BBM 102 – Introduction to Programming II

Spring 2018

Introduction to Java &

Introduction to Object Orientation

Today

- **Introduction to Java**
  - Java as a Platform
  - Your First Java Program
  - Basic Programming Elements
- **Object Oriented Paradigm**
  - Principles of Object Orientation
  - Classes and Objects
  - Sample Object Designs

What is Java?

- *An **island** of Indonesia lying between the Indian Ocean and the Java Sea.*

What is Java?

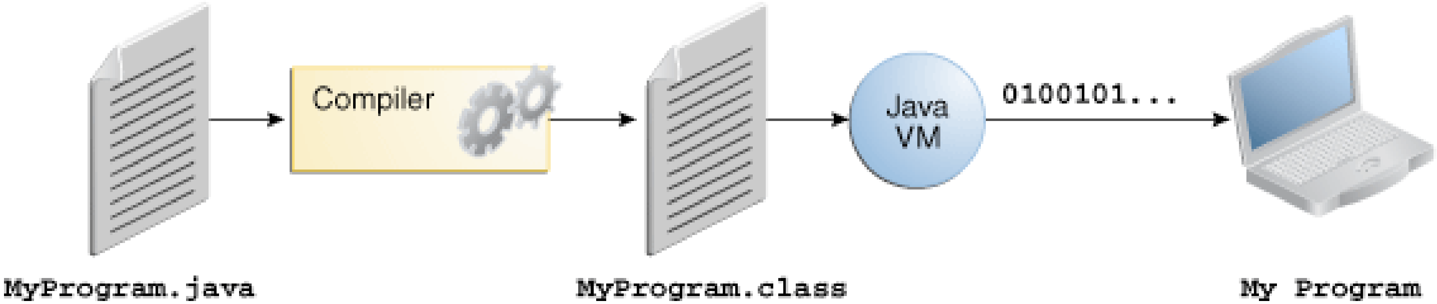
- *Informal. Brewed **coffee**.*

What is Java?

- A technology which is both a programming language and a platform.
- Developed by Sun Microsystems.
- First public version was released in 1995.

Software Development with Java

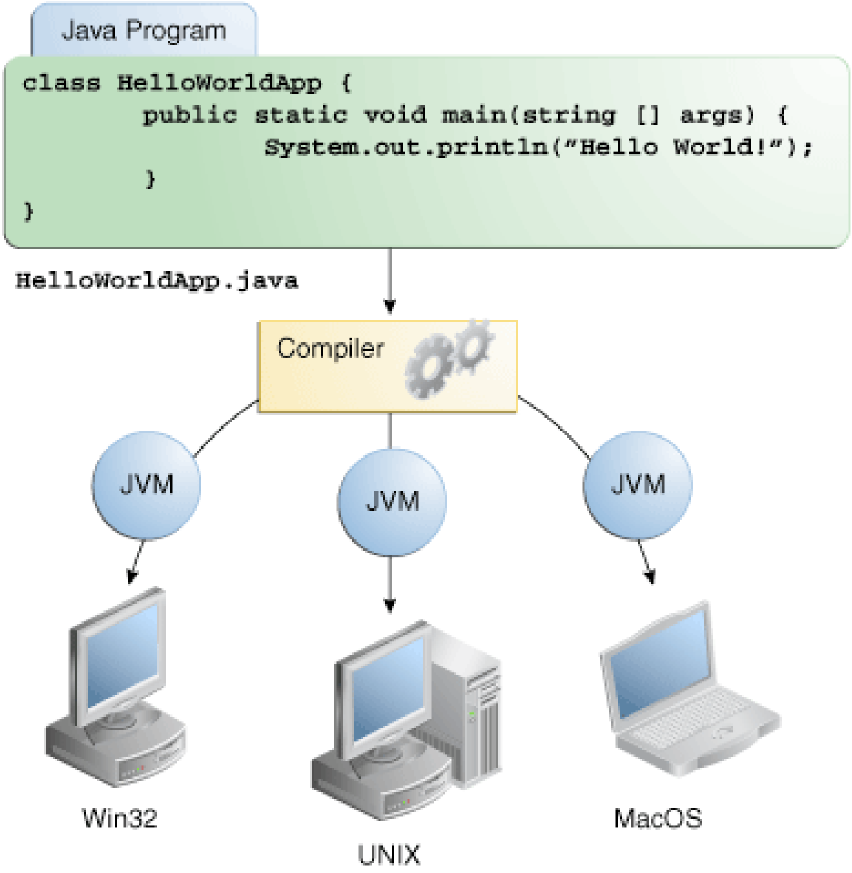
- All source code is first written in plain text files ending with the ".java" extension.
- Those source files are then compiled into ".class" files by the javac compiler.
- A ".class" file does not contain code that is native to your processor; it instead contains *bytecodes* — the machine language of the Java Virtual Machine (Java VM).
- The java launcher tool then runs your application with an instance of the Java Virtual Machine, i.e. your code is run by JVM.



http://docs.oracle.com/javase/tutorial/getStarted/intro/definition.html

Platform Independence:
Write Once Run Anywhere

- Because the Java VM is available on many different operating systems, the same .class files are capable of running on Microsoft Windows, the Solaris™ Operating System (Solaris OS), Linux, or Mac OS.

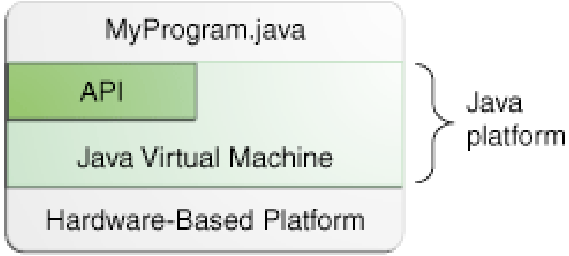


```
class HelloWorldApp {
        public static void main(string [] args) {
                System.out.println("Hello World!");
        }
}
```

http://docs.oracle.com/javase/tutorial/getStarted/intro/definition.html

The Java Platform

- A *platform* is the hardware or software environment in which a program runs.
- The Java platform has two components:
  - ✦The *Java Virtual Machine:* It's the base for the Java platform and is ported onto various hardware-based platforms
  - ✦The *Java Application Programming Interface* (API): It is a large collection of ready-made software components that provide many useful capabilities.



- As a platform-independent environment, the Java platform can be a bit slower than native code.
  - ✦However, advances in compiler and virtual machine technologies are bringing performance close to that of native code without threatening portability.

http://docs.oracle.com/javase/tutorial/getStarted/intro/definition.html

Your First Java Program

HelloWorld.java

```
public class HelloWorld {

      public static void main(String[] args) {
            System.out.println("Hello world!");
      }


}
```

```
$ javac HelloWorld.java ←  Compile
$ java HelloWorld       ←  Run
Hello world!
```

Basic Programming Elements

- Variables, Types and Expressions
- Flow of Control
  - Branching
  - Loops

Variables

- **Variables** in a program are used to store data such as numbers and letters. They can be thought of as containers of a sort.
- You should choose variable names that are helpful. Every variable in a Java program must be declared before it is used for the first time.
- A variable declaration consists of a type name, followed by a list of variable names separated by commas. The declaration ends with a semicolon.

```
Syntax:
data_type variable_name [ = initial_value ];
```

```
int styleNumber, numberOfChecks, numberOfDeposits;
double amount, interestRate;
char answer;
```

Primitive Data Types

Type Name	Kind of Value	Memory Used	Range of Values
byte	Integer	1 byte	-128 to 127
short	Integer	2 bytes	-32,768 to 32,767
int	Integer	4 bytes	-2,147,483,648 to 2,147,483,647
long	Integer	8 bytes	-9,223,372,036,8547,75,808 to 9,223,372,036,854,775,807
float	Floating-point	4 bytes	±3.40282347 × 10+38 to ±1.40239846 × 10−45
double	Floating-point	8 bytes	±1.79769313486231570 × 10+308 to ±4.94065645841246544 × 10−324
char	Single character (Unicode)	2 bytes	All Unicode values from 0 to 65,535
boolean		1 bit	True or false

There are also Class Data Types which we will cover later.

Identifiers

- The technical term for a name in a programming language, such as the name of a variable, is an **identifier.**
- An identifier can contain only letters, digits 0 through 9, and the underscore character “_”.
- The first character in an identifier cannot be a digit.
- There is no limit to the length of an identifier.
- Java is **case sensitive** (e.g., *personName* and *personname* are two different variables).

Identifier	Valid?
`outputStream`	Yes
`4you`	No
`my.work`	No
`FirstName`	Yes
`_tmp`	Yes
`Public`	No

Public is a reserved word.

Java Reserved Words

abstract	assert	boolean	break	byte	case
catch	char	class	const	continue	default
double	do	else	enum	extends	FALSE
final	finally	float	for	goto	if
implements	import	instanceof	int	interface	long
native	new	null	package	private	protected
public	return	short	static	strictfp	super
switch	synchronized	this	throw	throws	transient
TRUE	try	void	volatile	while	

Naming Conventions

- Class types begin with an uppercase letter (e.g. **String**).
- Primitive types begin with a lowercase letter (e.g. **float**).
- Variables of both class and primitive types begin with a lowercase letters (e.g. **firstName**, **classAverage**).
- Multiword names are "punctuated" using uppercase letters.

