Name: ___________________ Key: _____________ Section: _____________

Instructions:

1. There are test questions on the front and the back of each sheet.

2. This is a closed book exam. Do not use any notes, books, or neighbors except your one page, two side, handwritten, cheat sheet which MUST be turned in with your exam.

3. Show your work. Partial credit will be given. Grading will be based on correctness and clarity.

4. You have 75 minutes to complete the exam. Watch your time appropriately. You should take about 15 minutes per question section.

Integrity: The University of Richmond’s Honor Code is “We, the students of the University of Richmond, shall promote and uphold a community of integrity and trust.” Upon accepting admission to University of Richmond, a student immediately assumes a commitment to uphold the Honor Code, to accept responsibility for learning, and to follow the philosophy and rules of the Honor System. Students will be required to state their commitment on examinations, research papers, and other academic work. Ignorance of the rules does not exclude any member of the Richmond community from the requirements or the processes of the Honor System.

I agree to uphold this commitment and produce original work in this exam, i.e., I will not cheat nor will I consciously let anyone cheat.

Signature: ________________________________

DO NOT BEGIN THE EXAM UNTIL INSTRUCTED TO DO SO. GOOD LUCK!

<table>
<thead>
<tr>
<th>Question</th>
<th>Points</th>
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<tr>
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<td>received</td>
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<td>1</td>
<td>20</td>
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<td>2</td>
<td>20</td>
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<td>Bonus</td>
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1. **Definitions** (20 points, 2 points each). For each of the following, fill in the blanks with the most accurate term.

(a) Computer science is the study of computer architecture, problem solving, and interaction with computing devices.

(b) Computer programs typically run as a layer interacting directly with the operating system.

(c) The data type defines both the possible values of the data and the operations on the data.

(d) An expression is any combination of variables, operators, and function calls that generates a new value.

(e) Type conversion is the process of reinterpreting the value of a variable as a new data type. It can happen in two ways, explicitly with a cast or implicitly by the compiler.

(f) The sequence of statements that the program executes is called the control flow, also referring to the possible paths the program could take. When a control structure is located within another control structure, this is referred to as nesting.

(g) An array is a set of a fixed number of elements all of the same type. Strings are similar to one made up of characters (do not name a Java type, rather what it represents).

(h) Scope is the lifetime of a variable. In other words, it defines where in a program you are allowed to use a variable.

(i) A pointer is a variable who’s value is (or contains) a memory address.

(j) Creating two or more functions with the same name but different argument lists is referred to as overloading.
2. **Diagramming** (20 points, 5 points each). For each of the following create a flow chart (circles, blocks, diamonds, arrows, and labels), but do not describe the individual elements. Simply label items appropriately.

(a) General algorithmic process.

(b) Basic computer organization.

(c) Control flow of a for loop.

(d) Control flow of a do-while loop.
3. **Syntax** (20 points). The following question deal specifically with Java syntax. Always write snippets of code in valid Java. Don’t forget your semicolons (where appropriate).

(a) Write the signature of function `main` (2 points):

```
public static void main(String[] args)
```

(b) Given the code: `String hello = "Hello";`. Write the snippets for the following (6 points):

<table>
<thead>
<tr>
<th>Type</th>
<th>String</th>
</tr>
</thead>
<tbody>
<tr>
<td>Declaration</td>
<td>String hello</td>
</tr>
<tr>
<td>Variable</td>
<td>hello</td>
</tr>
<tr>
<td>Literal</td>
<td>&quot;Hello&quot;</td>
</tr>
<tr>
<td>Assignment</td>
<td>hello = &quot;Hello&quot;</td>
</tr>
<tr>
<td>Initialization</td>
<td>hello = &quot;Hello&quot;</td>
</tr>
</tbody>
</table>

(c) Given that `a` is a `double`, `b` is an `int`, and `c` is a `String`, what is the type of the expression `a*b + c`? (2 points)

```
String
```

(d) Write a snippet of code to convert a `String s` to a `long l` (2 points).

```
long l = Long.parseLong(s);
```

(e) Write a snippet of code to randomly generate an integer `c` in the range `[a, b]` where `a` is an integer and `b` is an integer (2 points). You must use `Math.random()`.

```
int c = (int)(Math.random()*(b - a + 1)) + a;
```

(f) Write Java syntax to declare, create, and initialize a 3D multiarray of `3 × 4 × 5 byte` values: (2 points)

```
byte[][][] values = new byte[3][4][5];
```

(g) Given the function signature: `public static float foo(String s)`. Write snippets for the following (4 points):

Privacy and memory context:  
Return type: `float`  
Method name: `foo`  
Parameter list: `String s`
4. **Tracing** (30 points, 5 points each). For each of the following pieces of pseudocode or Java, determine the final value of all variables and the output. For array show the content of their elements. If you show your work neatly (in a table not just scratch marks), I can give some partial credit.

