, 35, 21]
D. [39, 35, 31, 36, 12, 27, 21]

Question No: 15 (Marks: 01) - Please choose the correct option

How many types of heap are there?

A. 2
B. 3
C. 4
D. 5

All parents ≤ children ✓ This is a Min Heap.
All parents ≥ children ✓ This is a Max Heap.

Question No: 16 (Marks: 01) - Please choose the correct option

Heap can be used as _____

E. Priority queue
F. Stack
G. A decreasing order array
H. Normal Array

Question No: 17 (Marks: 01) - Please choose the correct option

Suppose Min heap is implemented by using an array. Which one of the following array cannot be a Min heap?



A. 17, 19, 21, 23, 25, 29, 31
B. 17, 21, 19, 25, 23, 31, 29
C. 17, 25, 19, 29, 31, 21, 23
D. 17, 25, 21, 31, 29, 19, 23

// All parents ≤ children ✓ This is a Min Heap.

Question No: 18 (Marks: 01) - Please choose the correct option

In deletMin method, before calling the percolatedown method( ) the _____element of the array will be placed as the root element of the tree.

A. first
B. second
C. third
D. last

// In the deleteMin() method of a **Min Heap**, the steps are:

1. The **minimum element** (root) is removed.
2. The **last element** in the heap is **moved to the root**.
3. Then percolateDown() is called to restore the heap property.

Question No: 19 (Marks: 01) - Please choose the correct option

In union operation, the _____can be used to name the set.

A. Root
B. Left child
C. Right child
D. Leaf node

// In the **Union-Find** data structure (Disjoint Set), during a **union operation**, the **root of the tree** is used to represent or **name the set**. Each set is identified by the root of its tree.

Question No: 20 (Marks: 01) - Please choose the correct option

Which of the following method takes an array along with its size as an argument and constructs a heap out of it?

A. Insert( )
B. Buildheap( )
C. Percolatedown()
D. IncreaseKey( )

Question No: 21 (Marks: 01) - Please choose the correct option

How many properties will an equivalent relationship satisfy?

A. 1
B. 2
C. 3 **// Reflexive, Symmetric, Transitive**
D. 4

Question No: 22 (Marks: 01) - Please choose the correct option

The _____method constructs a heap using a single item while maintaining heap order.

A. Insert( )
B. Buildheap( )
C. Percolatedown()
D. IncreaseKey( )

Question No: 23 (Marks: 01) - Please choose the correct option

Inside the insert method of min heap, we will call the _____method.

A. isFull()
B. isEmpty()
C. getmin()
D. IncreaseKey( )

Question No: 24 (Marks: 01) - Please choose the correct option

Suppose a relation R = {(2, 2), (5, 5), (5, 2), (5, 5), (6, 6)} on S = {2, 5, 6}. Here R is known as _____

A. equivalence relation
B. reflexive relation
C. symmetric relation
D. transitive relation

Question No: 25 (Marks: 01) - Please choose the correct option

Which part of the code performs the union of two sets in Union by Size method?

A. The find operation
B. The loop in the find operation
C. The union operation
D. The comparison in the if-condition

Question No: 26 (Marks: 01) - Please choose the correct option

What happens to the number of levels in the trees after a union operation in Union by Size method?

A. The number of levels increases
B. The number of levels decreases
C. The number of levels remains the same
D. The number of levels cannot be determined

Question No: 27 (Marks: 01) - Please choose the correct option

How is the root node identified in Union by Size method?

A. By setting its parent to -1
B. By setting its parent to the number of nodes in the tree in negative form
C. By finding the node with negative parent
D. By finding the node with positive parent

Question No: 28 (Marks: 01) - Please choose the correct option

How is a raw digital image stored in numbers?

A. Between 0 and 255 **// (This is for 8-bit grayscale images)**
B. Between 0 and 4
C. Between 0 and 10
D. Between 0 and 100

Question No: 29 (Marks: 01) - Please choose the correct option

What does the number 0 in the matrix example represent?

A. Gray color
B. Black color
C. White color
D. Red color

Question No: 30 (Marks: 01) - Please choose the correct option

What is the purpose of threshold value in image segmentation?

A. To determine the color of the pixels
B. To group the pixels based on their intensity
C. To calculate the texture of the image
D. To determine the size of the image

Question No: 31 (Marks: 01) - Please choose the correct option

What is a symbol table in compilers?

A. A data structure used to store information about identifiers in the source code.
B. A tool used to debug the code.
C. A technique for compressing the code.
D. A way to generate machine code from the source code.

Question No: 32 (Marks: 01) - Please choose the correct option

What is the function of the union/find algorithm in image segmentation?