Assignment Statements

- An assignment statement is used to assign a value to a variable.
- The "equal sign" is called the *assignment operator*
- Syntax:

```
variable_name = expression;
```

where **expression** can be another variable, a *literal* or *constant*, or something to be evaluated by using *operators*.

```
amount = 100;
interestRate = 0.12;
answer = ‘Y’;
fullName = firstName + “ “ + lastName;
```

Initializing Variables

- A variable that has been declared, but not yet given a value is said to be *uninitialized.*
- Uninitialized class variables have the value **null**.
- Uninitialized primitive variables may have a default value.

Data Type	Default Value
byte	0
short	0
int	0
long	0L
float	0.0f
double	0.0d
char	'\u0000'
String (or any object)	null
boolean	FALSE

- It's good practice not to rely on a default value.

Constants

- Literal expressions such as **2, 3.7,** or **'y'** are called *constants*.

- Integer constants can be preceded by a **+** or **-** sign, but cannot contain commas.

- Floating-point constants can be written with digits after a decimal point or using *e notation.*
  - `765000000.0` can be written as `7.65e8`
  - `0.000483` can be written as `4.83e-4`

Imprecision in Floating Point Numbers

- Floating-point numbers often are only approximations since they are stored with a finite number of bits.

- Hence **1.0/3.0** is slightly less than 1/3.

- **1.0/3.0 + 1.0/3.0 + 1.0/3.0** is less than 1.

Named Constants

- Java provides a mechanism that allows you to define a variable, initialise it, and moreover fix the variable’s value so that it cannot be changed.

```
public static final Type Variable = Constant;
```

- The convention for naming constants is to use all uppercase letters, with an underscore symbol “_” between words.

```
public static final double PI = 3.14159;
public static final int DAYS_PER_WEEK = 7;
…
float area = PI * r * r ;
int daysInYear = 52 * DAYS_PER_WEEK ;
```

Assignment Compatibility

- Java is *strongly typed.*

- A value of one type can be assigned to a variable of any type further to the right (not to the left):

  byte → short → int → long → float → double

- You can assign a value of type **char** to a variable of type **int**.

Type Conversion (Casting)

- Implicit conversion

```
double doubleVariable = 5;           // 5.0
int intVariable = 5;                 // 5
doubleVariable = intVariable;        // 5.0
```

- Explicit conversion

```
double doubleVariable = 5.0;
int intVariable = doubleVariable ;           // Illegal
int intVariable = (int) doubleVariable ;     // Legal, 5
```

Operators and Precedence

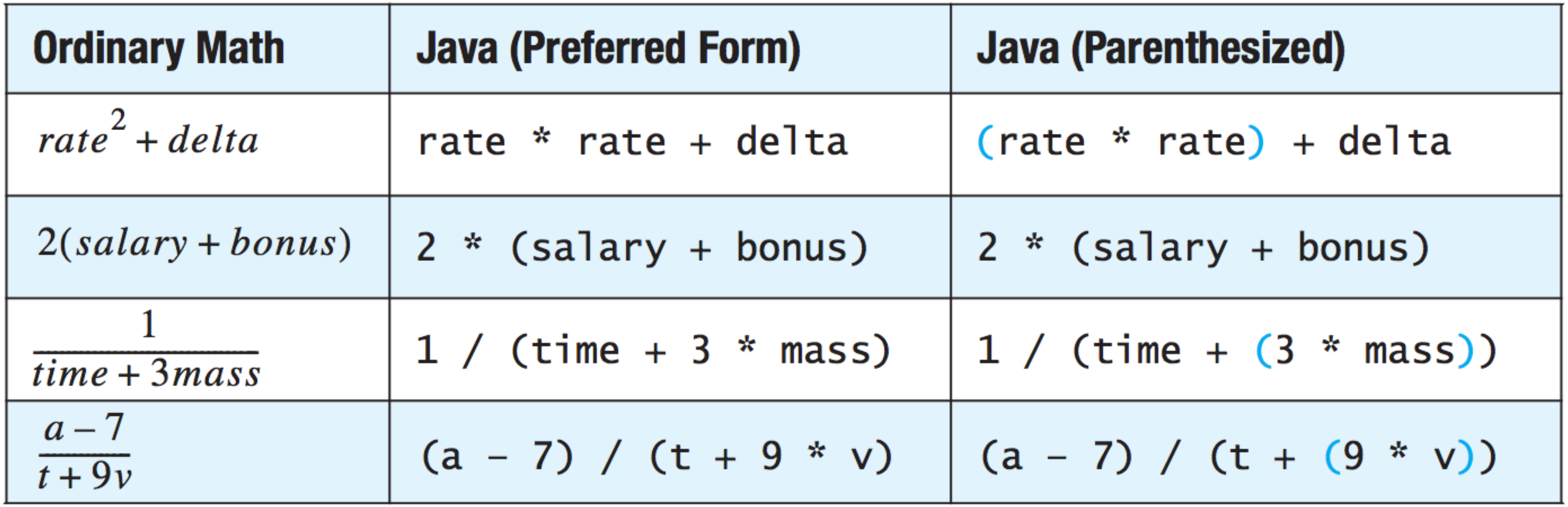
- Precedence
  - First: The unary operators: plus (+), minus(-), not (!), increment (++) and decrement (--)
  - Second: The binary arithmetic operators: multiplication (*), integer division (/) and modulus (%)
  - Third: The binary arithmetic operators: addition (+) and subtraction (-)

- When binary operators have equal precedence, the operator on the left acts before the operator(s) on the right.

- When unary operators have equal precedence, the operator on the right acts before the operation(s) on the left.

- Parenthesis can change the precedence.

Operators and Precedence - Example



Ordinary Math	Java (Preferred Form)	Java (Parenthesized)
$rate^2 + delta$	`rate * rate + delta`	`(rate * rate) + delta`
$2(salary + bonus)$	`2 * (salary + bonus)`	`2 * (salary + bonus)`
$\frac{1}{time + 3mass}$	`1 / (time + 3 * mass)`	`1 / (time + (3 * mass))`
$\frac{a - 7}{t + 9v}$	`(a - 7) / (t + 9 * v)`	`(a - 7) / (t + (9 * v))`

Figure from “Java - An Introduction to Problem Solving and Programming, Walter Savitch, Pearson, 2012”

Arrays

- Array is a sequence of values.
- Array indices begin at zero.
- Defining Arrays

```
Base_Type[] Array_Name = new Base_Type[Length];
```

```
int[] numbers = new int[100];           // or,
```

```
int[] numbers;
numbers = new int[100];
```

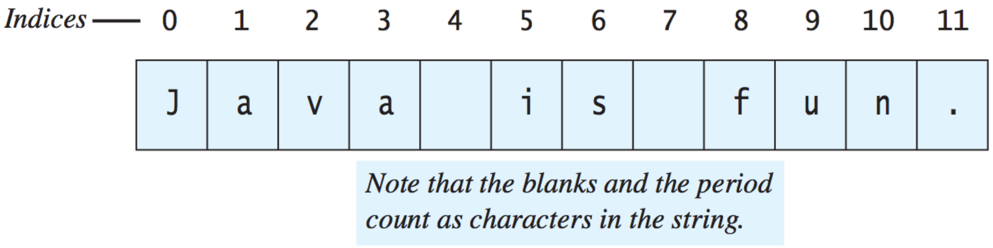
- Initialising Arrays

```
double[] reading = {3.3, 15.8, 9.7};    // or,
```

```
double[] reading = new double[3];
reading[0] = 3.3;
reading[1] = 15.8;
reading[2] = 9.7;
```

Strings

- A value of type **String** is a
  - Sequence (Array) of characters treated as a single item
  - Character positions start with 0



Indices	0	1	2	3	4	5	6	7	8	9	10	11
	J	a	v	a		i	s		f	u	n	.

Note that the blanks and the period count as characters in the string.

- Can be declared in three ways:

```
String greeting;
greeting = "Hello World!”;
```

```
String greeting = "Hello World!”;
```

```
String greeting = new String("Hello World!”);
```

Figure from “Java - An Introduction to Problem Solving and Programming, Walter Savitch, Pearson, 2018”

Concatenating Strings

- You can connect—or join or paste—two strings together to obtain a larger string. This operation is called **concatenation** and is performed by using the “+” operator.

```
String greeting, sentence;
greeting = "Hello”;

sentence = greeting + “ my friend!”;
System.out.println(sentence);     // Hello my friend!
```

```
String solution = “The answer is ” + 42;
System.out.println(solution);     // The answer is 42

// Java converts the number constant 42 to the
// string constant "42" and then concatenates the
// two strings
```

String Methods

- **Homework**: Investigate the methods given below. You will be responsible in the exams.

charAt (Index)	length()
compareTo(A_String)	replace(OldChar, NewChar)
concat(A_String)	substring(Start)
equals(Other_String)	substring(Start,End)
equalsIgnoreCase(Other_String)	toLowerCase()
indexOf(A_String)	toUpperCase()
lastIndexOf(A_String)	trim()

