# CSC 1051 Algorithms and Data Structures I

## Midterm Examination

**February 26, 2015**

**Name:**

**Key**

<table>
<thead>
<tr>
<th>Question</th>
<th>Value</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
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<tr>
<td>2</td>
<td>10</td>
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<td>3</td>
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<td>8</td>
<td>10</td>
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</tr>
<tr>
<td>9</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

**Total** 100

*Please answer questions in the spaces provided. If you make a mistake or for some other reason need more space, please use the back of pages and clearly indicate where the answer can be found.*
1. [ /10] Short answer questions.

a) How many bits/bytes are needed to store a color picture that is 300 pixels wide and 400 pixels high under each of the following schemes? Express your answer as approximate number of KB or MB, etc., as appropriate. Show your work and fill in the answers below:

Total # pixels 120,000 300x400 = 120,000

<table>
<thead>
<tr>
<th>Scheme</th>
<th># bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitmap (1bit/pixel)</td>
<td>15 KB</td>
</tr>
<tr>
<td>Greyscale (1byte/pixel)</td>
<td>120 KB</td>
</tr>
<tr>
<td>RGB (3 bytes/pixel)</td>
<td>360 KB</td>
</tr>
</tbody>
</table>

# bits 120,000 bits or 120kbits, 960,000 or 960Kbits ≈ 3Mbits

b) List all binary codes that can be made with 3 bits

000
010
011
001
111
100
101
110

c) With 8 bits we can have \(2^8 = 256\) different binary codes

d) If we are to create a code to uniquely represent each of the 50 states, we need at least 6 bits.
1. [ /10] Short answer questions.

a) How many bits/bytes are needed to store a color picture that is 400 pixels wide and 200 pixels high under each of the following schemes? Express your answer as approximate number of KB or MB, etc., as appropriate. Show your work and fill in the answers below:

<table>
<thead>
<tr>
<th>Scheme</th>
<th># pixels</th>
<th># bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitmap (1bit/pixel)</td>
<td>80,000</td>
<td>10 KB</td>
</tr>
<tr>
<td>Greyscale (1byte/pixel)</td>
<td>80,000</td>
<td>80 KB</td>
</tr>
<tr>
<td>RGB (3 bytes/pixel)</td>
<td></td>
<td>240 KB</td>
</tr>
</tbody>
</table>

Total # pixels: $400 \times 200 = 80,000$

# bits: $80,000$ bits or $80k$ bits.  $640,000$ or $640K$ bits $\approx 2M$ bits

b) List all binary codes that can be made with 3 bits

- 000
- 010
- 011
- 001
- 111
- 100
- 101
- 110

c) With 8 bits we can have $2^8 = 256$ different binary codes

d) If we are to create a code to uniquely represent each of the 50 states, we need at least $6$ bits.
2. (**/ 10)

a) Which of the following code fragments correctly executes three assignments if the condition is true? Mark the correct one and explain your answer, briefly.

i)
```java
if (x < 0)
a = b * 2;
y = x;
z = a – y;
```

ii)
```java
{  
    if (x < 0)  
a = b * 2;
y = x;
z = a – y;
}
```

iii)
```java
if { (x < 0)  
a = b * 2;
y = x;
z = a – y ;
}
```

iv)
```java
if (x < 0) // This is the only one that works
{ // because it uses the braces correctly
    a = b * 2;
y = x;
z = a – y;
}
```

b) Which of the code fragments below will add 1 to x if x is positive and subtract 1 from x if x is negative, but leave x alone if x is 0? Explain your answer, briefly.

i)
```java
if (x > 0)
x++;
else
    x--;
```

ii)
```java
if (x > 0)
x++;
else if (x < 0) // This is the only one that works because it leaves the x unchanged when it is zero.
x--;
```

iii)
```java
if (x == 0)
x = 0;
else x++;
x--;
```

iv)
```java
x++;
x--;
```
2. (10/10)

a) Which of the following code fragments correctly executes three assignments if the condition is true? Mark the correct one and explain your answer, briefly.

