Creating Classes and objects

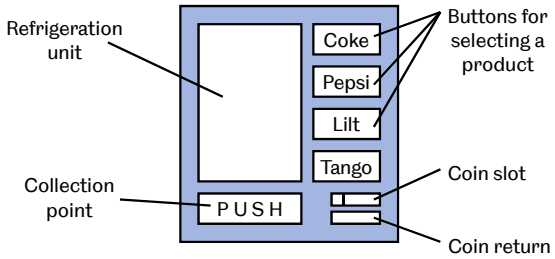
This lecture will

- Review the principles of object orientation
- Explain how to write methods in Java and the difference between an **actual parameter** and a **formal parameter**
- Explain how to write a simple class in Java
- Explain **constructor chaining**
- Introduce the use of `private` methods

The rationale for object-orientation

- Many things in the real world can be described in terms of their **state**, and in terms of the **actions** they perform.
- Objects that have a state and associated actions are good models of real-world problems.
- Consider a vending machine…

User interface of a vending machine



The rationale for object-orientation

- Example: A vending machine
  - We can perform actions on the machine, e.g. selecting an item to buy, or requesting a coin refund.
  - The machine has a state that affects its behaviour, e.g. it may not be able to give change to a customer.
  - The inner workings of the machine are hidden; to the customer it is a 'black box'.

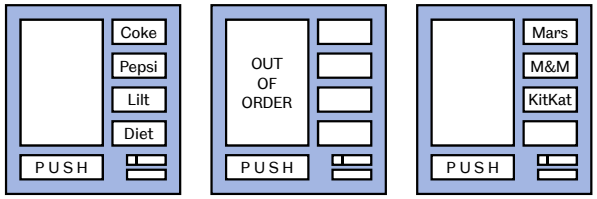
Principles of object-oriented approach

- An object provides operations that the user can invoke, these operations are called **methods**
- An object has an internal **state**. Some of that state may be available to the user
- An object is a black box. Some of its internal state is hidden from the user (**information hiding**)

Objects and classes

- There are many types of vending machine, but all have the same core functionality
- We say there is a **class** of vending machines
- For this class, we can specify in general terms its state and the actions it will provide, e.g. all vending machines will dispense a product of some kind

Same structure, different state



Objects and classes

- We say there is a **class** of vending machines
- Specific vending machines are **instances** of the class of vending machines. They have the same methods, but different states
- An **object** is an **instance** of a **class**

Software classes

- Software classes are used to package related values and the things one might want to do with them together in a sort of black box with the workings hidden
- For a **class**, we specify the information it will store and the actions (**methods**) it will provide

Software classes and objects

- A class can be used to create multiple **objects**, versions of the underlying class where each version is based on the class but has its own copies of the information
- Objects are **instances** of the class; they are created using the word **new** and have the same methods, but different information
- Classes are useful because they can be used as the building blocks of larger and more complicated systems

Methods

- Methods are blocks of instructions which the program can **invoke**, cause to be obeyed
- They can, but need not, have **parameters** which act as input data to the method
- You have been using them all along
  - `System.out.println("Hello world");`
  - `Math.round(x);`
  - `String world = "Hello world".substring(6);`

Software objects

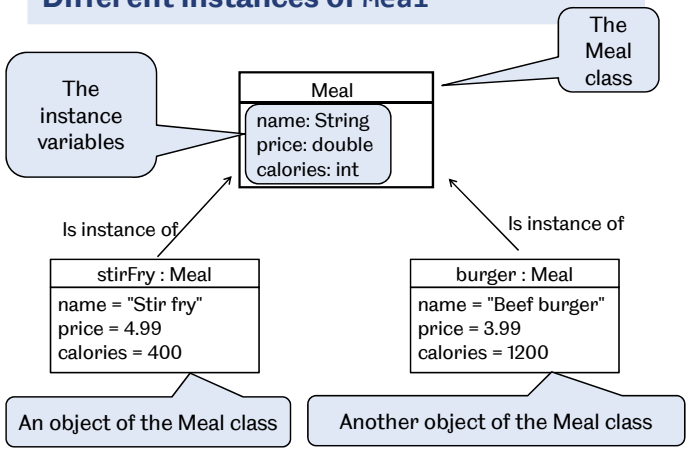
- Consider a class for representing meals. The **attributes** of the meal, the information we want to store, might be the name, the price and the number of calories
- We need a Java class of the general form:

```
public class Meal {
  // instance variables
  // method declarations
}
```