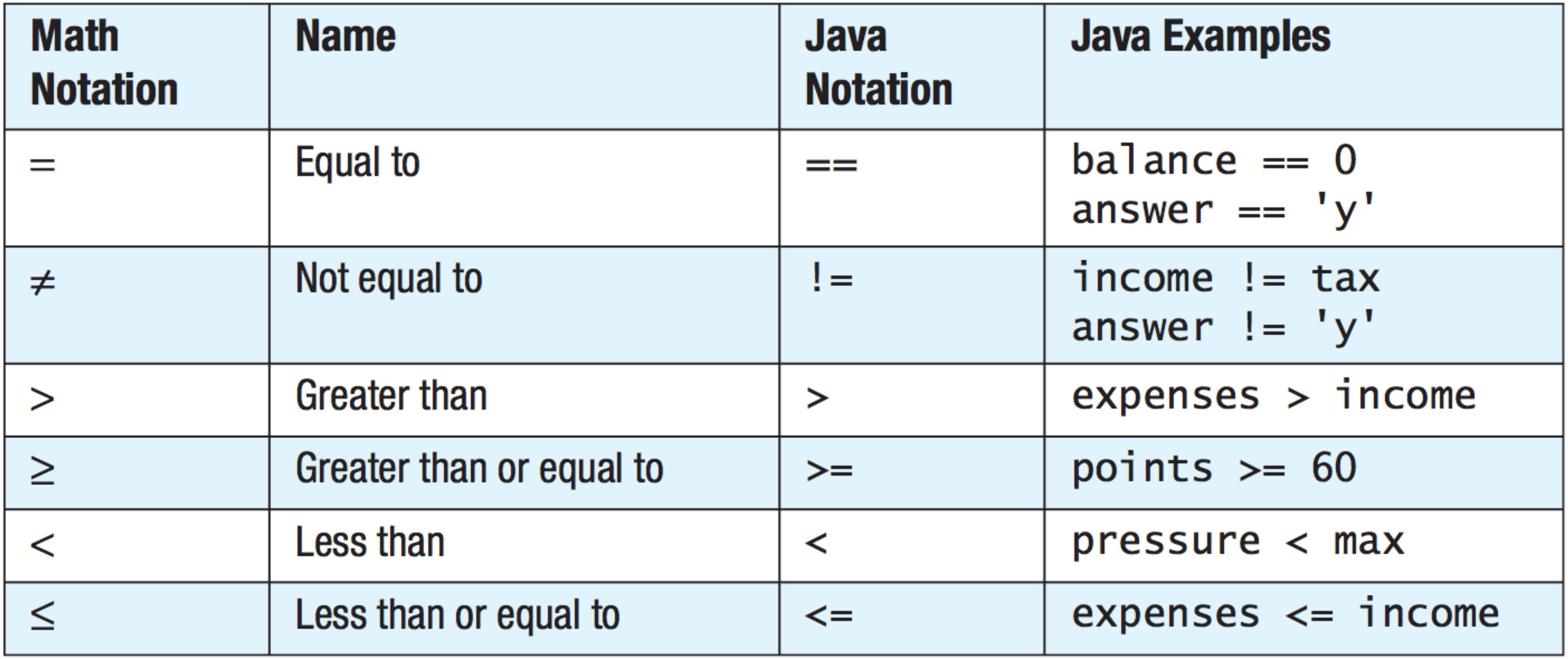
Boolean Type

- Java has the logical type boolean

- Type boolean has two literal constants
  - true
  - false

```
int number = -5;
boolean isPositive = (number > 0);        // False
```

Java Comparison Operators



Math Notation	Name	Java Notation	Java Examples

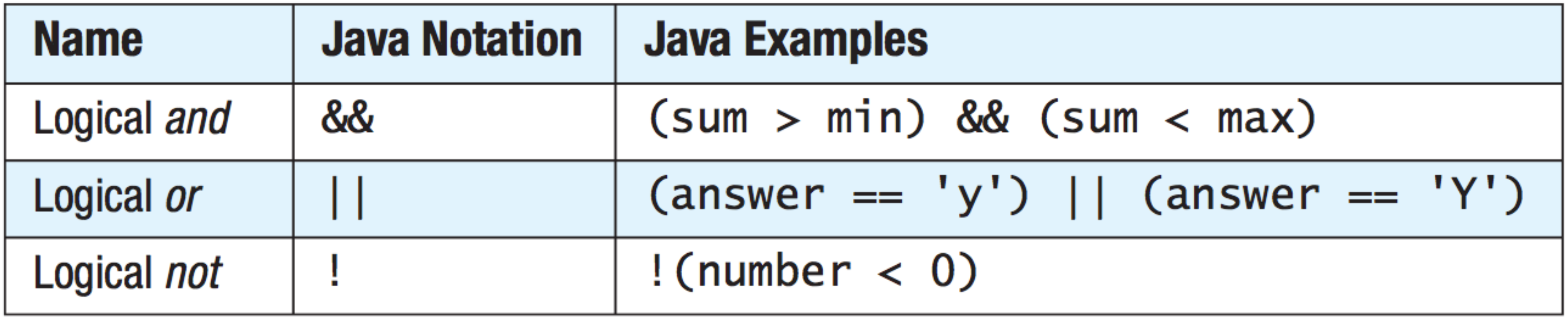
=	Equal to	`==`	`balance == 0`
			`answer == 'y'`

≠	Not equal to	`!=`	`income != tax`
			`answer != 'y'`

>	Greater than	`>`	`expenses > income`
≥	Greater than or equal to	`>=`	`points >= 60`
<	Less than	`<`	`pressure < max`
≤	Less than or equal to	`<=`	`expenses <= income`

Figure from “Java - An Introduction to Problem Solving and Programming, Walter Savitch, Pearson, 2012”

Java Logical Operators



Name	Java Notation	Java Examples
Logical *and*	&&	`(sum > min) && (sum < max)`
Logical *or*	||	`(answer == 'y') || (answer == 'Y')`
Logical *not*	!	`!(number < 0)`

Figure from “Java - An Introduction to Problem Solving and Programming, Walter Savitch, Pearson, 2012”

Flow of Control

- *Flow of control* is the order in which a program performs actions.

- A *branching statement* chooses between two or more possible actions.
  - If-else, switch statements

- A *loop statement* repeats an action until a stopping condition occurs.
  - For, while, do-while loops

Basic if Statement

- Syntax

```
if (Expression)
   Action
```

- If the *Expression* is true then execute *Action*
- *Action* is either a single statement or a group of statements within braces

```
if (value2 < value1) {     // Rearrange numbers so
       int tmp = value1;   // value2 variable should
       value1 = value2;    // hold the bigger value
       value2 = tmp;
}
```

if-else Statement

- Syntax

```
if (Expression)
   Action1
else
   Action2
```

- If *Expression* is true then execute *Action1* otherwise execute *Action2*
- The actions are either a single statement or a list of statements within braces

```
int maximum;
if (value1 < value2) {    // is value2 larger?
   maximum = value2;      // yes: value2 is larger
}
else {                    // (value1 >= value2)
   maximum = value1;      // no: value2 is not larger
}
```

if-else-if Statement

- If statements can be nested (also called as multi-way, multi-branch if statement)

```
if (a == ‘0’)
       System.out.println (“zero”);
else if (a == ‘1’)
       System.out.println (“one”);
else if (a == ‘2’)
       System.out.println (“two”);
else if (a == ‘3’)
       System.out.println (“three”);
else if (a == ‘4’)
       System.out.println (“four”);
else
       System.out.println (“five+”);
```

Switch Statement

- Switch statement can be used instead of multi-way if statement.
- Syntax

```
switch(controlling_expression) {
      case expression1:
            action1;
            break;
      case expression2:
            action2;
            break;
      …
      default:
            actionN;
}
```

- Every case ends with *break* statement.

Switch Statement

- Switch statements are more readable than nested if statements

```
switch (a) {
    case ‘0’:
        System.out.println (“zero”); break;
    case ‘1’:
        System.out.println (“one”); break;
    case ‘2’:
        System.out.println (“two”); break;
    case ‘3’:
        System.out.println (“three”); break;
    case ‘4’:
        System.out.println (“four”); break;
    default:
        System.out.println (“five+”); break;
}
```

The Conditional (Ternary) Operator

- The **?** and **:** together are called the *conditional operator* or *ternary operator.*

```
if (n1 > n2)
   max = n1;
else
   max = n2;
```

can be written as:

```
max = (n1 > n2) ? n1 : n2;
```

for Loops

- The for loop is a pretest loop statement. It has the following form.

```
for (initialisation; boolean-expression; increment){
    nested-statements
}
```

- *initialisation* is evaluated first.
- *boolean-expression* is tested *before* each iteration of the loop.
- *increment* is evaluated at the end of each iteration.
- *nested-statements* is a sequence of statements. If there is only one statement then the braces may be omitted

Varying Control Variable

- for (int i = 1; i <= 100; i++)
  - from 1 to 100 in increments of 1

- for (int i = 100; i >= 1; i--)
  - from 100 to 1 in increments of -1

- for (int i = 7; i <= 77; i += 7)
  - from 7 to 77 in increments of 7

- for (int i = 20; i >= 2; i -= 2)
  - from 20 to 2 in decrements of 2

For Loop Example

```
String[] classList = {"Jean", "Claude", "Van",
                              "Damme"};

for (int i=0; i<classList.length; i++) {
      System.out.println(classList[i]);
}
```

```
Jean
Claude
Van
Damme
```

```
for (String name : classList) {
      System.out.println(name);
}
```

```
Jean
Claude
Van
Damme
```

While Loop

- The while loop is a pretest loop statement. It has the following form.

```
while (boolean-expression) {
      nested-statements
}
```

- *boolean-expression* is an expression that can be true or false.

- *nested-statements* is a sequence of statements. If there is only one statement then the braces can be omitted.

