10 pages; 100 points. Some programming questions will ask you to write code (and write methods) to make the Turtle graphics shown here.

INSTRUCTIONS

This is a closed book and note examination, with 1 8 1/2 x 11 inch paper sheet of notes allowed. No other written material and no interpersonal or other communication or discussion (except with the prof. or proctors) or sharing of information is allowed. Cell phones or any electronic devices (other than a calculator or a device that only does language translation) are strictly forbidden! If you need to leave the room, come to the front, leaving your paper and ask permission. You may take NOTHING with you to leave the room. Failure to abide by any of these terms will result in a grade of zero for the exam.

NAME __________________________________________________________

NET ID _________________________________________________________

NAME OF YOUR TA: ____________________________________________

------- For scoring use only. Do not write below this line ------------
Section 1 Doubly-nested loop programming. (10 points)

An imaginary 201 class wrote the application below which printed what is reproduced on the right. Three weeks later they were assigned to write an application that prints EXACTLY THE SAME output, but uses a doubly-nested loop to do it. Write your solution to that 4th week assignment below.

```java
public class BabyTableApp
{
    public static void main(String[] a)
    {
        System.out.print("( + 1 + , + 1 + ) ");
        System.out.print("( + 2 + , + 1 + ) ");
        System.out.print("( + 3 + , + 1 + ) ");
        System.out.println("");
        System.out.print("( + 1 + , + 2 + ) ");
        System.out.print("( + 2 + , + 2 + ) ");
        System.out.print("( + 3 + , + 2 + ) ");
        System.out.println("");
        System.out.print("( + 1 + , + 3 + ) ");
        System.out.print("( + 2 + , + 3 + ) ");
        System.out.print("( + 3 + , + 3 + ) ");
        System.out.println("");
        System.out.print("( + 1 + , + 4 + ) ");
        System.out.print("( + 2 + , + 4 + ) ");
        System.out.print("( + 3 + , + 4 + ) ");
        System.out.println("");
    }
}
```

```
(1, 1) (2, 1) (3, 1)
(1, 2) (2, 2) (3, 2)
(1, 3) (2, 3) (3, 3)
(1, 4) (2, 4) (3, 4)
```

Rules:
Your answer must have only ONE
System.out.print( .. );
statement (which we wrote for your convenience) and ONLY ONE
System.out.println("");
statement.
Section 2 – Multiple Choice and Short Answer (10 questions, 3 points each)
Select the best answer to the question from the choices provided.

1. (3) Which is not a method of the Pixel class? Hint: THINK of what Pixels have and can do, versus what they don't have or can't do. Each method name is preceded by the type of value it returns, or void if it doesn't return any value.
   a. Color getColor()
   b. void forward(int steps)
   c. int getRed()
   d. void setRed(int intensity)
   e. int getY()

2. (3) Which is Java's built-in operator symbol that means "copy the value of the expression on the right into the variable named on the left"? That is also called "assign".
   a. <=
   b. copyTo
   c. ==
   d. =
   e. !=

3. (3) Here's a fragment of Java code. TRACE what the computer does line by line!! Show your thoughts by writing or copying old values in the boxes to demonstrate what the computer actually does.

   ```java
   int X;
   int Y;
   X = 1;
   Y = 2;
   X = Y + X;
   Y = X + Y;
   System.out.print(X);
   System.out.print(" "); // 2 spaces
   System.out.print(Y);
   ```

4. (3) Then answer: What does it print?
   a. 1 2
   b. 3 3
   c. 3 5
   d. 5 5
   e. 5 3
5. (3) In Project 3, you had to program code like \( \text{redA}*w + \text{redB}*(1.0-w) \) to compute the weighted average of two integer (red) color intensities using a double precision (floating point or decimal) weight. You then had to program a Java \texttt{cast} operation to make the weighted average be the parameter value in calling Guzdial and Ericson’s \texttt{setRed} method (of \texttt{Pixel}) or in the \texttt{Color(int r, int g, int b)} constructor from Java’s API (Application Programming Interface). What you had to code was, for example, \texttt{pix.setRed((int) (redA*w + redB*(1.0-w)))};

Why must you program the \texttt{cast} operation \texttt{(int)}
?

This question requires you to think...Some of the "wrong" choices might be false statements!

a. \texttt{Pixel}s are confined to an (integer) pixel grid.
b. They made programming their \texttt{Pixel}s or \texttt{Color}s easier.
c. Throwing away the fractional part of a decimal value makes colors look nicer because they are less fragmented.
d. These methods require parameter(s) of type \texttt{int} and the Java language requires a cast whenever a conversion (like from a \texttt{double} to an \texttt{int}) would throw away some data like a fractional part.
e. If you have a better answer choice, write it here:
________________________________________________________
________________________________________________________

6. (3) When the following application is run once, how many times is the \texttt{BODY} code run?

```java
public class codeRunner {
    public static void main(String[] a) {
        SETUP May take unpredictable input from a person or a file.
        while( TEST )
            { BODY }
    }
}
```

a. 0 times is the only possibility.
b. 1 time is the only possibility.
c. Only 0 or 1 time is possible.
d. Any number of times that is at least 1.
e. Any number of times, possibly none at all.

