Building Java Programs

Using Objects

Point objects

- suggested reading: 3.3

Point objects

- Java has a class of objects named `Point`.
  - To use `Point`, you must write: `import java.awt.*;`
- Constructing a `Point` object, general syntax:

```
Point <name> = new Point(<x>, <y>);
Point <name> = new Point();  // the origin, (0, 0)
```

  - Examples:

```
Point p1 = new Point(5, -2);
Point p2 = new Point();
```

- `Point` objects are useful for several reasons:
  - They store two values, an (x, y) pair, in a single variable.
  - They have useful methods we can call in our programs.

Point object methods

- Data stored in each `Point` object:

Field name	Description
`x`	the point's x-coordinate
`y`	the point's y-coordinate

- Useful methods of each `Point` object:

Method name	Description
`distance(`*p*`)`	how far away the point is from point *p*
`setLocation(`*x*`, `*y*`)`	sets the point's x and y to the given values
`translate(`*dx*`, `*dy*`)`	adjusts the point's x and y by the given amounts

  - `Point` objects can also be printed using `println` statements:

```
Point p = new Point(5, -2);
System.out.println(p);    // java.awt.Point[x=5,y=-2]
```

Using Point objects

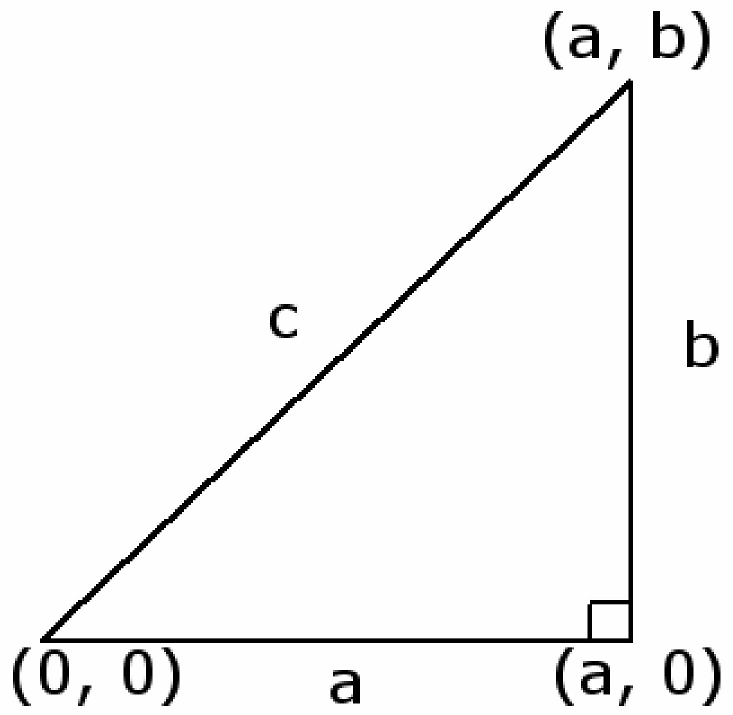
- An example program that uses `Point` objects:

```
import java.awt.*;

public class PointMain {
    public static void main(String[] args) {
        // construct two Point objects
        Point p1 = new Point(7, 2);
        Point p2 = new Point(4, 3);

        // print each point and their distance apart
        System.out.println("p1 is " + p1);
        System.out.println("p2: (" + p2.x + ", " + p2.y + ")");
        System.out.println("distance = " + p1.distance(p2));

        // translate the point to a new location
        p2.translate(1, 7);
        System.out.println("p2: (" + p2.x + ", " + p2.y + ")");
        System.out.println("distance = " + p1.distance(p2));
    }
}
```

Point objects question

- Write a program that computes a right triangle's perimeter.
  - The perimeter is the sum of the triangle's side lengths *a*+*b*+*c*.
  - Read values *a* and *b* and compute side length *c* as the distance between the points (0, 0) and (*a*, *b*).

```
side a? 12
side b? 5
perimeter is 30.0
```



Point objects answer

```
import java.awt.*;    // for Point
import java.util.*;   // for Scanner

public class TrianglePerimeter {
    public static void main(String[] args) {
        Scanner console = new Scanner(System.in);

        System.out.print("side a? ");
        int a = console.nextInt();
        System.out.print("side b? ");
        int b = console.nextInt();

        Point p1 = new Point();       // 0, 0
        Point p2 = new Point(a, b);
        double c = p1.distance(p2);
        double perimeter = a + b + c;
        System.out.println("perimeter is " + perimeter);
    }
}
```

Objects as parameters: value vs. reference semantics

- suggested reading: 3.3

Swapping primitive values

- Consider the following code to swap two `int` variables:

```
public static void main(String[] args) {
    int a = 7;
    int b = 35;
    System.out.println(a + " " + b);

    // swap a with b
    a = b;
    b = a;

    System.out.println(a + " " + b);
}
```

  - What is wrong with this code? What is its output?