- The boolean expression is tested *before* each iteration of the loop. The loop terminates when it is false.

While Loop Example

```
int[] numbers = { 1, 5, 3, 4, 2 };
int i=0, key = 33;

boolean found = false;

while (!found){
      if (numbers[i++] == key)
            found=true;
}

if (found)
      System.out.println("Key is found in the array");
else
      System.out.println("Key is NOT found!");
```

Let’s look for something that does not exist.

Is there a problem here?

While Loop Example

```
int[] numbers = { 1, 5, 3, 4, 2 };
int i=0, key = 33;

boolean found = false;

while (!found && i<numbers.length){
      if (numbers[i++] == key)
            found=true;
}

if (found)
      System.out.println("Key is found in the array");
else
      System.out.println("Key is NOT found!");
```

Make sure that the loop ends somehow.

Figure from “Java - An Introduction to Problem Solving and Programming, Walter Savitch, Pearson, 2012”

Do-While Loop

- The do-while loop is a post-test loop statement. It has the following form.

```
do {
      nested-statements
} while (boolean-expression);
```

- *nested-statements* is a sequence of statements. If there is only one statement then the braces may be omitted.
- *boolean-expression* is an expression that can be true or false.
- The boolean expression is tested *after* each iteration of the loop. The loop terminates when it is false.

Do-While Example

```
Scanner scan = new Scanner(System.in);
int myNumber;

do {
      System.out.println(
            "Enter a number between 0 and 100: ");

      myNumber = scan.nextInt();

} while (!(myNumber >= 0 && myNumber <= 100));

System.out.println("You entered a valid number");
```

Break Statement

- The break statement is used in loop (for, while, and do-while) statements and switch statements to terminate execution of the statement. A break statement has the following form.

```
break;
```

- After a break statement is executed, execution proceeds to the statement that follows the enclosing loop or switch statement.

- Use **`break`** statements sparingly (if ever).

Continue Statement

- A **continue** statement
  - Ends current loop iteration
  - Begins the next one

- Use of continue statement is not recommended
  - Introduce unneeded complications

Breaking a Loop

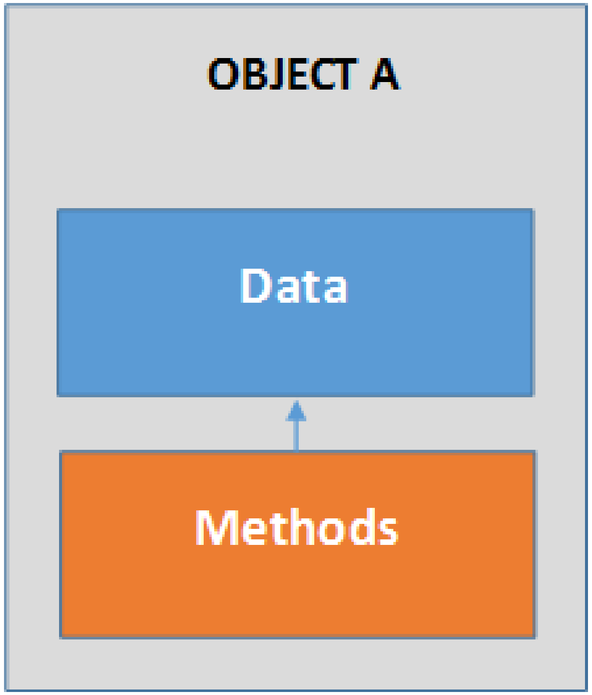
```
int[] numbers = { 1, 5, 3, 4, 2 };
int i = 0, key = 3;

while (i < numbers.length) {
      if (numbers[i] == key)
            break;
      i++;
}

if (i < numbers.length)
      System.out.println("Key is found in the array");
else
      System.out.println("Key is NOT!");
```

Object-Oriented Paradigm

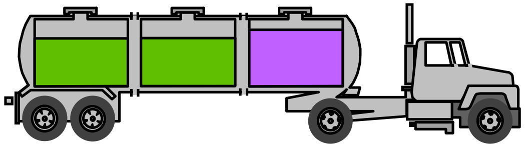
- Centered on the concept of the object
- Object
  - Is data with methods
    - Data (**attributes**) can be simple things like number or character strings, or they can be other objects.
  - Defines things that are responsible for themselves
    - Data to know what state the object is in.
    - **Method** (code) to function properly.



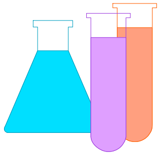
What is an Object?

- Informally, an object represents an entity which is either physical, conceptual or software.

  - Physical entity
  - Conceptual entity
  - Software entity

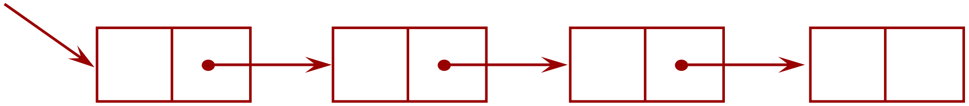


Truck



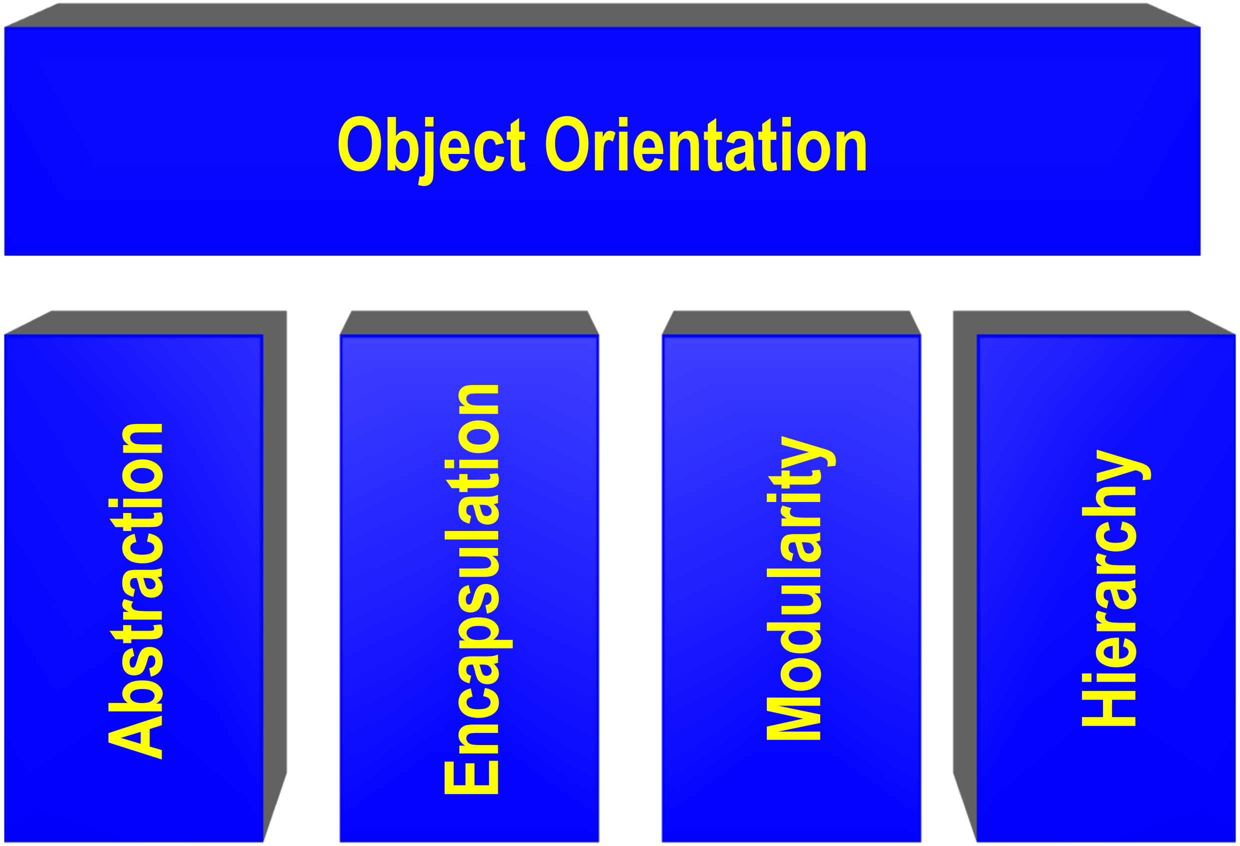
Chemical Process

Bank Account



Linked List

Basic Principles of Object Orientation



What is Abstraction?

Abstraction is one of the fundamental ways that we as humans cope with complexity.

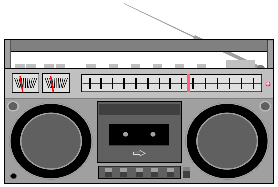
Salesperson

Not saying

which salesperson

just a salesperson in general!

