HW1 CodeCamp

Thanks to Nick Parlante for much of this handout

For this first homework, you will run through a series of small coding problems to get warmed up with Java code, `Collection` classes, unit tests, and some basic OOP design. Get in the habit of pulling up the javadoc pages for `String`, `Collection`,... leveraging the built-in libraries. Download the hw1CodeCamp.zip file from the course page. That contains a hw1CodeCamp directory that is an Eclipse project -- import it into Eclipse to get started. This homework is due at 11:59pm on Wed Oct 1. Part A is made of several small Java problems with strings, arrays, lists, and maps, all with unit tests. Part B is a short OOP design exercise (wait for the OOP design lecture for that part).

For part A, you have a variety of small coding problems to solve, each with unit tests. You should fill out the set of unit tests for each problem until you are confident that your solution is correct. The deliverable is that there are 5 or more `assertEquals()` or other assertions for each `public` method in part A. The starter code has some tests filled in for some of the problems to get you started, and you should add more tests. Part of this assignment is about experimenting with unit tests to really nail down the correctness of your code beyond the usual "it appears to work" level. Since the problems are only moderately hard, have well-defined input/output interfaces, and you can write unit tests, it is a reasonable goal that you will turn in literally perfect code for all the problems -- zero bugs. Producing a body of zero bug code does not happen by accident. It requires some organized effort at testing.

Part B centers on designing and writing a `Shape` class from scratch. For part B, the point is thinking about the OOP design of the `Shape` class.

Our grading for Part A will be pretty simple -- we just have automated tests for each problem that verify that your solution works correctly for a variety of inputs. The grading in that case will mostly just be about correctness. That said you should still try to write clean code and use decomposition. For Part B, we just want to see a reasonable effort at the OOP design.

CS108 homework ground rules: the starter code will often include some boilerplate such as the prototypes for methods you need to write. A starter method may include a throwaway line like `return 0;` just so it compiles when you first load the project. Your code can assume that all inputs are formatted and structured correctly. Your solution should work correctly when presented with valid inputs, and we will not worry about invalid inputs (yet). If your code takes in a parameter such as a `String` or a `List`, you may assume that the `String` or `List` passed in is not `null`, unless `null` is specifically mentioned in the specification. In other words, `null` is not a valid `String` or `List`. The empty string and empty list are valid of course, but in Java those are different from `null`. Your code should never change the public interfaces given for homework problems. Very often, we have tests that call your code in various ways, and obviously that only works if your code keeps the same interface as given in the starter code. For the same reason, *you should leave your classes in the default package, so our testing code can find it*. You are free to **add** additional or helper methods -- adding extra methods will not confuse our testing code. Very often, my own solution decomposes out private helper methods for parts of the problem, pulling some complexity out of the main methods.

Part A

These are just medium complex Java methods to dust off those Java brain cells and get you started with unit tests.

String Code

String blowup(String str)

Returns a version of the original string as follows: each digit 0-9 that appears in the original string is replaced by that many occurrences of the character to the right of the digit. So the string `"a3tx2z"` yields `"attttxzzz"`, and `"12x"` yields `"2xxx"`. A digit not followed by a character (i.e. at the end of the string) is replaced by nothing.

int maxRun(String str)

Given a string, returns the length of the largest run in the string. A "run" is a series of zero or more adjacent characters that are the same. So the max run of `"xxyyyz"` is 3, and the max run of `"xyz"` is 1.

boolean stringIntersect(String a, String b, int len)

Given 2 strings, consider all the substrings within them of length `len`. Returns `true` if there are any such substrings which appear in both strings. Compute this in O(n) time using a `HashSet`. `len` will be 1 or more.

CharGrid

The `CharGrid` class encapsulates a 2-d `char` array with a couple operations.

int charArea(char ch)

Given a `char` to look for, find the smallest rectangle that contains all the occurrences of that `char` and return the rectangle's area. If there is only a single occurrence of the `char`, then the rectangle to enclose it is 1x1 and the area is 1. If the character does not appear, return an area of 0. For example, given the grid…

```
abcd
a cb
xbca
```

The area for `'a'` is `12` (3 x 4) while for `'c'` it is `3` (3 x 1). The second row contains a `' '`, but that's still just a regular char.

