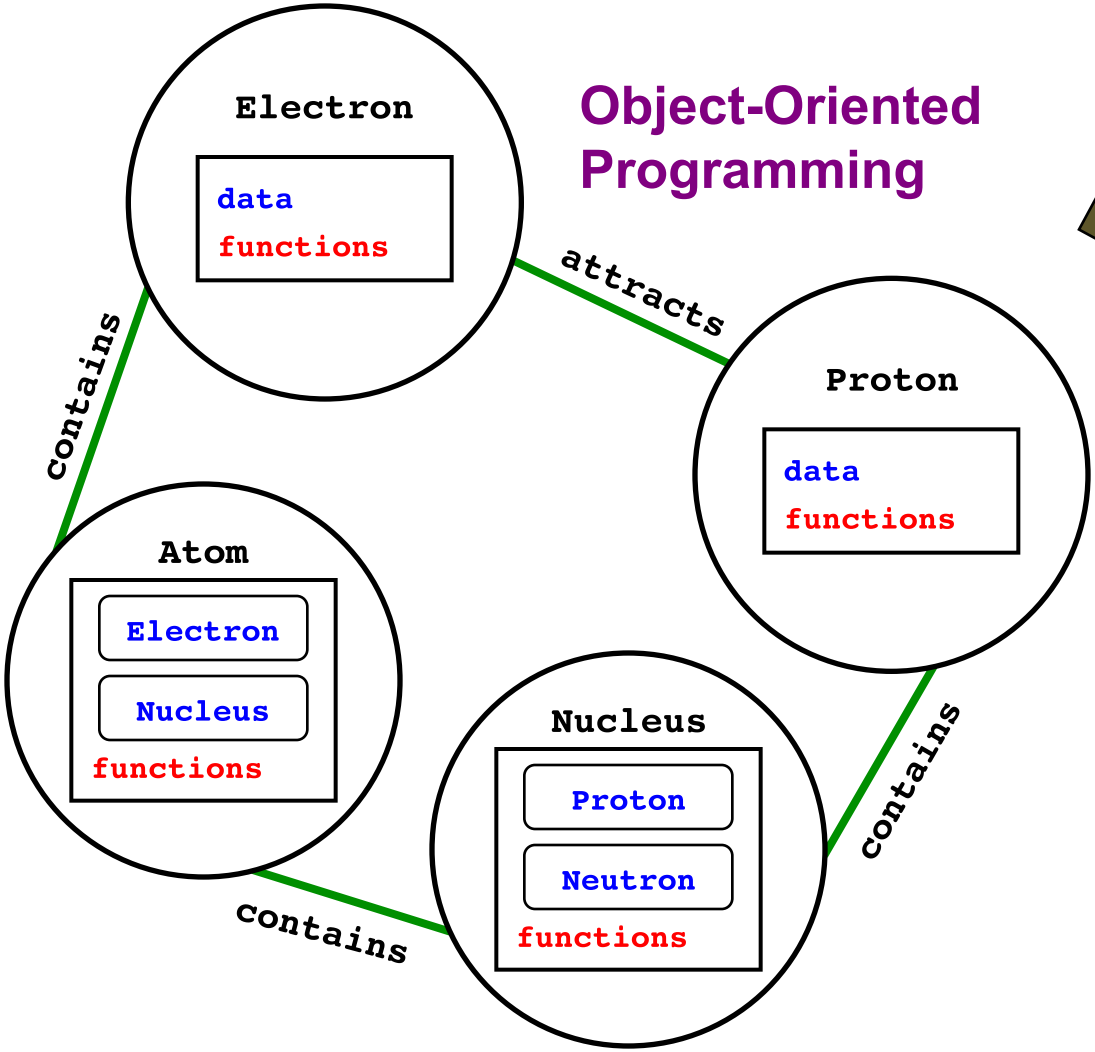
Scientific Programming Using Object-Oriented Languages
Module 1: Introduction and Basic Concepts

Aims of Module 1:

- Become familiar with using the ECLIPSE package to develop basic Java programs.
- Understand some of the basic concepts behind object-oriented programming.
- Be able to write a simple Java program.
- Understand the basic elements of the Java programming language: data types & variables, functions and algorithm control.

