Thinking in Objects

CSE160: Computer Science A: Honors
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http://www.cs.stonybrook.edu/~cse160
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- Scope of Variables and Default values
- The `this` Keyword
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  - Designing and implementing the Course Class
  - Designing and implementing the StackOfIntegers Class
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- `StringBuilder` and `StringBuffer`
- The Character Class
- Designing Classes
**Immutable object**: the contents of an object cannot be changed once the object is created

- its class is called an **immutable class**
- Example immutable class: no set method in the Circle class:

```java
public class Circle{
    private double radius;
    public Circle() { }
    public Circle(double radius) {
        this.radius = radius;
    }
    public double getRadius() {
        return radius;
    }
}
```

- radius is private and cannot be changed without a set method
What Class is Immutable?

• A class with all private data fields and without mutators is not necessarily immutable!

• An **immutable class**:
  1. It must mark all data fields **private**!
  2. Provide **no mutator (set)** methods!
  3. Provide **no accessor methods** that would return a reference to a mutable data field object!
Example mutable

```java
public class Student {
    private int id;
    private BirthDate birthDate;
    public Student(int ssn, int year, int month, int day) {
        id = ssn;
        birthDate =
            new BirthDate(year, month, day);
    }
    public int getId() {
        return id;
    }
    public BirthDate getBirthDate() {
        return birthDate;
    }
}

public class BirthDate {
    private int year;
    private int month;
    private int day;
    public BirthDate(int newYear, int newMonth, int newDay) {
        year = newYear;
        month = newMonth;
        day = newDay;
    }
    public void setYear(int newYear) {
        year = newYear;
    }
    public int getYear() {
        return year;
    }
}

public class Test {
    public static void main(String[] args) {
        Student student = new Student(111223333, 1998, 1, 1);
        student.getBirthDate().setYear(2050);
        // Now the student birth year is changed:
        System.out.println(student.getBirthDate().getYear()); // 2050
    }
}
```
Scope of Variables

• The scope of a local variable starts from its declaration and continues to the end of the block that contains the variable
  • Also a local variable must be initialized explicitly before it can be used.

  vs.

• Data Field Variables can be declared anywhere inside a class
  • The scope of instance and static variables is the entire class!
  • Initialized with default values.
The this Keyword

• The **this** keyword is the name of a reference that refers to an object itself

• Common uses of the **this** keyword:
  1. Reference a class’s “*hidden*” data fields.
  2. To enable a constructor to **invoke** another constructor of the same class as the first statement in the constructor.
Reference the Hidden Data Fields

```java
public class Foo {
  private int i = 5;
  private static double k = 0;

  void setI(int i) {
    this.i = i;
  }

  static void setK(double k) {
    Foo.k = k;
  }
}
```

Suppose that f1 and f2 are two objects of Foo.

Invoking `f1.setI(10)` is to execute `this.i = 10`, where `this` refers `f1`.

Invoking `f2.setI(45)` is to execute `this.i = 45`, where `this` refers `f2`. 
public class Circle {
    private double radius;

    public Circle(double radius) {
        this.radius = radius;
    }

    public Circle() {
        this(1.0);  // this is used to invoke another constructor
    }

    public double getArea() {
        return this.radius * this.radius * Math.PI;
    }
}

Every instance variable belongs to an instance represented by this, which is normally omitted.

This must be explicitly used to reference the data field radius of the object being constructed.
Class Abstraction and Encapsulation

**Class Abstraction** = separate class implementation from the use of the class (API)

- The creator of the class provides a description of the class and let the user know how the class can be used.
- The user does not need to know how the class is implemented: it is *encapsulated* (private fields and only the public API is used).
Designing the Loan Class

