Objects and Classes -- Introduction

- Now that some low-level programming concepts have been established, we can examine objects in more detail

- Chapter 4 focuses on:
  - the concept of objects
  - the use of classes to create objects
  - using predefined classes
  - defining methods and passing parameters
  - defining classes
  - visibility modifiers
  - static variables and methods
  - method overloading

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Objects

- An object has:
  - *state* - descriptive characteristics
  - *behaviors* - what it can do (or be done to it)

- For example, a particular bank account
  - has an account number
  - has a current balance
  - can be deposited into
  - can be withdrawn from

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Classes

- A *class* is a blueprint of an object
- It is the model or pattern from which objects are created
- A class defines the methods and types of data associated with an object
- Creating an object from a class is called *instantiation*; an object is an *instance* of a particular class
- For example, the `Account` class could describe many bank accounts, but `toms_savings` is a particular bank account with a particular balance

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Creating Objects

- The `new` operator creates an object from a class:

```
Account toms_savings = new Account ();
```

- This declaration asserts that `toms_savings` is a variable that refers to an object created from the `Account` class

- It is initialized to the object created by the `new` operator

- The newly created object is set up by a call to a *constructor* of the class

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Constructors

- A constructor is a special method used to set up an object
- It has the same name as the class
- It can take parameters, which are often used to initialize some variables in the object
- For example, the `Account` constructor could be set up to take a parameter specifying its initial balance:

```
Account toms_savings = new Account (125.89);
```


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Object References

- The declaration of the *object reference* variable and the creation of the object can be separate activities:

```
Account toms_savings;

toms_savings = new Account (125.89);
```

- Once an object exists, its methods can be invoked using the *dot operator*:

```
toms_savings.deposit (35.00);
```


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The String Class

- A character string in Java is an object, defined by the `String` class

```
String name = new String ("Ken Arnold");
```

- Because strings are so common, Java allows an abbreviated syntax:

```
String name = "Ken Arnold";
```

- Java strings are *immutable*; once a string object has a value, it cannot be changed

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The String Class

- A character in a string can be referred to by its position, or *index*
- The index of the first character is zero
- The `String` class is defined in the `java.lang` package (and is therefore automatically imported)
- Many helpful methods are defined in the `String` class
- See `Carpe_Diem.java`

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The StringTokenizer Class

- The `StringTokenizer` class makes it easy to break up a string into pieces called *tokens*
- By default, the *delimiters* for the tokens are the space, tab, carriage return, and newline characters (white space)
- The `StringTokenizer` class is defined in the `java.util` package
- See `Int_Reader.java`

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The Random Class

- A program may need to produce a random number
- The `Random` class provides methods to simulate a *random number generator*
- The `nextInt` method returns a random number from the entire spectrum of `int` values
- Usually, the number must be *scaled* and *shifted* into a particular range to be useful
- See `Flip.java`

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The Random Class

Expression	Range
`Math.abs (rand.newInt()) % 6 + 1`	1 to 6
`Math.abs (rand.newInt()) % 10 + 1`	1 to 10
`Math.abs (rand.newInt()) % 101`	0 to 100
`Math.abs (rand.newInt()) % 11 + 20`	20 to 30
`Math.abs (rand.newInt()) % 11 - 5`	-5 to 5

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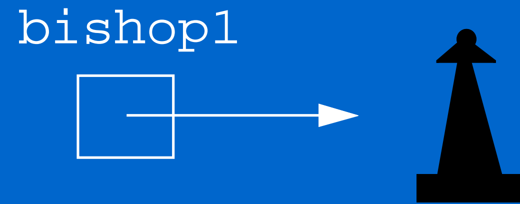
References

- An object reference holds the memory address of an object

```
Chess_Piece bishop1 = new Chess_Piece();
```



- All interaction with an object occurs through a reference variable

- References have an effect on actions such as assignment

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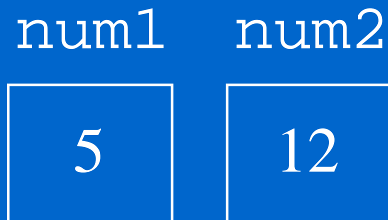
Assignment

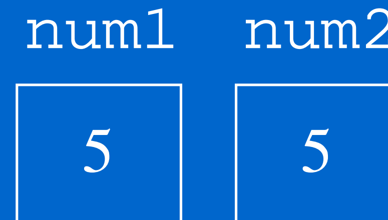
- The act of assignment takes a copy of a value and stores it in a variable
- For primitive types:

```
num2 = num1;
```