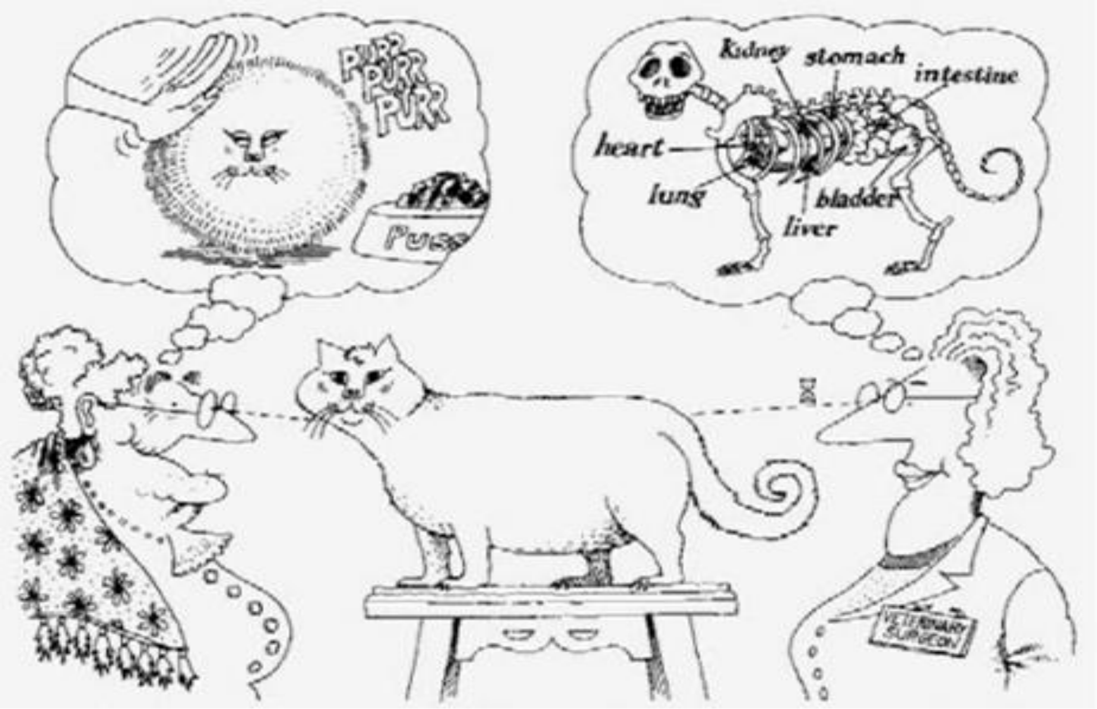
Customer



Product

Dahl, Dijkstra, and Hoare suggest that “abstraction arises from a recognition of similarities between certain objects, situations, or processes in the real world, and the decision to *concentrate upon these similarities and to ignore for the time being the differences*”.

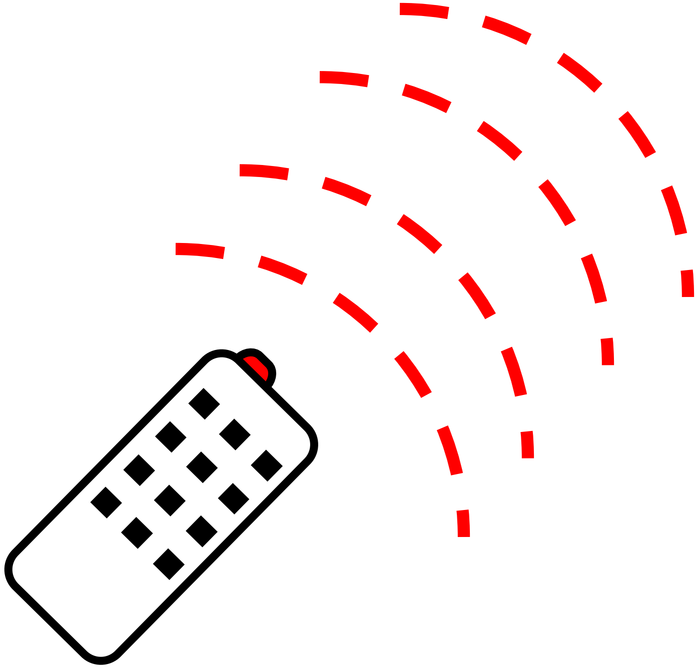
What is Abstraction?

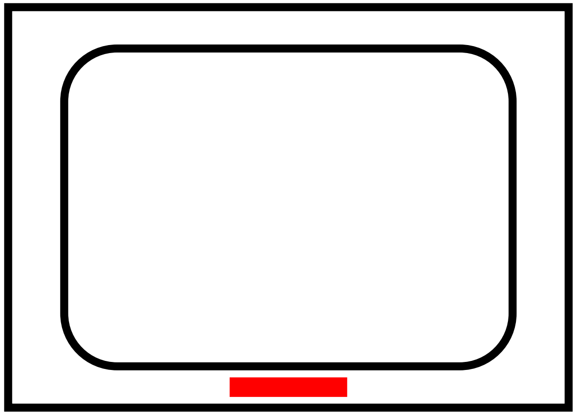


Abstraction focuses upon the essential characteristics of some object, relative to the perspective of the viewer.

What is Encapsulation?

- Hide implementation from clients
  - Clients depend on interface

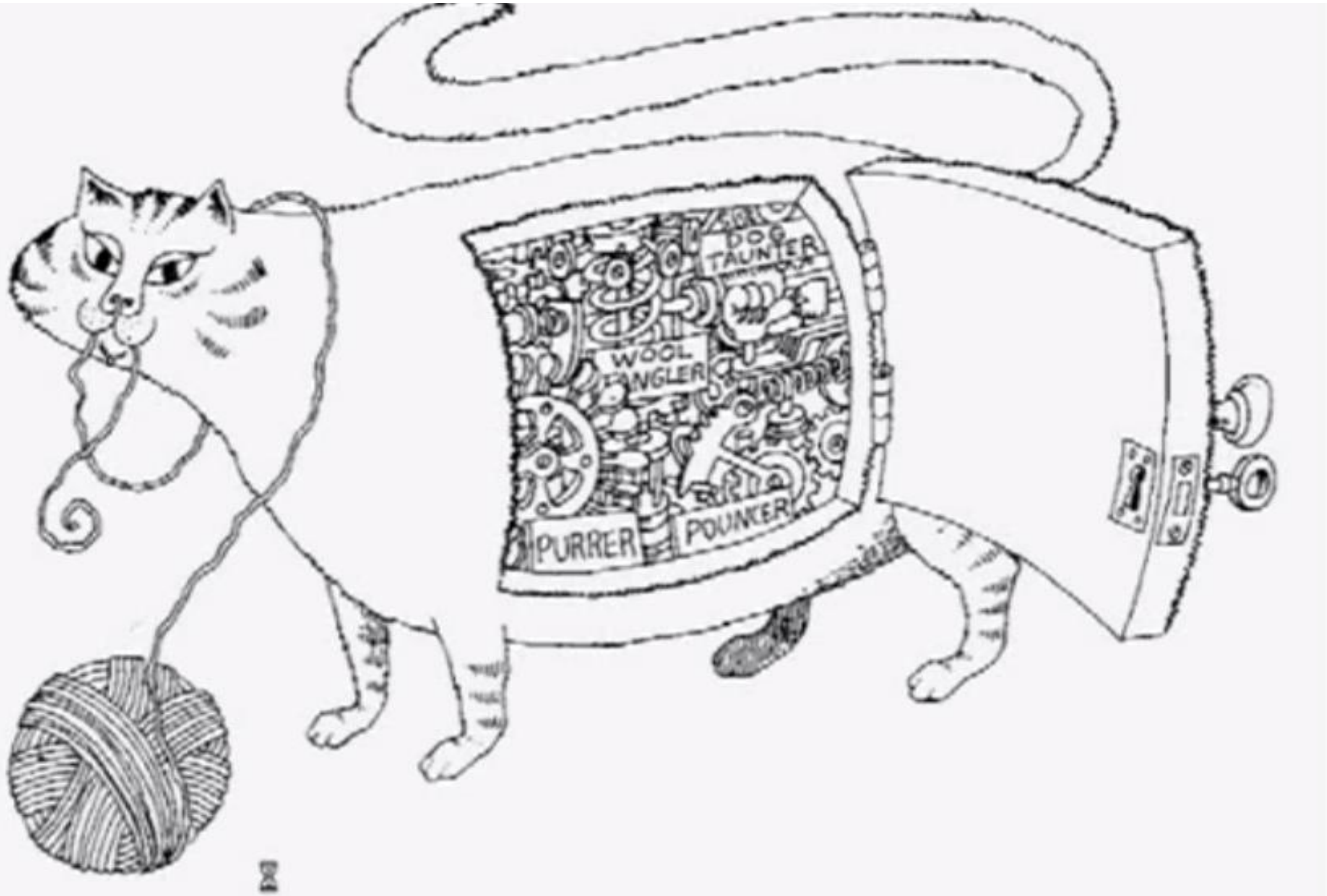




Information Hiding:
How does an object encapsulate?
What does it encapsulate?

Abstraction and encapsulation are complementary concepts: Abstraction focuses on the observable behavior of an object, whereas encapsulation focuses on the implementation that gives rise to this behavior.

