COS 126	General Computer Science	Spring 2007

Exam 1

This test has 10 questions worth a total of 50 points. You have 120 minutes. 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. **Write out and sign the Honor Code pledge before turning in the test.**

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

Signature

Name:

NetID:

Problem	Score
0	
1	
2	
3	
4	
Sub 1	

Problem	Score
5	
6	
7	
8	
9	
Sub 2	

Total	

P01	TTh 1:30	Andrea
P01A	TTh 1:30	Sid
P01B	TTh 1:30	Woo Chang
P02	TTh 2:30	Forrest
P02A	TTh 2:30	Ananya
P03	TTh 3:30	Chang
P04	TTh 7:30	Tim
P05	WF 10	Yaping
P06	WF 11	Maia
P07	WF 1:30	Ganesh
P07A	WF 1:30	Sonya
P07B	WF 1:30	Yi

0. **Miscellaneous. (1 point)**

   (a) Write your name and Princeton NetID in the space provided on the front of the exam, and circle your precept number.

   (b) Write and sign the honor code on the front of the exam.

1. **Number systems. (4 points)**

   (a) What is the decimal representation of the 16-bit two's complement integer 111001_2? Circle your answer.

   (b) Convert the decimal integer 2008_{10} to hexadecimal. Circle your answer.

   (c) Write the decimal integer -77 as an 8-bit two's complement integer. Circle your answer.

   (d) The absolute value in Java's `Math` library computes the absolute value of an `int` (32-bit, two's complement integer) as follows:

```
public static int abs(int a) {
    if (a < 0) return -a;
    return a;
}
```

   There is one value of `x` that makes `Math.abs(x)` return a negative integer. What is it? Circle your answer.

$$-2^{31} \qquad -2^{31}-1 \qquad 0 \qquad 2^{31}-1 \qquad 2^{31}$$

This page is intentionally left blank. Feel free to use for scratch work.

2. **Nested loops and conditionals. (4 points)**

Consider the following program.

```
public class Triangle {

    public static void main(String[] args) {
        int N = Integer.parseInt(args[0]);

        for (int i = -N; i <= N; i++) {
            for (int j = -N; j <= N; j++) {
                if (i - j >= 0) System.out.print(i-j + " ");
                else            System.out.print(". ");
            }
            System.out.println();
        }

    }

}
```

It takes takes a command-line parameter `N` and prints out a pattern, as below.

```
% java Triangle 3
0 . . . . . .
1 0 . . . . .
2 1 0 . . . .
3 2 1 0 . . .
4 3 2 1 0 . .
5 4 3 2 1 0 .
6 5 4 3 2 1 0
```

Describe in *10 words or less* how to modify `Triangle` to print a mirror image, as below.

```
% java Triangle 3
0 1 2 3 4 5 6
. 0 1 2 3 4 5
. . 0 1 2 3 4
. . . 0 1 2 3
. . . . 0 1 2
. . . . . 0 1
. . . . . . 0
```

3. **Java loops and functions. (4 points)**

   For each of the following code fragments, how many lines of output (number of calls to `System.out.println()`) does it produce? Circle your answers.

   (a)

```
for (int i = 0; i < 100; i++) {
   i = i*i*i;
   System.out.println("Princeton");
}
```

   (b)

```
public static void cube(int i) {
   i = i*i*i;
}

for (int i = 0; i < 100; i++) {
   cube(i);
   System.out.println("Tigers");
}
```

4. **Debugging and arrays. (8 points)**

Recall the *coupon collector problem*: repeatedly select one of `N` card types at random, and continue until you have collected one of each type. The program `Coupon.java` below attempts to simulate this process, printing out the total number of coupons collected.

```
% more Coupon.java

public class CouponCollector {

   public static void main(void) {

      // read number of coupon types from command-line
      N = Integer.parseInt(args[0]);

      int cardcnt = 0;   // number of cards collected
      int valcnt;        // number of distinct cards collected

      // found[i] = true if card type i already collected
      boolean found = new boolean[N];

      // select cards at random, until you collect 1 of each type
      while (cardcnt > 0) {

         // select a new card type at random
         double val = (int) (Math.random() * N);
         cardcnt++;

         // check whether the card has already been collected
         if (found[i] = false)
            found[i] = true;
            valcnt++;

      }

      // print out total number of cards collected
      System.out.println(cardcnt);
   }

}
```

The code has at least 10 *independent* syntax and logical errors. Identify, circle, and correct 8 of them above.

