15-112
Fundamentals of Programming

Lecture 1:
Introduction + Basic Building Blocks of Programming

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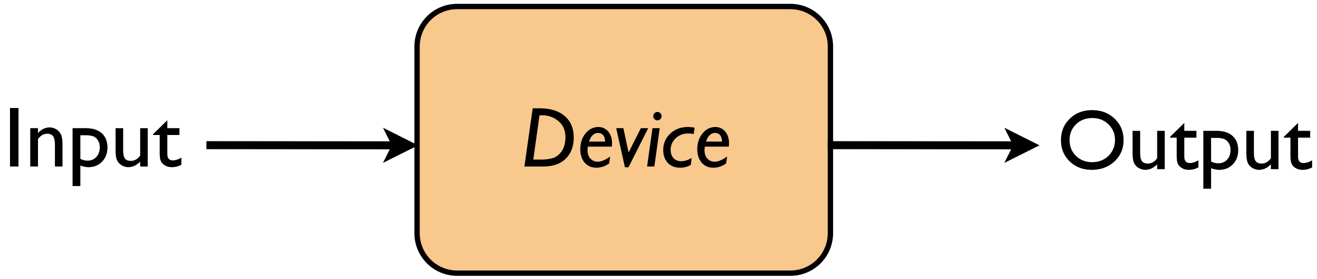
What is programming (coding) ?

What is *computer* programming ?

What is a computer?

Any device that manipulates/processes data (information)

Usually



We call this process **computation**.

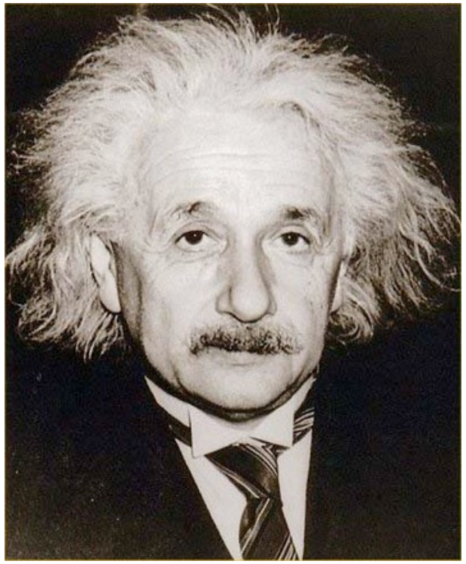
Calculation: manipulation of numbers.
(i.e., computation restricted to numbers)