<table>
<thead>
<tr>
<th>Loan</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-annualInterestRate: double</td>
<td>The annual interest rate of the loan (default: 2.5).</td>
</tr>
<tr>
<td>-numberOfYears: int</td>
<td>The number of years for the loan (default: 1)</td>
</tr>
<tr>
<td>-loanAmount: double</td>
<td>The loan amount (default: 1000).</td>
</tr>
<tr>
<td>-loanDate: Date</td>
<td>The date this loan was created.</td>
</tr>
<tr>
<td>+Loan()</td>
<td>Constructs a default Loan object.</td>
</tr>
<tr>
<td>+Loan(annualInterestRate: double, numberOfYears: int, loanAmount: double)</td>
<td>Constructs a loan with specified interest rate, years, and loan amount.</td>
</tr>
<tr>
<td>+getAnnualInterestRate(): double</td>
<td>Returns the annual interest rate of this loan.</td>
</tr>
<tr>
<td>+getNumberOfYears(): int</td>
<td>Returns the number of years of this loan.</td>
</tr>
<tr>
<td>+getLoanAmount(): double</td>
<td>Returns the amount of this loan.</td>
</tr>
<tr>
<td>+getLoanDate(): Date</td>
<td>Returns the date of the creation of this loan.</td>
</tr>
<tr>
<td>+setAnnualInterestRate( annualInterestRate: double): void</td>
<td>Sets a new annual interest rate to this loan.</td>
</tr>
<tr>
<td>+setNumberOfYears( numberOfYears: int): void</td>
<td>Sets a new number of years to this loan.</td>
</tr>
<tr>
<td>+setLoanAmount( loanAmount: double): void</td>
<td>Sets a new amount to this loan.</td>
</tr>
<tr>
<td>+getMonthlyPayment(): double</td>
<td>Returns the monthly payment of this loan.</td>
</tr>
<tr>
<td>+getTotalPayment(): double</td>
<td>Returns the total payment of this loan.</td>
</tr>
</tbody>
</table>
public class Loan {
    private double annualInterestRate;
    private int numberOfYears;
    private double loanAmount;
    private java.util.Date loanDate;

    public Loan() {
        this(2.5, 1, 1000);
    }

    public Loan(double annualInterestRate, int numberOfYears, double loanAmount) {
        this.annualInterestRate = annualInterestRate;
        this.numberOfYears = numberOfYears;
        this.loanAmount = loanAmount;
        loanDate = new java.util.Date();
    }

    public double getMonthlyPayment() {
        double monthlyInterestRate = annualInterestRate / 1200;
        double monthlyPayment = loanAmount * monthlyInterestRate / (1 -
            (Math.pow(1 / (1 + monthlyInterestRate), numberOfYears * 12)));
        return monthlyPayment;
    }

    public double getTotalPayment() {
        double totalPayment = getMonthlyPayment() * numberOfYears * 12;
        return totalPayment;
    }
}
The BMI Class

<table>
<thead>
<tr>
<th>BMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>- name: String</td>
</tr>
<tr>
<td>- age: int</td>
</tr>
<tr>
<td>- weight: double</td>
</tr>
<tr>
<td>- height: double</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ BMI(name: String, age: int, weight: double, height: double)</td>
<td>Creates a BMI object with the specified name, age, weight, and height.</td>
</tr>
<tr>
<td>+ BMI(name: String, weight: double, height: double)</td>
<td>Creates a BMI object with the specified name, weight, height, and a default age 20.</td>
</tr>
<tr>
<td>+ getBMI(): double</td>
<td>Returns the BMI</td>
</tr>
<tr>
<td>+ getStatus(): String</td>
<td>Returns the BMI status (e.g., normal, overweight, etc.)</td>
</tr>
</tbody>
</table>

The get methods for these data fields are provided in the class, but omitted in the UML diagram for brevity.

- The name of the person.
- The age of the person.
- The weight of the person in pounds.
- The height of the person in inches.

Creates a BMI object with the specified name, age, weight, and height.

Creates a BMI object with the specified name, weight, height, and a default age 20.

Returns the BMI

Returns the BMI status (e.g., normal, overweight, etc.)
public class BMI {
    private String name;
    private int age;
    private double weight; // in pounds
    private double height; // in inches
    public static final double KILOGRAMS_PER_POUND = 0.45359237;
    public static final double METERS_PER_INCH = 0.0254;
    public BMI(String name, int age, double weight, double height) {
        this.name = name; this.age = age; this.weight = weight; this.height = height;
    }
    public double getBMI() {
        double bmi = weight * KILOGRAMS_PER_POUND /
                           ((height * METERS_PER_INCH) * (height * METERS_PER_INCH));
        return Math.round(bmi * 100) / 100.0;
    }
    public String getStatus() {
        double bmi = getBMI();
        if (bmi < 16) return "seriously underweight";
        else if (bmi < 18) return "underweight";
        else if (bmi < 24) return "normal weight";
        else if (bmi < 29) return "over weight";
        else if (bmi < 35) return "seriously over weight";
        else return "gravely over weight";
    }
    public String getName() { return name; }
    public int getAge() { return age; }
    public double getWeight() { return weight; }
    public double getHeight() { return height; }
}
## Example: The Course Class