A. To convert an image into a binary form
B. To combine pixels into sets based on their values
C. To divide an image into different parts
D. To make a program for image processing

Question No: 33 (Marks: 01) - Please choose the correct option

Suppose a hash table already contains some numbers using the key "K" and hash function **K % 13**. If the number 37 is already in the hash table, then adding which of the following number will cause a collision?

A. 1141
B. 1142 // **37 % 13 = 11 (any other number whose hash also result in 11 will cause a collision.) 1142 % 13 = 11**
C. 1143
D. 1144

Question No: 34 (Marks: 01) - Please choose the correct option

In open addressing to resolve the collision in hashing we _____.

A. Check next position one by one to find an empty place
B. Check odd positions to find an empty place
C. Check even positions to find an empty place
D. Open addressing is not a collision resolution technique

Question No: 35 (Marks: 01) - Please choose the correct option

Which of the following technique is/are used by compiler to construct a symbol table?

A. Hashing
B. Linked List
C. Binary Search Tree
D. All Hashing, Linked list and BST are used

Question No: 36 (Marks: 01) - Please choose the correct option

Data structure which is used to search an element in constant time is called _____.

A. Linked List
B. Binary Search Tree
C. AVL Tree
D. Hashing

Question No: 37 (Marks: 01) - Please choose the correct option

Which of the following is not a collision avoidance technique?

A. Linear Probing
B. Rehashing
C. Linked list
D. Increase the size of table

Question No: 38 (Marks: 01) - Please choose the correct option

Selecting a card from deck of cards and arranging them in an order is an example of _____.

A. Insertion sort
B. Selection sort
C. Merge sort
D. Heapsort

Question No: 39 (Marks: 01) - Please choose the correct option

Which of the following sorting algorithm do not use swapping technique while sorting the data?

A. Insertion sort
B. Selection sort
C. Merge sort
D. Quicksort

Question No: 40 (Marks: 01) - Please choose the correct option

Which of the following sorting algorithm uses pivot value to split the array?

A. Selection sort
B. Insertion sort
C. Merge sort
D. Quicksort

Question No: 41 (Marks: 03)

Explain the scenario with the help of a diagram, in which balance factor of an AVL Tree root node comes out to be -1.

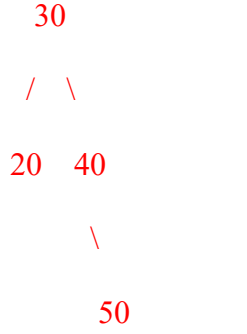
Answer

In an AVL tree, the **balance factor** of any node is calculated as:

Balance Factor = Height of Left Subtree − Height of Right Subtree

A **balance factor of -1** means:

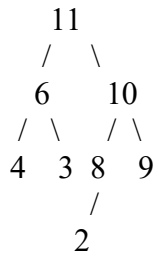
- The **right subtree is one level taller** than the left subtree.
- The tree is still **balanced** because valid balance factors are **-1, 0, or +1**.



Balance Factor of root (30) = 1 − 2 = −1

Question No: 42 (Marks: 03)

Consider the following heap:



(a) Is it a heap? Justify with solid reason
(b) Show the array representation of this tree.

Answer

(a) Yes, it is a valid Max-Heap because it satisfies both the completeness and heap order properties.

(b) Array Representation:
[11, 6, 10, 4, 3, 8, 9, 2]

How?

(a) Is it a Heap? Justify

There are two types of heaps:

Max-Heap: Parent node ≥ child nodes.

Min-Heap: Parent node ≤ child nodes.

Let's verify if it's a **Max-Heap** (because 11 is the root and the largest, which hints at Max-Heap structure)

Question No: 43 (Marks: 03)

Define and explain the disjoint set with examples.

Answer

A **Disjoint Set** (also called a *Union-Find Set*) is a data structure that keeps track of a set of elements partitioned into **non-overlapping subsets**. It is primarily used to manage elements that are split into one or more disjoint (non-intersecting) sets.

Example:

Suppose we have the following elements:

`{1}, {2}, {3}, {4}, {5}`

We perform the following operations:

```cpp
MakeSet(1), MakeSet(2), MakeSet(3), MakeSet(4), MakeSet(5)
Union(1, 2)
Union(3, 4)
Union(2, 4)
```

Explanation:

- After `Union(1, 2)`: `{1, 2}`, `{3}`, `{4}`, `{5}`
- After `Union(3, 4)`: `{1, 2}`, `{3, 4}`, `{5}`
- After `Union(2, 4)`: `{1, 2, 3, 4}`, `{5}`

Now all elements from 1 to 4 are in the same set.

