資料結構 Data Structures
Spring 2019
10720EECS204001
Professor Yi-Shin Chen

Midterm Exam

1. [6%]Algorithms & Performance Analysis

a. [3%]Sort the following time complexity expressions in descending order.
   1. $O(2n)$ 2. $O(nlog(n))$ 3. $O(n)$ 4. $O(n^{100})$
   5. $O(log(n))$ 6. $O(2^n)$

b. [3%]An algorithm needs to satisfy several criteria: Output, finiteness, input, definiteness and effectiveness. The following algorithm violates three of these criteria, please describe which ones and explain why.

```
int popSeveral(stack<int> myStack, stack<float> myStack) {
    int data;

   while(true) {
      data = myStack.front();
      myStack.pop();
   } else {
      printf("Could not retrieve data, Stack is empty.\n");
   }
}
```

2. [6%]Array Representations

a. [3%]There are 2 types of array representations. What are they? What are the advantages and disadvantages of each representation?

b. [3%]Consider the polynomial: $P(x) = 8x^3+7x^2+6x+3$. Give both representations for this polynomial. For each representation, explain how the exponents and coefficients are represented. (Hint: draw the data structures that correspond to each representation.)

3. [4%]C++ concepts

Consider the code below. What will be the output? (Note: If the code won't compile, specify the error.)

```
#include <iostream>
using namespace std;

int foo = 0;

class Base{
    public:
        Base() {cout << foo; }
};

class A: public Base {
    private:
        int foo;
    public:
        A(){ foo = 1; cout << foo; }
    friend class B;
};

class B: public Base{
    public:
        void show(A& a){ cout << a.foo << foo; }
};

int main() {
    A a; B b;
    b.show(a);
}
```

4. [4%]Stacks & queues

Many behaviours in real life can be modeled with stacks and queues.
Which data structure represents the items below the most accurately? (Sort them into 2 categories: "stack" or "queue")

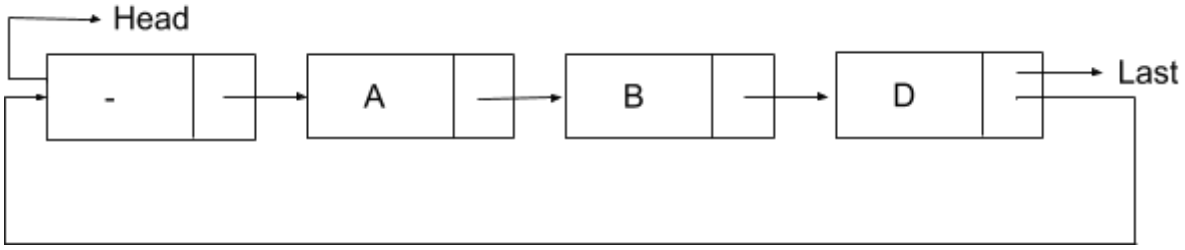
a. Incoming emails in an inbox display (ordered by date)
b. Editing steps in a text editor (Word) (editing steps are steps you can do and undo using Ctrl+z, Ctrl+y)
c. Printing jobs in a printer with several users
d. People getting in and out of an elevator

5. [10%]Linked lists

Given the linked list below, answer the following questions:

a. [5%]We would like to insert a ‘C’ in between ‘B’ and ‘D’. What are the steps we must follow in order to do so?

b. [5%]The first node marked ‘-’ is a dummy node. Why do we need this dummy node?



6. [15%]Postfix/infix/prefix notation & Trees

Consider the binary tree below.

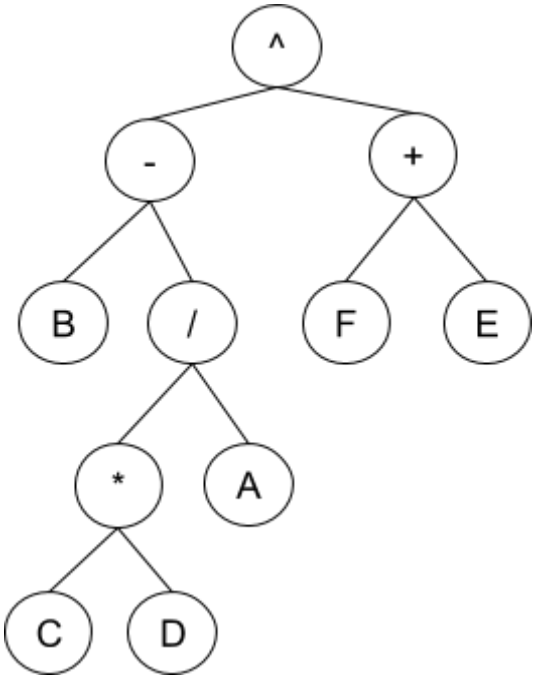
a. [4%]Which binary tree traversal method can derive an **infix** expression? Write down this infix expression *(*Hint: Remember to add proper parentheses for clarification.*)*

b. [4%]Which binary tree traversal method can derive a **postfix** expression? Write down this postfix expression.

c. [4%]During the tree traversal, we might want to use a data structure to store the visited nodes so far. What kind of data structure is the most appropriate to do so?

d. [3%]Please write the prefix and postfix notation of the expression given below.