State

Actions

Different instances of `Meal`



Public and private

- The class and its methods are usually declared `public` so that other classes can use them
- Instance variables are usually declared `private` so that their values are only available within the class
- Like the vending machine, we hide the internal workings of the object and provide an interface to the outside world (the methods)

The Meal class

```
public class Meal {
  // instance variables
  private String name;
  private double price;
  private int calories;
  // method declarations
  ....
}
```

- Instance variable declarations appear in the body of the class declaration
- The order in which the variables and methods are declared is irrelevant but it should have some logic to it and be commented

Instance variables

- Instance variables are persistent (their values are retained so long as the object exists)
- Instance variables have global scope (their values are accessible within any method contained in the class)
- That means they can be used before they are declared

Using instance variables

- The instance variables of an object should be **`private`** but other classes may need to change or discover the state of the object, that is the value of an instance variable
- We can provide public methods to access and change the value of private instance variables

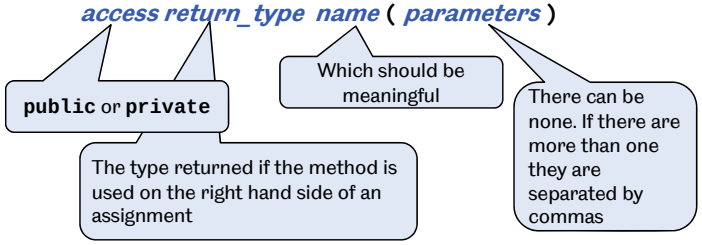
Providing get and set methods

- By convention, methods that change the value of an instance variable are called **mutator methods** (or **set methods**) and start with the word **set**
- Methods that retrieve the value of an instance variable are called **accessor methods** (or **get methods**) and start with the word **get**

Declaring methods

- Method declarations consist of a **signature** followed by a **body** (in curly brackets):
- The signature is

access return_type name (*parameters*)



Declaring methods

- Method declarations consist of a **signature** followed by a **body** in curly brackets
- The signature is

access return_type name (*parameters*)

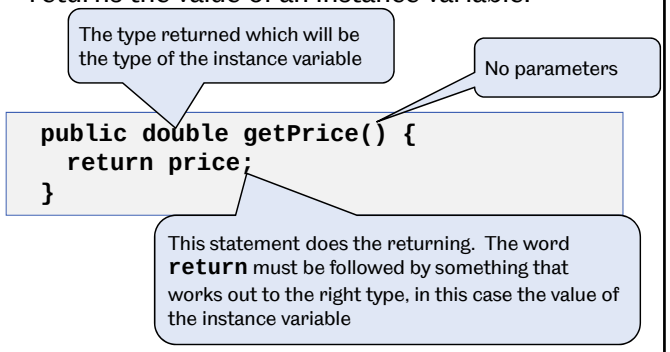
- The whole thing is

```
access return_type name ( parameters ) {
    //Statements to be obeyed
}
```

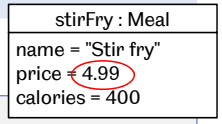
The method body

Writing accessor methods

- An accessor method is a **`public`** method that returns the value of an instance variable:



Writing accessor methods




```
public double getPrice() {
  return price;
}
```

- So, if **`stirFry`** is an instance of **`Meal`** then we can write:

```
double cost = stirFry.getPrice();
```

Writing mutator methods

- Mutator methods change the value of instance variables
- Their identifiers start **`set`**
- Set (mutator) methods are also public
- Set methods do not return a value
- They have a parameter which looks like a variable declaration whose type is that of the instance variable being set

Writing mutator methods

- This method sets the price of a Meal:

```
public void setPrice(double p) {
  price = p;
}
```

- It does not return a value so the return type is **`void`** and it has no **`return`** statement
- The value of the parameter becomes the new value of the price of the meal

Mutator method's parameters

```
public void setPrice(double p) {
  price = p;
}
```

- Information is passed into the method by a process of **parameter passing**
- There is a **formal parameter** **p**, of type **double** but when the method is invoked, we specify an **actual parameter** whose value is assigned to the formal parameter before the body of the statement is executed

Calling a set method

```
public void setPrice(double p) {
  price = p;
}
```

- If **stirFry** is an instance of **Meal**, we can write:

```
stirFry.setPrice(5.99);
```

