Creating Data Types

Spec FAQ Project Submit

The purpose of this assignment is to give you practice creating data types. The first exercise involves an immutable data type; the second exercise considers a mutable data type.

1. **Color data type.** Write a data type `ColorHSB.java` that represents a color in *hue–saturation–brightness (HSB) format*, along with a sample client. The HSB color format is widely used in color pickers.

   HSB = (240°, 100%, 100%)

   A color in HSB format is composed of three components:

   - The *hue* is an integer between 0 and 359. It represents a pure color on the color wheel, with 0° for red, 120° for green, and 240° for blue.
   - The *saturation* is an integer between 0 and 100. It represents the purity of the hue.
   - The *brightness* is an integer between 0 and 100. It represents the percentage of white that is mixed with the hue.

   Implement the following public API:

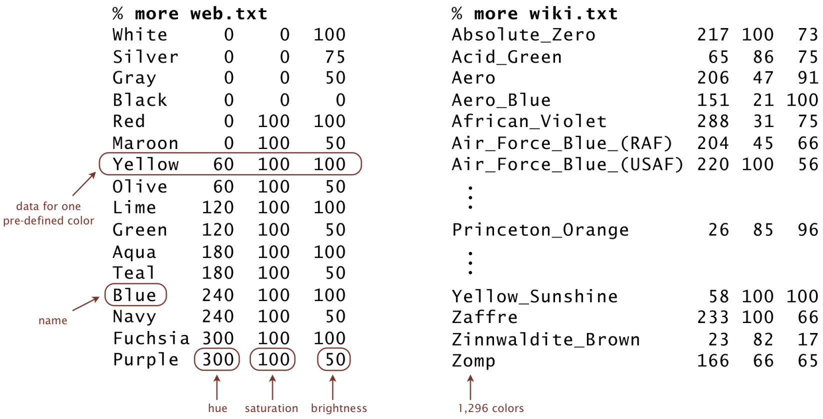
```
public class ColorHSB {

    // Creates a color with hue h, saturation s, and brightness b.
    public ColorHSB(int h, int s, int b)

    // Returns a string representation of this color, using the format (h, s, b).
    public String toString()

    // Is this color a shade of gray?
    public boolean isGrayscale()

    // Returns the squared distance between the two colors.
    public int distanceSquaredTo(ColorHSB that)

    // Sample client (see below).
    public static void main(String[] args)

}
```

   Here is some more information about the required behavior:

   - *Corner cases.* Throw an `IllegalArgumentException` in the constructor if any component is outside its prescribed range (0 to 359 for the hue, 0 to 100 for the saturation and brightness); throw an `IllegalArgumentException` in `distanceSquaredTo()` if its argument is `null`.
   - *String representation.* Return a string composed of the integers for hue, saturation, and brightness (in that order), separated by commas, and enclosed in parentheses. An example is `(26, 85, 96)`.
   - *Grayscale.* A color in HSB format is a shade of gray if either its saturation or brightness component is 0% (or both).
   - *Distance.* The squared distance between two colors (h_1, s_1, b_1) and (h_2, s_2, b_2) is defined to be

     $$\min\left\{(h_1 - h_2)^2\ ,\ \ (360 - |h_1 - h_2|)^2\right\}\ \ +\ \ (s_1 - s_2)^2\ \ +\ \ (b_1 - b_2)^2$$

