Name: ______________________________

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______________________________ ______________________________
Signature Date

(10) 1. **Tracing Functions**

The code below defines three different function definitions:

```
def mystery(x):

    def puzzle(x, y=5):
        return x * y

    def enigma(y):
        return y ** x

    return enigma(puzzle(x=2)) + enigma(puzzle(3,x))

if __name__ == '__main__':
    print(mystery(3))
```

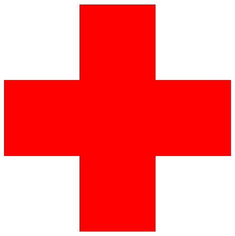
For each function, every time that function would *return* a value, indicate what that value would be. If the function returns multiple times, put each value on a new line, in the order they would be returned.

mystery	puzzle	enigma

(20) 2. **Interactive Graphics**

Write a graphical program that using the PGL library to accomplish the following:

1. Creates the below cross as a `GCompound` containing two filled rectangles:



   The color of the cross should be red, as in the emblem of the International Red Cross. The horizontal rectangle should be 60×20 pixels in size and the vertical one should be 20×60. They cross at their centers.

2. Add the cross to the graphics window so that it appears in the exact center of the window.
3. Moves the cross at a speed of 2 pixels every 20 milliseconds in a constant random direction, which is specified as a random real number between 0 and 360 degrees.
4. Every time you click *inside the cross*, its direction changes to some new constant random direction–again chosen as a random real number between 0 and 360 degrees–but its speed remains the same. Clicks outside the cross have no effect.

If you were actually working on a program with this setup, you would presumably supply some means of making it stop, such as when the cross moves off the screen. For this problem, just have the program run continuously without worrying about objects moving off-screen or how to stop the timer.

(20) 3. **Working with Arrays**

There is a simple mobile game that I discovered a while back that relies on placing red and blue squares onto a grid. The puzzle lies in the fact that:

- no row or column can ever be duplicated. That is to say, you can't have any two rows with the same sequence of red and blue squares, or any two columns with the same sequence of red and blue squares.
- there can never be three adjacent colors of one type in any row or in any column.

Generally the game starts with some initial population of squares filled in as either red or blue, and then you, the player, need to fill in the rest according to the rules. While the strategies to implement solving the puzzle are beyond this class, we absolutely have the necessary machinery to *check* a given puzzle to ensure it obeys all the rules. To that end, in this problem you should write two predicate functions:

```
def no_duplicate_rows(puzzle):

def no_3petes_in_rows(puzzle):
```

Each will take as input the `puzzle`, which will be a 2D array with strings (`"R"` or `"B"`) as the elements. `no_duplicate_rows` should check all the rows in the puzzle and return `False` if any two rows are exact copies. Otherwise, it should return `True`. `no_3petes_in_rows` should check the elements of each row to ensure that three red or blue squares are never adjacent. If this is true for *all* the rows, then `no_3petes_in_rows` should return `True`, otherwise it should return `False`.

I'm only asking you to check the rows here, despite the fact that columns are also part of the game rules. My reasoning is that you already wrote a function to rotate a 2D array by 90 degrees in Imageshop. So presumably, after checking the rows, you could just rotate the puzzle by 90 degrees (so that the columns are now rows) and then check the columns using the exact same functions. *You do not need to do this here! I am merely pointing out that it would be simple and saves having to write more functions.*

As an example, the below 3×3 puzzle is valid and should thus return `True` when passed into both functions.

```
puzzle = [ ["R", "B", "R"],
           ["R", "B", "B"],
           ["B", "R", "R"] ]
```

whereas this 4×4 puzzle would fail the duplicate rows check and the 3-pete check:

```
bad_puzzle = [  ["R", "B", "R", "B"],
                ["R", "B", "B", "R"],
                ["R", "R", "R", "B"],
                ["R", "B", "B", "R"] ]
```

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(10) 1. **Tracing Functions**

The code below defines three different function definitions:

```
def puzzle(t):
    def mystery(r,x):
        x += 1
        def enigma(s=0):
            return r[s::x]
        return enigma

    x = 2
    y = mystery(t,x=x)
    return y(x) + y()

if __name__ == '__main__':
    print(puzzle("angriest"))
```

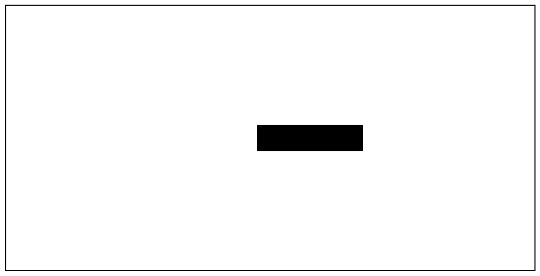
For each function, every time that function would *return* a value, indicate what that value would be. If the function returns multiple times, put each value on a new line, in the order they would be returned.

