Lecture 3

- Covers
  - Object-oriented concepts
  - Objects, classes, attributes and operations
  - Methods, messages and message passing
  - Information hiding (encapsulation) and interfaces
  - Inheritance and polymorphism
  - Algorithms

- Reading: Savitch 1.2

- Objects

Objects

- In the object-oriented paradigm everything is viewed as an object
- An object is an entity that has a state and behaviour
- The data that describe an object's state are called its attributes
- An object's behaviour is defined by the operations it can perform

pictures from www.amazon.com

Pop-up Toasters

Abstraction

- Each toaster has many attributes (colour, weight, height, price, etc.)
- In fact, it is not possible to list all the attributes of a toaster (or any object at all)
- We usually need to describe only some of its attributes - those that are of interest to us from a certain viewpoint
- Such a description is known as an abstraction

A view of the toasters

- Suppose we are now looking at the toasters from the viewpoint of *how they perform their toasting function*
- Then, from this viewpoint, we may describe them as shown in the next few slides

Toaster A

- 2 racks
- Each rack holds 2 slices of bread
- Darkness set at light
- Racks are up

Toaster B

- 4 racks
- Each rack holds 1 slice of bread
- Darkness is set at medium
- Racks are down

Toaster C

- 3 racks
- Each rack holds 1 slice of bread
- Darkness is set at medium-dark
- Racks are down

Toaster D

- 2 racks
- Each rack holds 1 slice of bread
- Darkness is set at medium
- Racks are up

Describing a Pop-up Toaster

- Attributes are pieces of data that describe the state of an object
- They have a value at any given time

State and attributes

- It is possible for two distinct objects to have the same state, i.e. the same values for their attributes
- E.g. if my brother and I both buy the same make and model of toaster and they are currently in the same state, they are still separate objects

Behaviour

- The behaviour of an object, like its attributes, is theoretically inexhaustible
- We usually only need to describe the behaviour of an object from a certain viewpoint
- In the object-oriented approach, we describe the behaviour of objects in terms of the operations they support

The behaviour of a Pop-up Toaster

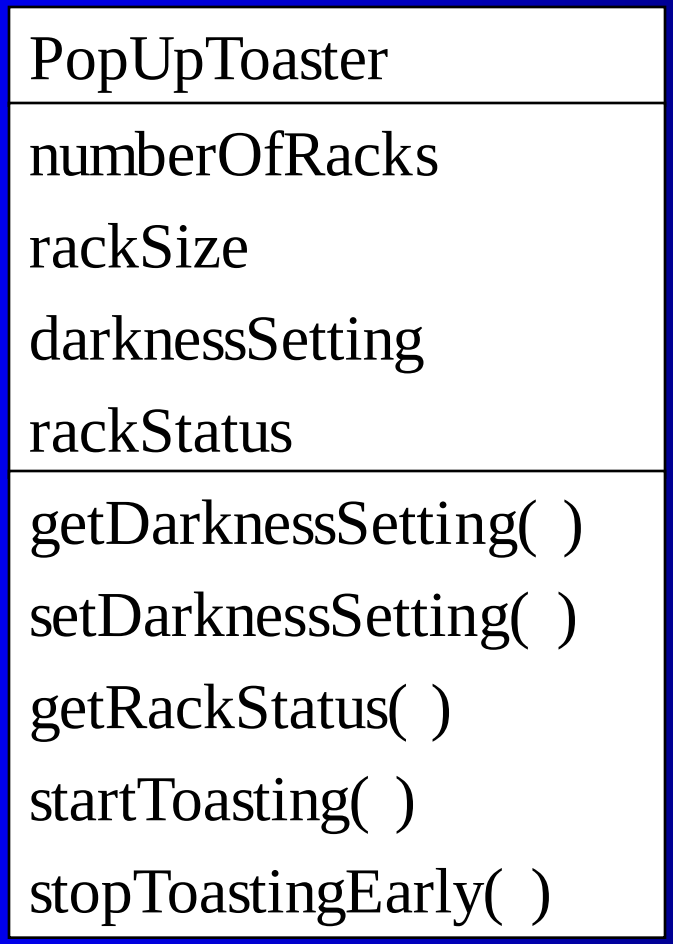
- Is defined by the operations it supports
  - view darkness setting
  - change darkness setting
  - lower rack / start toasting
  - view rack status
  - stop toasting