<table>
<thead>
<tr>
<th>Course</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-name: String</td>
<td>The name of the course.</td>
<td></td>
</tr>
<tr>
<td>-students: String[]</td>
<td>The students who take the course.</td>
<td></td>
</tr>
<tr>
<td>-numberOfStudents: int</td>
<td>The number of students (default: 0).</td>
<td></td>
</tr>
<tr>
<td>+Course(name: String)</td>
<td>Creates a Course with the specified name.</td>
<td></td>
</tr>
<tr>
<td>+getName(): String</td>
<td>Returns the course name.</td>
<td></td>
</tr>
<tr>
<td>+addStudent(student: String): void</td>
<td>Adds a new student to the course list.</td>
<td></td>
</tr>
<tr>
<td>+getStudents(): String[]</td>
<td>Returns the students for the course.</td>
<td></td>
</tr>
<tr>
<td>+getNumberOfStudents(): int</td>
<td>Returns the number of students for the course.</td>
<td></td>
</tr>
</tbody>
</table>
public class Course {
    private String courseName;
    private String[] students = new String[100];
    private int numberOfStudents;
    public Course(String courseName) {
        this.courseName = courseName;
    }
    public void addStudent(String student) {
        if(numberOfStudents >= students.length) {
            String[] temp = new String[students.length * 2];
            System.arraycopy(students, 0, temp, 0, students.length);
            students = temp;
        }
        students[numberOfStudents++] = student;
    }
    public String[] getStudents() {
        return students;
    }
    public int getNumberOfStudents() {
        return numberOfStudents;
    }
    public String getCourseName() {
        return courseName;
    }
}
### Example: The `StackOfIntegers` Class

<table>
<thead>
<tr>
<th>StackOfIntegers</th>
</tr>
</thead>
<tbody>
<tr>
<td>- elements: int[]</td>
</tr>
<tr>
<td>- size: int</td>
</tr>
<tr>
<td>+ StackOfIntegers()</td>
</tr>
<tr>
<td>+ StackOfIntegers(capacity: int)</td>
</tr>
<tr>
<td>+ empty(): boolean</td>
</tr>
<tr>
<td>+ peek(): int</td>
</tr>
<tr>
<td>+ push(value: int): int</td>
</tr>
<tr>
<td>+ pop(): int</td>
</tr>
<tr>
<td>+ getSize(): int</td>
</tr>
</tbody>
</table>

- An array to store integers in the stack.
- The number of integers in the stack.
- Constructs an empty stack with a default capacity of 16.
- Constructs an empty stack with a specified capacity.
- Returns true if the stack is empty.
- Returns the integer at the top of the stack without removing it from the stack.
- Stores an integer into the top of the stack.
- Removes the integer at the top of the stack and returns it.
- Returns the number of elements in the stack.
Designing the **StackOfIntegers** Class

![Diagram of StackOfIntegers](image-url)
Implementing `StackOfIntegers` Class

```
<table>
<thead>
<tr>
<th>elements[0]</th>
<th>elements[1]</th>
<th>...</th>
<th>elements[size-1]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>top</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>size</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>size</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>bottom</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

- `elements[0]` to `elements[size-1]`: Array of size `size`.
- `top`: Index of the next available position to insert an element.
- `bottom`: Index of the position below the top element.
- `capacity`: Total number of elements the stack can hold.
public class StackOfIntegers {
    private int[] elements;
    private int size;
    public static final int DEFAULT_CAPACITY = 16;
    public StackOfIntegers() {
        this(DEFAULT_CAPACITY);
    }
    public StackOfIntegers(int capacity) {
        elements = new int[capacity];
    }
    public void push(int value) {
        if (size >= elements.length) {
            int[] temp = new int[elements.length * 2];
            System.arraycopy(elements, 0, temp, 0, elements.length);
            elements = temp;
        }
        elements[size++] = value;
    }
    public int pop() {
        return elements[--size];
    }
    public int peek() {
        return elements[size - 1];
    }
    public int getSize() {
        return size;
    }
}
The String class in detail

• Remember the String class discussed at the beginning of the semester?

  • Constructing Strings:

```java
String newString = new String(stringLiteral);
```

• Example:

```java
String message = new String("Welcome to Java");
```

• Since strings are used frequently, Java provides a shorthand initializer for creating a string:

```java
String message = "Welcome to Java";
```

  // an Interned String
Strings Are Immutable

- A String object is immutable; its contents cannot be changed

```
String s = "Java";
s = "HTML";
```

After executing `String s = "Java";

After executing `s = "HTML";

This string object is now unreferenced

Strings Are Immutable

- A String object is immutable; its contents cannot be changed

```
String s = "Java";
```

After executing `String s = "Java";

Contents cannot be changed

After executing `s = "HTML";

This string object is now unreferenced

String object for "Java"

String object for "HTML"
**Interned Strings**

- *String interning* is a method of storing **only one copy** of each distinct compile-time constant/explicit string in the source code stored in a string intern pool (e.g., `s1` and `s3`).
- If we use the `new` operator, then a new object is created in heap (e.g., `s2`).