What's This Course All About?



Electron

data

functions

attracts

Proton

data

functions

contains

Atom

Electron

Nucleus

functions

contains

Nucleus

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Neutron

functions

contains

Object-Oriented Programming

using

Java™

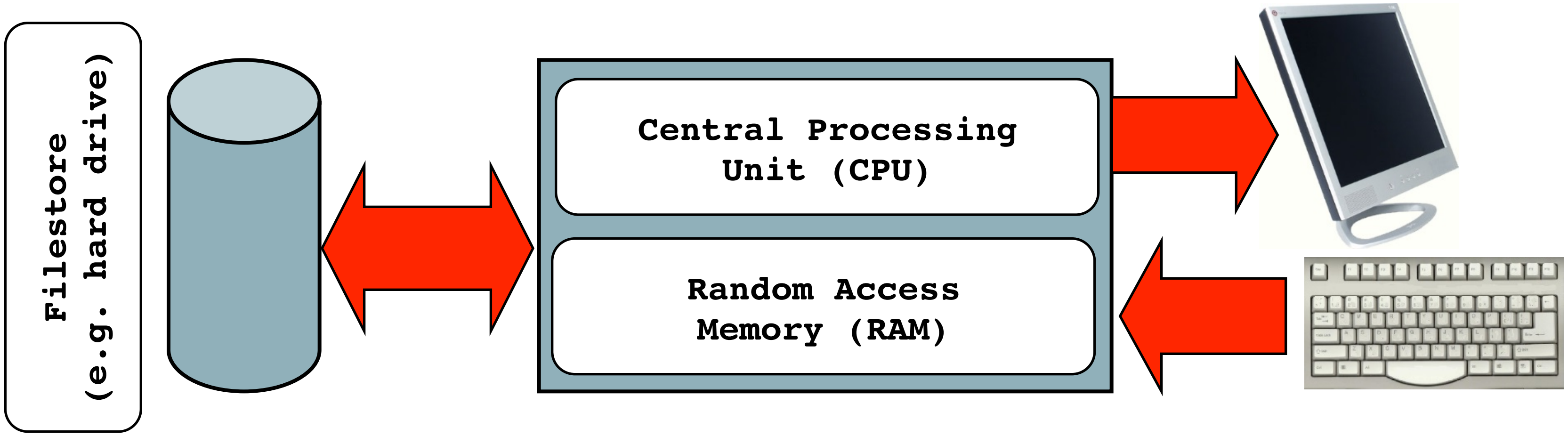
Why Do We Write Computer Programs?

- Perform calculations.
- Read, manipulate and store data.
- Simulate some aspect of real-life (“abstraction”).
- [Play games]

- All programs will therefore contain :
  - **Data**: describe/store the state of a system.
  - **Functions**: manipulate/change the state of a system.

Programming Languages

- It’s useful to have a very simple model of a computer in mind:



- Ultimately a CPU only understands very simple instructions such as :
  - “read contents of memory location **`0x15a7`**”
  - “increment register **`0xa74f`** by **`1`**”
  - … etc.

Low-Level and High-Level Languages

- Writing a program using such “low-level” instructions would be impossibly tedious.
- Some 50 years ago, “high-level” languages were developed.
- These languages contain logical and arithmetic instructions that are much easier to read, write and understand.
- The disadvantage is that they must be “compiled” or translated into the simple instructions that a computer can understand, before they can be run.
- The Java language appeared on the scene in 1995, as a high-level object-oriented (“OO”) language. It was designed to be a highly portable language “**W**rite **O**nce, **R**un **A**nywhere”. This often makes it the language of choice for web applications, for example.