For testing, you can set up a 2-d char[row][col] array literal like this (row 0 is `"cax"`)

```
char[][] grid = new char[][] {
        {'c', 'a', 'x'},
        {'b', ' ', 'b'},
        {' ', ' ', 'a'}
    };
```

int countPlus()

Look for a '+' pattern in the grid made with repetitions of a character. A + is made of single character in the middle and four "arms" extending out up, down, left, and right. The arms start with the middle char and extend until the first different character or grid edge. To count as a +, all the arms should have two or more chars and should all be the same length. For example, the grid below contains exactly 2 +'s...

```
  p
  p    x
ppppp xxx
  p  y x
  p yyy
zzzzzyzzz
  xx y
```

Hint: consider decomposing out a private helper method to avoid repeating the code to measure each of the four arms.

TetrisGrid

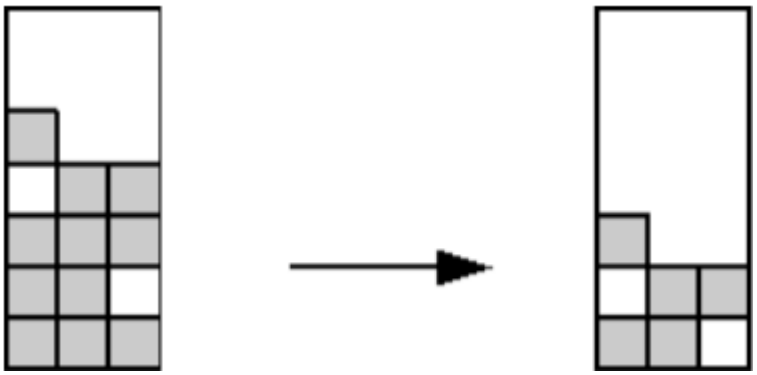
The `TetrisGrid` class encapsulates the classic rectangular board for the game Tetris (we'll play around with Tetris on homework 2, so here's a chance to get a head start on that code). We'll store the Tetris board as a grid of `booleans`, where `true` is a filled square, and `false` is an empty square. We'll use the convention that `grid[x][y]` refers to a cell in the board, with `grid[0][0]` representing the lower left square in the board, `x` growing to the right, `y` growing up (the standard Cartesian coordinate system). In the Tetris code, `grid[x][y]` is a natural way to think about the game, but notice that it's different from a `grid[row][col]` convention.

Constructor -- the `TetrisGrid` constructor should take in a `boolean[][] grid` argument. The width and height of the `grid` will both be at least one. For example, below is a `grid` that is width 2 and height 3. The 2-d array literal syntax is row/col oriented, so our `grid[x][y]` appears rotated 90 degrees clockwise.

```
boolean[][] grid = new boolean[][] {
  {false, false, true},    // this is grid[x=0][...]
  {true,  true,  false}    // this is grid[x=1][...]
};
```

void clearRows()

The one key method in `TetrisGrid` is `clearRows()` which should delete the full rows in the grid, shifting the rows above down and adding empty rows at the top, like this:



There is a simple `getGrid()` that exposes the grid stored in `TetrisGrid`, so unit tests can call `clearRows()` and then `getGrid()` to check the resulting `grid`.

Collections

<T> int sameCount(Collection<T> a, Collection<T> b)

In the `Appearances` class, the `static Appearances.sameCount()` method takes in two collections -- `A` and `B` -- containing a generic `<T>` element type. Assume that the T elements implement `equals()` and `hashCode()` correctly, and so may be compared and hashed. The elements are in no particular order. Every element in `A` appears in `A` one or more times, using `.equals()` to compare elements for equality (the standard definition of `equals()` for java collections). Likewise every element in `B` appears one or more times. `sameCount()` counts the number of elements that appear in both collections the same number of times.

For example, with the collections `{"a", "b", "a", "b", "c"}` and `{"c", "a", "a", "d", "b", "b", "b"}` it returns `2`, since the `"a"` and the `"c"` appear the same number of times in both collections. Use hashing to compute the number of appearances efficiently.

class Taboo<T>

Most of the previous problems have been about single methods, but `Taboo` is a class. The `Taboo` class encapsulates a "rules" list such as `{"a", "c", "a", "b"}`. The rules define what objects should not follow other objects. In this case `"c"` should not follow `"a"`, `"a"` should not follow `"c"`, and `"b"` should not follow `"a"`. The objects in the rules may be any type, but will not be `null`.