Swapping, corrected

- When swapping, you should set aside one variable's value into a temporary variable, so it won't be lost.
  - Better code to swap two int variables:

```
public static void main(String[] args) {
    int a = 7;
    int b = 35;
    System.out.println(a + " " + b);

    // swap a with b
    int temp = a;
    a = b;
    b = temp;

    System.out.println(a + " " + b);
}
```

A swap method?

- Swapping is a common operation, so we might want to make it into a method.
  - Does the following swap method work? Why or why not?

```
public static void main(String[] args) {
    int a = 7;
    int b = 35;
    System.out.println(a + " " + b);

    // swap a with b
    swap(a, b);

    System.out.println(a + " " + b);
}
```

```
public static void swap(int a, int b) {
    int temp = a;
    a = b;
    b = a;
}
```

Value semantics

- **value semantics**: Behavior where variables are copied when assigned to each other or passed as parameters.
  - Primitive types in Java use value semantics.
  - When one variable is assigned to another, the value is copied.
  - Modifying the value of one variable does not affect others.

- Example:

```
int x = 5;
int y = x;      // x = 5, y = 5
y = 17;         // x = 5, y = 17
x = 8;          // x = 8, y = 17
```

Modifying primitive parameters

- When we call a method and pass primitive variables' values as parameters, we can assign new values to the parameters inside the method.
  - But this does not affect the value of the variable that was passed; its value was copied, and the two variables are otherwise distinct.
  - Example:

```
public static void main(String[] args) {
    int x = 1;
    foo(x);
    System.out.println(x);   // output: 1
}
```

$x\ \boxed{1}$

$x\ \boxed{\cancel{1}}\ 2$

value 1 is copied into parameter

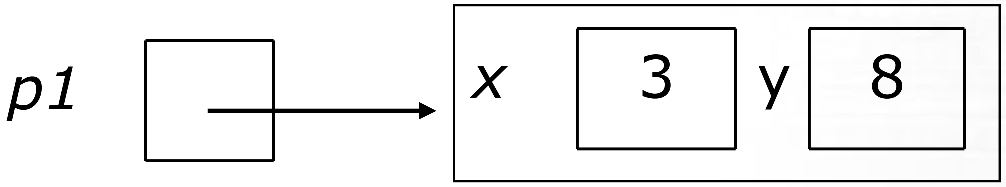
```
public static void foo(int x) {
    x = 2;
}
```

parameter's value is changed to 2 (variable `x` in `main` is unaffected)

Reference semantics

- **reference semantics**: Behavior where variables refer to a common value when assigned to each other or passed as parameters.
  - Objects in Java use reference semantics.
  - Object variables do not actually store an object; they store the address of an object's location in the computer memory.
    - Variables for objects are called *reference variables*.
    - We often draw reference variables as small boxes that point an arrow toward the object they refer to.
  - Example:

    ```
    Point p1 = new Point(3, 8);
    ```

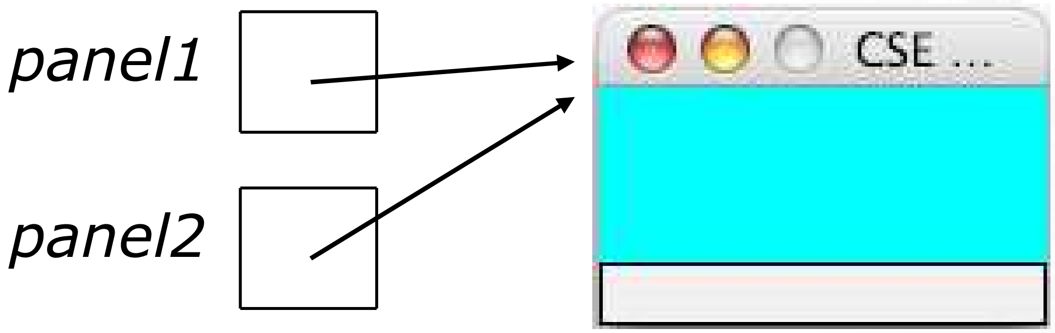


Multiple references to object

- If two reference variables are assigned to refer to the same object, the object is *not* copied.
  - Both variables literally share the same object.
  - Calling a method on either variable will modify the same object.