`puzzle`	`mystery`	`enigma`

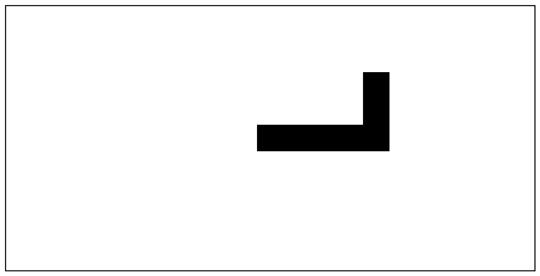
(20) 2. **Interactive Graphics**

In this problem, your mission is to write a program that plays a very simplified version of the graphical game called "Snake", which was popular on the first generation of Nokia phones. When the program begins, there is nothing on the graphics window, but there is an invisible snake head at the center of the window. In each time step of the animation, the snake head moves 15 pixels in some direction, leaving behind a 15×15 filled square at the position it just left.

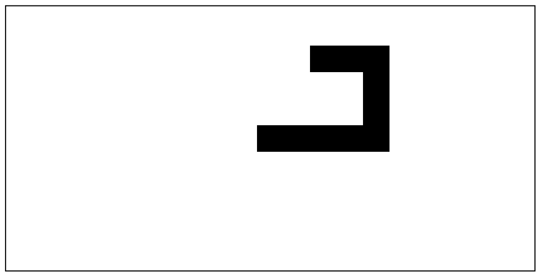
At the beginning of the game, the snake head is moving eastward, so after four time steps, it will have generated a trail of four squares (which run together on the screen), like this.



In this implementation of the game, you turn the snake by clicking the mouse. In this initial situation, with the snake moving horizontally, clicking the mouse above the current y position of the snake head sends it northward, and clicking below the current y position would send it south. In this particular example, let's assume that the player clicked above the snake head, so that its direction changes to the north. After three more time steps, the window would look something like this:



When the snake is moving vertically, clicking to the left of the snake head sends it westward, and clicking to the right sends it eastward. Clicking to the left would therefore send the snake off to the west, as follows:



In the actual game, the player loses if the path of the snake moves outside the window or closses its own path. For this problem, you can ignore the problem of stopping and just get the motion working.

While the program may seem complicated, there are not that many pieces which you need to get it working. Here are a few general hints or things to keep in mind as you get started:

- You need to keep track of three things: the x and y positions of the snake head, and some indication of what direction the snake is currently moving (North, South, East or West).
- The function that executes each time step must create a new black square whose center is at the current position, and *then* move the head on to the next square by updating the coordinates as appropriate to the current direction.
- The listener method that responds to mouse clicks has to look at the current position and direction and then use those together with the mouse click location to determine how to update the direction.
- Remember that you don't need to check whether the snake remains on the window or crosses its own path. You can implement those features on your own time after the exam if you really want!

(20) 3. **Working with Arrays**

Write a function called `rotate_array` that takes a list and an integer as two arguments. The function should have the effect of shifting every element of the list the integer number of positions. Positive integers should result in the elements being shifted toward the beginning of the list, whereas negative integers should result in the elements being shifted towards the end. Elements shifted off either end of the list should wrap around and reappear on the other end of the list. For example, if the array `digits` has the contents:

`digits`

0	1	2	3	4	5	6	7	8	9

then calling `rotate_array(digits, 1)` would shift each of the values one position to the left and move the first value to the end:

`digits`

1	2	3	4	5	6	7	8	9	0

Calling `rotate_array(digits, -3)` however would shift all the elements 3 positions to the right:

`digits`

7	8	9	0	1	2	3	4	5	6

Note that although the example array here just had integers as its elements, your function should properly shift *any* type of data the necessary number of positions. Also note that the function should shift the elements *in place*, it should not return a new list.