(a) ```
int x = 7;
int y = x;
x = 3*y;
y = x/2;
x = x + 1;
System.out.println(y+x);
```

| x: | 22 |
| y: | 10 |
| Output: | 32 |

(b) ```
int x = 51;
if(x % 7 == 5)
x *= 2;
else if(x % 4 == 3)
x /= 2;
System.out.print(x<100);
```

| x: | 25 |
| Output: | true |

(c) ```
double x ← 6
double y ← −6
while(x > 1)
x ← x / 2
y ← y − x
return x + y
```

| x: | 0.75 |
| y: | -11.25 |
| Output: | -10.5 |

(d) ```
int[] x = {1, 2, 3};
int[] y = new int[3];
for(int a = 50; a > 10; a /= 2) {
y[a % 3] += x[a % 3];
x[a % 2 + 1] += 1;
}
System.out.println(x[0] + y[2]);
```

| a: | 6 |
| x: | {1, 4, 4} |
| y: | {1, 3, 3} |
| Output: | 4 |

(e) ```
public static double foo(int x) {
int j = x/2;
return j;
}
```

| j: | 2 |
| Output: | 4.5 |
public static String[] bar(String[] y) {
    y[1] = "Japan";
    y = new String[1];
    y[0] = new String("Good bye");
    return y;
}

public static void main(String[] args) {
    String[] x = {
        "Hi", "Korea"
    };
    String[] y = bar(x);
    System.out.print(x[0]);
    Main's y: {"Good bye"}
    Output: Hi
}
5. **Algorithm** (10 points). For the following question, please write pseudocode (not Java code) for a function.

(a) You are given an array of $N$ doubles called `values` (as in just use $N$ and `values`, do not declare or initialize them). Compute the standard deviation $\text{stdev}$ of the array using:

$$
\sqrt{\left(\frac{1}{N} \sum_{i=0}^{N-1} x_i^2 \right) - \bar{x}^2}
$$

where $\Sigma$ means the sum, $x_i$ is the $i$th element of the array, and $\bar{x}$ is the mean (average) of the array. Hint: Use a single loop to simultaneously sum the numbers for the average and sum the square of the numbers.

**Function StDev**

**Input:** Array `values`, Length $N$

**Output:** Standard deviation $\text{stdev}$

```plaintext
    sum ← 0, sqsum ← 0
    for i ← 0; i < N; ++ i do
        sum ← sum + values[i]
        sqsum ← sqsum + values[i] * values[i]
    mean ← sum/N
    return sqrt(sumsq/N - mean * mean)
```
6. **Bonus** (up to 20 points, 5 points each). Answer the following conceptual or programming questions on computing and Java.

   (a) Describe one method for how a multidimensional array is mapped to memory (use a picture to help your explanation).
   
   One way for a multidimensional array to map to memory would be that each element of a dimension $i$ is a pointer to an array for dimension $i+1$. The last dimension actually would store values. For example, take a 2D matrix. Each row points to an array (columns) that holds the element values.

   (b) What is bytecode? What generates bytecode? What runs bytecode? Why is bytecode beneficial?
   
   Bytecode is a set of architecture independent instructions specific to the Java programming language (similar to 0s and 1s for computers). A Java compiler generates it (.class files). The Java Virtual Machine (JVM) runs it (program java at the command line). Bytecode allows Java programs to be portable between any machine (assuming they have the appropriate JVM installed).

   (c) What does the operator `?:` do? What is this type of operator called?
   
   `a ? b : c` is a shorthand for *if-else*. Essentially, if $a$ evaluates to true then $b$ is evaluated and returned. Otherwise $c$ is evaluated and returned. This is called a ternary operator because it takes three operands.

   (d) Write a valid `switch` statement for handling a keyboard press to move a point. Assume the key pressed is stored in a `char` named `key` and the point has an $x$ and $y$ value. When ‘a’, ‘s’, ‘d’, or ‘w’ is typed move the point by 1 unit in an appropriate direction. If any other key is pressed reset the point to the origin.
   
   ```java
   switch(key) {
     case 'a': x -= 1; break;
     case 's': y -= 1; break;
     case 'd': x += 1; break;
     case 'w': y += 1; break;
     default: x = y = 0; break;
   }
   ```