- Example:

```
DrawingPanel panel1 = new DrawingPanel(80, 50);
DrawingPanel panel2 = panel1;   // same window
panel2.setBackground(Color.CYAN);
```



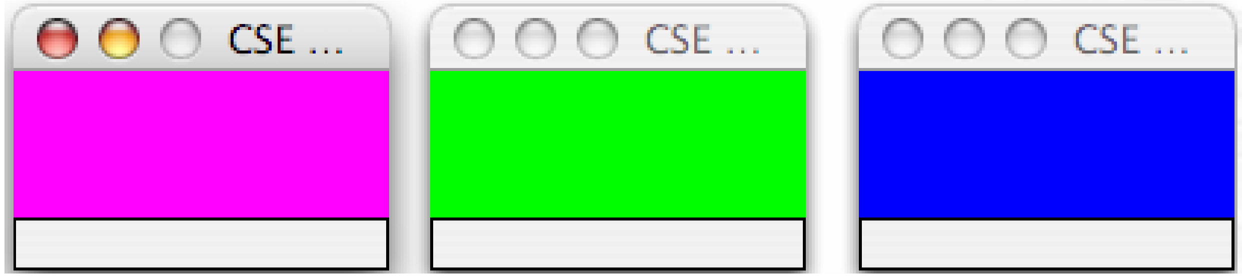
Why references?

- The fact that objects are passed by reference was done for several reasons:
  - *efficiency.* Objects can be large, bulky things. Having to copy them every time they are passed as parameters would slow down the program.
  - *sharing.* Since objects hold important state and have behavior that modifies that state, it is often more desirable for them to be shared by parts of the program when they're passed as parameters. Often we want the changes to occur to the same object.

Reference semantics example

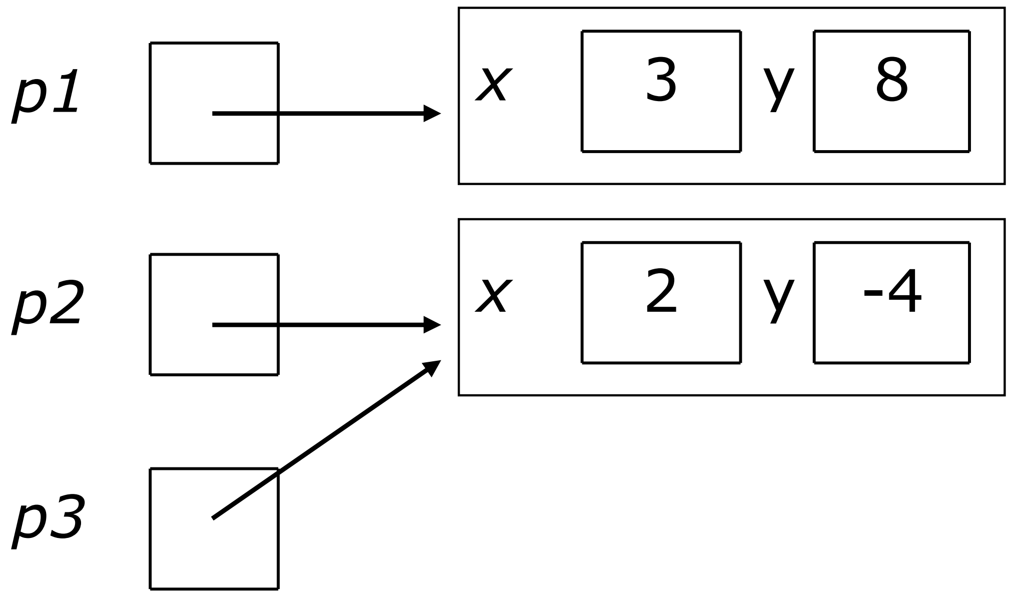
- When `panel2` refers to the same object as `panel1`, modifying either variable's background color will affect the same object (and therefore the same window):

```
DrawingPanel panel1 = new DrawingPanel(80, 50);
DrawingPanel panel2 = new DrawingPanel(80, 50);
DrawingPanel panel3 = new DrawingPanel(80, 50);
panel1.setBackground(Color.RED);
panel2.setBackground(Color.GREEN);
panel3.setBackground(Color.BLUE);

panel2 = panel1;
panel2.setBackground(Color.MAGENTA);
```