- The actual parameter, **5.99**, is assigned to the formal parameter

Calling a set method

```
public void setPrice(double p) {
  price = p;
}
```

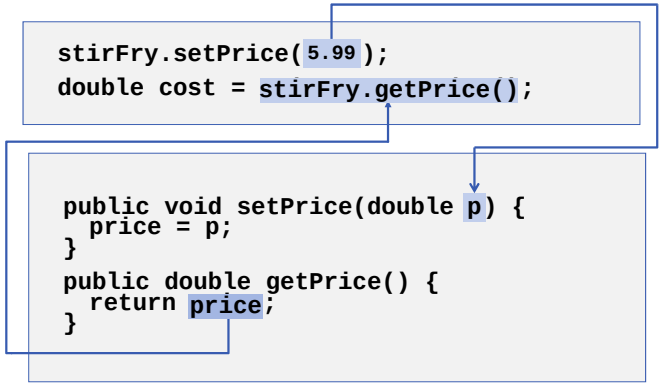
Formal parameter

- Calling a set method changes the state of the object:

Actual parameter

```
stirFry.setPrice(5.99);
double cost=stirFry.getPrice(); // cost is 5.99
```

Parameter passing again



Writing constructors

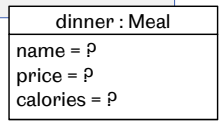
- Objects are created by calling a special method called the **constructor**:

```
Meal dinner = new Meal();
```

- The simplest constructor has no parameters and no body:

```
public Meal() { }
```

- This creates an instance of the `Meal` class in which the instance variables exist but are undefined

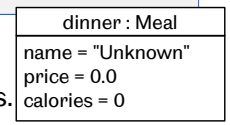


Constructors should initialise

- It is better to write a constructor that sets the instance variables to default values:

```
public Meal() {
  name = "Unknown";
  price = 0.0;
  calories = 0;
}
```

- Now, invoking the constructor creates an instance and initialises the instance variables.



A constructor with parameters

- We can write a constructor that allows the initial values of `Meal` attributes to be set via parameters:

```
public Meal(String n, double p, int c) {
  name = n;
  price = p;
  calories = c;
}
```

- We could invoke this constructor as follows:

```
Meal dinner = new Meal("scampi", 5.49, 600);
```

A constructor with parameters

```
public Meal(String n, double p, int c) {
  name = n;
  price = p;
  calories = c;
}
```

```
Meal dinner = new Meal("scampi", 5.49, 600);
```

- Formal and actual parameters are matched in order, so an instance of `Meal` is created with the instance variables set according to the parameter values.

Overloading the constructor

- We now have **two** constructors

```
public Meal() { ... }
public Meal(String n, double p, int c) { ... }
```

- The compiler knows which constructor to call by matching the actual parameters against the formal parameters.
- We can have several methods with the same name but different formal parameters.
- This is called **overloading**.

The `toString` method

- It would be convenient if we could display the attributes of a **`Meal`** object by invoking a single method.
- The solution is to provide a **`toString`** method:

```
public String toString() {
  return "Meal Name=" + name +
               ", Price=" + price +
                " and Calories=" + calories;
}
```

- Java always uses the **`toString`** method in any expression that requires a **`String`**

Invoking the `toString` method

- Consider the following program fragment:

```
Meal pizza =
    new Meal("Special Pizza", 8.99, 800);
System.out.println(pizza);
```

- The output from this code is:

```
Meal Name=Special Pizza, Price=8.99 and Calories=800
```

- It is as though we had written the following:

```
System.out.println(pizza.toString());
```

The `main` Method

- Remember this

```
public class Simple {
   public static void main(String[] args) {
      System.out.print("Running a Java application");
      System.out.println("...finished.");
   }
}
```

A class which contains nothing except a **`main`** method which did everything

- Any program we write will still need a **`main`** method as an entry point and won't work without it

The `Meal` class's `main` method

- There has to be one otherwise the program will throw a run time error if you type

```
U:\myJava>java Meal
```

- The **`main`** method ought to do something sensible if only create a **`Meal`** and print it out

```
public static void main (String [] args) {
     Meal chickenAndChips =
       new Meal("Chicken and Chips", 7.25, 1119);
     System.out.println(chickenAndChips);
}
```

The `Meal` class

```
public class Meal {
     private String name;
     private double price;
     private int calories;

     public String toString() {…}
     public String getName() {…}
     public double getPrice() {…}
     public int getCalories() {…}
     public void setName(String n)  {…}
     public void setPrice(double p) {…}
     public void setCalories(int c) {…}
     public Meal () {…}
     public Meal (String n, double p, int c) {…}

     public static void main (String [] args) {…}
 }
```