Examples

Push
Push

CASHO
TWO WAY POWER
ELECTRONIC CALCULATOR
CS-270
12345678.
8-DIGIT
MC
MR
M−
M+
OFF
ON
CE
C
%
√
×
÷
+
−
=

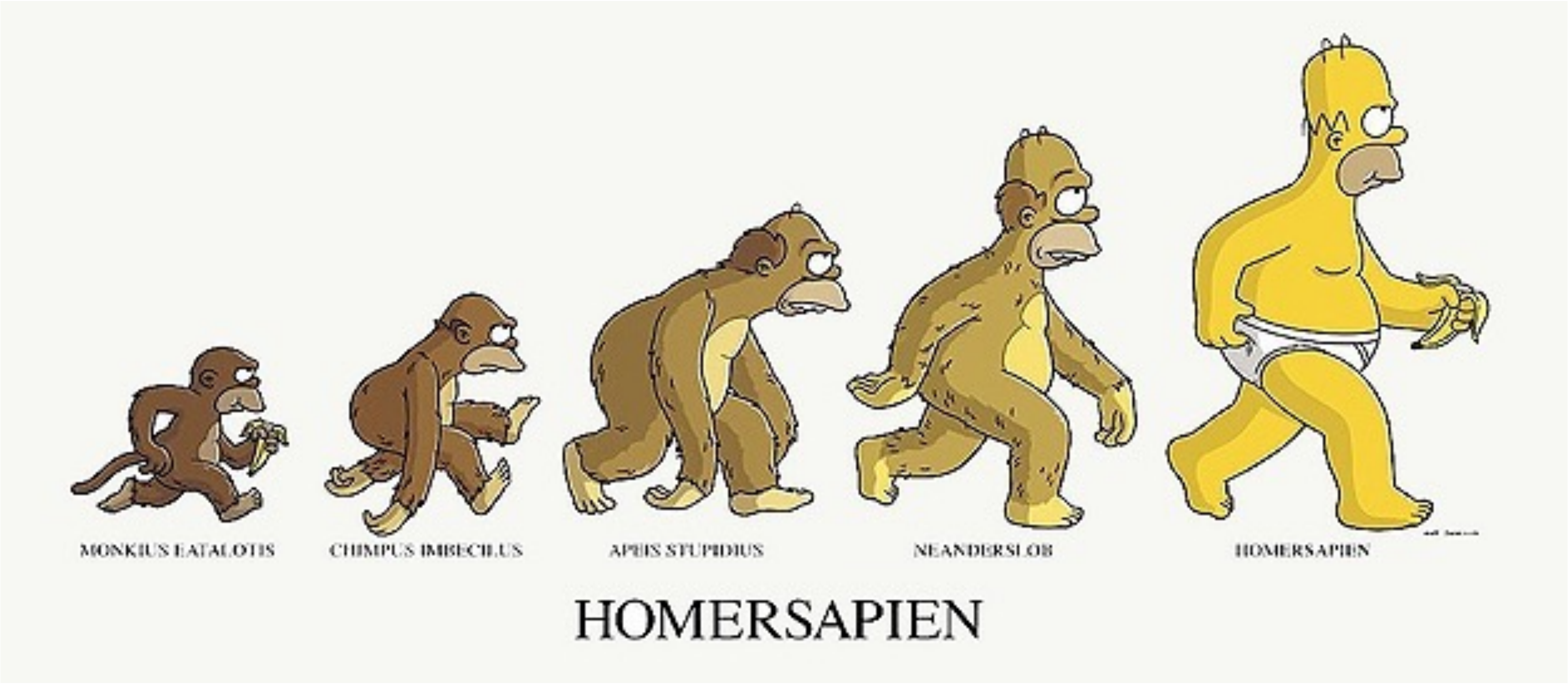
disk II
disk II



“Computers” in early 20th century

Examples: Nature (?)

Evolution



Computer Science:
The science that studies computation.

The computational lens

Computational physics

Computational biology

Computational chemistry

Computational neuroscience

Computational finance

…

A more refined definition of “computer”

- Restricted to electronic devices

A more refined definition of “computer”

- Restricted to electronic devices

- “Universal”
  programmable to do any task.

Computer:

An electronic device that can be programmed to carry out a set of basic instructions in order to acquire data, process data and produce output.

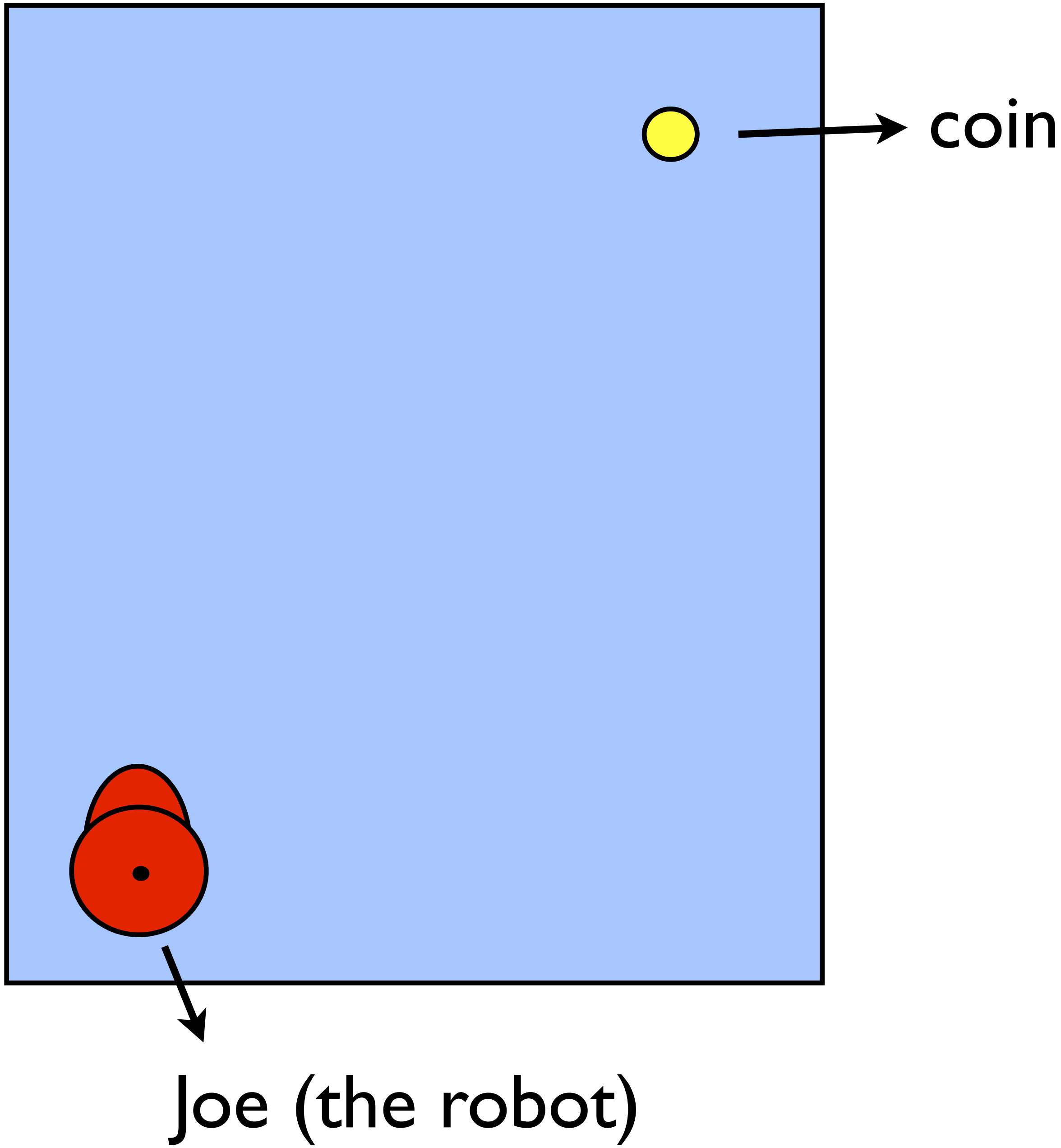
What is a computer program ?

