1 Short Answer

a) **Write pseudocode, or explain in paragraph form an algorithm to return the deepest element in a binary search tree. If there is a tie, you may return any element from the deepest level.**

b) **Let $f(n) = 52n^3 + log_5 n + 19\sqrt{n}$, show that $f(n) = O(n^4)$. Provide a c and n_0 and demonstrate that they are sufficient.**

c) **Suppose we are entering dates into a hashtable with 100 rows. Explain why a hashfunction which maps the date to the index corresponding to the first two numbers from its year is or is not desirable**
For example, January 14, 2016 would map to the 20th index in the table because '20' are the first two digits of the year.

d) **Draw two separate, valid min-heaps that contain the priorities: [4,8,18,22,30]. For each, draw both the tree and array representations**

2 Big O notation

For the following functions, determine the tightest, worst-case bigO upper bound in terms of n. Write your answers on the line provided. You do not need to justify your answer

a)
```
void f1(int n) {
    for (int i = 2; i < n; i = 2*i) {
        for(int j = 0; j < n; j++){
            System.out.println("!");
        }
    }
}
```

O(_______)

b)
```
void f2(int n) {
    for(int i=0; i < n; i++) {
        for(int j=0; j < i*n; j++) {
            for(int k=n; k > 0; k--) {
                for(int m=0; m < j; m++) {
                    System.out.println("!");
    }   }   }   }
}
```

O(_______)

c)
```
int f3(int n){
    if(n < 0) return 0;
    if (n \% 10 == 0) return n;
    else if(n < 1000) return f3(n-2);
    else return f3(n-1);
}
```

O(_______)

3 Heaps

a) Show a min-heap after performing these inserts in the following order:

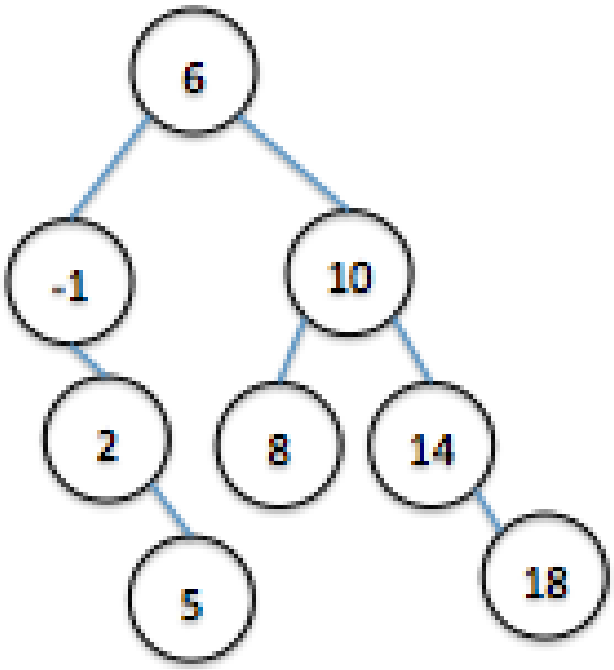
$$[22, 18, 14, 2, 8, 13, -4]$$

You may show either the tree or the array in your result, and intermediate steps are not required.

b) Show the above tree after two calls to deleteMin()

4 Traversals

Provide the pre-order, in-order, post-order and BFS traversal of the following tree. Additionally, identify whether or not the tree is an AVL tree.



AVL: Yes / No (Circle one)

Pre-order:

In-order:

Post-order:

Breadth-first Search:

5 AVL insertions

Show an AVL tree after performing these inserts in the following order:

$$[-5, -2, 3, 11, 9, 4, 15, 22]$$

You only need to show the final result, but showing intermediate steps may earn you partial credit if a mistake is made.

6 Hashtables

Populate the following hashtable using Quadriatic probing. Use modulo 10 as your hash function. Insert the following integers, in order. If an element fails to insert, indicate which one and stop inserting:

$$[86, 91, 14, 54, 48, 36, 64, 16]$$

7 Design Decision

The client is trying to track visitors to a webpage. As new visitors arrive, their information should be stored into a data structure. Each time a visitor appears, the data structure should be able to identify if the visitor has been to the page relatively quickly. No deletions will be made from the data structure. The company is small, so memory is constrained, but there are 2000 new visitors per day. There will be roughly 30,000 look ups per day. When added into the data structure, a unique ID is assigned to the user. Along with the ID, the data structure will need to save the user's preferences, which are an array of Strings and their date of birth, which is a long.

Specify an ADT and a data structure which supports the clients demands. Justify these design decisions using material from the course. This includes but is not limited to: asymptotic runtimes, memory usage, experimental results and data structure properties.