Main Operations of Disjoint Set:

1- **MakeSet(x)**:
Creates a new set containing the single element x.
2- **Find(x)**:
Returns the **representative (or parent)** of the set that contains x.
Used to check if two elements belong to the same set.
3- **Union(x, y)**:
Merges the sets containing elements x and y into a single set.

Question No: 44 (Marks: 03)

What is the purpose of Image Segmentation?

Answer

Lecrure No. 37 **Page #416**

Image Segmentation is the process of dividing an image into meaningful regions or segments to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze.

In Urdu:

"Image Segmentation ایک ایسا عمل ہے جس کے ذریعے تصویر کو مختلف حصوں میں بانٹ دیا جاتا ہے تاکہ ہر حصہ کسی خاص شے یا مقصد کی نمائندگی کرے، اور تصویر کا تجزیہ کرنا آسان ہو جائے

Question No: 45 (Marks: 03)

How does the union/find algorithm work in image segmentation?

Answer

Union/Find algorithm in image segmentation is used to **group connected pixels** into regions (connected components). It works as follows:

1-MakeSet: Treat each pixel as its own set.

2-Compare Neighbors: For each pixel, compare with neighbors (top/left).

3-Union: If neighbors are similar, merge their sets.

4-Find: Retrieve the representative (label) of each pixel's set.

5-Result: Pixels in the same set belong to the same segment.

✓ It is efficient for **connected component labeling** in binary and grayscale images.

Question No: 46 (Marks: 03)

Consider the C++ code of "hashFunc" given below, if fruit name "**banana**" is passed to this function as an argument then what will be **return value** of "hashFunc"?

Note: The ASCII code of a = 97, b = 98 and n = 110.

```
int hashFunc(char* s) {
        int i, sum = 0;

        for(i=0; i<strlen(s); i++)
                { sum = sum + s[i];
        }
        return sum % 11;
}
```

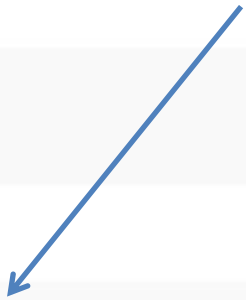
Answer

how?

The characters in `"banana"` are:

```
css

b  a  n  a  n  a
```



◆ ASCII values:

```
ini

b = 98
a = 97
n = 110
a = 97
n = 110
a = 97
```

◆ Sum of ASCII values:

```
ini

sum = 98 + 97 + 110 + 97 + 110 + 97 = 609
```

◆ Return value:

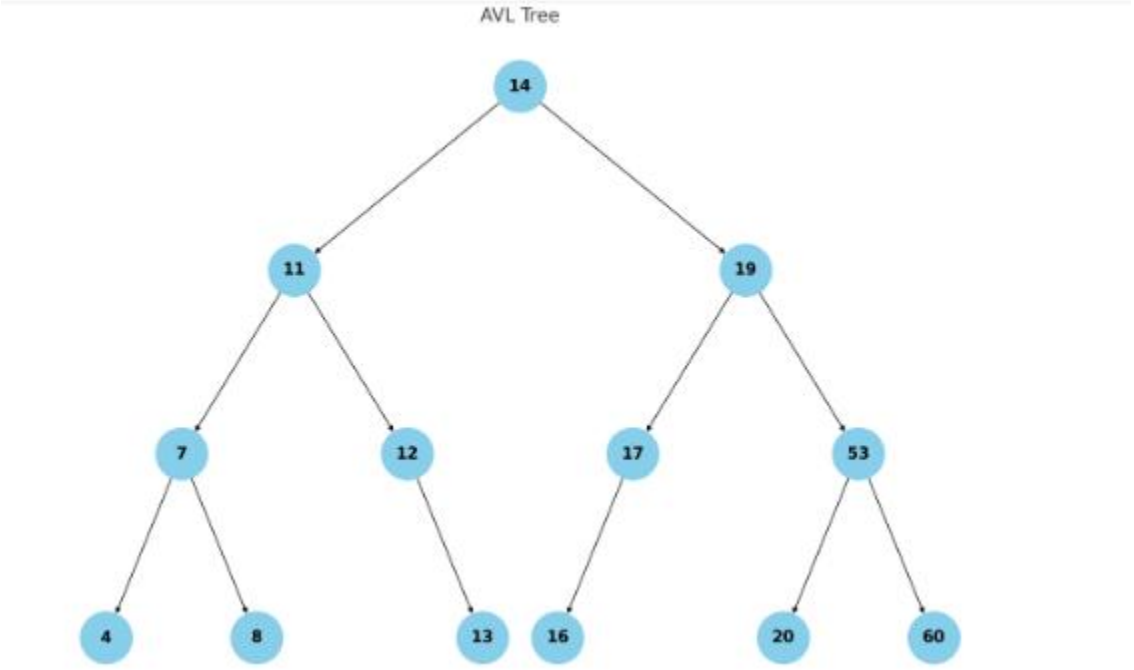
```
cpp

return sum % 11 = 609 % 11 = 4
```

Question No: 47 (Marks: 05)

Construct AVL tree by inserting the following data (read the from left to right):
14,17,11,7,53,4,13,12,8,60,19,16,20
Just show the final tree, you don't need to show all steps.