Before



After



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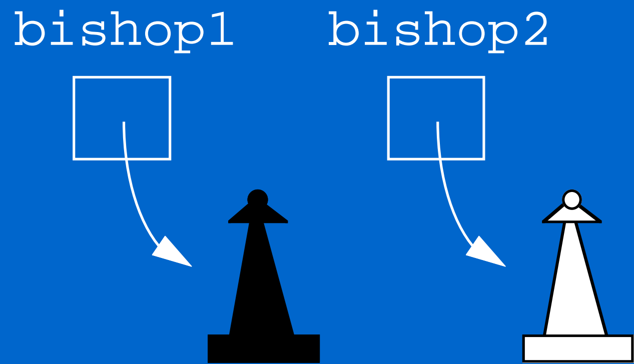
Reference Assignment

- For object references, the value of the memory location is copied:

```
bishop2 = bishop1;
```

<u>Before</u>



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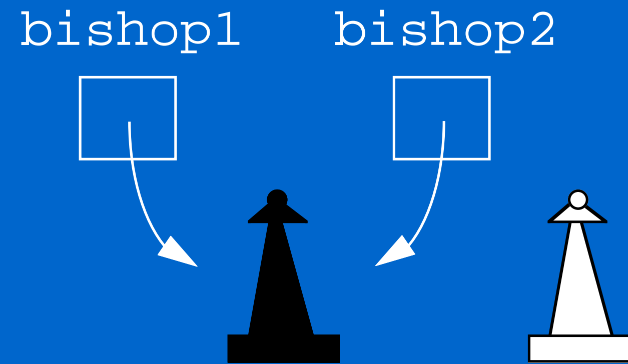

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Aliases

- Two or more references that refer to the same object are called *aliases* of each other
- There is only one copy of the object (and its data), but with multiple ways to access it
- Aliases can be useful, but should be managed carefully
- Affecting the object through one reference affects it for all aliases, because they refer to the same object

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Garbage Collection

- When an object no longer has any valid references to it, it can no longer be accessed by the program
- It is useless, and therefore called *garbage*
- Java performs *automatic garbage collection* periodically, returning an object's memory to the system for future use
- In other languages, the programmer has the responsibility for performing garbage collection

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Methods

- A class contains methods; prior to defining our own classes, we must explore method definitions
- We've defined the `main` method many times
- All methods follow the same syntax:

```
return-type method-name ( parameter-list ) {
    statement-list
}
```


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Methods

- A method definition:

```
int third_power (int number) {
   int cube;
   cube = number * number * number;
   return cube;
}  // method third_power
```


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Methods

- A method may contain *local declarations* as well as executable statements
- Variables declared locally can only be used locally
- The `third_power` method could be written without any local variables:

```
int third_power (int number) {
   return number * number * number;
}  // method third_power
```


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The return Statement

- The *return type* of a method indicates the type of value that the method sends back to the calling location
- A method that does not return a value (such as `main`) has a `void` return type
- The *return statement* specifies the value that will be returned
- Its expression must conform to the return type

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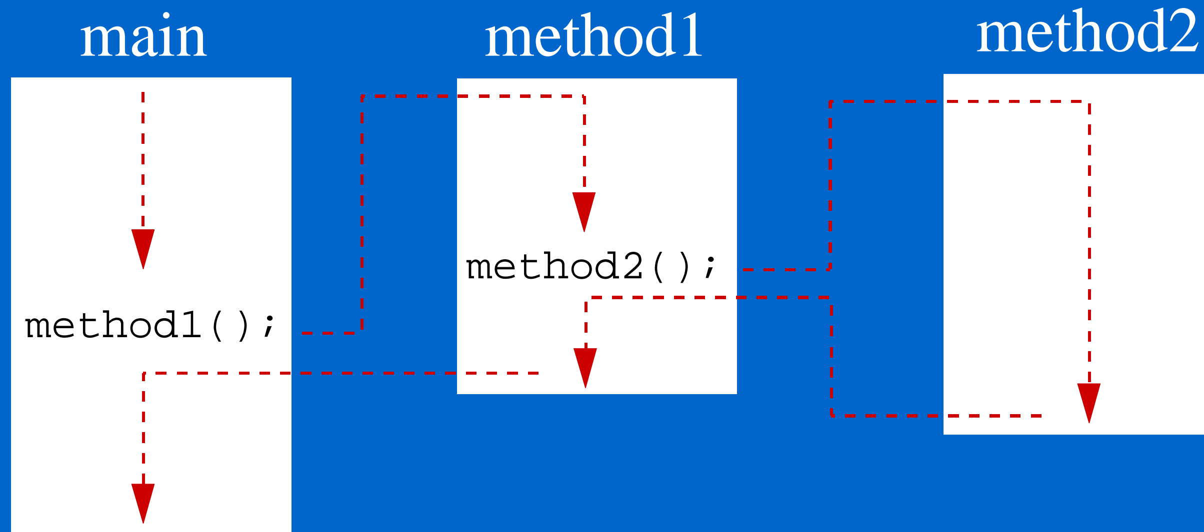
Method Flow of Control