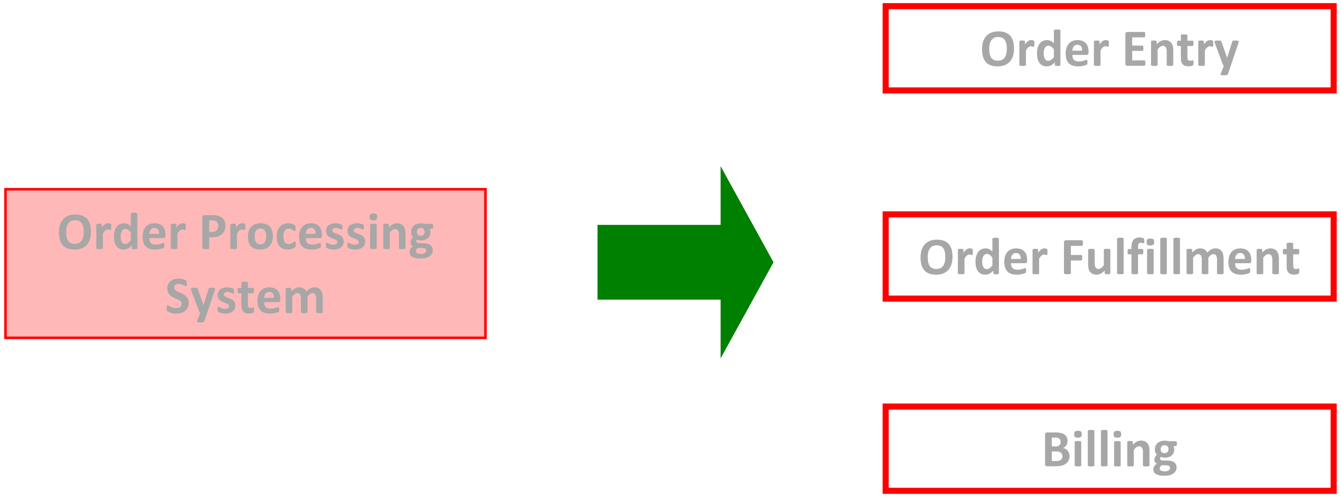
What is Encapsulation?



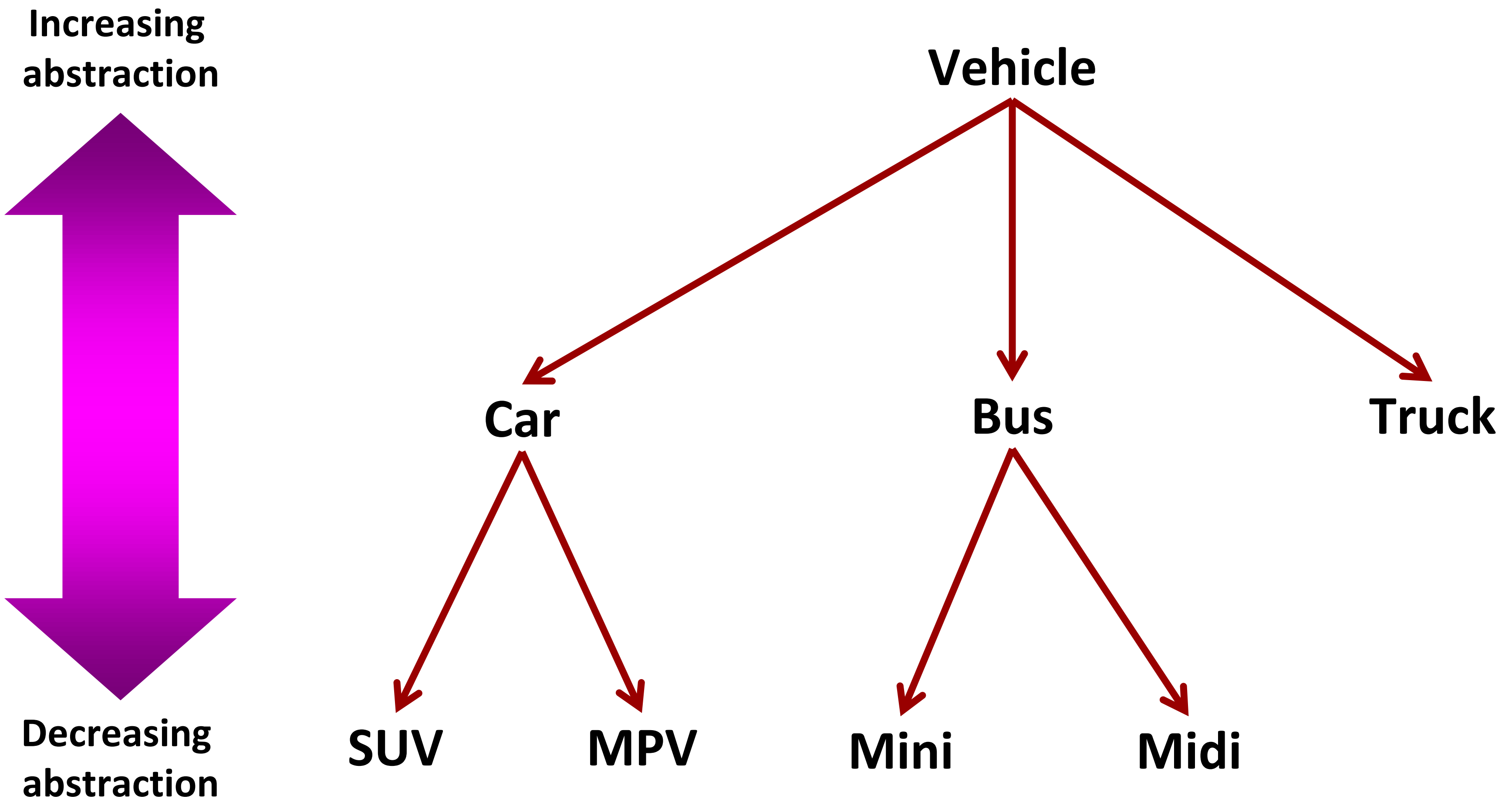
Encapsulation hides the details of the implementation of an object.

What is Modularity?

- The breaking up of something complex into manageable pieces.



What is Hierarchy?



Elements at the same level of the hierarchy should be at the same level of abstraction.

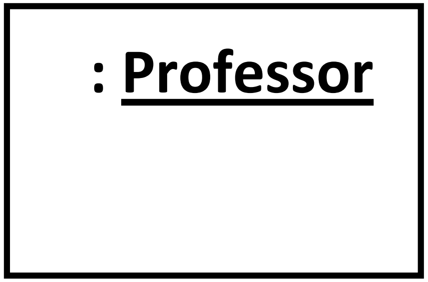
What is Really an Object?

- Formally, an object is a concept, abstraction, or thing with sharp boundaries and meaning for an application.

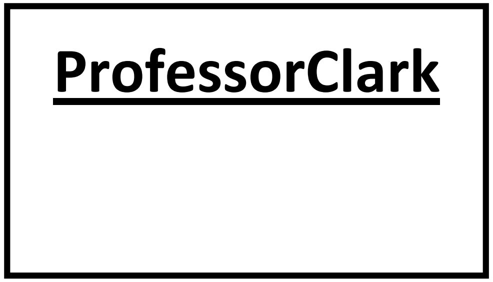
- An object is something that has:
  - State (property, attribute)
  - Behavior (operation, method)
  - Identity

Representing Objects

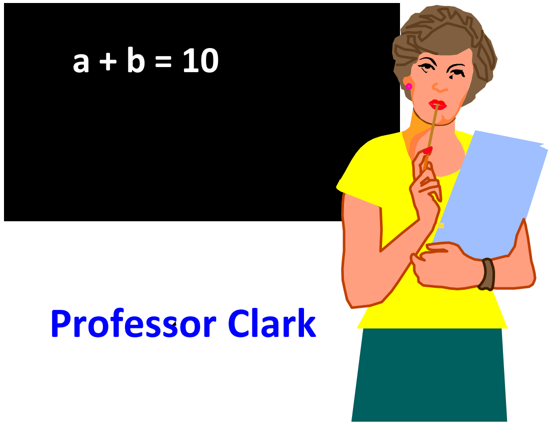
- An object is represented as rectangles with underlined names.

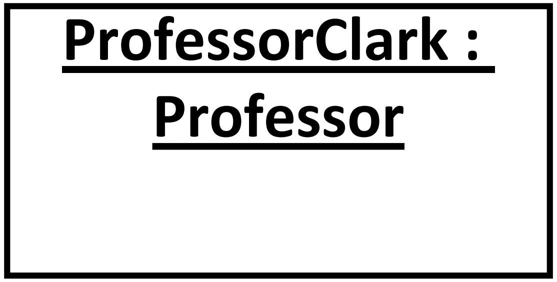


Class Name Only



Object Name Only





Class and Object Name

What is a Class?