5. **Functions. (6 points)**

   (a) Given three positive integers x, y, z, you can form a triangle with the given side lengths if and only if each number is strictly less than the sum of the other two. Write a function `areTriangular()` that takes 3 integer arguments `x`, `y`, and `z`, and returns `false` if any number is greater than or equal to the sum of the other two, and `true` otherwise. Your answer will be graded for correctness and clarity.

```
public static boolean areTriangular(int x, int y, int z) {









}
```

   (b) List two compelling reasons why experienced programmers use functions.

6. **Standard input, standard output, and redirection. (9 points)**

Suppose that you have an input file containing a sequence of students and their grades. The input format consists of the number of assignments `N`, followed by a sequence of entries, each consisting of a `String` (the student's last name) followed by `N` integer scores.

```
% more data.txt
4
Ananya      96 78 61 83
Andrea      89 90 56 98
Chang       96 78 61 88
Forrest     87 78 61 93
Ganesh      96 78 61 83
Kevin       80 80 80 80
Maia        92 78 61 80
Sid         91 83 54 83
Sonya       94 78 72 81
Tim         88 78 64 83
Woo         87 85 66 83
Yaping      84 78 66 83
Yi          90 88 45 99
```

On the facing page, write a complete Java program `Assignments.java` that reads in data (in the given format) from standard input, and prints each student's name and their average score to standard output. Assume that you have access to the library `StdIn.java`. Do *not* use arrays. Your answer will be graded for correctness and clarity.

Here is a sample execution.

```
% java Assignments < data.txt
Ananya 79.5
Andrea 83.25
Chang 80.75
Forrest 79.75
Ganesh 79.5
Kevin 80.0
Maia 77.75
Sid 77.75
Sonya 81.25
Tim 78.25
Woo 80.25
Yaping 77.75
Yi 80.5
```

(a)

```
public class Assignments {
    public static void main(String[] args) {
        int N = StdIn.readInt();    // number of assignments









    }
}
```

(b) Suppose that you want to save the output of running program `Assignments` on the input file `data.txt` into an output file named `output.txt`. Write the command that you would use to do this.