x ^ y / (5 * z) + 10 / f ^ q

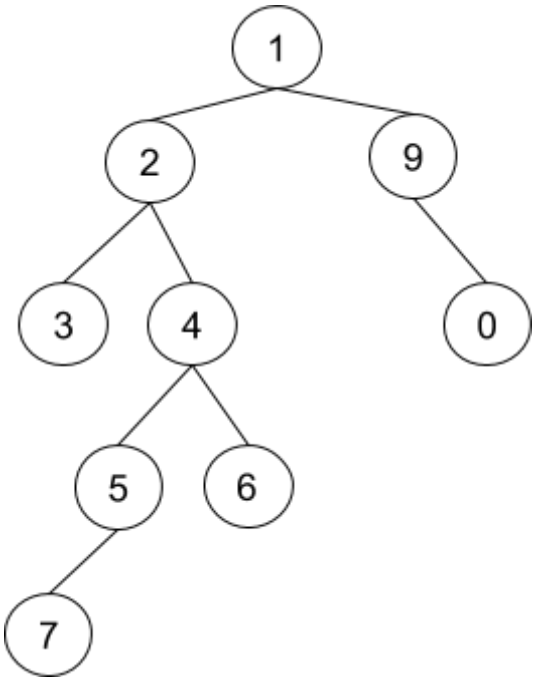


7. [10%]Trees

Given the tree below, answer the following questions:

a. [5%]List the following nodes:
   - List all the nodes that don't have a sibling.
   - List all the nodes that don't have any children.
   - List all the nodes that don't have parents.
   - List all the cousins of node '0'.

b. [5%]We want to implement the operation Find(x) on this tree. Illustrate how using the 'collapsing rule' might improve the implementation. What will the achieved time complexity be?

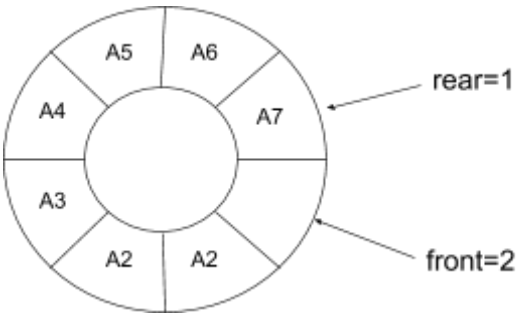


8. [8%]Circular queues

Given the circular queue below, answer the following questions:

a. [4%]What is the array representation of the circular queue below before and after doubling capacity?

b. [4%]Where will the rear and front pointers point after doubling capacity?



9. [12%]Fast transpose

Eva wants to transpose the matrix below by using the “fast transpose” method she learnt in the data structures class. She remembers there are several steps, including calculating the rowSize, and rowStart. Please help her to complete the table below. (Note: Please write down the answer on your answer sheet)

$$\begin{bmatrix} 0 & 3 & 0 & 44 & 0 & -5 \\ 0 & 0 & 2 & 18 & -10 & 0 \\ 0 & 78 & 0 & -6 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 91 & 0 & 0 & 0 & 0 & 23 \end{bmatrix}$$

A^T	rowSize	rowStart
[0]		
[1]		
[2]		
[3]		
[4]		
[5]		

10. [15%]Quiz questions

a. [5%]What are the differences between while-loop and repeat-loop. Illustrate with examples.

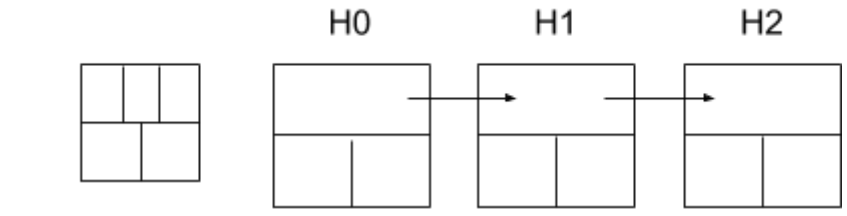
b. [5%]Explain the differences between abstraction and encapsulation. You can illustrate with examples.

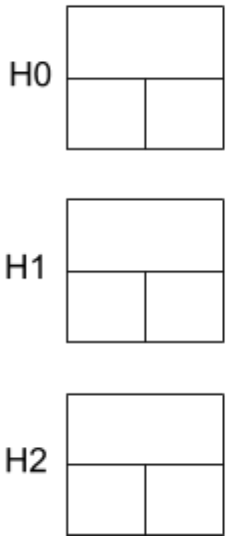
c. [5%]What is a complete binary tree. Illustrate with an example.

11. [12%]Linked-lists for sparse matrices

Brian wants to store the sparse matrix shown below using a linked-list structure. He plans to use two types of nodes, i.e., header nodes and element nodes (as mentioned in the textbook). Please give him a hand and complete the sketch below with the corresponding nodes and links (arrows). Remember to fill in the nodes with the appropriate values. (Note: Please write down the answer on your answer sheet)

$$\begin{bmatrix} 1 & 0 & 0 \\ 8 & 0 & 0 \\ 0 & 4 & 0 \\ 0 & 0 & 0 \\ 0 & 2 & 3 \end{bmatrix}$$





12. [8%]Max heap

Consider the max-heap below.

a. [4%]Suppose we want to insert the node 11. Show how the tree looks step by step during the insertion process.

b. [4%]Suppose we want to make a deletion. Which node will be deleted? Show how the tree looks step by step during the deletion process.