7. (3) Two of the six cases of matching { .. }, ( .. ), and [ .. ] in the above pseudo–code have been identified. Identify the same way the \textbf{other 4 pairs} of matching parenthesis type symbols. Warning: My indentation is not perfect (but acceptable!)
8. (3) Early in the semester, we viewed diagrams of computer memory in which a memory location is located by its address (which cannot change). The diagram shows that the data stored in the memory location is different (it can change). Memory addresses are numbers similar to the kind of numbers that locate variables in an array. In the same way, two numbers of this kind locate Pixels in a Picture.

What kind of numbers are these?
   a. The color stored in the Pixel, a combination of three integer 0–255 numeric intensities of red, green and blue light.
   b. The number that is stored in the variable.
   c. Double precision numbers between 0.0 and 1.0
   d. Integers (whole number) >= 0
   e. Approximate numbers

9. (3) Finish drawing the flowchart for the following general pattern of Java code:

```java
if (TEST) {
    //BODY
}
```

The two possible outcomes of the test are true and false.

Sketch your flowchart answer here.
10. (10 points) A CALLER initiates a method call (by calling a method) and CALLEE get called, that is, receive calls. The CALLEE runs the code in the method's body. Check EXACTLY ONE box in each row.

<table>
<thead>
<tr>
<th>Task</th>
<th>CALLER (initiator, who calls the method.)</th>
<th>CALLEE (recipient, who runs the method body code)</th>
</tr>
</thead>
<tbody>
<tr>
<td>initiates the call</td>
<td>□</td>
<td></td>
</tr>
<tr>
<td>determines the parameter values</td>
<td></td>
<td></td>
</tr>
<tr>
<td>reads and uses the parameter values from parameter variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>does the work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>waits for the work to be completed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>determines whether the code in the method should keep running, or stop so code in the caller can run again.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
11. (10 points) Acting like a WW II human computer is handy for understanding what a given piece of code actually does, sensible or not. (Brief: Do what computer does.) Consider the following code fragment:

```
int red = 0;
int purple = 0; //HINT: Write zeros in the red and purple boxes
                //FIRST (done for you free.)
while ( red < 10 )
{
    red = 1 - purple;
    System.out.println( red );
    purple = (-2) * red;
    System.out.println( purple );
}
```

Figure out and write what the computer prints on each line. That’s hard to do right! So first write every value as it currently is in the two variables (one value changes, the other stays the same) first, before you make a wrong guess for what the computer prints! (So..show only one change per line!)

Write numbers in this and other boxes:

<table>
<thead>
<tr>
<th>red</th>
<th>purple</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

Write each number the computer prints on this line and below:

```
red
---
0
0

purple
---
0
0
```
Section 3 – Coding!

12. (A1 8) Extend the Turtle class by writing your own method for drawing a 200 pix. tall two-prong arrow, similar to what’s on the cover of this exam. (A2 8) Make sure that before returning, your method makes this (a Turtle) go back to its original location and head pointing direction. Your method's head is already printed in the exam.

13. Assume you solved the previous problem correctly. We started to write parametrized ArrowMakingTurtle method named drawManyArrows with one parameter variable declared int nArrows. When called, (A 3) it should first print "Hey, I'm going to draw a number of arrows on your World." (B 3) Second it should print what number of arrows it should draw. (C 11) Third, it should CALL your drawArrow method from INSIDE A LOOP to make this (an ArrowMakingTurtle) draw a circle of arrows with nArrows (number of) arrows spaced at equal angles. Strategy hint: Program it to divide (with / ) 360.0 degrees by nArrows to calculate how many degrees the Turtle should turn after each arrow.

Notes: (1) Do NOT copy or rewrite ANYTHING from the body of drawArrow() that you wrote already!
(2) Do NOT code a main( ) method! Only code a new method that gives Turtle the capability to draw a circle of ANY, unpredictable number of arrows. The number is determined by the caller, NOT the callee code. You write the callee code.

Answer Questions 12-13 on the next page, for 33 points
and don't overlook Question 14 on page 10 (10 points).

The programming questions will be graded on bases of CLARITY, NEATNESS, UNDERSTANDABILITY, REASONABLE EFFICIENCY, INDENTATION, ETC, in addition to logical correctness. Minor syntax errors will be forgiven.
public class ArrowMakingTurtle extends Turtle
{
    public ArrowMakingTurtle( World w )
    { super( w ); }
    public void drawArrow() {
        this.forward( 200 ); //You write the rest!
    }
    //End of the drawArrow method
    public void drawManyArrows( ) {
        //Code the loop that calls drawArrow repeatedly:
    }
    //End of the drawManyArrows method.
} //End of the ArrowMakingTurtle class definition.
14. Harder programming problem (10 points)

Extend the G&E Picture class with the method started below. When called, it should paint a black line, one single Pixel thick, slanted at 45 degrees (going right-to-left as you go down, as shown) by blackening the Pixels between and including those located with \((x, y)\) coordinates \((sideLen, 0)\) and \((0, sideLen)\).

Rules/notes: Use a singly nested loop. No Turtle! Blacken Pixels in the line with \(\text{this.getPixel}(?,?,?)\).setColor(java.awt.Color.black);

"sideLen" of course is the parameter value. Assume the width and height of the Picture are at least \(sideLen+1\).

```java
public class RibbonablePicture extends Picture {
    public void ribbon( int sideLen )
    {   //You code the loop below!
    }
    public RibbonablePicture( int w, int h )
    {   super( w, h );   }
}
```