A set of instructions that tells the computer how to manipulate data (information).

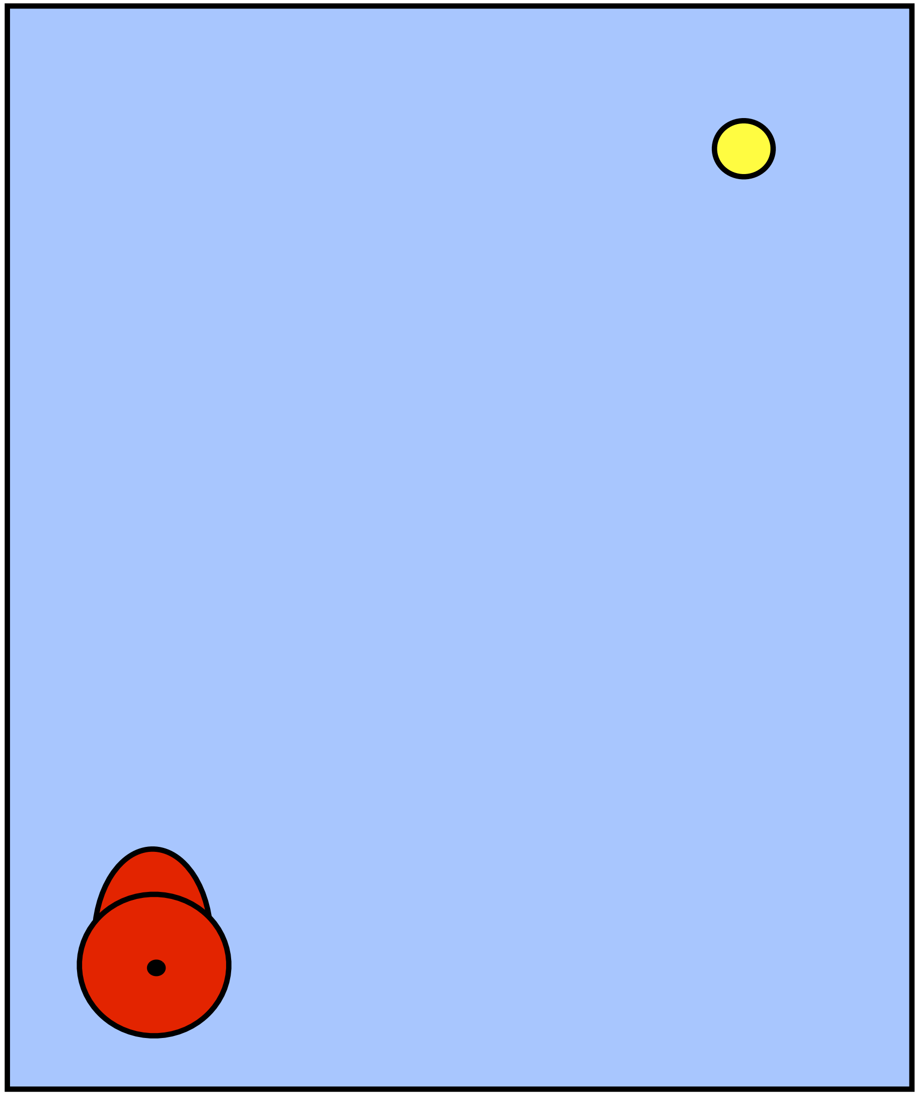
Who is a computer programmer ?

The person who writes the set of instructions.