Another reference example

```
Point p1 = new Point(3, 8);
Point p2 = new Point(2, -4);
Point p3 = p2;
```

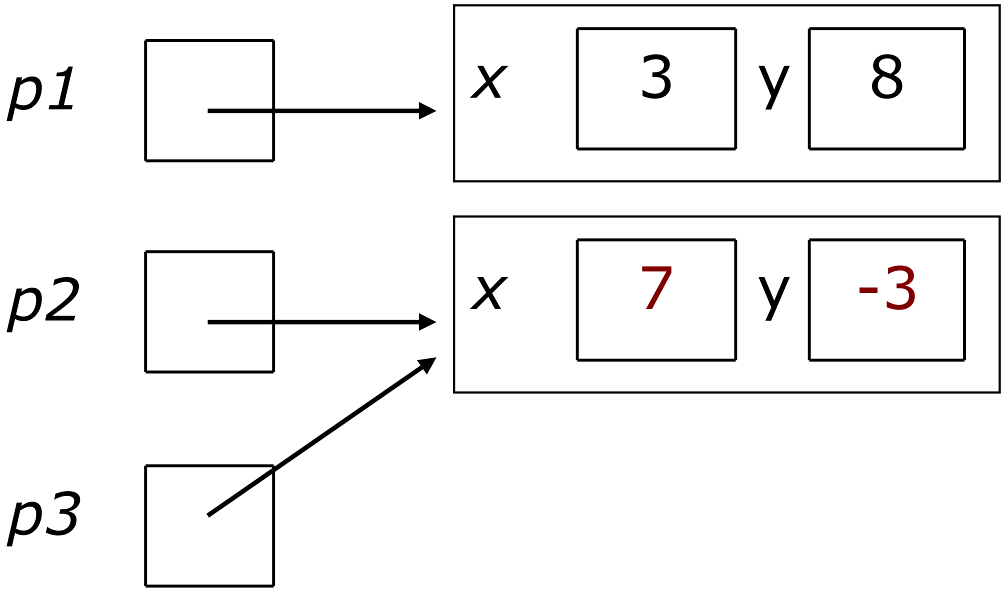


- We have 3 variables that refer to 2 unique objects. If we change p3, will p2 be affected? If we change p2, will p3 be affected?

Multiple references

- If two variables refer to the same object, modifying one of them *will* also make a change in the other:

```
p3.translate(5, 1);
System.out.println("(" + p2.x + " " + p2.y + ")");
```



OUTPUT:

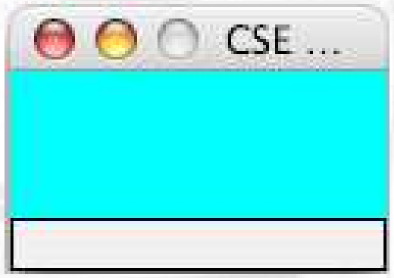
```
(7, -3)
```

Objects as parameters

- When an object is passed as a parameter, the object is *not* copied. The same object is referred to by both the original variable and the method's parameter.
  - If a method is called on the parameter, it *will* affect the original object that was passed to the method.

  - Example:

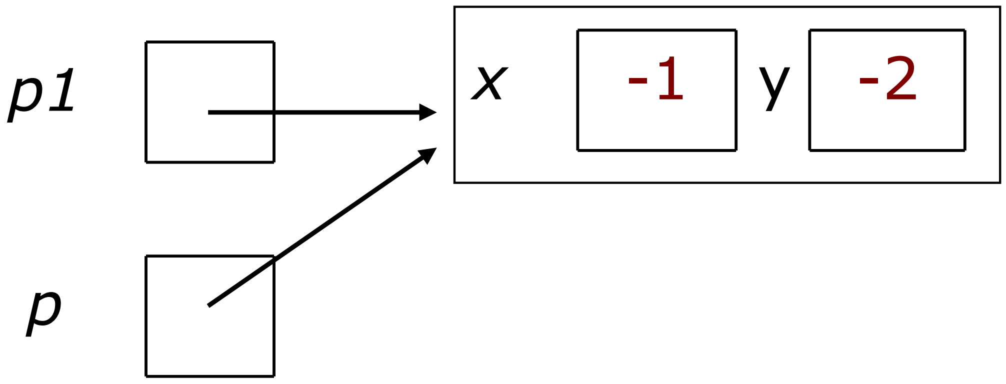
```
public static void main(String[] args) {
    DrawingPanel p = new DrawingPanel(80, 50);
    p.setBackground(Color.YELLOW);
    bg(p);
}

public static void bg(DrawingPanel panel) {
    panel.setBackground(Color.CYAN);
}
```



Another ref. param. example

- Since the variable p1 and the parameter p refer to the same object, modifying one *will* also make a change in the other:

```
public static void main(String[] args) {
    Point p1 = new Point(2, 3);
    example(p1);
}

public static void example(Point p) {
    p.setLocation(-1, -2);
}
```



String objects

- suggested reading: 3.3, 4.2

String objects

- **string**: A sequence of text characters.
  - One of the most common types of objects.
  - In Java, strings are represented as objects of class `String`.

- `String` variables can be declared and assigned, just like primitive values:

```
String <name> = "<text>";
String <name> = <expression that produces a String>;
```

  - Unlike most other objects, a `String` is not created with `new`.
  - Examples:

```
String name = "Marla Singer";

int x = 3, y = 5;
String point = "(" + x + ", " + y + ")";
```

Indexes

- The characters in a `String` are each internally numbered with an *index*, starting with 0:
  - Example:

    ```
    String name = "P. Diddy";
    ```

index	0	1	2	3	4	5	6	7
character	`'P'`	`'.'`	`' '`	`'D'`	`'i'`	`'d'`	`'d'`	`'y'`

- Individual characters are represented inside the `String` by values of a primitive type called `char`.
  - Literal `char` values are surrounded with apostrophe (single-quote) marks, such as `'a'` or `'4'`.
  - An escape sequence can be represented as a `char`, such as `'\n'` (new-line character) or `'\''` (apostrophe).

String methods

- Useful methods of each `String` object:

Method name	Description
`charAt(`*index*`)`	character at a specific index
`indexOf(`*str*`)`	index where the start of the given string appears in this string (-1 if it is not there)
`length()`	number of characters in this string
`substring(`*index1*`, `*index2*`)`	the characters in this string from *index1* (inclusive) to *index2* (exclusive)
`toLowerCase()`	a new string with all lowercase letters
`toUpperCase()`	a new string with all uppercase letters

- These methods are called using the dot notation:

```
String example = "speak friend and enter";
System.out.println(example.toUpperCase());
```

String method examples

```
//        index 012345678901
String s1 = "Stuart Reges";
String s2 = "Marty Stepp";
System.out.println(s1.length());          // 12
System.out.println(s1.indexOf("e"));      // 8
System.out.println(s1.substring(1, 4));   // tua

String s3 = s2.toUpperCase();
System.out.println(s3.substring(6, 10)); // STEP

String s4 = s1.substring(0, 6);
System.out.println(s4.toLowerCase());   // stuart
```

Modifying Strings

- The methods that appear to modify a string (`substring`, `toLowerCase`, `toUpperCase`, etc.) actually create and return a new string.

```
String s = "lil bow wow";
s.toUpperCase();
System.out.println(s);   // output: lil bow wow
```

- If you want to modify the variable, you must reassign it to store the result of the method call:

```
String s = "lil bow wow";
s = s.toUpperCase();
System.out.println(s);   // output: LIL BOW WOW
```

String methods

- Given the following string:

```
String book = "Building Java Programs";
```

  - How would you extract the word `"Java"` ?
  - How would you change book to store: `"BUILDING JAVA PROGRAMS"` ?
  - How would you extract the first word from any general string?