- The `main` method is invoked by the system when you submit the bytecode to the interpreter
- Each method call returns to the place that called it



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Parameters

- A method can be defined to accept zero or more parameters
- Each parameter in the parameter list is specified by its type and name
- The parameters in the method definition are called *formal parameters*
- The values passed to a method when it is invoked are called *actual parameters*

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Parameters

- When a parameter is passed, a copy of the value is made and assigned to the formal parameter
- Both primitive types and object references can be passed as parameters
- When an object reference is passed, the formal parameter becomes an alias of the actual parameter
- See `Parameter_Passing.java`
- Usually, we will avoid putting multiple methods in the class that contains the `main` method

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Defining Classes

- The syntax for defining a class is:

```
class class-name {
    declarations
    constructors
    methods
}
```

- The variables, constructors, and methods of a class are generically called *members* of the class

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Defining Classes

```
class Account {

   int account_number;
   double balance;

   Account (int account, double initial) {
      account_number = account;
      balance = initial;
   }  // constructor Account

   void deposit (double amount) {
      balance = balance + amount;
   }  // method deposit

}  // class Account
```


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Constructors

- A constructor:
  - is a special method that is used to set up a newly created object
  - often sets the initial values of variables
  - has the same name as the class
  - does not return a value
  - has no return type, not even `void`

- The programmer does not have to define a constructor for a class

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Classes and Objects

- A class defines the data types for an object, but a class does not store data values
- Each object has its own unique data space
- The variables defined in a class are called *instance variables* because each instance of the class has its own
- All methods in a class have access to all instance variables of the class
- Methods are shared among all objects of a class

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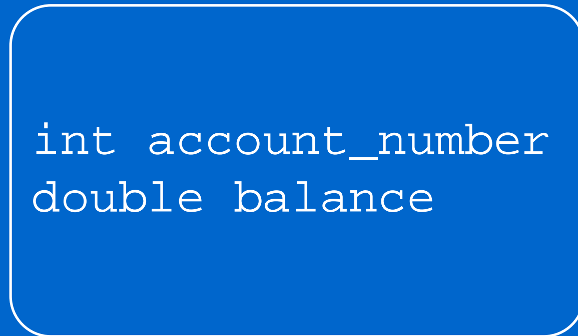
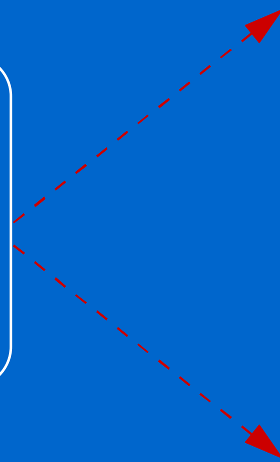
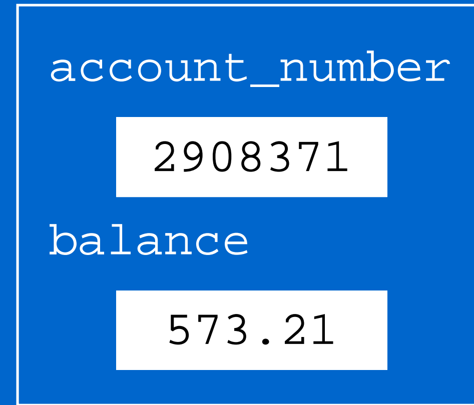
Classes and Objects