- Classes

Classes

- Classes describe a group of similar objects
- They form a template for the creation of instance objects
- Creating an instance object from a class template is called *instantiation*
- Classes determine what attributes an instance object of that type should have, though each instance object may have different values for each attribute
- Objects are examples of a class

Pop-up Toaster class



- Information Hiding

(also known as Encapsulation)

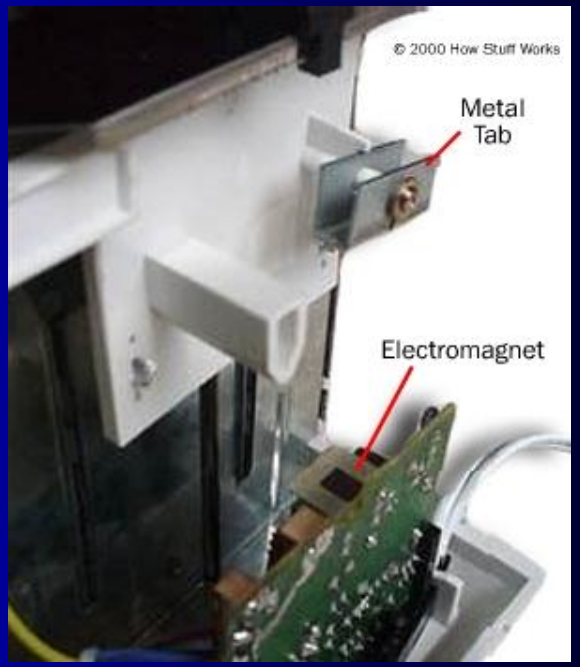
pictures and concepts from www.howstuffworks.com

How toasters work

- Infrared radiation
- Nichrome wire wrapped across a mica sheet
- Spring-loaded tray
- Timer turns toaster off and releases rack
- Grates to centre bread

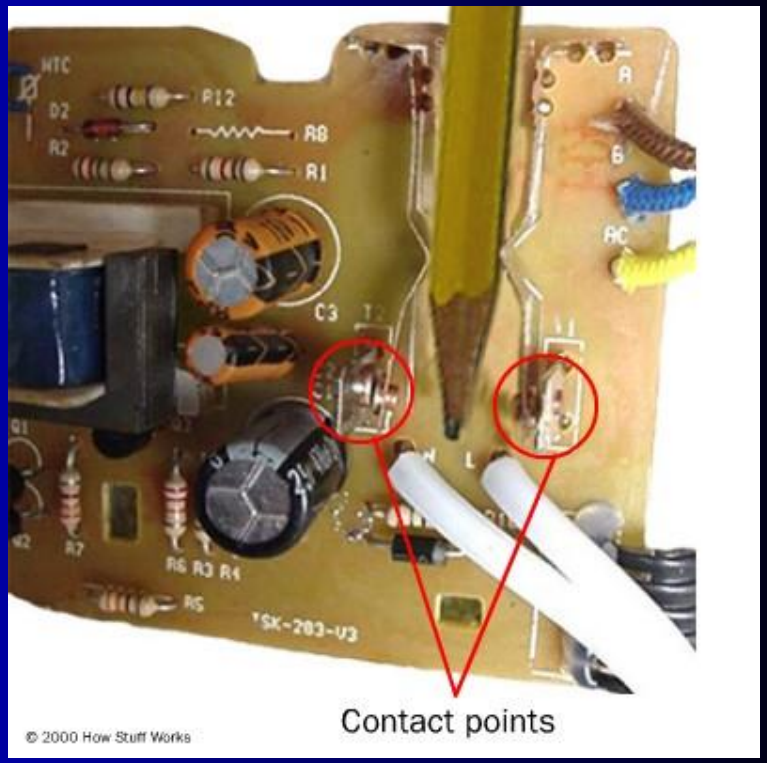
How toasters work

- Handle connected to rack to lower bread into toaster
- Electromagnet holds racks down



How toasters work

- Circuit board with contacts
- Variable resistor to control rate at which capacitor charges, which controls length of time before electromagnet is released (sets darkness)



How toasters work

- When you push down on the handle,
  - The plastic bar presses against the contacts and applies power to the circuit board
  - Power runs through the contacts to the nichrome wires to start toasting the bread
  - A circuit made up of transistors, resistors and capacitors, turns on and supplies power to the electromagnet
  - The electromagnet attracts the piece of metal on the handle, holding the bread in the toaster
  - The circuit acts as a timer. A capacitor charges and when it reaches a certain voltage it cuts off the power to the electromagnet. The spring pulls the two slices of bread up.
  - The plastic bar rises and cuts off power to the toaster.