Method name	Description
`charAt(`*index*`)`	character at a specific index
`indexOf(`*str*`)`	index where the start of the given string appears in this string (-1 if it is not there)
`length()`	number of characters in this string
`substring(`*index1*`, `*index2*`)`	the characters in this string from *index1* (inclusive) to *index2* (exclusive)
`toLowerCase()`	a new string with all lowercase letters
`toUpperCase()`	a new string with all uppercase letters

Comparing objects

- Relational operators such as < and == only behave correctly on primitive values.
  - The == operator on `Strings` often evaluates to `false` even when the `Strings` have the same letters in them.

  - Example (incorrect):

```
Scanner console = new Scanner(System.in);
System.out.print("What is your name? ");
String name = console.next();
if (name == "Barney") {
    System.out.println("I love you, you love me,");
    System.out.println("We're a happy family!");
}
```

  - This example code will compile, but it will never print the message, even if the user does type Barney

The equals method

- Objects (such as `String`, `Point`, and `Color`) should be compared for equality by calling a method named `equals`.

  - Example (correct):

```
Scanner console = new Scanner(System.in);
System.out.print("What is your name? ");
String name = console.next();
if (name.equals("Barney")) {
    System.out.println("I love you, you love me,");
    System.out.println("We're a happy family!");
}
```

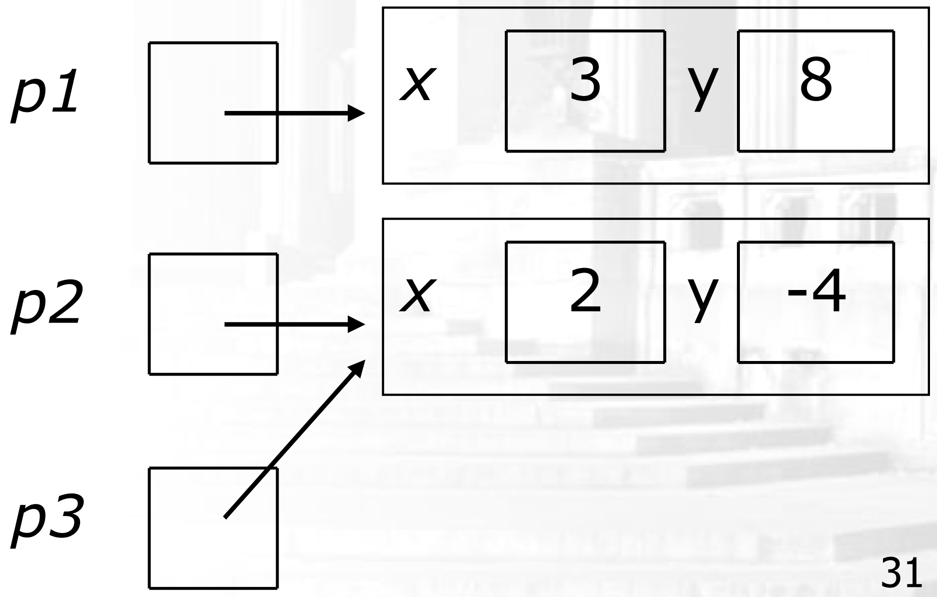
Another example

- The == operator on objects actually compares whether two variables refer to the same object.
- The `equals` method compares whether two objects have the same state as each other.
  - Given the following code:

```
Point p1 = new Point(3, 8);
Point p2 = new Point(2, -4);
Point p3 = p2;
```

  - What is printed?

```
if (p1 == p2) {
    System.out.println("1");
}
if (p1.equals(p2)) {
    System.out.println("2");
}
if (p2 == p3) {
    System.out.println("3");
}
```



String condition methods

- There are several methods of a `String` object that can be used as conditions in `if` statements:

Method	**Description**
`equals(`*`str`*`)`	whether two strings contain exactly the same characters
`equalsIgnoreCase(`*`str`*`)`	whether two strings contain the same characters, ignoring upper vs. lower case differences
`startsWith(`*`str`*`)`	whether one string contains the other's characters at its start
`endsWith(`*`str`*`)`	whether one string contains the other's characters at its end

String condition examples

- Hypothetical examples, assuming the existence of various `String` variables:

  -
    ```
    if (title.endsWith("Ph. D.")) {
        System.out.println("What's your number?");
    }
    ```

  -
    ```
    if (fullName.startsWith("Queen")) {
        System.out.println("Greetings, your majesty.");
    }
    ```

  -
    ```
    if (lastName.equalsIgnoreCase("lumberg")) {
        System.out.println("I need your TPS reports!");
    }
    ```