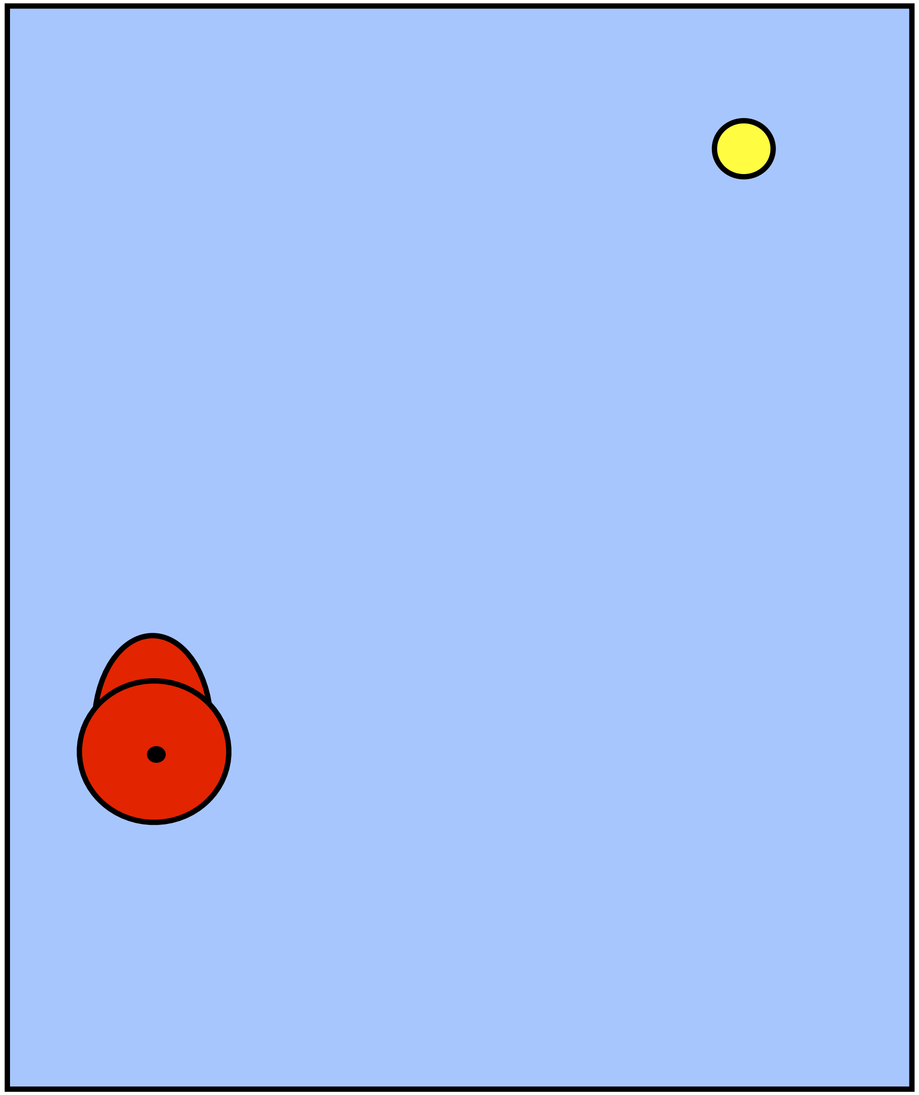
Example of a program



Example of a program

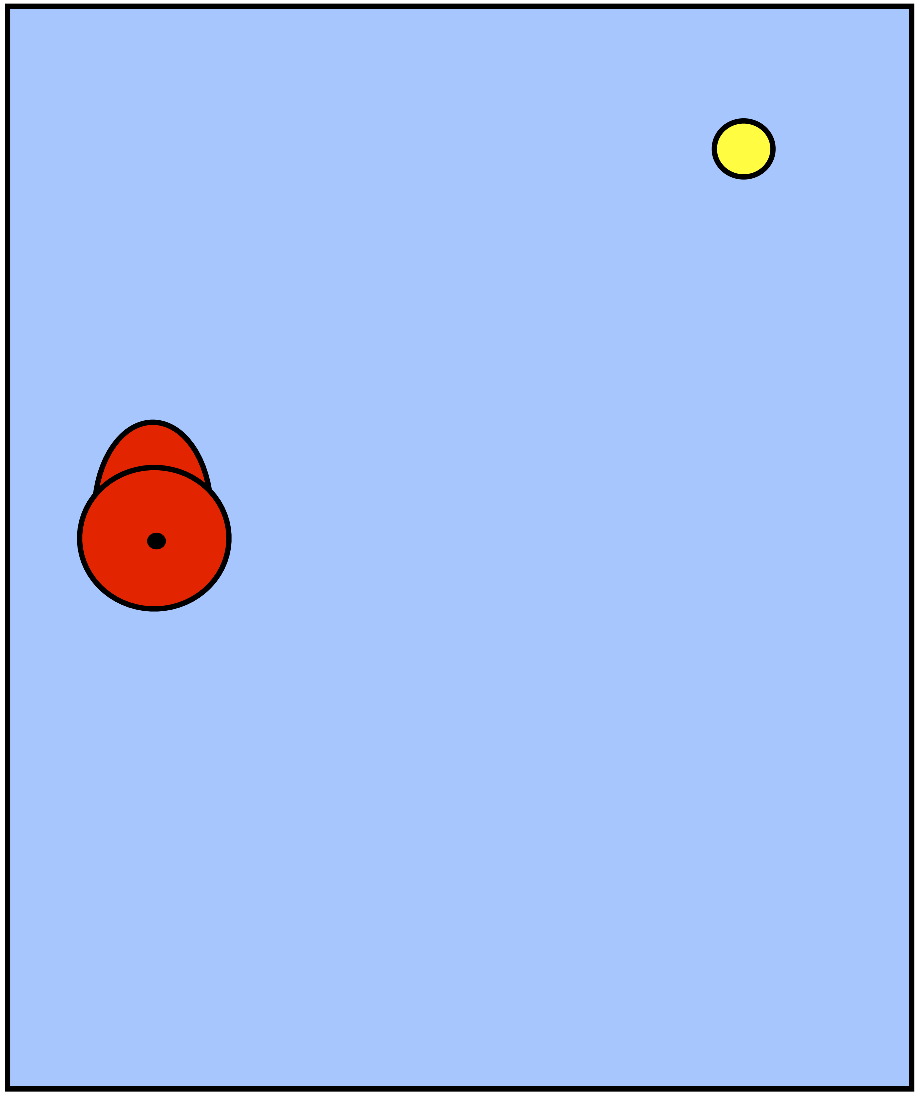


Example of a program



Move 1 step forward

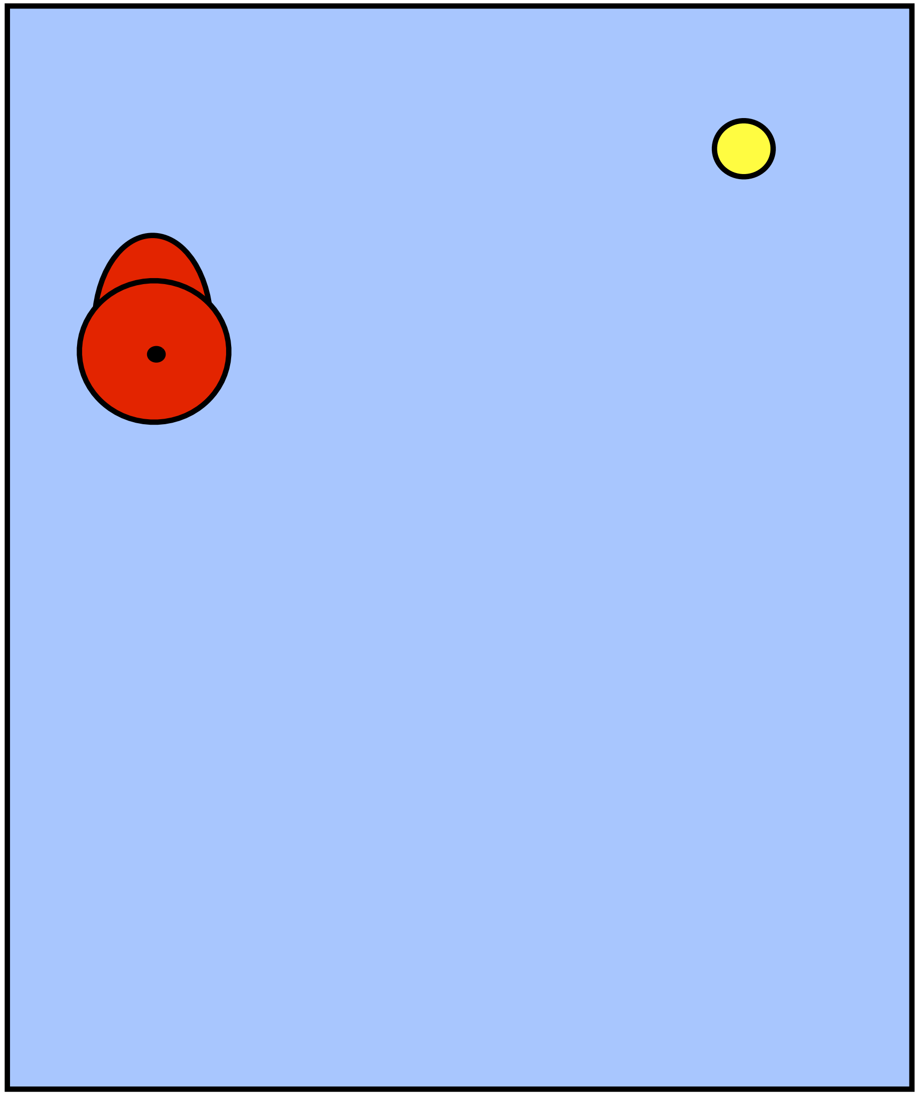