```java
String s1 = "Welcome to Java";
String s2 = new String("Welcome to Java");
String s3 = "Welcome to Java";

System.out.println("s1 == s2 is " + (s1 == s2));
System.out.println("s1 == s3 is " + (s1 == s3));
```

**displays:**

- `s1 == s3` is **true**
- `s1 == s2` is **false**
The String Class methods

- Compare strings (equals, compareTo)
- Obtaining String length
- Retrieving Individual Characters in a string
- String Concatenation (concat)
- Substrings (substring(index), substring(start, end))
- Finding a Character or a Substring in a String
- Matching, Replacing and Splitting by Patterns
- Converting Characters and Numeric Values to Strings
- Command-Line Parameters
String Comparisons

- `equals(Object object)`:

  ```java
  String s1 = new String("Welcome");
  String s2 = "Welcome";

  if (s1.equals(s2)){ // true
      // s1 and s2 have the same contents
  }

  if (s1 == s2) { // false
      // s1 and s2 have different references
  }
  ```
String Comparisons

- `equals(Object object)`:

  String s1 = "Welcome";
  String s2 = "Welcome";

  if (s1.equals(s2)){ // true
      // s1 and s2 have the same contents
  }

  if (s1 == s2) { // true
      // s1 and s2 have the same reference
  }
String Comparisons

- `compareTo(Object object)`:  

  ```java
  String s1 = new String("Welcome");
  String s2 = new String("Welcome");

  if (s1.compareTo(s2) > 0) {
      // s1 is greater than s2
  } else if (s1.compareTo(s2) == 0) {
      // s1 and s2 have the same contents
  } else {
      // s1 is less than s2
  }
  ```
String Comparisons

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>equals(String s1)</code></td>
<td>Returns true if this string is equal to string <code>s1</code>.</td>
</tr>
<tr>
<td><code>equalsIgnoreCase(String s1)</code></td>
<td>Returns true if this string is equal to string <code>s1</code> case-insensitive.</td>
</tr>
<tr>
<td><code>compareTo(String s1)</code></td>
<td>Returns an integer greater than 0, equal to 0, or less than 0 to indicate whether this string is greater than, equal to, or less than <code>s1</code>.</td>
</tr>
<tr>
<td><code>compareToIgnoreCase(String s1)</code></td>
<td>Same as <code>compareTo</code> except that the comparison is case-insensitive.</td>
</tr>
<tr>
<td><code>regionMatches(int toffset, String s1, int offset, int len)</code></td>
<td>Returns true if the specified subregion of this string exactly matches the specified subregion in string <code>s1</code>.</td>
</tr>
<tr>
<td><code>regionMatches(int toffset, String s1, int offset, int len, boolean ignoreCase)</code></td>
<td>Same as the preceding method except that you can specify whether the match is case-sensitive.</td>
</tr>
<tr>
<td><code>startsWith(String prefix)</code></td>
<td>Returns true if this string starts with the specified prefix.</td>
</tr>
<tr>
<td><code>endsWith(String suffix)</code></td>
<td>Returns true if this string ends with the specified suffix.</td>
</tr>
</tbody>
</table>
## String Length, Characters, and Combining Strings

<table>
<thead>
<tr>
<th>java.lang.String</th>
</tr>
</thead>
<tbody>
<tr>
<td>+length(): int</td>
</tr>
<tr>
<td>+charAt(index: int): char</td>
</tr>
<tr>
<td>+concat(s1: String): String</td>
</tr>
</tbody>
</table>

- Returns the number of characters in this string.
- Returns the character at the specified index from this string.
- Returns a new string that concatenate this string with string s1.
Retrieving Individual Characters in a String

- Use `message.charAt(index) → char`
- Index starts from 0

Indices: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

message: Welcome to Java

message.charAt(0)  message.length() is 15  message.charAt(14)
Extracting Substrings