The Taboo `noFollow(elem)` method returns the set of elements which should not follow the given element according to the rules. So with the rules `{"a", "c", "a", "b"}` the `noFollow("a")` returns the Set `{"c", "b"}`. `noFollow()` with an element not constrained in the rules, e.g. `noFollow("x")` returns the empty set (the utility method `Collections.emptySet()` returns a read-only empty set for convenience).

The `reduce(List<T>)` operation takes in a list, iterates over the list from start to end, and modifies the list by deleting the second element of any adjacent elements during the iteration that violate the rules. So for example, with the above rules, the collection `{"a", "c", "b", "x", "c", "a"}` is reduced to `{"a", "x", "c"}`. The elements in italics -- `{"a", ***"c",*** *"b",* "x", "c", *"a"}` -- are deleted during the iteration since they violate a rule.

The `Taboo<T>` class works on a generic `<T>` type which can be any type of object, and assume that the object implements `equals()` and `hashCode()` correctly (such as `String` or `Integer`). In the `Taboo` constructor, build some data structure to store the rules so that the methods can operate efficiently -- note that the rules data for the `Taboo` are given in the constructor and then never change.

A rules list may have nulls in it as spacers, such as `{"a", "b", null, "c", "d"}` -- `"b"` cannot follow `"a"`, and `"d"` cannot follow `"c"`. The `null` allows the rules to avoid making a claim about `"c"` and `"b"`.

Part B -- Shape -- Fundamental OOP Design

For this problem, design and implement a `Shape` class to best meet the small code problem described below. You do not need to implement any unit tests for your `Shape` class, although you may want to. Besides correctness, we are interested in seeing correct fundamental OOP and API design for the `Shape` class. You do not need Java2D or any other complicated graphics code to solve this. Just use collections and the provided immutable `Point` class (see Point.java).

The problem concerns "shapes" which are defined by a series of 2d points. We'll say that a shape is made of a series of straight lines that connect adjacent points, with a last line connecting the last point back to the first: point0-to-point1, point1-to-point2, ... pointN-to-point0. The shape will always have 3 or more points, and will not cross over itself anywhere, so the shape simply encloses a single region with a series of straight lines. Each shape defines a circle, where the center is the arithmetic average of all the shape points, and the circle goes through the point nearest to the center. With that definition of shape and circle, you need to be able to do three things:

- Be able to create a shape from a text `String` which lists the points that make up the shape, as an even number of `double` values `"x y"`, all separated by one or more whitespace chars. Here is the `String` for a square with its lower left corner at (0, 0):
  `"0 0  0 1  1 1  1.0 0.0"`
  (Note: look at the Java 5 `Scanner` class for parsing help.)

- Given two shapes `A` and `B`, compute if `A` "crosses" `B` if `A` has a line which crosses the `B` circle -- one endpoint of the line is within the circle and the other endpoint is not. We will say that a point which is on the edge of the circle counts as being in the circle. We will not worry about the case where the line crosses the circle, but both points are outside of it (it's an interesting problem, but we're not doing CS248!).

- Given two shapes `A` and `B`, compute how `A` "encircles" `B` in one of three ways, encoded as an `int`:
  2 : The center of B's circle is within A's circle

1 : otherwise, B's circle intersects A's circle
0: otherwise, the two circles have no intersection

Having defined the `Shape` class, create a `ShapeClient` class that contains only a `main()` hardwired to solve the following problem. Given four shapes `a,b,c,d`:

```
a  "0 0  0 1  1 1  1 0"
b  "10 10  10 11  11 11  11 10"
c  "0.5 0.5  0.5 -10  1.5 0"
d  "0.5 0.5  0.75 0.75  0.75 0.2"
```

ShapeClient `main()` should build the shapes and then compare shape a to the other three shapes and print the results, one per line, exactly like this:

```
a crosses b:false
a crosses c:true
a crosses d:false
a encircles b:0
a encircles c:1
a encircles d:2
```

Everyone's `main()` output for this problem should be exactly the same. The interesting part is looking at the `main()` client code as a measure of the `Shape` API. With a good OOP and API design of `Shape`, the client `main()` should be short and clean. OOP design -- push the data and its code into the `Shape` class. You may also want to think about decomposition to keep the implementation within the `Shape` clean, in particular keeping each shape object responsible for its own data. As usual for CS108, you should comment out your `println`s, so your code produces clean output when run.