  -
    ```
    if (name.toLowerCase().indexOf("jr.") >= 0) {
        System.out.println("You share your parent's name.");
    }
    ```

Text processing with String and char

- suggested reading: 4.4

Type char

- **char**: A primitive type representing single characters.
  - Individual characters inside a `String` are stored as `char` values.
  - Literal `char` values are surrounded with apostrophe (single-quote) marks, such as `'a'` or `'4'` or `'\n'` or `'\''`
  - It is legal to have variables, parameters, returns of type `char`

```
char letter = 'S';
System.out.println(letter);             // S
```

The charAt method

- The characters of a string can be accessed as `char` values using the `String` object's `charAt` method.

```
String word = console.next();
char firstLetter = word.charAt(0);
if (firstLetter == 'c') {
    System.out.println("That's good enough for me!");
}
```

- We often use `for` loops that print or examine each character.

```
String name = "tall";
for (int i = 0; i < name.length(); i++) {
    System.out.println(title.charAt(i));
}
```

Output:

```
t
a
l
l
```

Text processing

- **text processing**: Examining, editing, formatting text.
  - Text processing often involves `for` loops that examine the characters of a string one by one.
  - You can use `charAt` to search for or count occurrences of a particular value in a string.

```
// Returns the count of occurrences of c in s.
public static int count(String s, char c) {
    int count = 0;
    for (int i = 0; i < s.length(); i++) {
        if (s.charAt(i) == 't') {
            count++;
        }
    }
    return count;
}
```

  - `count("mississippi", 'i')` returns `4`

Other things to do with char

- char values can be concatenated with strings.

```
char initial = 'P';
System.out.println(initial + " Diddy");
```

- You can compare char values with relational operators:
  - `'a' < 'b'` and `'Q' != 'q'`
  - Note that you cannot use these operators on a `String`.

  - An example that prints the alphabet:

```
for (char c = 'a'; c <= 'z'; c++) {
    System.out.print(c);
}
```

char/int and type casting

- All `char` values are assigned numbers internally by the computer, called *ASCII* values.
  - Examples:
    `'A'` is `65`, `'B'` is `66`, `'a'` is `97`, `'b'` is `98`
  - Mixing `char` and `int` causes automatic conversion to `int`.
    `'a' + 10` is 107, `'A' + 'A'` is 130
  - To convert an integer into the equivalent character, type cast it.
    `(char) ('a' + 2)` is `'c'`

char vs. String

- `'h'` is a `char`

  ```
  char c = 'h';
  ```

  - `char` values are primitive; you cannot call methods on them
  - can't say `c.length()` or `c.toUpperCase()`

- `"h"` is a `String`

  ```
  String s = "h";
  ```

  - Strings are objects; they contain methods that can be called
  - *can* say `s.length()` $\longrightarrow$ `1`
  - *can* say `s.toUpperCase()` $\longrightarrow$ `"H"`
  - *can* say `s.charAt(0)` $\longrightarrow$ `h'`

- What is `s + 1` ? What is `c + 1` ?
- What is `s + s` ? What is `c + c` ?

Text processing questions

- Write a method named `pigLatinWord` that accepts a `String` as a parameter and outputs that word in simplified Pig Latin, by placing the word's first letter at the end followed by the suffix *ay*.
  - `pigLatinWord("hello")` prints `ello-hay`
  - `pigLatinWord("goodbye")` prints `oodbye-gay`

- Write methods named `encode` and `decode` that accept a `String` as a parameter and outputs that `String` with each of its letters increased or decreased by 1.
  - `encode("hello")` prints `ifmmp`
  - `decode("ifmmp")` prints `hello`

Text processing question

- Write a method `printName` that accepts a full name as a parameter, and prints the last name followed by a comma, followed by the first name and middle initial.
  - For example,
    `printName("James Tiberius Kirk");` would output:
    `Kirk, James T.`

Method name	Description
`charAt(`*index*`)`	character at a specific index
`indexOf(`*str*`)`	index where the start of the given string appears in this string (-1 if it is not there)
`length()`	number of characters in this string
`substring(`*index1*`, `*index2*`)`	the characters in this string from *index1* (inclusive) to *index2* (exclusive)
`toLowerCase()`	a new string with all lowercase letters
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