Solutions

COS 126 Midterm 1 Written Exam, Spring 2008

This test is 8 questions, weighted as indicated. The exam is closed book, except that you are allowed to use a one page cheatsheet. No calculators or other electronic devices are permitted. Give your answers and show your work in the space provided. Put your name, login ID, and precept number on this page (now), and write out and sign the Honor Code pledge before turning in the test. You have 50 minutes to complete the test.

"I pledge my honor that I have not violated the Honor Code during this examination."

<table>
<thead>
<tr>
<th>Question</th>
<th>Points</th>
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<tbody>
<tr>
<td>1</td>
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<td>2</td>
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<td>7</td>
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<td>8</td>
<td>15</td>
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<td><strong>TOTAL</strong></td>
<td><strong>75</strong></td>
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Signature

March 13, 2008
1. **Number representation** (10 points). Suppose that you have a 16-bit computer word, using two’s-complement representation for integers. In the blank spaces to the right, write the 4-digit hexadecimal representation of each entity described on the left.

   A. Decimal number 256  
      ________0100_________
   B. Decimal number 100  
      ________0064_________
   C. Binary number 100  
      ________0004_________
   D. Decimal number –100  
      ________FF9C_________
   E. TOY instruction to add register A to register B.  
      ___1BAB or 1BBA_____

2. **Toy instructions** (5 points). Which of the following TOY instructions is a no-op (never changes the contents of any register, any memory location, or the program counter)? Circle all the no-ops.

   F. 2330 is a no-op
   G. 4330 is a no-op
   H. 7303
   I. 8303
   J. C000
3. **Array declarations** (5 points). Among the following code fragments, circle the ones that will *not* cause a compile-time error.  B and D will not cause a compile-time error.

K. `int[] a = int[10];`

L. `int[] a = new int[10];`

M. `int[] a = {1, 2, 3}; int b = a;`

N. `int[] a;`

O. `int a = {1, 2, 3};`

4. **Scope** (5 points). Consider the following code.

```java
public class Cubes {
    public static int square(int i) {
        return i * i * i;
    }
    public static void main(String[] args) {
        for (int i = 1; i <= 1000; i++) {
            StdOut.println(square(i));
        }
    }
}
```

Among the following statements, circle those that are true.  D is true.

P. Will not compile because `i` is not declared in `square()`.

Q. Prints only a few lines because of scope clash with variable `i`.

R. Prints the squares of the integers from 1 to 1000.

S. **Prints the cubes of the integers from 1 to 1000.**

T. Goes into an infinite loop.
5. **Recursive method** (15 points). Consider the following (recursive) static method.

```java
public static int mystery(int n, int m) {
    if (m <= 0) return 0;
    else return n + mystery(n, m - 1);
}
```

What value is returned for the call `mystery(6, 3)`?

18 is returned.

What function does `mystery()` compute for positive `n` and `m`?

`mystery()` computes the product of `n` and `m`. 
6. **Nested loops** (5 points). Consider the following code fragment.

```java
int N = Integer.parseInt(args[0]);
char[][] pic = new char[N][N];
for (int i = 0; i < N; i++) {
    for (int j = 0; j < N; j++) {
        if (i == j || i == 0 || i == N - 1)
            pic[i][j] = '*';
        else
            pic[i][j] = '.';
    }
}
for (int i = 0; i < N; i++) {
    for (int j = 0; j < N; j++) {
        System.out.print(pic[i][j]);
    }
    System.out.println();
}
```

What is the output when N = 6? Circle your answer. **D is the answer.**

```
******  *****  *....*  ******  ******
**...*  ....*.  *...**  .*....  ...*...
*.*..*  ...*..  *..*.*  ..*...  ...*...
*..*.*  ..*...  *.*..*  ...*.  ...*...
*...**  .*....  **...*  ....*.  ...*...
******  *****  *....*  ******  ******
```
7. **Performance** (15 points). The following table gives approximate running times for a program with \( N \) inputs, for various values of \( N \).

<table>
<thead>
<tr>
<th>( N )</th>
<th>time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>5 seconds</td>
</tr>
<tr>
<td>2000</td>
<td>20 seconds</td>
</tr>
<tr>
<td>5000</td>
<td>2 minutes</td>
</tr>
<tr>
<td>10,000</td>
<td>8 minutes</td>
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Which of the following best describes the likely running time of this program for \( N = 100,000 \)? Using the doubling hypothesis, the increase appears to be quadratic. So, when \( N \) increases by 10 (from 10,000 to 100,000) the time increases by 100 (from 8 to 800 minutes). 800 minutes is a little over 13 hours, so the best of the answers if half a day.

V. A few minutes  
W. A few hours  
X. Half a day  
Y. A few days  
Z. A few weeks  

Refine a power-law hypothesis to give a formula for the approximate likely running time (in **minutes**) of this program as a function of \( N \). (You need to find the leading constant and the exponent.)

\[
8 \times 10^{-8} \times 2^N \text{ or } 8.3 \times 10^{-8} \times 2^N
\]
8. **Conditionals** (15 points). Consider the following program.

```java
public class Conditionals {
    public static void main(String[] args) {
        int N = Integer.parseInt(args[0]);
        String s = "a";
        String t = "b";
        if (N >= 10 && N <= 20) s = s + t;
        else if (N <= 5 || N >= 25) s = t + s;
        else if (N >= 30) s = s + s;
        else s = t + t;
        if (N % 3 == 0) {
            t = s + t;
            if (N % 5 != 0) t = t + s;
        }
        System.out.println(s + t);
    }
}
```

Give the result of executing this program with
```
% java Conditionals 15
ababb
```

Which (one or more) of the following correspond to the output of `Conditionals` for some positive input value of `N`? Circle all correct answers. **Last 4 are all possible answers.**

- aaaaab
- ababbab
- abb
- bbb
- bbbbbbb

- N=12
- N=10
- N=22
- N=21