Boğaziçi University, Dept. of Computer Engineering

CMPE 250, DATA STRUCTURES AND ALGORITHMS

Fall 2011, Midterm 1

Name: ________________________________

Student ID: __________________________

Signature: ____________________________

• Please print your name and student ID number and write your signature to indicate that you accept the University honour code.

• During this examination, you may not use any notes or books.

• Read each question carefully and WRITE CLEARLY. Unreadable answers will not get any credit.

• There are 5 questions. Point values are given in parentheses.

• You have 120 minutes to do all the problems.

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1. What is . . (Give short answers. Long answers do not get any credit.)

(a) the notation $O(g(n)) = f(n)$ ? (1pt)

(b) the notation $Θ(g(n)) = f(n)$ ? (1pt)

(c) the notation $Ω(g(n)) = f(n)$ ? (1pt)

(d) the asymptotic notation for the statement: $f(n)$ is upper bounded by $Cn^{2+ε}$ for some $C$. ? (1pt)

(e) the meaning of the expression `float** p;` in C++ ? (1pt)

(f) Deep copy? (1pt)

(g) Shallow copy? (1pt)

(h) the output of the following code segment C++ ? Explain (2pts)

```
char a = 'c'; char& c=a; c = 'a'; cout << 'a' << a << 'c' << c;
```

(i) a possible way of allocating dynamic memory in C++ ? (1pt)

(10 points)
2. Order the following functions by growth rate, indicate functions that have the same growth rate. Functions:

\[ n, \sqrt{n}, n^{1/5}, n^2, n \log n, n \log \log n, n \log^2 n, n \log(n^2), 2/n, 2^n, 2^{n/2}, 10, n^2 \log n, n^3 \]

(10 points)

3. Show the result of inserting 10, 12, 1, 14, 6, 5, 8, 15, 3, 9, 7, 4, 11, 13, 2 into a initially empty binary heap (one at a time).

(20 points)
4. Give an algorithm to find and print all nodes less than some given value $X$ in a min-heap. First, explain your idea in a few sentences.

[Hint: Consider inorder traversal of a binary tree]

- Your algorithm must be $O(K)$ where $K$ is the number of elements less than $X$.
- You should not modify the heap

(30 points)
5. What is the output of the following C++ program? For each line numbered from 1-11, write the output. Every step must be explained. (Hint: Be careful with implicit calls to constructors and destructors).

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

template <typename T>
struct obj{
    T i;
    obj(T j=0) : i(j) {cout<<'+';};
    obj(obj<T>& o2){this->i=o2.i; cout<<'<'};
    ~obj(){cout<<'-';}
    obj& operator=(obj<T>& o2){this->i=o2.i; cout<<'='; return o2;};
    T operator/(obj<T>& o2){cout<<'/'; return this->i/o2.i;};
    T operator/(int j){cout<<"i/"; return this->i/j;};
};

template <typename T>
void fun1(obj<T>& o){o.i=1; cout<<'1'; return;}

void fun2(obj<int> o){o.i=2; cout<<'2';};
template <typename T>
void fun2(obj<T> o){o.i=3; cout<<'3';};

int main(){
    1    obj<int> o;          Output:
    2    obj<double> p(2);    Output:
    3    fun1(o); cout<<o.i;  Output:
    4    fun2(o); cout<<o.i;  Output:
    5    obj<int> o2=o;       Output:
    6    obj<int> o3(o);     Output:
    7    o2 = o;             Output:
    8    cout << o.i/p.i;     Output:
    9    cout << o/o1/2;      Output:
   10    cout << p/p;        Output:
   11    return 0;          Output:
}
```

(30 points)