i)  
```c
if (x < 0)
    a = b * 2;
    y = x;
    z = a - y;
```

ii)  
```c
if (x < 0) // This is the only one that works
    // because it uses the braces correctly
    { 
        a = b * 2;
        y = x;
        z = a - y;
    }
```

iv)  
```c
if { (x < 0) 
    a = b * 2;
    y = x;
    z = a - y; 
}
```

b) Which of the code fragments below will add 1 to x if x is positive and subtract 1 from x if x is negative, but leave x alone if x is 0? Explain your answer, briefly.

i)  
```c
if (x > 0)
    x++;
else
    x--;
```

iii)  
```c
if (x == 0)
    x = 0;
else x++;
    x--;
```

iv)  
```c
x++; 
    x--; 
```

ii)  
```c
if (x > 0) // This is the only one that works because it
    x++;
else if (x < 0) //leaves the x unchanged when it is zero.
    x--;
```
3. (___/10) What gets printed?
Please show output as it will appear, or indicate “NO OUTPUT”, or show some of the output followed by “INFINITE LOOP.”

```java
int a = 0;
while (a > 0)
{
    System.out.println(a);
    a = a + 3;
}
```

Output: 
```
NO OUTPUT
```

```java
int a = 5;
while (a >= 5)
{
    System.out.println(a);
    a++;
}
```

Output: 
```
5
6
7
... INFINITE LOOP
```

```java
int a = 4;
while (a > 0)
{
    System.out.println(a * 2);
    a--;
}
```

Output: 
```
8
6
4
2
```

```java
String a = "rgb";
int x = 0;
while (x < a.length())
{
    System.out.print(a.charAt(x));
    System.out.print(a.charAt(x));
    x++;
}
```

Output: 
```
rrggb
```
3. (_____ /10) What gets printed?
Please show output as it will appear, or indicate “NO OUTPUT”, or show some of the output followed by “INFINITE LOOP.”

```java
int a = 3;
while (a > 0)
{
    System.out.println(a * 2);
    a--;
}
```

Output:
```
6
4
2
```

```java
int a = 0;
while (a > 0)
{
    System.out.println(a);
    a = a + 3;
}
```

Output: NO OUTPUT

```java
String a = "rgb";
int x = 0;
while (x < a.length())
{
    System.out.print(a.charAt(x));
    System.out.print(a.charAt(x));
    x++;
}
```

NOTE: typo in exam here, it said st.charAt(x) instead of a.charAt(x)

Output: rrggbb

```java
int a = 4;
while (a >= 4)
{
    System.out.println(a);
    a++;
}
```

Output:
```
4
5
6
7 ...
```

... INFINITE LOOP
4. (_____/ 10) Complete the java code below so that it prints a table for the Investment problem:
You put $10,000 into a bank account that earns 5% interest per year. Show the yearly returns on your investment until it doubles.

```java
import java.text.NumberFormat;
public class Investment {
    public static void main (String[] args) {
        int year = 0;
        double balance = 10000;
        double rate = 0.05;

        System.out.println("year\tinterest\tbalance");
        NumberFormat fmt = NumberFormat.getCurrencyInstance();
        System.out.println (year + "\t" + " \t" + fmt.format(balance));
        double interest;
        while (balance < 20000) {
            year++;
            interest = balance * rate;
            balance += interest;
            System.out.println (year + "\t" + fmt.format(interest) + "\t" + fmt.format(balance));
        }
    }
}
```

<table>
<thead>
<tr>
<th>year</th>
<th>interest</th>
<th>balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>$10,000.00</td>
</tr>
<tr>
<td>1</td>
<td>$500.00</td>
<td>$10,500.00</td>
</tr>
<tr>
<td>2</td>
<td>$525.00</td>
<td>$11,025.00</td>
</tr>
<tr>
<td>3</td>
<td>$551.25</td>
<td>$11,576.25</td>
</tr>
<tr>
<td>4</td>
<td>$578.81</td>
<td>$12,155.06</td>
</tr>
</tbody>
</table>

... (keep going until balance >= $20000)
5. [ /10] Given the following declarations:

```java
int iResult, num1 = 9, num2 = 2;
double fResult, val1 = 9.0;
boolean status, part1 = true;
```

What result is stored by each of the following assignment statements?