Example of a program



Move 1 step forward

Move 1 step forward

Example of a program

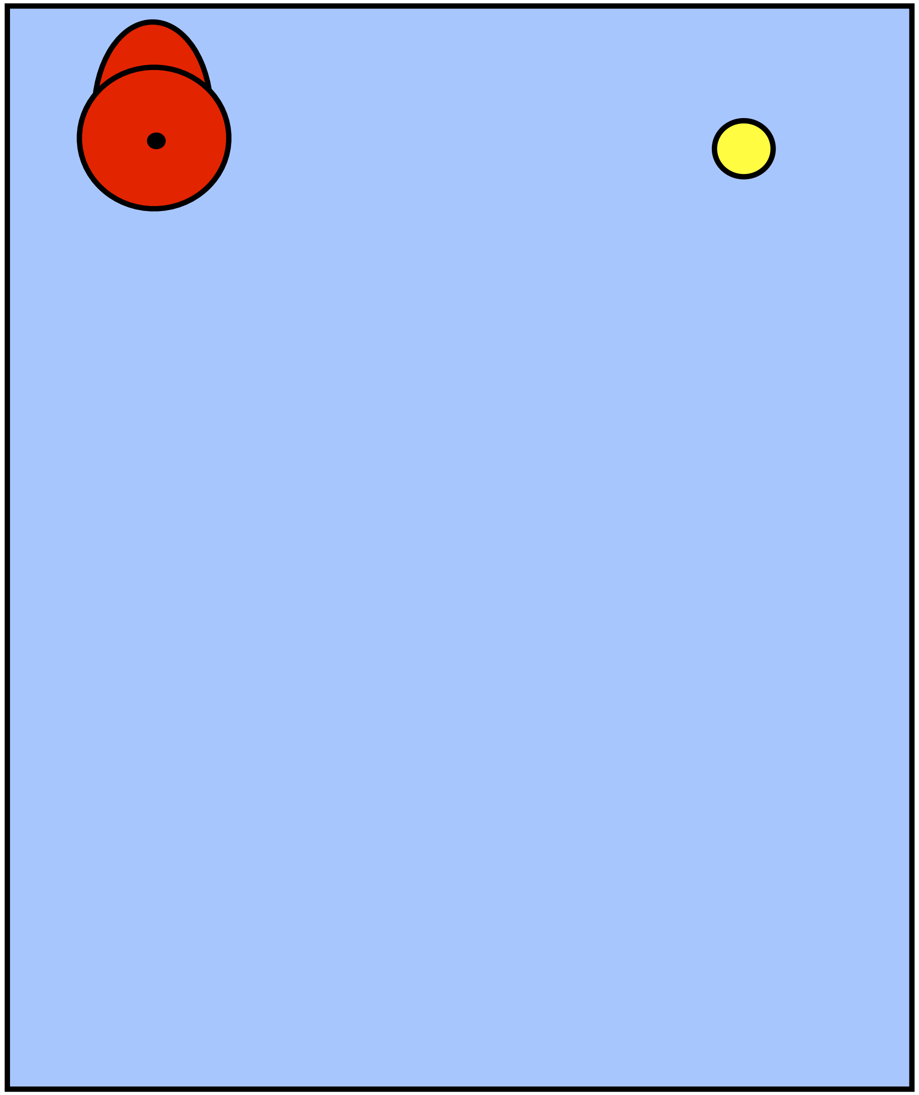


Move 1 step forward

Move 1 step forward

Move 1 step forward

Example of a program