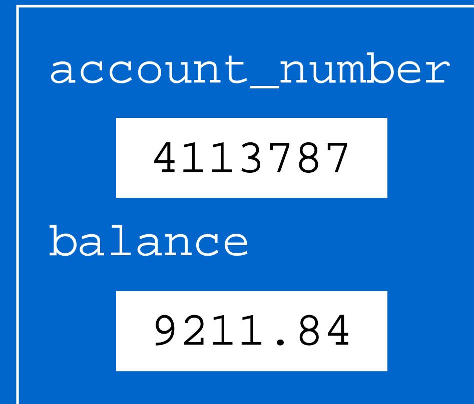
Class





Objects





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Encapsulation

- You can take one of two views of an object:
  - internal - the structure of its data, the algorithms used by its methods
  - external - the interaction of the object with other objects in the program
- From the external view, an object is an *encapsulated* entity, providing a set of specific services
- These services define the *interface* to the object

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Encapsulation

- An object should be self-governing; any changes to the object's state (its variables) should be accomplished by that object's methods
- We should make it difficult, if not impossible, for another object to "reach in" and alter an object's state
- The user, or *client*, of an object can request its services, but it should not have to be aware of how those services are accomplished

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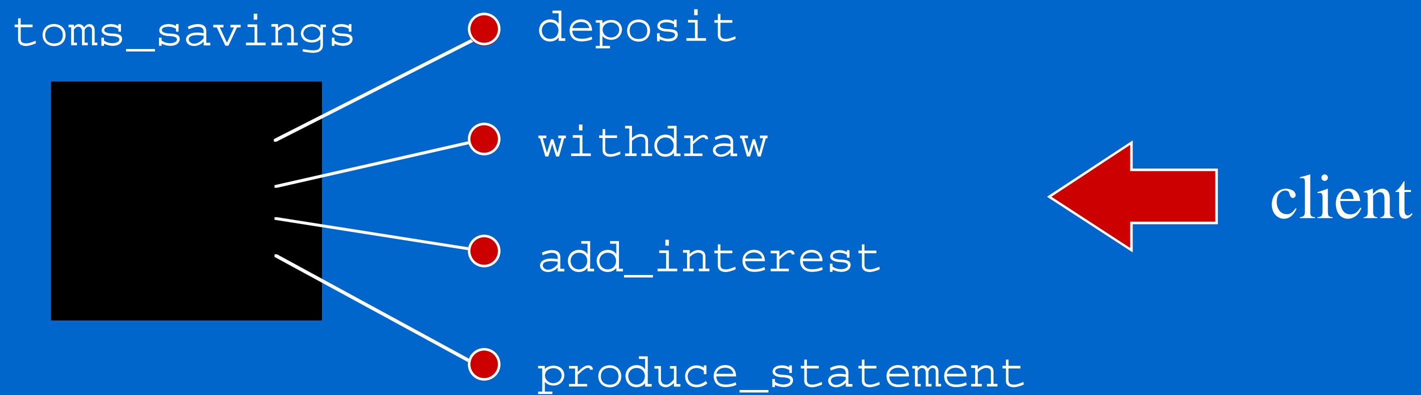
Encapsulation

- An encapsulated object can be thought of as a *black box*; its inner workings are hidden to the client



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Abstraction

- Encapsulation is a powerful abstraction
- An *abstraction* hides the right details at the right time
- We use abstractions every day:
  - driving a car
  - using a computer
- Encapsulation makes an object easy to manage mentally because its interaction with clients is limited to a set of well-defined services

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Visibility Modifiers

- We accomplish encapsulation through the appropriate use of *visibility modifiers*
- A *modifier* is a Java reserved word that specifies particular characteristics of a programming construct
- We've used the modifier `final` to define a constant
- Java has three visibility modifiers: `public`, `private`, and `protected`
- We will discuss the `protected` modifier later

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Visibility Modifiers

- Members of a class that are declared with *public visibility* can be accessed from anywhere
- Members of a class that are declared with *private visibility* can only be accessed from inside the class
- Members declared without a visibility modifier have *default visibility* and can be accessed by any class in the same package
- Java modifiers are discussed in detail in Appendix F

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Visibility Modifiers

- As a general rule, no object's data should be declared with public visibility
- Methods that provide the object's services are usually declared with public visibility so that they can be invoked by clients
- Public methods are also called *service methods*
- Other methods, called *support methods*, can be defined that assist the service methods; they should not be declared with public visibility

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Classes and Objects

- See `Tunes.java`

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The static Modifier

- The `static` modifier can be applied to variables or methods
- It associates a variable or method with the class rather than an object
- This approach is a distinct departure from the normal way of thinking about objects