<table>
<thead>
<tr>
<th>Source code</th>
<th>Result stored</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>fResult = (num1 + 2)/ 2;</code></td>
<td>5.0</td>
</tr>
<tr>
<td><code>iResult = num2 % num1;</code></td>
<td>2</td>
</tr>
<tr>
<td><code>fResult = val1 / 2;</code></td>
<td>4.5</td>
</tr>
<tr>
<td>`status = part1</td>
<td></td>
</tr>
<tr>
<td><code>status = part1 &amp;&amp; (num1 &gt; num2);</code></td>
<td>true</td>
</tr>
<tr>
<td><code>fResult = (double) num1 / 2;</code></td>
<td>4.5</td>
</tr>
</tbody>
</table>
Given the following declarations:

```java
int iResult, num1 = 7, num2 = 2;
double fResult, val1 = 9.0;
boolean status, part1 = false;
```

What result is stored by each of the following assignment statements?

<table>
<thead>
<tr>
<th>Source code</th>
<th>Result stored</th>
</tr>
</thead>
<tbody>
<tr>
<td>fResult = (num1 + 2)/ 2;</td>
<td>4.0</td>
</tr>
<tr>
<td>iResult = num1 % num2;</td>
<td>1</td>
</tr>
<tr>
<td>fResult = val1 / 2;</td>
<td>4.5</td>
</tr>
<tr>
<td>fResult = (double) num1 / 2;</td>
<td>3.5</td>
</tr>
<tr>
<td>status = part1 &amp;&amp; (num1 &gt; num2);</td>
<td>false</td>
</tr>
<tr>
<td>status = part1</td>
<td></td>
</tr>
</tbody>
</table>
6. (_____/ 10) Review the program and answer the questions below:

```java
import java.awt.*;
import javax.swing.JApplet;

public class FinalApplet extends JApplet
{
    public void paint( Graphics page)
    {
        Color myColor = new Color(50, 50, 50); // what's this color?
        page.setColor( myColor);
        page.fillRect(0, 0, 200, 300);

        page.setColor( Color.blue );
        page.drawLine(0, 300, 200, 0);
        page.setColor( Color.red );
        page.fillOval(-100,-100,200,200);
    }
}
```

a) What do you think the `myColor` looks like? _______gray_____

b) Draw a sketch of the image displayed by the applet – indicate the color of each figure or line. Be sure to label the coordinate system.
6. (_____ / 10) Review the program and answer the questions below:

```java
import java.awt.*;
import javax.swing.JApplet;

public class FinalApplet extends JApplet {
    public void paint( Graphics page )
    {
        Color myColor = new Color(0, 255, 0); // what’s this color?
        page.setColor( myColor);
        page.fillRect(0, 0, 200, 300);
        page.setColor( Color.blue );
        page.drawLine(0, 300, 200, 0);
        page.setColor( Color.red);
        page.fillOval(-100, -100, 200, 200);
    }
}
```

a) What do you think the myColor looks like? _______green____

b) Draw a sketch of the image displayed by the applet – indicate the color of each figure or line. Be sure to label the coordinate system.
7. (_____/ 10) Suppose you look up a class in the Java API and find the following info about the (alas, made-up!) SpringBreak class:

```java
java.exam
Class SpringBreak
java.lang.Object
  java.exam.SpringBreak

Constructor Summary
SpringBreak()  
  Creates a new SpringBreak object.

Method Summary
  void destination(String x)
  static boolean shouldIStayOrShouldIGo(double x)
```

a) Write some code to declare variables for two objects of this class, named thing1 and thing2.

```java
SpringBreak thing1 = new SpringBreak();
SpringBreak thing2 = new SpringBreak();
```

b) Circle all of the following that are valid Java statements:

```java
SpringBreak.destination = "Puerto Vallarta";

thing1.destination("Cancun");

thing2.destination(thing1);

SpringBreak.destination("Miami");

System.out.print(thing2.destination("Cancun"));

thing2.shouldIStayOrShouldIGo(21.6) = true;

System.out.print(SpringBreak.shouldIStayOrShouldIGo(32.4));
```
8. (_____ / 10) Suppose a variable `total` holds the number of pennies in your piggy bank. Write a code fragment (not a complete program) that computes the number of dollar bills and quarters that can be “made” with the pennies stored in your piggy bank (Note: we will not bother with nickels and dimes, so the total should be broken down into dollars, quarters, and pennies). Assume all variables have already been declared as follows and the value of `total` has already been obtained from the user:

```java
Scanner scan = new Scanner(System.in);
int total, dollars, quarters, pennies;
System.out.print("Please enter the amount of pennies");
total = scan.nextInt();
dollars = total / 100;
total = total % 100;
quarters = total / 25;
pennies = total % 25;
```
9. (_____/ 10)