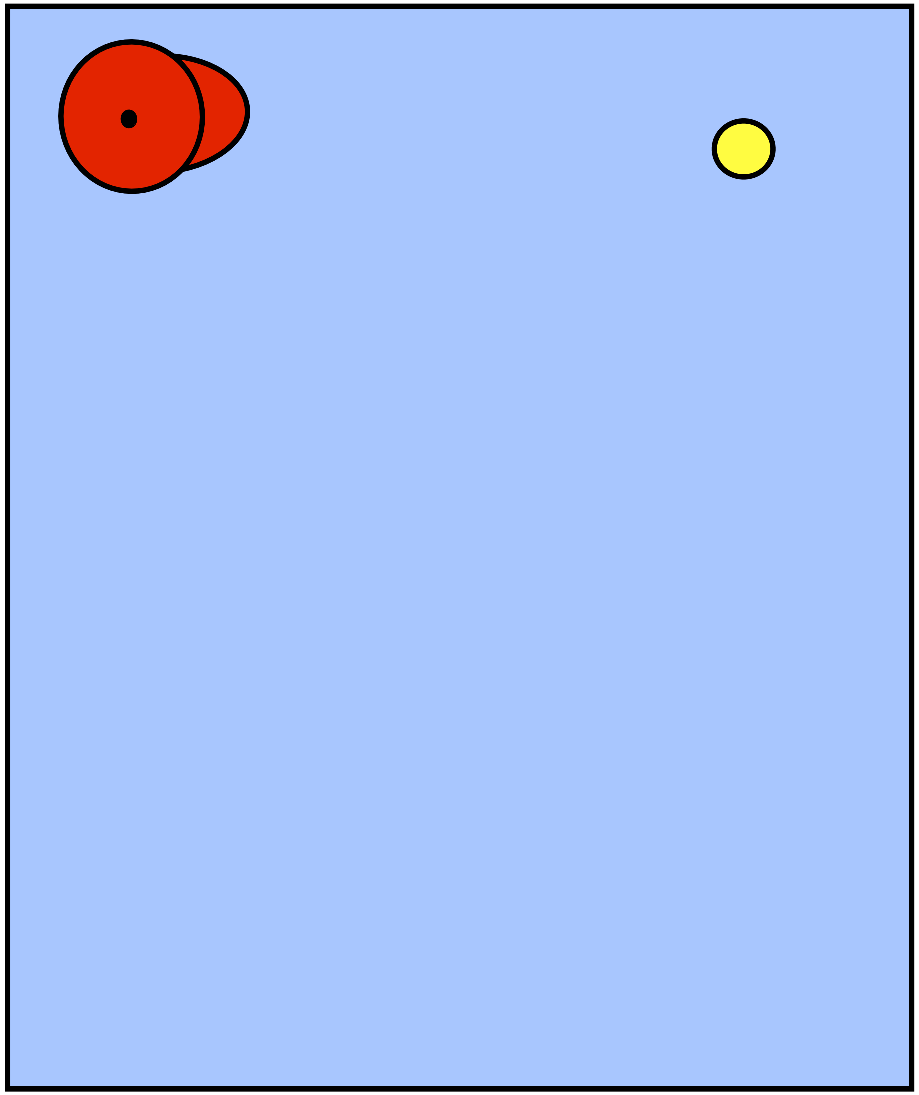
Move 1 step forward

Move 1 step forward

Move 1 step forward

Move 1 step forward

Example of a program



Move 1 step forward

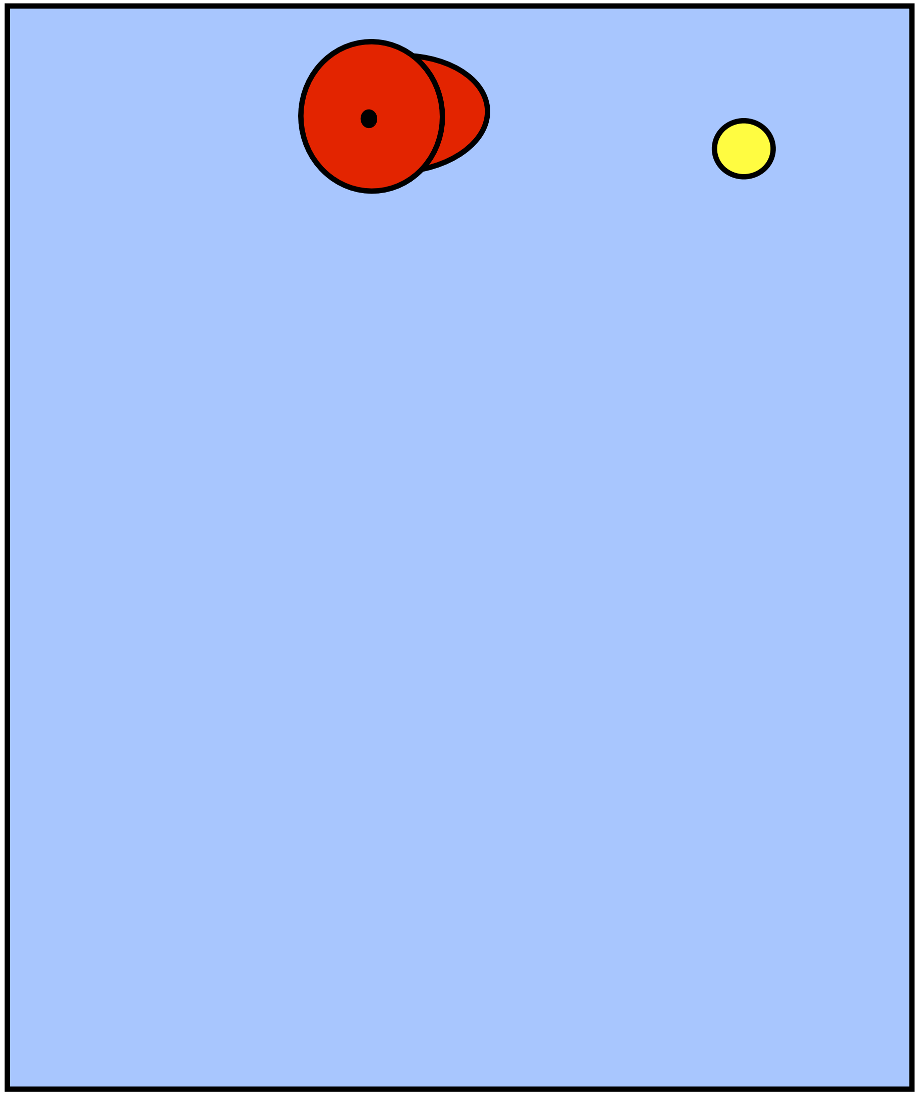
Move 1 step forward