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Static Variables

- Normally, each object has its own data space
- If a variable is declared as static, only one copy of the variable exists for all objects of the class

```
private static int count;
```

- Changing the value of a static variable in one object changes it for all others
- Static variables are sometimes called *class variables*

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Static Methods

- Normally, we invoke a method through an instance (an object) of a class
- If a method is declared as static, it can be invoked through the class name; no object needs to exist
- For example, the `Math` class in the `java.lang` package contains several static mathematical operations

`Math.abs (num)` -- absolute value

`Math.sqrt (num)` -- square root

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Static Methods

- The `main` method is static; it is invoked by the system without creating an object
- Static methods cannot reference instance variables, because instance variables don't exist until an object exists
- However, they can reference static variables or local variables
- Static methods are sometimes called *class methods*

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Overloaded Methods

- *Method overloading* is the process of using the same method name for multiple methods
- The *signature* of each overloaded method must be unique
- The signature is based on the number, type, and order of the parameters
- The compiler must be able to determine which version of the method is being invoked by analyzing the parameters
- The return type of the method is <u>not</u> part of the signature

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Overloaded Methods

- The `println` method is overloaded:

```
println (String s)
println (int i)
println (double d)
```

etc.

- The lines

```
System.out.println ("The total is:");
System.out.println (total);
```

invoke different versions of the `println` method

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Overloaded Methods

- Constructors are often overloaded to provide multiple ways to set up a new object

```
Account (int account) {
   account_number = account;
   balance = 0.0;
}   // constructor Account

Account (int account, double initial) {
   account_number = account;
   balance = initial;
}  // constructor Account
```

- See `Casino.java`

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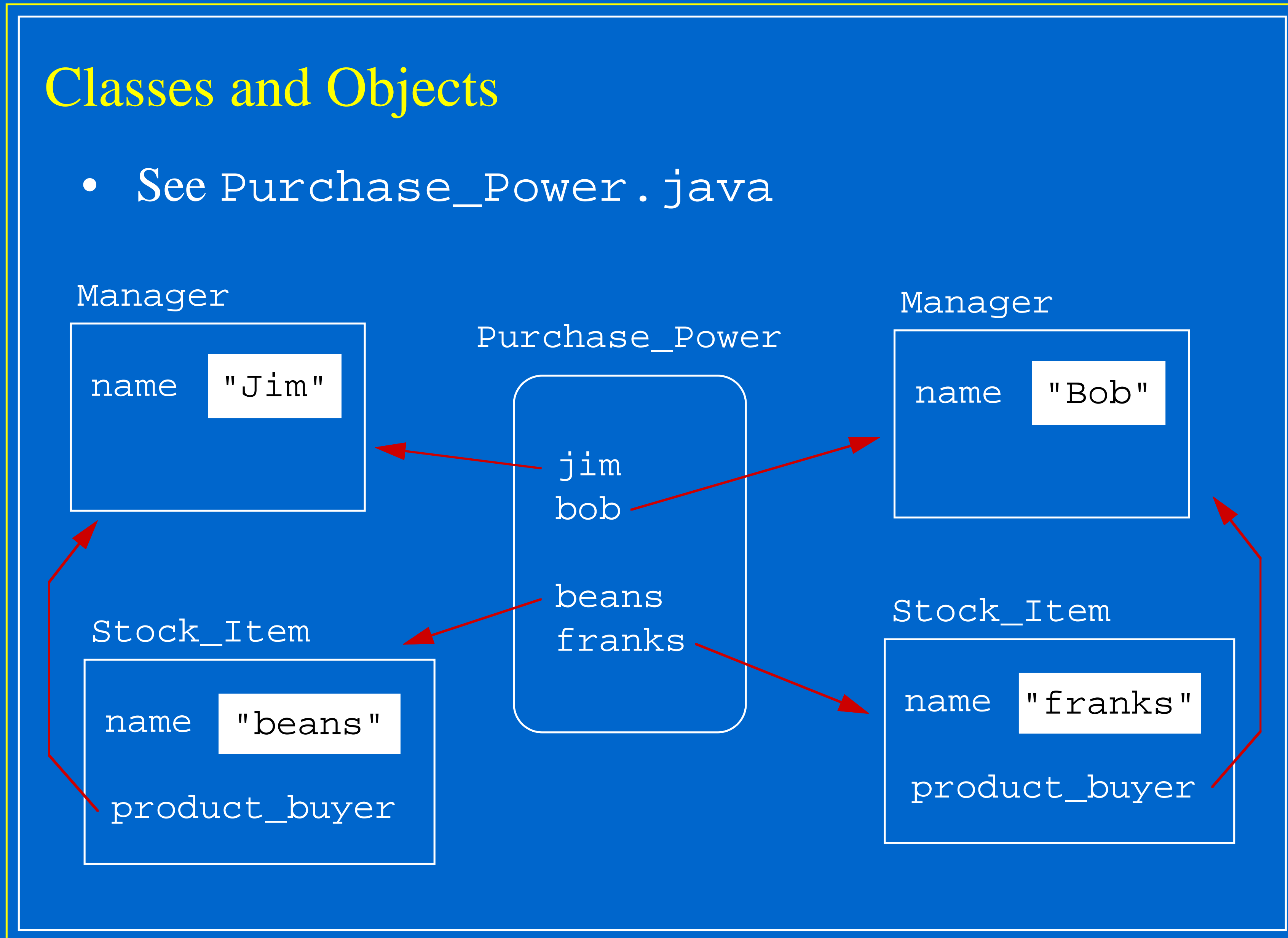
Classes and Objects