Construct an algorithm that inputs a number num and prints all its factors (i.e., all the values of x in the range 2...(num-1), such that num is divisible by x). After the factors are printed, print a goodbye message.

Example: If num (i.e., the input) is 20, the algorithm should print:
The factors of 20 are:
2  4  5  10
Goodbye

Directions:
Write your algorithm by rearranging and structuring elements chosen from the list below, using indentation to show structure. Do not use anything else and note that not all of these are needed, but you may use one of them more than once, if necessary.

```
input num
input x
x = 1
x = 2
x = x + 1
if (num % x == 0)
if (num % 2 == 0)
if (num % 2 == x)
else

while (x < num)
while (x <= num)
while (num %2 == x)
while (num % 2 == 0)
print "The factors of " num " are:"
print x
print num
print "Goodbye"
```


```
=====
input num
x = 2
print "The factors of " num " are:"
while (x < num)
    if (num % x == 0)
        print x
    x = x + 1
print "Goodbye"

=====
```
9. (_____/10)
Construct an algorithm that inputs an integer num and 10,000 other integers and prints a message indicating whether num was found among the 10,000 other integers, followed by a goodbye message.

Hint: You need to use a boolean variable found to keep track of whether you found a match.

Example: If num (i.e., the first number input) is 1318, and 10,000 other numbers are input after that, none of which is equal to 1318, the algorithm should print:

```
Searching for 1318
Not found
Goodbye
```

Alternatively, if the number 1318 occurred one or more times among the other numbers, it should print:

```
Searching for 1318
Found it!
Goodbye
```

Directions:
Write your algorithm by rearranging and structuring elements chosen from the list below, using indentation to show structure. Do not use anything else and note that not all of these are needed, but you may use one of them more than once, if necessary.

```python
found = true
found = false
input num
input x
count = 1
count = count + 1
x = x + 1
if (x == num)
if (found)
if (found == true)
if (found == false)
if (x != num)
```

```python
input num
found = false
count = 1
while (count <= 10000)
    input x
    if (x == num)
        found = true
        count = count + 1
    if (found)
        print “Found it!”
    else
        print “Not found”
else
    print “Goodbye”
```
10. (_____/10) Write a complete Java program that asks your first name and last name and then prints a greeting using your initials.

For example, an interaction might look like this:

    Please enter your first name: Grace
    Please enter your last name: Hopper
    Great meeting you, G.H., have a nice day.

It is NOT necessary to include comments with your code, but be sure to use good indentation.

```java
import java.util.Scanner;

public class Initials {
    public static void main(String[] args) {
        Scanner scan = new Scanner(System.in);
        String firstName, lastName;

        System.out.println("Please enter your first name:");
        firstName = scan.nextLine();

        System.out.println("Please enter your last name:");
        lastName = scan.nextLine();

        char firstInitial = firstName.charAt(0);
        char lastNameInitial = lastName.charAt(0);

        System.out.println("Great meeting you, " + firstInitial + "." + lastNameInitial + ", have a nice day.");
    }
}
```
10. (_____/ 10) Write a complete Java program that asks your name and then prints it out one letter per line.
For example, an interaction might look like this:

```
Please enter your name: Grace
Hello...
G
r
a
c
e
```

It is NOT necessary to include comments with your code, but be sure to use good indentation

```java
import java.util.Scanner;

public class MidtermS15 {
    public static void main (String[] args) {
        Scanner scan = new Scanner(System.in);
        System.out.println("Please enter your name:");
        String name = scan.nextLine();
        System.out.println("Hello...");
        int i = 0;
        while (i < name.length()) {
            System.out.println(name.charAt(i));
            i++;
        }
    }
}
```
Drawing a Line

\[ \text{page.drawLine (10, 20, 150, 45);} \]
\[ \text{page.drawLine (150, 45, 10, 20);} \]

\[
\begin{array}{c}
\text{Start x} \\
\text{Y} \\
\end{array}
\]

\[
\begin{array}{c}
\text{End x} \\
\text{Y} \\
\end{array}
\]