```
<table>
<thead>
<tr>
<th>String</th>
<th>+subString(beginIndex: int): String</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Returns this string’s substring that begins with the character at the specified beginIndex and extends to the end of the string.</td>
</tr>
<tr>
<td></td>
<td>Returns this string’s substring that begins at the specified beginIndex and extends to the character at index endIndex – 1. Note that the character at endIndex is not part of the substring.</td>
</tr>
</tbody>
</table>
```
Extracting Substrings

String s1 = "Welcome to Java";
String s2 = s1.substring(0, 11) + "HTML";

s2 will be "Welcome to HTML"
# Finding a Character or a Substring in a String

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>indexOf(ch: char): int</code></td>
<td>Returns the index of the first occurrence of <code>ch</code> in the string. Returns -1 if not matched.</td>
</tr>
<tr>
<td><code>indexOf(ch: char, fromIndex: int): int</code></td>
<td>Returns the index of the first occurrence of <code>ch</code> after <code>fromIndex</code> in the string. Returns -1 if not matched.</td>
</tr>
<tr>
<td><code>indexOf(s: String): int</code></td>
<td>Returns the index of the first occurrence of <code>string s</code> in this string. Returns -1 if not matched.</td>
</tr>
<tr>
<td><code>indexOf(s: String, fromIndex: int): int</code></td>
<td>Returns the index of the first occurrence of <code>string s</code> in this string after <code>fromIndex</code>. Returns -1 if not matched.</td>
</tr>
<tr>
<td><code>lastIndexOf(ch: int): int</code></td>
<td>Returns the index of the last occurrence of <code>ch</code> in the string. Returns -1 if not matched.</td>
</tr>
<tr>
<td><code>lastIndexOf(ch: int, fromIndex: int): int</code></td>
<td>Returns the index of the last occurrence of <code>ch</code> before <code>fromIndex</code> in this string. Returns -1 if not matched.</td>
</tr>
<tr>
<td><code>lastIndexOf(s: String): int</code></td>
<td>Returns the index of the last occurrence of <code>string s</code>. Returns -1 if not matched.</td>
</tr>
<tr>
<td><code>lastIndexOf(s: String, fromIndex: int): int</code></td>
<td>Returns the index of the last occurrence of <code>string s</code> before <code>fromIndex</code>. Returns -1 if not matched.</td>
</tr>
</tbody>
</table>
Finding a Character or a Substring in a String

<table>
<thead>
<tr>
<th>Indices</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>message</td>
<td>W</td>
<td>e</td>
<td>l</td>
<td>c</td>
<td>o</td>
<td>m</td>
<td>e</td>
<td>t</td>
<td>o</td>
<td>J</td>
<td>a</td>
<td>v</td>
<td>a</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

"Welcome to Java".indexOf('W') returns 0.
"Welcome to Java".indexOf('x') returns -1.
"Welcome to Java".indexOf('o', 5) returns 9.
"Welcome to Java".indexOf("come") returns 3.
"Welcome to Java".indexOf("Java", 5) returns 11.
"Welcome to Java".indexOf("java", 5) returns -1.
"Welcome to Java".lastIndexOf('a') returns 14.
### Converting, Replacing, and Splitting Strings

<table>
<thead>
<tr>
<th>java.lang.String</th>
</tr>
</thead>
<tbody>
<tr>
<td>+toLowerCase(): String</td>
</tr>
<tr>
<td>+toUpperCase(): String</td>
</tr>
<tr>
<td>+trim(): String</td>
</tr>
<tr>
<td>+replace(oldChar: char, newChar: char): String</td>
</tr>
<tr>
<td>+replaceFirst(oldString: String, newString: String): String</td>
</tr>
<tr>
<td>+replaceAll(oldString: String, newString: String): String</td>
</tr>
<tr>
<td>+split(delimiter: String): String[]</td>
</tr>
</tbody>
</table>
Examples

"Welcome".toLowerCase() returns a new string, "welcome".
"Welcome".toUpperCase() returns a new string, "WELCOME".
"Welcome to Java".trim() returns a new string, "Welcome to Java".
"Welcome".replace('e', 'A') returns a new string, "WAlcomA".
"Welcome".replaceFirst("e", "AB") returns a new string, "WABlcome".
"Welcome".replaceAll("e", "AB") returns a new string, "WABlcomAB".
"Welcome".replaceAll("el", "AB") returns a new string, "WABcome".
Splitting a String

String[] tokens = "Java#HTML#Perl".split("#");
for(int i = 0; i < tokens.length; i++)
  System.out.println(tokens[i]);

displays
  Java
  HTML
  Perl
Matching, Replacing and Splitting by Patterns

- The `replaceAll`, `replaceFirst`, `split` and `matches` methods can be used with a regular expression (a sequence of characters that specifies a search pattern).

- Example: the following statement returns a new string that replaces $, ±, or # in "a+b$#c" by the string NNN.