- A class is a description of a group of objects with common properties (attributes), behavior (operations), relationships, and semantics
  - An object is an instance of a class

- A class is an abstraction in that it:
  - Emphasizes relevant characteristics
  - Suppresses other characteristics

Example Class

Class

Course

Properties

Name

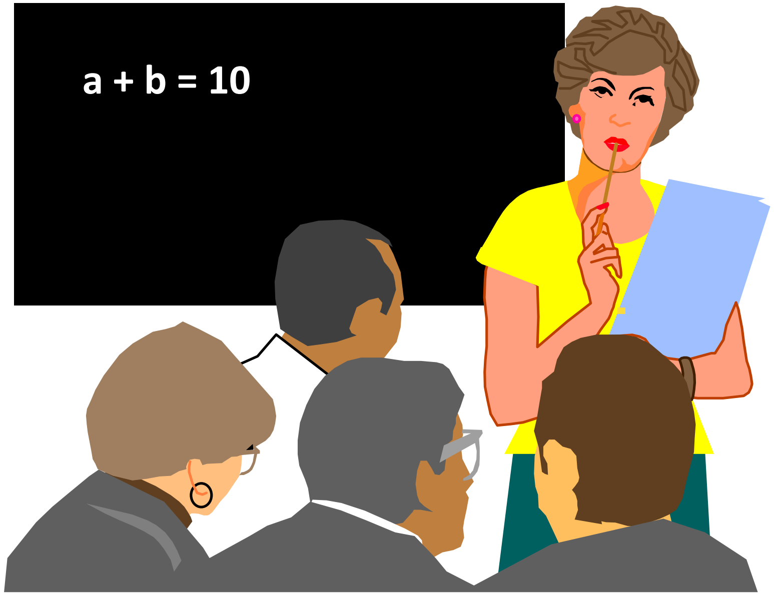
Location

Days offered

Credit hours

Start time

End time



Behavior

Add a student

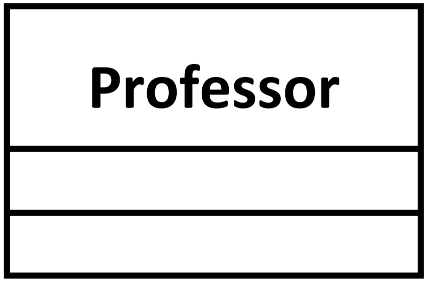
Delete a student

Get course roster

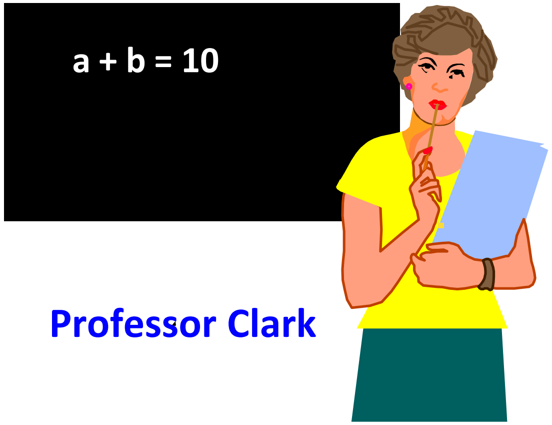
Determine if it is full

Representing Classes

- A class is represented using a compartmented rectangle

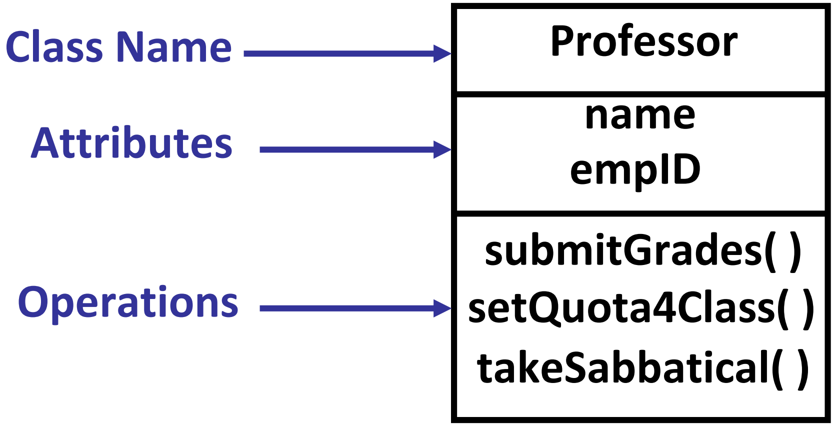


Professor



Class Compartments

- A class is comprised of three sections
  - The first section contains the **class name**
  - The second section shows the **structure** (attributes)
  - The third section shows the **behavior** (operations)



Class Name

Attributes

Operations

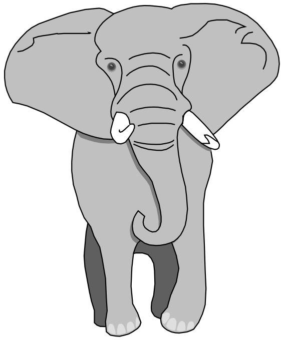
Professor

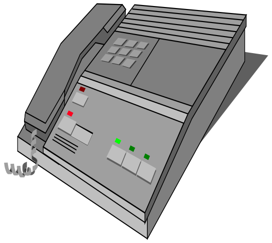
name
empID

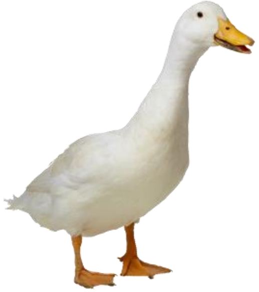
submitGrades( )
setQuota4Class( )
takeSabbatical( )

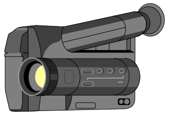
Represented in UML (Unified Modeling Language)

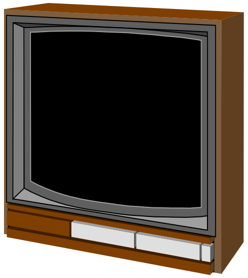
How Many Classes do you See?

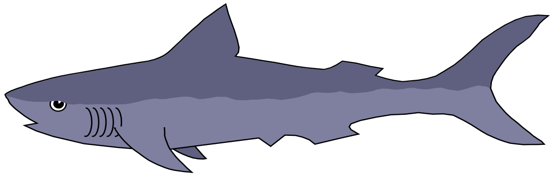






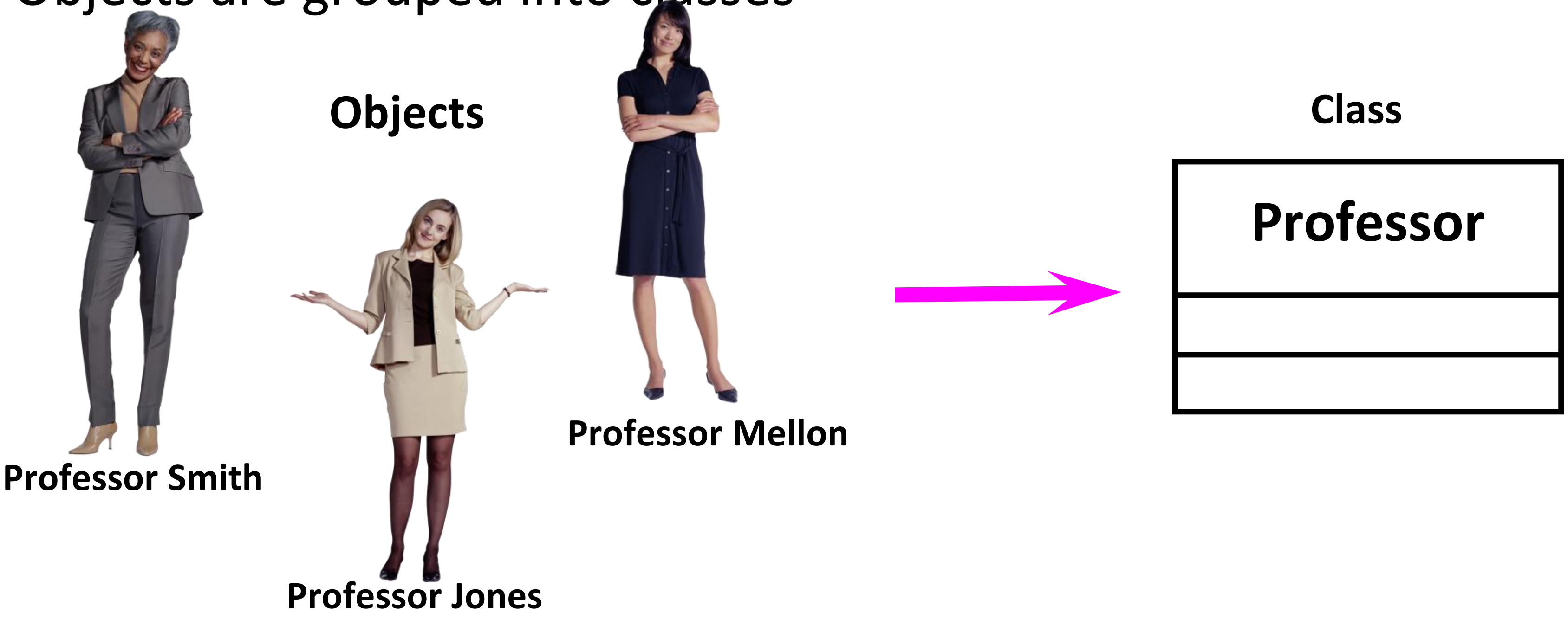






Relationship between Classes and Objects

- A class is an abstract definition of an object
  - It defines the structure and behavior of each object in the class
  - It serves as a template for creating objects
- Objects are grouped into classes