Move 1 step forward

Move 1 step forward

Turn right

Example of a program



Move 1 step forward

Move 1 step forward

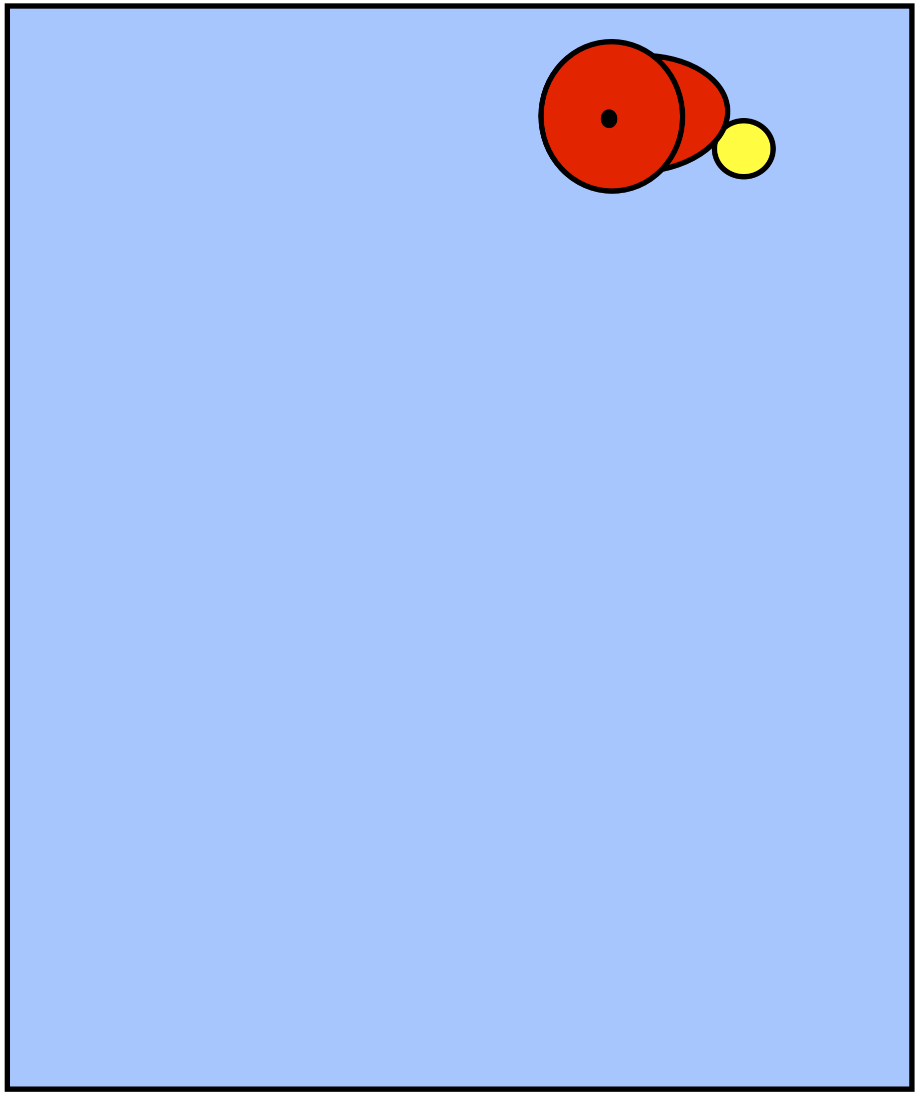
Move 1 step forward

Move 1 step forward

Turn right

Move 1 step forward