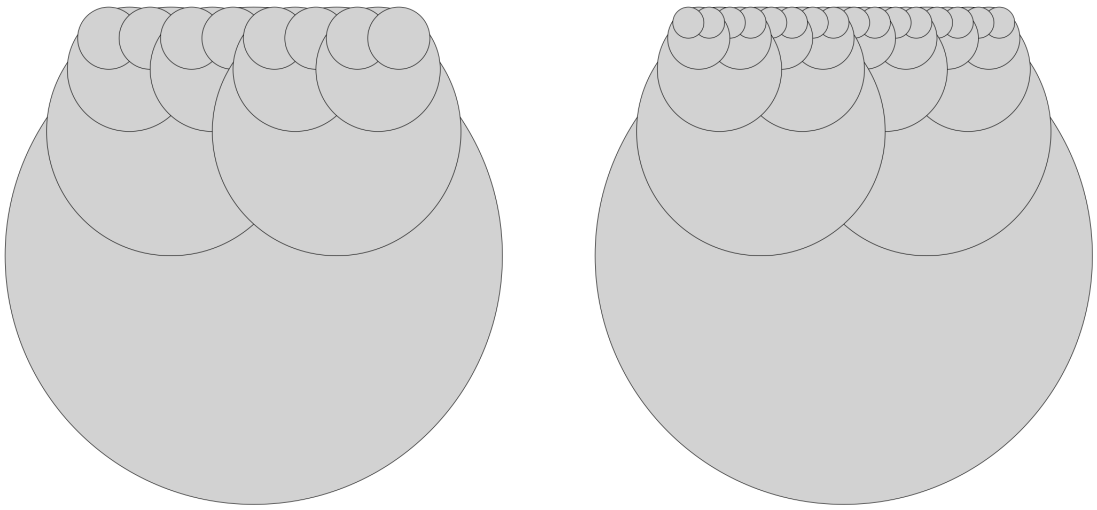
7. **Recursive graphics. (6 points)**

Consider the following recursive Java function.

```
public static void circles(int n, double x, double y, double size) {
   if (n == 0) return;                                  // 1
   drawShadedCircle(x, y, size);                        // 2
   circles(n-1, x - size/3, y + size/2, size/2);        // 3
   circles(n-1, x + size/3, y + size/2, size/2);        // 4
}
```

The function call `circles(4, .5, .5, .5)` produces the output on the left.

(a) Give the order in which the 4 statements should appear in `circles()` so that the function call `circles(4, .5, .5, .5)` produces the output on the right. Circle your answer.



1 2 3 4

(b) Describe what would happen if the statements within `circles()` were ordered `4 3 2 1` and you called `circles(4, .5, .5, .5)`?

8. **TOY I. (2 points)**

(a) Approximately how many *total bits* of storage does the TOY machine have? Circle the best answer.

2^8 2^{10} 2^{12} 2^{16} 2^{256}

(b) Which of the following are key features of the *von Neumann architecture*? Circle the best answer.

I. Data are encoded as sequences of bits.

II. Program and data are stored in the same shared memory.

III. Most widely used machine architecture today.

(a) I only.
(b) I and II only.
(c) I and III only.
(d) I, II and III.
(e) None.

9. **TOY II. (6 points)**

Consider the following TOY program, stored in memory locations `10` through `19`.

```
10: 73FF            R[3] <- 00FF
11: 7101            R[1] <- 0001
12: 72AA            R[2] <- 00AA
13:                 R[3] <- R[3] - R[1] = R[3] - 1
14: A403            R[4] <- mem[R[3]]
15:                 if (R[4] == 0) pc <- 18
16:                 if (R[4] >  0) pc <- 13
17: 72BB            R[2] <- 00BB
18:                 write R[2] to standard output
19: 0000            halt
```

(a) Fill in the missing machine code above for location `13`, `15`, `16` and `18`.

(b) Run the program above, given the following values in memory locations `FA` through `FE`.

```
FA:  9117
FB:  0000
FC:  4004
FD:  076F
FE:  6FF0
```

What (if anything) is printed to standard output? Circle your answer.

(c) Give values for `FA` through `FE` that yield a different answer from (b).

```
                TOY REFERENCE CARD


INSTRUCTION FORMATS

              | . . . . | . . . . | . . . . | . . . . |
  Format 1:   | opcode  |    d    |    s    |    t    |  (0-6, A-B)
  Format 2:   | opcode  |    d    |       addr        |  (7-9, C-F)


ARITHMETIC and LOGICAL operations
    1: add               R[d] <- R[s] +  R[t]
    2: subtract          R[d] <- R[s] -  R[t]
    3: and               R[d] <- R[s] &  R[t]
    4: xor               R[d] <- R[s] ^  R[t]
    5: shift left        R[d] <- R[s] << R[t]
    6: shift right       R[d] <- R[s] >> R[t]

TRANSFER between registers and memory
    7: load address      R[d] <- addr
    8: load              R[d] <- mem[addr]
    9: store             mem[addr] <- R[d]
    A: load indirect     R[d] <- mem[R[t]]
    B: store indirect    mem[R[t]] <- R[d]

CONTROL
    0: halt              halt
    C: branch zero       if (R[d] == 0) pc <- addr
    D: branch positive   if (R[d] >  0) pc <- addr
    E: jump register     pc <- R[d]
    F: jump and link     R[d] <- pc; pc <- addr


Register 0 always reads 0.
Loads from mem[FF] come from stdin.
Stores to  mem[FF] go to stdout.

16-bit registers
16-bit memory locations
 8-bit program counter
```