- See `Purchase_Power.java`



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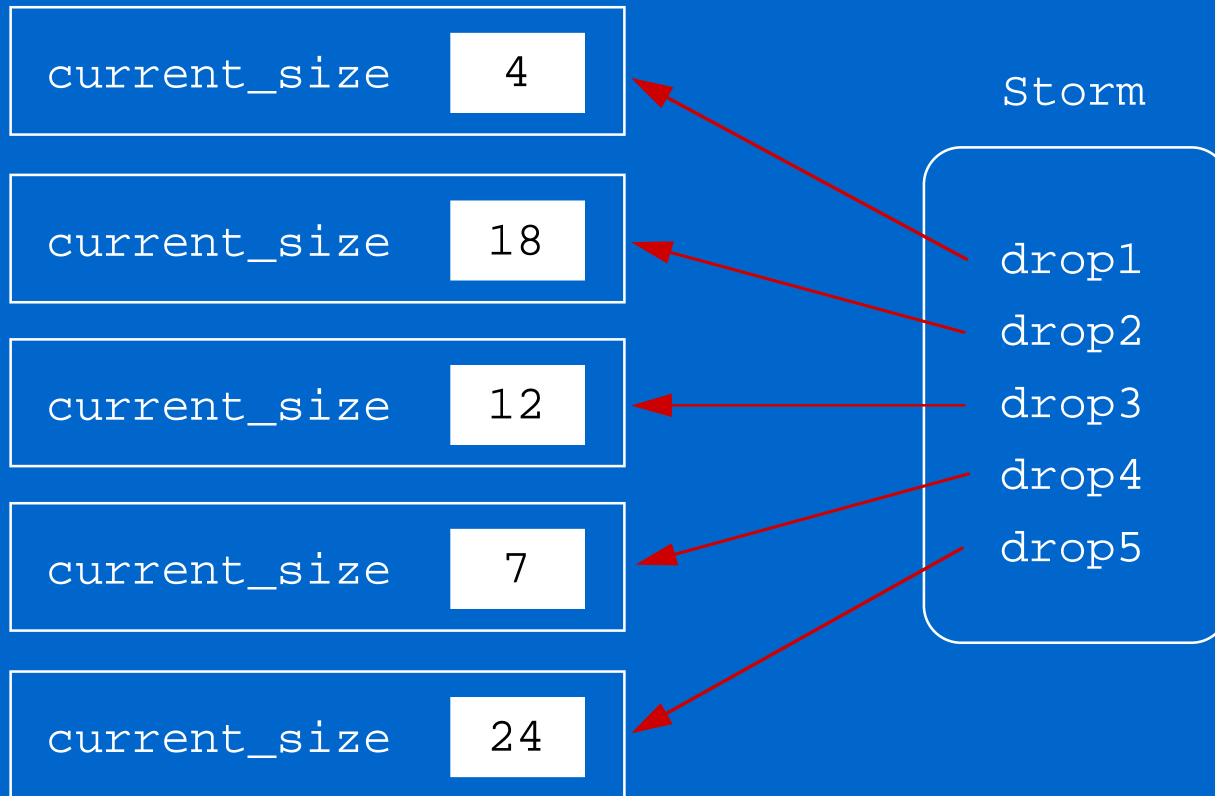
Classes and Objects

- See `Storm.java`



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