Objects

Class

Professor

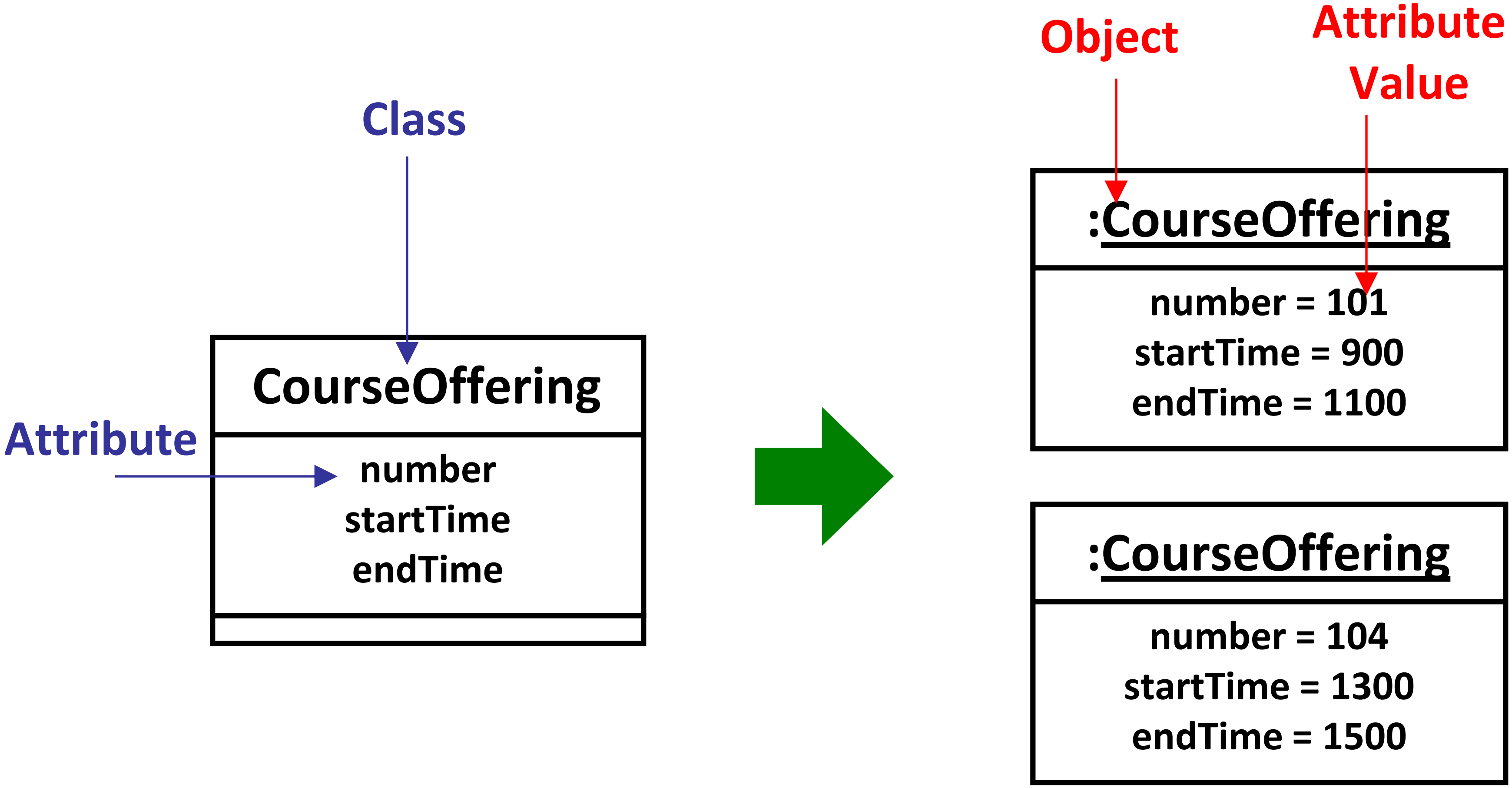
Professor Smith

Professor Mellon

Professor Jones

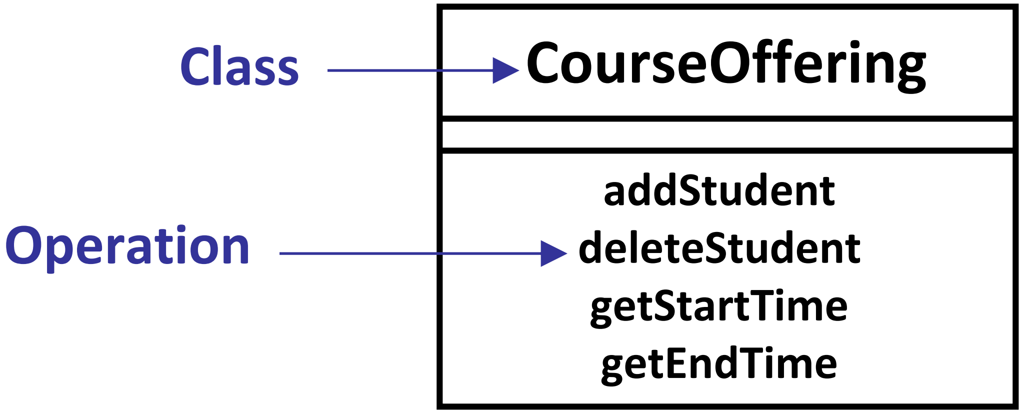
State of an Object (property or attribute)

- The state of an object encompasses all of the (usually static) properties of the object plus the current (usually dynamic) values of each of these properties.



Behavior of an Object (operation or method)

- Behavior is how an object acts and reacts, in terms of its state changes and message passing.



Class

CourseOffering

Operation

addStudent
deleteStudent
getStartTime
getEndTime

Identity of an Object

- Each object has a unique identity, even if the state is identical to that of another object.

Professor "J Clark" teaches Biology

Professor "J Clark" teaches Biology

Sample Class: Automobile

- Attributes
  - manufacturer’s name
  - model name
  - year made
  - color
  - number of doors
  - size of engine

- Methods
  - Define attributes (specify manufacturer’s name, model, year, etc.)
  - Change a data item (color, engine, etc.)
  - Display data items

Sample Class: Circle

- Attributes
  - Radius
  - Center Coordinates
    - X and Y values

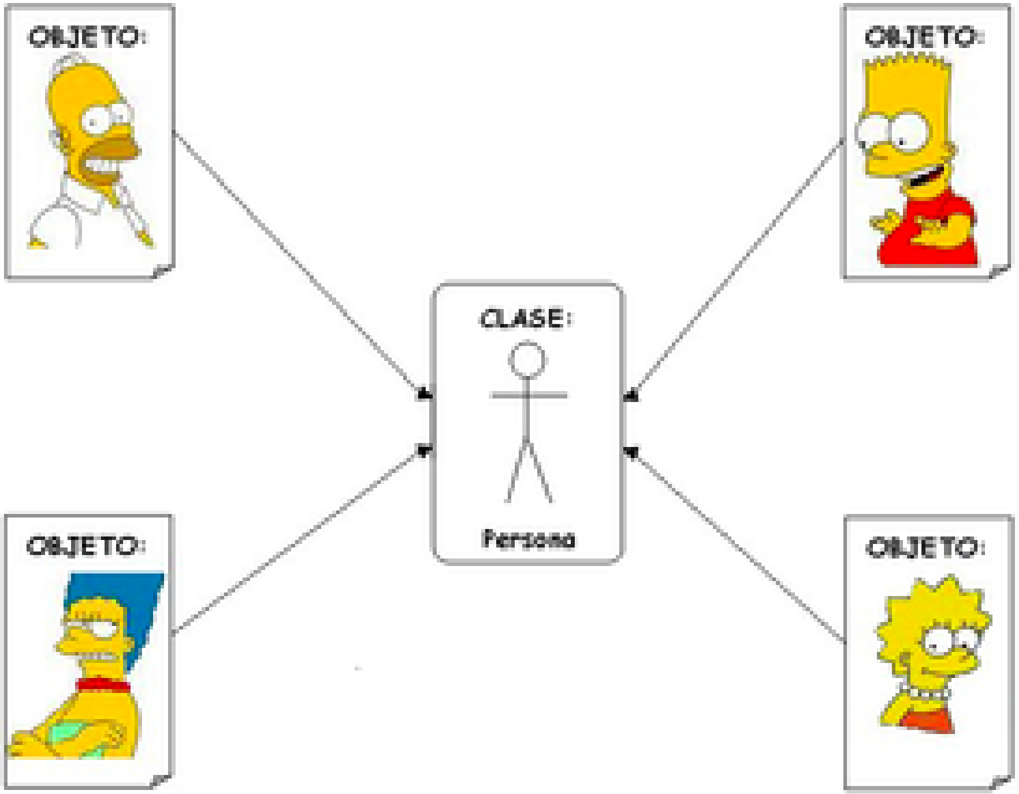
- Methods
  - Define attributes (radius and center coordinates)
  - Find area of the circle
  - Find circumference of the circle

Sample Class: Baby

- Attributes
  - Name
  - Gender
  - Weight
  - Decibel
  - # poops so far

- Methods
  - Get or Set specified attribute value
  - Poop

Sample Class: Person



Summary

- So far, we covered basics of objects and object oriented paradigm.
  - We tried to think in terms of objects.

- From now on, we should be seeing objects everywhere ☺
  - Or, we should be realizing that we were seeing objects everywhere already.
  - This is actually something you do naturally. Why not do programming that way?

- We will continue next week with actually creating objects by using Java.

Acknowledgments

- The course material used to prepare this presentation is mostly taken/adopted from the list below:
  - Software Enginering (9th ed) by I.Sommerville, Pearson, 2011.
  - Object Oriented Analysis and Design with Applications, Grady Booch, Robert A. Maksimchuk, Michael W. Engle, Bobbi J. Young, Jim Conallen and Kelli A. Houston, Addison Wesley, 2007.
  - OOAD Using the UML - Introduction to Object Orientation, v 4.2, 1998-1999 Rational Software
  - Java - An Introduction to Problem Solving and Programming, Walter Savitch, Pearson, 2012.
  - Ku-Yaw Chang, Da-Yeh University.