Bits and Bytes and All That

Let’ s recall some basics :

- A bit can take the value **`0`** or **`1`**.
- A byte is comprised of 8 bits.
- Longer “words” consist of 32 or 64 bits.
- Integers are represented in binary format, for example:

0	0	1	0	1	1	0	1	= 45

- The representation of real numbers (floating point numbers) is slightly more complicated.
- All high-level computing languages have representations of commonly used entities — logicals, numbers and characters:
  – **`boolean`** (true/false), **`integer`**, **`float`**, **`character`**

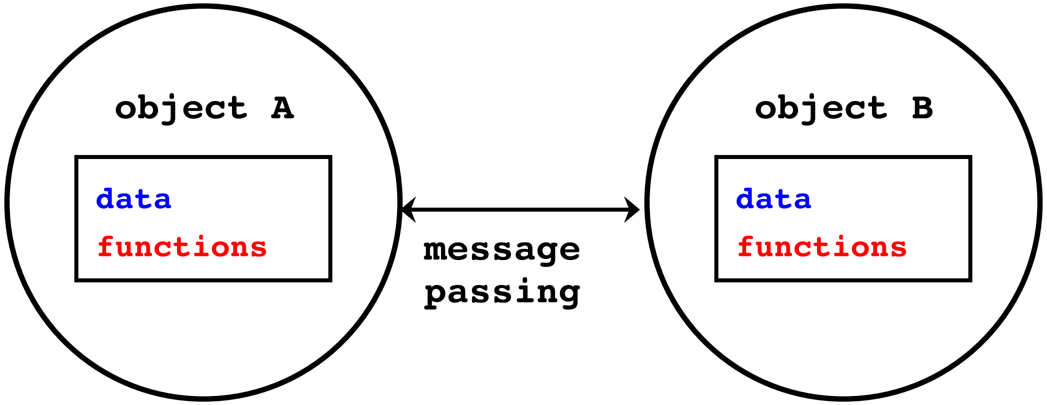
Some Object-Oriented Nomenclature

- OO languages infinitely extend the range of possible ***types***.
  - Not just **`boolean`**, **`integer`**, **`float`**, …
  - But **`vector`**, **`matrix`**, **`particle`**, **`electron`**, **`atom`**, etc.
- We can write much more natural looking code using these programmer-defined types.
- These new types have their own ***class definitions***. This is a bit like the “mold” or “archetypal” representation of an ideal object.
- A program creates or ***instantiates*** real objects according to their class definition. Different objects of the same type can have different values for their properties.

Plato

But What Is An Object?

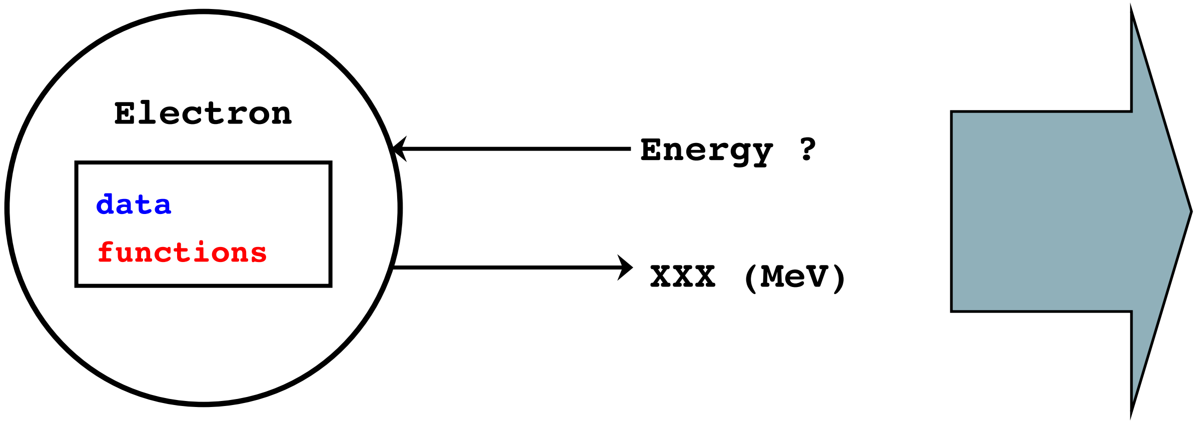
- Logically, an object can be thought of as a kind of "bundle" of data and functions (or "***methods***") that act on the data.
- The tight "coupling" between the data and functions comprising an object is a very powerful way of organising and managing a large programming task.
- A program advances by objects communicating with one another through the passing of "messages".