The `Meal`class - a template to make `Meal` objects

```
public class Meal {
     private String name;
     private double price;
     private int calories;

     public String toString() {…}
     public String getName() {…}
     public double getPrice() {…}
     public int getCalories() {…}
     public void setName(String n)  {…}
     public void setPrice(double p) {…}
     public void setCalories(int c) {…}
     public Meal () {…}
     public Meal (String n, double p, int c) {…}

     public static void main (String [] args) {…}
 }
```

The instance variables

The `Meal` class - a template to make `Meal` objects

```
public class Meal {
     private String name;
     private double price;
     private int calories;

     public String toString() {…}
     public String getName() {…}
     public double getPrice() {…}
     public int getCalories() {…}
     public void setName(String n)  {…}
     public void setPrice(double p) {…}
     public void setCalories(int c) {…}
     public Meal () {…}
     public Meal (String n, double p, int c) {…}

     public static void main (String [] args) {…}
 }
```

The accessor methods

The mutator methods

The `Meal` class - a template to make `Meal` objects

```
public class Meal {
     private String name;
     private double price;
     private int calories;

     public String toString() {…}
     public String getName() {…}
     public double getPrice() {…}
     public int getCalories() {…}
     public void setName(String n)  {…}
     public void setPrice(double p) {…}
     public void setCalories(int c) {…}
     public Meal () {…}
     public Meal (String n, double p, int c) {…}

     public static void main (String [] args) {…}
 }
```

Constructors

The `Meal` class - a template to make `Meal` objects

```
public class Meal {
     private String name;
     private double price;
     private int calories;

     public String toString() {…}
     public String getName() {…}
     public double getPrice() {…}
     public int getCalories() {…}
     public void setName(String n)  {…}
     public void setPrice(double p) {…}
     public void setCalories(int c) {…}
     public Meal () {…}
     public Meal (String n, double p, int c) {…}

     public static void main (String [] args) {…}
 }
```

The **`toString`** method

The **`main`** method

Growing classes

- When using classes it is good practice to start with something simple, test it and then complicate it further
- We are going to complicate the **`Meal`** class by adding an indication of what sort of diet it is suitable for

Adding an attribute

- To add any attribute we must
  - Add another instance variable with its own get and set methods
  - Modify all the constructors
  - Modify the **`toString`** method
  - Probably modify the **`main`** method

The Meal class with diet

```
public class Meal {
   enum Diet {OMNIVOROUS, VEGAN, VEGETARIAN,
              UNSPECIFIED};
   // instance variables
   private String name;
   private double price;
   private int calories;
   private Diet diet;
   ....
   public void setDiet(Diet d) { diet=d; }
   public Diet getDiet() { return diet; }
   ....
```

toString for Meal with Diet

```
public String toString() {
   String d = " which is suitable for a "+diet+" diet";
   return "Meal Name=" + name +  ", Price=" + price +
     ", Calories=" + calories + d.toLowerCase();
}
```

```
Meal pizza = new Meal("Special Pizza", 8.99, 800,
                                   Diet.VEGETARIAN);
System.out.println(pizza);
```

```
Special Pizza, Price=8.99, Calories=800 which is
                        suitable for a vegetarian diet
```

toString for Meal with Diet

```
public String toString() {
   return name +  ", Price=" + price +
            ", Calories=" + calories +
            " and Diet=" + diet;
}
```

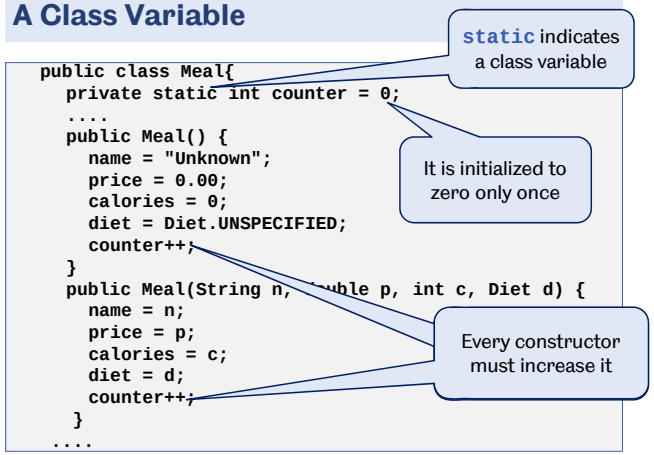
```
Meal pizza =
     new Meal("Special Pizza", 8.99, 800,
                                   Diet.OMNIVOROUS);
System.out.println(pizza);
```

```
Special Pizza, Price=8.99, Calories=800 and Diet=OMNIVOROUS
```