How toasters work

- The darkness control is simply a variable resistor.
  - Changing the resistance changes the rate at which the capacitor charges, and this controls how long the timer waits before releasing the electromagnet.

Using a toaster

- To use a toaster, do you need to know how the toaster works?
- In fact most of the mechanism is hidden from view
- To use a toaster, we only need to be able to use its controls (operations)
- A pop-up toaster has few operations to control it
- We refer to the set of operations available to its user as its interface

Information hiding

- In the object-oriented paradigm, the details of an object that do not need to be known to use that object are hidden from view
- A user is only allowed to know about the details necessary to operate the object
- The set of operations visible to a user of an object is called the object's interface

Information hiding

- We may not want to allow access to the internals of an object for a number of reasons
  - Confusing and unnecessary for a user to know
  - Dangerous to the user of the object
  - Dangerous to the object
- The property of providing a limited interface and hiding the details is called information hiding or encapsulation

Message passing

- To request that an object performs one of its operations, a message must be sent to that object
- Message passing is the name given to the process of sending a message to an object to request the execution of one of its operations
- A message must have
  - A receiver (the object to which it is sent)
  - An operation selector (the name of the operation to be carried out)
- A message may also have
  - Associated data to work with

- Operations and methods

Operations and methods

- An operation is the name of a task that can be carried out
- The way the operation works is called its method
- The method specifies how the operation is to be carried out
- The method is described by some algorithm (sequence of steps performed in doing the operation)
- Sometimes the terms operation and method are used interchangeably

Constructors

- When we create instance objects from a class template, we may want to initialise some of its values
- A constructor is a special operation that is performed when we create an instance of a class
- The constructor is generally used to give initial values to an object's attributes
- E.g. when we construct a toaster instance we may want to set the rack size and number of racks: this could be done in a constructor

Accessor and mutator methods

- By encapsulating attributes, we hide them from outside view
- Sometimes we need to allow other objects or users to find out or change the value of an attribute
- A method that simply allows the user to view the state of an attribute is called an accessor method
- E.g. getDarknessSetting( )

Accessor and mutator methods

- A method that simply allows the user to set the state of an attribute to a new value is called a mutator method
- E.g. setDarknessSetting( )

Class attributes and methods

- Instance attributes describe the state of an instance object (e.g. darknessSetting)
- Instance methods work in relation to a specific object (e.g. startToasting( ))
- Sometimes we want to store information about the class as a whole, such as totals or averages: these are called class attributes

Class attributes and methods

- For example we could store the total number of toaster instances, or the average rack size of all toaster instances
- Class methods work with a class as a whole and not on an individual instance (e.g. calculateAverageRackSize( ))

- Inheritance

Inheritance

Toaster

PopUpToaster

RollerToaster

ToasterOven

Inheritance

- Is the way we define specialisation and generalisation among classes
- A superclass is more generalised than its subclasses
- A toaster is a more general form which includes pop-up toasters, roller toasters and toaster ovens

Inheritance

- Allows us to define properties (both attributes and operations) common to a number of classes once
- Allows us to define specialised classes which can access attributes and operations defined in a general class
- Allows us to refer to different types of objects collectively
  - E.g. we can refer to pop-up toasters and toaster ovens collectively as “toasters”

Inheritance

- Subclass “is a type of” superclass
- Subclass “is a” superclass
- The subclass “inherits” the properties of the superclass (base class)

Polymorphism

- Allows the same message to be sent to different types of objects with their own way of carrying out the requested operation
- E.g. send a "toast" message to a pop-up toaster or a roller toaster; each has an operation that "toasts" but the method of toasting is defined differently
- Polymorphism – "many forms"

- Object-oriented vs. procedural programming

Algorithms

- An algorithm is a set of unambiguous instructions defined to perform some task
- An algorithm can be expressed in a human language, or some form of code, diagram or programming language
- We often use pseudocode to describe an algorithm in an English-like manner (allowing transformation into different programming languages)

Procedural vs OO programming

- Procedural programming considers programs as a set of algorithms. These algorithms work on some data.
- OO programming views programs as a set of interacting objects which have their own states (attributes) and behaviour (methods)
- Algorithms are important in OO programming as the “body” of methods

Next lecture

- Program components
- Designing algorithms
- A simple Java program