```java
String s = "a+b$#c".replaceAll("[$+#]", "NNN");
System.out.println(s);
```

Displays: aNNNbnNNNNNNc

- The regular expression `[$+#]` specifies a pattern that matches $, ±, or #
Matching, Replacing and Splitting by Patterns

<table>
<thead>
<tr>
<th>java.lang.String</th>
</tr>
</thead>
<tbody>
<tr>
<td>+matches(regex: String): boolean</td>
</tr>
<tr>
<td>+replaceAll(regex: String, replacement: String): String</td>
</tr>
<tr>
<td>+replaceFirst(regex: String, replacement: String): String</td>
</tr>
<tr>
<td>+split(regex: String): String[]</td>
</tr>
</tbody>
</table>

- Returns true if this string matches the pattern.
- Returns a new string that replaces all matching substrings with the replacement.
- Returns a new string that replaces the first matching substring with the replacement.
- Returns an array of strings consisting of the substrings split by the matches.
Matching, Replacing and Splitting by Patterns

- The **matches** method tells whether or not a string matches a given regular expression.

  "Java is fun".matches("Java.*")

    true

Social security numbers is \texttt{xxx-xx-xxxx}, where x is a digit:

\[
[\texttt{d}]^3 - [\texttt{d}]^2 - [\texttt{d}]^4
\]

An even number ends with digits \texttt{0, 2, 4, 6, or 8}:

\[
[\texttt{d}]^*[02468]
\]

Telephone numbers \texttt{(xxx) xxx-xxxx}, where x is a digit and the first digit cannot be zero:

\[
\texttt{((1-9)[d]^2) [d]^3-[d]^4}
\]
# Regular Expressions

<table>
<thead>
<tr>
<th>Regular Expression</th>
<th>Matches</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>a specified character x</td>
<td>Java matches Java</td>
</tr>
<tr>
<td>.</td>
<td>any single character</td>
<td>Java matches J..a</td>
</tr>
<tr>
<td>(ab</td>
<td>cd)</td>
<td>ab or cd</td>
</tr>
<tr>
<td>[abc]</td>
<td>a, b, or c</td>
<td>Java matches Ja[uvw]a</td>
</tr>
<tr>
<td>[^abc]</td>
<td>any character except a, b, or c</td>
<td>Java matches Ja[^ars]a</td>
</tr>
<tr>
<td>[a-z]</td>
<td>a through z</td>
<td>Java matches [A-M]av[a-d]</td>
</tr>
<tr>
<td>[^a-z]</td>
<td>any character except a through z</td>
<td>Java matches Jav[^b-d]</td>
</tr>
<tr>
<td>[a-e[m-p]]</td>
<td>a through e or m through p</td>
<td>[A-G[I-M]]av[a-d]</td>
</tr>
<tr>
<td>[a-e&amp;&amp;[c-p]]</td>
<td>intersection of a-e with c-p</td>
<td>[A-P&amp;&amp;[I-M]]av[a-d]</td>
</tr>
<tr>
<td>\d</td>
<td>a digit, same as [1-9]</td>
<td>Java2 matches &quot;Java[\d]&quot;</td>
</tr>
<tr>
<td>\D</td>
<td>a non-digit</td>
<td>$Java matches &quot;[\D][\D]ava&quot;</td>
</tr>
<tr>
<td>\w</td>
<td>a word character</td>
<td>Java matches &quot;[\w]ava&quot;</td>
</tr>
<tr>
<td>\W</td>
<td>a non-word character</td>
<td>$Java matches &quot;[\W][\w]ava&quot;</td>
</tr>
<tr>
<td>\s</td>
<td>a whitespace character</td>
<td>&quot;Java 2&quot; matches &quot;Java\s2&quot;</td>
</tr>
<tr>
<td>\S</td>
<td>a non-whitespace char</td>
<td>Java matches &quot;[\S]ava&quot;</td>
</tr>
<tr>
<td>p*</td>
<td>zero or more</td>
<td>Java matches &quot;[\w]*&quot;</td>
</tr>
<tr>
<td>p+</td>
<td>one or more</td>
<td>Java matches &quot;[\w]+&quot;</td>
</tr>
<tr>
<td>p?</td>
<td>zero or one</td>
<td>Java matches &quot;[\w]?Java&quot;</td>
</tr>
<tr>
<td>p{n}</td>
<td>exactly n</td>
<td>Java matches &quot;[\w]{4}&quot;</td>
</tr>
<tr>
<td>p{n,}</td>
<td>at least n</td>
<td>Java matches &quot;[\w]{3,}&quot;</td>
</tr>
<tr>
<td>p{n,m}</td>
<td>between n and m</td>
<td>Java matches &quot;[\w]{1,9}&quot;</td>
</tr>
</tbody>
</table>

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The following statement splits the string into an array of strings delimited by some punctuation marks:

```java
String[] tokens = "Java,C;C#.C++".split("[,;.]";
for (int i = 0; i < tokens.length; i++)
    System.out.println(tokens[i]);
```

Displays:

- Java
- C
- C#
- C++
Examples

String s = "Java Java Java".replaceAll("v\\w", "wi") ;  // “Jawi Jawi Jawi”

String s2 = "Java Java Java".replaceFirst("v\\w", "wi") ;  // “Jawi Java Java”

String[] s3 = "Java1HTML2Perl".split("\\d");  // [“Java”, “HTML”, “Perl”]
class TestMain {
    public static void main(String[] args) {
        ...
    }
}

• We can run the program with:
java TestMain arg0 arg1 arg2 ... argn

or the EclipseIDE Run Configuration arguments

• In the main method, get the arguments args[0], args[1], ..., args[n] corresponds to arg0, arg1, ..., argn in the command line or the EclipseIDE Run Configuration arguments
public class Calculator {

    public static void main(String[] args) {
        if (args.length != 3) {
            System.out.println("Usage: java Calculator operand1 operator operand2");
            System.exit(0);
        }

        int result = 0;
        switch (args[1].charAt(0)) {
            case '+':
                result = Integer.parseInt(args[0]) + Integer.parseInt(args[2]);
                break;
        ...
    }
}
}
StringBuilder and StringBuffer

- The **StringBuilder/StringBuffer** classes are alternatives to the **String** class:
  - **StringBuilder/StringBuffer** can be used wherever a string is used
    - **StringBuffer** is synchronized i.e. thread safe. It means two threads can't call the methods of **StringBuffer** simultaneously.
    - **StringBuilder** is non-synchronized i.e. not thread safe. It means two threads can call the methods of StringBuilder simultaneously.
  - **StringBuilder/StringBuffer** is more flexible than **String**
    - You can add, insert, or append new contents into a string buffer, whereas the value of a **String** object is fixed once the string is created
### StringBuilder Constructors

<table>
<thead>
<tr>
<th>java.lang.StringBuilder</th>
</tr>
</thead>
<tbody>
<tr>
<td>+StringBuilder()</td>
</tr>
<tr>
<td>+StringBuilder(capacity: int)</td>
</tr>
<tr>
<td>+StringBuilder(s: String)</td>
</tr>
</tbody>
</table>
Modifying StringBuilder(s)