Instance and Class Variables

- Every object of a class has its own copy of the instance variables
- Sometimes we want a variable whose value is shared by all instances of the class
- An example is when we want to keep a count of the number of instances of a class that have been created
- A class variable belongs to the class, rather than any instance of the class

A Class Variable




```
public class Meal{
  private static int counter = 0;
  ....
  public Meal() {
    name = "Unknown";
    price = 0.00;
    calories = 0;
    diet = Diet.UNSPECIFIED;
    counter++;
  }
  public Meal(String n, double p, int c, Diet d) {
    name = n;
    price = p;
    calories = c;
    diet = d;
    counter++;
   }
  ....
```

Instance and Class Methods

- We can provide class methods to access class variables
- Class methods, like class variables, are declared using the `static` keyword.
- Class methods are called by preceding the name of the method with the name of the class and a dot rather than the name of an object (an instance of the class) and a dot.

A Class Method

```
public class Meal {
     private static int counter = 0;
     ....
     public Meal(String n, double p, int c, Diet d) {
        name = n;
        price = p;
        calories = c;
        diet = d;
        counter++;
     }
     ....
     public static int getCount () {
       return counter;
     }
```

A class method because it is `static`

Note class name

```
     System.out.println(Meal.getCount() +
        " meals have been created so far");
```

Constants

- Objects (instances of a class) can have variables and methods
- Classes can have static variables and methods
- What about constants?

Class Constants

- Obvious class constants for our **`Meal`** class are

```
private static final double DEFAULT_PRICE = 7.5;
private static final int DEFAULT_CALORIES = 700;
```

Using class constants

- The default constructor becomes

```
public Meal() {
   name = "Unknown";
   price = DEFAULT_PRICE;
   calories = DEFAULT_CALORIES;
   diet = Diet.UNSPECIFIED;
   counter++;
}
```

- If we had a public class constant it could be referred to outside the class by prefixing it with the class name just as class methods are used

More about constructors

- A constructor creates a new object and returns a reference to the block of memory in which the object is stored
- Constructors normally initialize the instance variables
- Constructors can be overloaded (take different parameters)

More about constructors

```
public Meal(String n, double p, int c, Diet d) {
   name = n;
   price = p;
   calories = c;
   diet = d;
   counter++;
}
```

```
public Meal() {
   name = "Unknown";
   price = DEFAULT_PRICE;
   calories = DEFAULT_CALORIES;
   diet = Diet.UNSPECIFIED;
   counter++;
}
```

Chaining constructors

- We can make this shorter, and avoid the risk of forgetting to update the **`counter`** class variable, by using constructor **chaining**

```
public Meal(String n, double p, int c, Diet d) {
     name = n;
     price = p;
     calories = c;
     diet = d;
     counter++;
}
public Meal() {
     this("Unknown", DEFAULT_PRICE, DEFAULT_CALORIES,
                     Diet.UNSPECIFIED);
}
```

The call to `this()` invokes another constructor of the same class that matches the parameter list

`private` and `public`

- Instance variables should always be **`private`**, to hide the internal state of your objects
- Instance and class constants can be either **`private`** or **`public`**, since they are **`final`** they cannot be altered from outside your class so making them accessible is quite safe
- Methods can be **`private`** as well as **`public`**
- **`private`** methods are used to support the **`public`** methods of the class

Public and private methods

- If a method is **`private`**, it can only be accessed from within the class

```
private double price;

private boolean validPrice(double price) {
   return price>0.0;
}

public void setPrice(double p) {
   if (  validPrice(p)  )
      price = p;
   else {
      System.out.println("Bad price in setPrice");
      System.exit(0);
   }
}
```

Terminates the program

More about private methods

- We can use the **`validPrice()`** method in other methods too, such as the constructor:

```
public Meal(String n, double p, int c, Diet d) {
   name = n;
   if  (  validPrice(p)  )
     price = p;
   else
     price = DEFAULT_PRICE;
   if  (  validCalories(c)  )
     calories = c;
   else
     calories = DEFAULT_CALORIES;
   diet = d;
}
```

Another **`private`** method

Summary of key points

- A class is template for the creation of objects and an object is an **instance** of a class with a private internal state (**attributes**) and a set of actions (**methods**)
- Information is passed into methods via **parameters** and returned from methods via a `return` statement
- Classes should have **get** and **set methods** to find and change attribute values, constructors to create new objects and a **`toString()` method** to display the object
- Classes can have their own variables, methods and constants that are independent of any instance; they are declared to be `static`