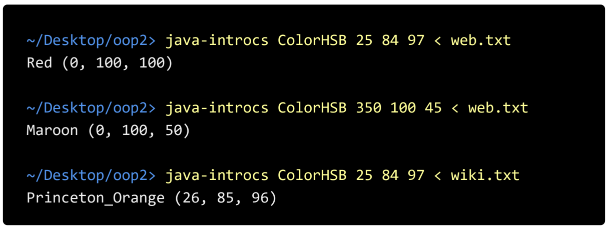
     For example, the squared distance between (350, 100, 45) and (0, 100, 50) is $10^2 + 0^2 + 5^2 = 125$.
   - *Sample client.* The `main()` method should take three integer command-line arguments *h*, *s*, and *b*; read a list of pre-defined colors from standard input; and print to standard output the pre-defined color that is closest to (h, s, b).
     - *Input specification.* The input from standard input consists of a sequence of one or more lines. Each line contains a string (the name of a pre-defined color) and three integers (its hue, saturation, and brightness components), separated by whitespace. The data files web.txt and wiki.txt are in the specified format.



```
% more web.txt
White      0    0  100
Silver     0    0   75
Gray       0    0   50
Black      0    0    0
Red        0  100  100
Maroon     0  100   50
Yellow    60  100  100
Olive     60  100   50
Lime     120  100  100
Green    120  100   50
Aqua     180  100  100
Teal     180  100   50
Blue     240  100  100
Navy     240  100   50
Fuchsia  300  100  100
Purple   300  100   50
```

```
% more wiki.txt
Absolute_Zero          217 100  73
Acid_Green              65  86  75
Aero                   206  47  91
Aero_Blue              151  21 100
African_Violet         288  31  75
Air_Force_Blue_(RAF)   204  45  66
Air_Force_Blue_(USAF)  220 100  56
   ⋮
Princeton_Orange        26  85  96
   ⋮
Yellow_Sunshine         58 100 100
Zaffre                 233 100  66
Zinnwaldite_Brown       23  82  17
Zomp                   166  66  65
```

- *Output specification.* The output to standard output consists of one line: the name of the nearest pre-defined color and the string representation of that color, separated by whitespace.



```
~/Desktop/oop2> java-introcs ColorHSB 25 84 97 < web.txt
Red (0, 100, 100)

~/Desktop/oop2> java-introcs ColorHSB 350 100 45 < web.txt
Maroon (0, 100, 50)

~/Desktop/oop2> java-introcs ColorHSB 25 84 97 < wiki.txt
Princeton_Orange (26, 85, 96)
```

2. **Clock data type.** Write a data type `Clock.java` that represents time on a 24-hour clock, such as 00:00, 13:30, or 23:59. Time is measured in *hours* (00–23) and *minutes* (00–59). To do so, implement the following public API:

```
public class Clock {

    // Creates a clock whose initial time is h hours and m minutes.
    public Clock(int h, int m)

    // Creates a clock whose initial time is specified as a string, using the format HH:MM.
    public Clock(String s)

    // Returns a string representation of this clock, using the format HH:MM.
    public String toString()

    // Is the time on this clock earlier than the time on that one?
    public boolean isEarlierThan(Clock that)

    // Adds 1 minute to the time on this clock.
    public void tic()

    // Adds Δ minutes to the time on this clock.
    public void toc(int delta)

    // Test client (see below).
    public static void main(String[] args)
}
```

Here is some more information about the required behavior:

- *Two-argument constructor.* Throw an `IllegalArgumentException` if either integer argument is outside its prescribed bounds (hours between 0 and 23, minutes between 0 and 59).
- *One-argument constructor.* The string argument is composed of two digits, followed by a colon, followed by two digits, such as 09:45. Throw an `IllegalArgumentException` if either the string argument is not in this format or if it does not correspond to a valid time between 00:00 and 23:59.
- *String representation.* The format is the hours (2 digits), followed by a colon, followed by the minutes (2 digits). Two examples are `00:00` and `23:59`.
- *Ordering.* Times are ordered from 00:00 (earliest) to 23:59 (latest).
- *Tic.* Add one minute to the current time. For example, one minute after 06:00 is 06:01; one minute after 23:59 is 00:00.
- *Toc.* Add Δ minutes to the current time. For example, 60 minutes after 12:34 is 13:34. Throw an `IllegalArgumentException` if Δ is negative.
- *Test client.* The `main()` method must call each instance method directly and help verify that they work as prescribed.

- *Performance.* All instance methods must take constant time.

Submission. Submit a `.zip` file containing `ColorHSB.java` and `Clock.java`. You may not call library functions except those in the `java.lang` (such as `Integer.parseInt()` and `Math.sqrt()`). Use only Java features that have already been introduced in the course (e.g., objects but not interfaces).

This assignment was developed by Kevin Wayne.