Some Concepts of Object-Oriented Programming (1)

Encapsulation

- Closely related to "information-hiding".
- In order for an application programmer to be able to use objects of type **X**, he need only be familiar with the ***interface*** of that type.
- He does not need to be concerned with the internal workings of the object. In this sense, the objects are "black-boxes".



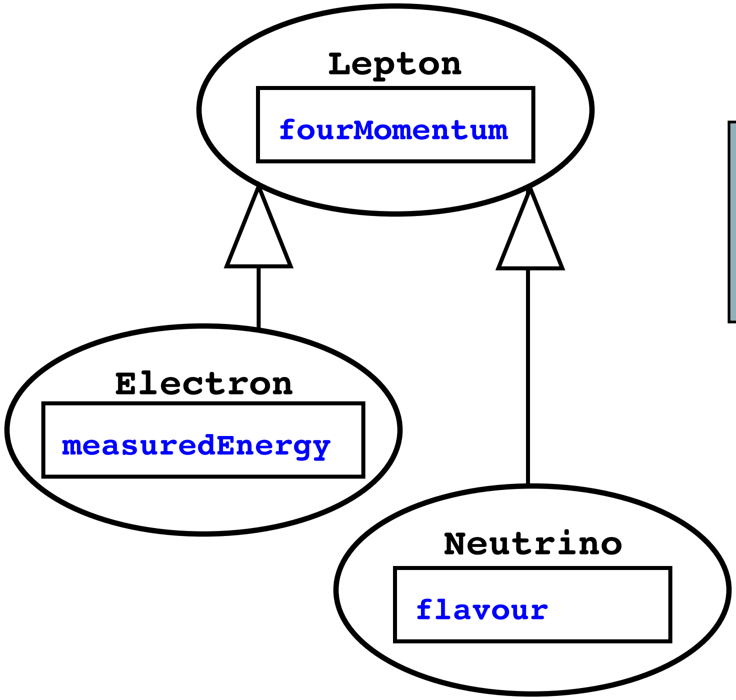
Do not need to know the details of how the energy is stored and/ or calculated on the fly.

- Makes code much more maintainable — as long the interfaces are stable.

Some Concepts of Object-Oriented Programming (2)

Inheritance

- An **apple** is a type of **fruit**. An **electron** is a type of **lepton**.
- Object-oriented languages provide a formal structure called “inheritance” for expressing these relationships.



Exploiting inheritance and other relationships between objects is critical to good OO program design.

Some Concepts of Object-Oriented Programming (3)

Polymorphism

- “One entity has many forms”.
- Polymorphism itself can mean many things!
- One example: 2 objects may respond in different ways to the same message from another object.
  - Suppose a program contains a “**`shape`**” object.
  - The “**`shape`**” object is asked what its area is.
  - If the “**`shape`**” object is in fact a “**`rectangle`**” then it will return “length × height”.
  - If the “**`shape`**” object is in fact a “**`triangle`**” then it will return “0.5 × based × height”.

For Today…

- We will introduce objects in more detail in Module 2.
- Today we are concerned with basic Java syntax and how to compile and run simple programs.

Start on the Module 1 Exercises
Please ask Questions !