```java
java.lang.StringBuilder

+append(data: char[]): StringBuilder
+append(data: char[], offset: int, len: int): StringBuilder
+append(v: aPrimitiveType): StringBuilder
+append(s: String): StringBuilder
+delete(startIndex: int, endIndex: int): StringBuilder
+deleteCharAt(index: int): StringBuilder
+insert(index: int, data: char[], offset: int, len: int): StringBuilder
+insert(offset: int, data: char[]): StringBuilder
+insert(offset: int, b: aPrimitiveType): StringBuilder
+insert(offset: int, s: String): StringBuilder
+replace(startIndex: int, endIndex: int, s: String): StringBuilder
+reverse(): StringBuilder
+setCharAt(index: int, ch: char): void
```

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>append(data: char[])</code></td>
<td>Appends a char array into this string builder.</td>
</tr>
<tr>
<td><code>append(data: char[], offset: int, len: int)</code></td>
<td>Appends a subarray in data into this string builder.</td>
</tr>
<tr>
<td><code>append(v: aPrimitiveType)</code></td>
<td>Appends a primitive type value as a string to this builder.</td>
</tr>
<tr>
<td><code>append(s: String)</code></td>
<td>Appends a string to this string builder.</td>
</tr>
<tr>
<td><code>delete(startIndex: int, endIndex: int)</code></td>
<td>Deletes characters from startIndex to endIndex.</td>
</tr>
<tr>
<td><code>deleteCharAt(index: int)</code></td>
<td>Deletes a character at the specified index.</td>
</tr>
<tr>
<td><code>insert(index: int, data: char[], offset: int, len: int)</code></td>
<td>Inserts a subarray of the data in the array to the builder at the specified index.</td>
</tr>
<tr>
<td><code>insert(offset: int, data: char[])</code></td>
<td>Inserts data into this builder at the position offset.</td>
</tr>
<tr>
<td><code>insert(offset: int, b: aPrimitiveType)</code></td>
<td>Inserts a value converted to a string into this builder.</td>
</tr>
<tr>
<td><code>insert(offset: int, s: String)</code></td>
<td>Inserts a string into this builder at the position offset.</td>
</tr>
<tr>
<td><code>replace(startIndex: int, endIndex: int, s: String)</code></td>
<td>Replaces the characters in this builder from startIndex to endIndex with the specified string.</td>
</tr>
<tr>
<td><code>reverse()</code></td>
<td>Reverses the characters in the builder.</td>
</tr>
<tr>
<td><code>setCharAt(index: int, ch: char)</code></td>
<td>Sets a new character at the specified index in this builder.</td>
</tr>
</tbody>
</table>

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StringBuilder stringBuilder =
    new StringBuilder();
StringBuilder.append("Java");
StringBuilder.insert(2,"HTML and ");
StringBuilder.delete(3, 4);
StringBuilder.deleteCharAt(5);
StringBuilder.reverse();
StringBuilder.replace(4, 8, "HTML");
StringBuilder.setCharAt(0, 'w');
The `toString`, `capacity`, `length`, `setLength`, and `charAt` Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>toString()</code>: String</td>
<td>Returns a string object from the string builder.</td>
</tr>
<tr>
<td><code>capacity()</code>: int</td>
<td>Returns the capacity of this string builder.</td>
</tr>
<tr>
<td><code>charAt(index: int): char</code></td>
<td>Returns the character at the specified index.</td>
</tr>
<tr>
<td><code>length()</code>: int</td>
<td>Returns the number of characters in this builder.</td>
</tr>
<tr>
<td><code>setLength(newLength: int): void</code></td>
<td>Sets a new length in this builder.</td>
</tr>
<tr>
<td><code>substring(startIndex: int): String</code></td>
<td>Returns a substring starting at startIndex.</td>
</tr>
<tr>
<td><code>substring(startIndex: int, endIndex: int): String</code></td>
<td>Returns a substring from startIndex to endIndex-1.</td>
</tr>
<tr>
<td><code>trimToSize()</code>: void</td>
<td>Reduces the storage size used for the string builder.</td>
</tr>
</tbody>
</table>
The Character Class

<table>
<thead>
<tr>
<th>java.lang.Character</th>
</tr>
</thead>
<tbody>
<tr>
<td>+Character(value: char)</td>
</tr>
<tr>
<td>+charValue(): char</td>
</tr>
<tr>
<td>+compareTo(anotherCharacter: Character): int</td>
</tr>
<tr>
<td>+equals(anotherCharacter: Character): boolean</td>
</tr>
<tr>
<td>+isDigit(ch: char): boolean</td>
</tr>
<tr>
<td>+isLetter(ch: char): boolean</td>
</tr>
<tr>
<td>+isLetterOrDigit(ch: char): boolean</td>
</tr>
<tr>
<td>+isLowerCase(ch: char): boolean</td>
</tr>
<tr>
<td>+isUpperCase(ch: char): boolean</td>
</tr>
<tr>
<td>+toLowerCase(ch: char): char</td>
</tr>
<tr>
<td>+toUpperCase(ch: char): char</td>
</tr>
</tbody>
</table>

Constructs a character object with char value
Returns the char value from this object
Compares this character with another
Returns true if this character equals to another
Returns true if the specified character is a digit
Returns true if the specified character is a letter
Returns true if the character is a letter or a digit
Returns true if the character is a lowercase letter
Returns true if the character is an uppercase letter
Returns the lowercase of the specified character
Returns the uppercase of the specified character
equals and compareTo

Character charObject = new Character('b');

carObject.equals(new Character('b'))
returns true

carObject.equals(new Character('d'))
returns false

carObject.compareTo(new Character('a'))
returns 1

carObject.compareTo(new Character('b'))
returns 0

carObject.compareTo(new Character('c'))
returns -1

carObject.compareTo(new Character('d'))
returns -2
Designing Classes

- Coherence: A class should describe a single entity

- Separating responsibilities: A single entity with too many responsibilities can be broken into several classes to separate responsibilities

- Reuse: Classes are designed for reuse!
Designing Classes

- Follow standard Java programming style and naming conventions:
  - Choose informative names for classes, data fields, and methods
  - Place the data declaration before the constructor, and place constructors before methods.
  - Provide a public no-arg constructor and override the `equals` method and the `toString` method (returns a `String`) whenever possible