Drawing a Rectangle

\[
\begin{array}{c}
\text{page.drawRect (50, 20, 100, 40);} \\
\end{array}
\]

\[
\begin{array}{c}
\text{Start x} \\
\text{Y} \\
\end{array}
\]

\[
\begin{array}{c}
\text{Width} \% \text{Height} \\
\end{array}
\]

Drawing an Oval

\[
\begin{array}{c}
\text{page.drawOval (175, 20, 50, 80);} \\
\end{array}
\]

\[
\begin{array}{c}
\text{Oval} \\
\end{array}
\]

Drawing an Arc

- An arc is defined by an oval, a start angle, and an arc angle:
Random class

<table>
<thead>
<tr>
<th>Type</th>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>double</td>
<td>nextDouble()</td>
<td>Returns the next pseudorandom, uniformly distributed double value between 0.0 and 1.0</td>
</tr>
<tr>
<td>int</td>
<td>nextInt()</td>
<td>Returns the next pseudorandom, uniformly distributed int value from this random number generator's sequence.</td>
</tr>
<tr>
<td>int</td>
<td>nextInt(int n)</td>
<td>Returns a pseudorandom, uniformly distributed int value between 0 (inclusive) and the specified value (exclusive), drawn from this random number generator's sequence.</td>
</tr>
</tbody>
</table>

Some methods of the Math class

<table>
<thead>
<tr>
<th>Type</th>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>static double</td>
<td>abs(double a)</td>
<td>Returns the absolute value of a double value.</td>
</tr>
<tr>
<td>static double</td>
<td>cos(double a)</td>
<td>Returns the trigonometric cosine of an angle.</td>
</tr>
<tr>
<td>static double</td>
<td>pow(double a, double b)</td>
<td>Returns the value of the first argument raised to the power of the second argument.</td>
</tr>
<tr>
<td>static double</td>
<td>random()</td>
<td>Returns a double value greater than or equal to 0.0 and less than 1.0.</td>
</tr>
<tr>
<td>static long</td>
<td>round(double a)</td>
<td>Returns the closest long to the argument.</td>
</tr>
<tr>
<td>static double</td>
<td>sin(double a)</td>
<td>Returns the trigonometric sine of an angle.</td>
</tr>
<tr>
<td>static double</td>
<td>sqrt(double a)</td>
<td>Returns the correctly rounded positive square root of a double value.</td>
</tr>
</tbody>
</table>

String class

<table>
<thead>
<tr>
<th>Type</th>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>boolean</td>
<td>isEmpty()</td>
<td>Returns true if, and only if, length() is 0.</td>
</tr>
<tr>
<td>char</td>
<td>charAt(int index)</td>
<td>Returns the char value at the specified index.</td>
</tr>
<tr>
<td>int</td>
<td>length()</td>
<td>Returns the length of this string.</td>
</tr>
<tr>
<td>String</td>
<td>toUpperCase()</td>
<td>Converts all of the characters in this String to upper case using the rules of the default locale.</td>
</tr>
</tbody>
</table>
import java.text.NumberFormat;
import java.util.Scanner;
public class Wages
{
    public static void main (String[] args)
    {
        final double RATE = 8.25;  // regular pay rate
        final int STANDARD = 40;   // standard hours in a work week

        Scanner scan = new Scanner (System.in);

        double pay = 0.0;

        System.out.print ("Enter your name: ");
        String name = scan.nextLine();

        System.out.print ("Enter the number of hours worked: ");
        int hours = scan.nextInt();

        System.out.println ("");

        // Pay overtime at "time and a half"
        if (hours > STANDARD)
            pay = STANDARD * RATE + (hours-STANDARD) * (RATE * 1.5);
        else
            pay = hours * RATE;

        NumberFormat fmt = NumberFormat.getCurrencyInstance();

        System.out.println("Name: " + name);
        System.out.println("Gross earnings: " + fmt.format(pay));
    }
}