Answer



Question No: 48 (Marks: 05)

Construct Huffman tree from the following data:

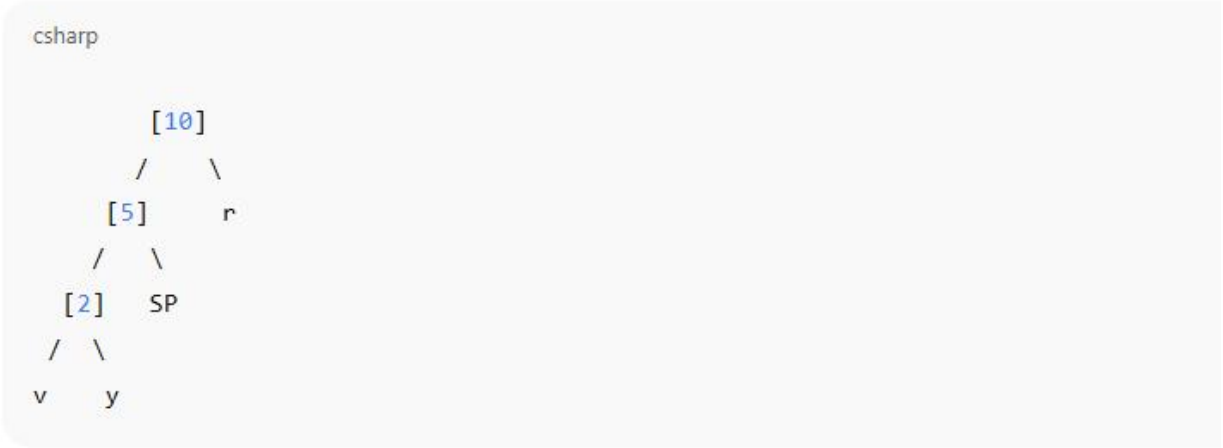
Character	Frequency
r	5
v	1
y	1
SP	3

Answer

Lecture # 26

✅ Final Tree (Text form):

csharp



Question No: 49 (Marks: 05)

In case of implementing minimum heap, write down the code of perculateDown() method.

Answer

Lecture No. 32 Page # 370

```
// hole is the index at which the percolate begins.
template <class eType>
void Heap<eType>::percolateDown( int hole )
{
   int child;
   eType tmp = array[ hole ];

   for( ; hole * 2 <= currentSize; hole = child )
   {
      child = hole * 2;

      if( child != currentSize && array[child+1] < array[ child ] )
         child++; // right child is smaller

      if( array[ child ] < tmp )
         array[ hole ] = array[ child ];
      else break;
   }

   array[ hole ] = tmp;
}
```

Question No: 50 (Marks: 05)

Consider the C++ code of a sort algorithm given below. If array showing in table is passed to sorting algorithm, then what will be the index of "29" after execution of code?

```
void mySort(int *arr, int N)

        { int temp;

        for (int i = 0; i < N - 1; i++)
                { int min = i;

                for (int j = i + 1; j < N; j++)
                        { if (arr[j] < arr[min])
                                min = j;
                }

                temp = arr[min];

                arr[min] = arr[i];
                arr[i] = temp;

                if(i == 3)
                        break;
        }
}
```

29	27	18	13	87	66	52	51	12	36
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

Give only one index, giving more than one indexes will be considered incorrect solution.

Answer

The code is doing **selection sort**, but stops after **4 steps** (`if(i == 3) break;`).

Initial array:

`[29, 27, 18, 13, 87, 66, 52, 51, 12, 36]`

After 4 steps:

```yaml
Step 1: swap 29 ↔ 12 → [12, 27, 18, 13, ..., 29, ...]
Step 2: swap 27 ↔ 13 → [12, 13, 18, 27, ..., 29, ...]
Step 3: no swap (18 already smallest)
Step 4: no swap (27 already smallest)
```

Final array after 4 steps:

`[12, 13, 18, 27, 87, 66, 52, 51, 29, 36]`

🔍 **29 is now at index** `8`

✅ **Answer: 8**

Best of Luck ☺

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