Example of a program



Move 1 step forward

Move 1 step forward

Move 1 step forward

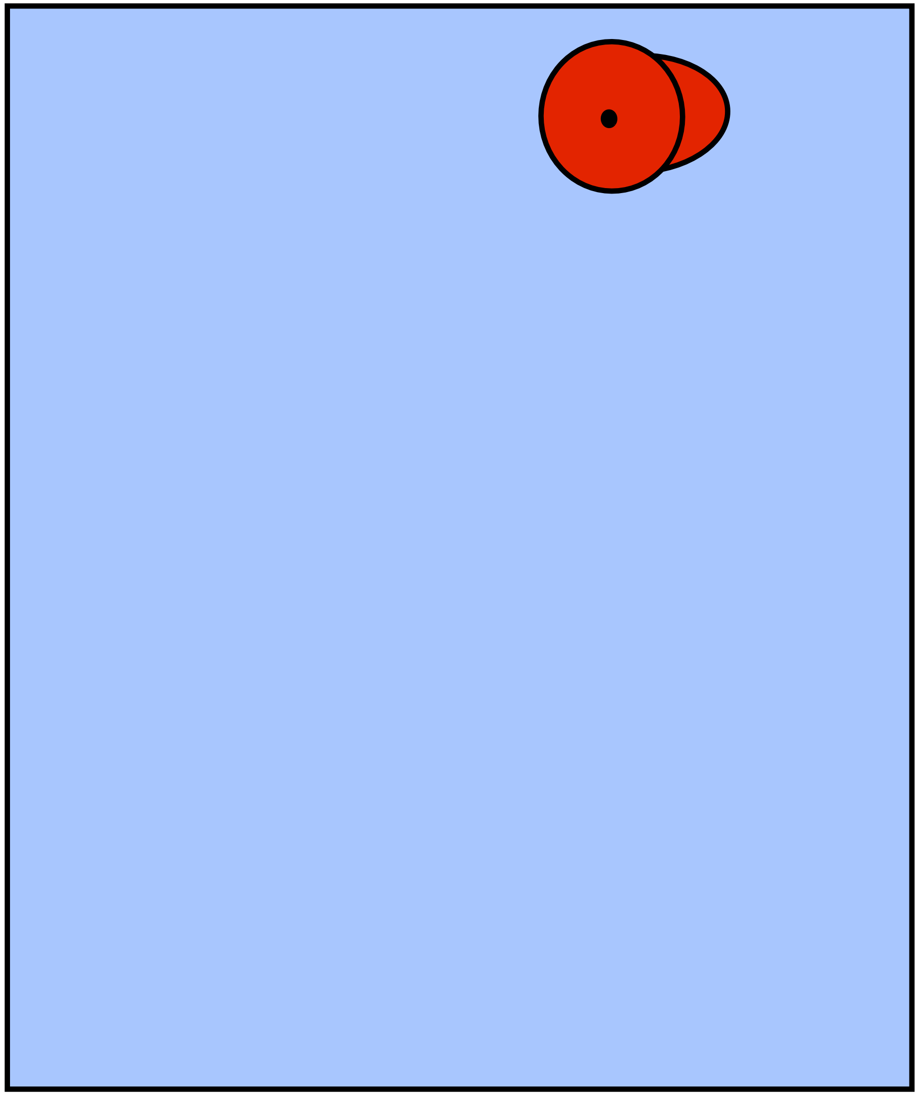
Move 1 step forward

Turn right

Move 1 step forward

Move 1 step forward

Example of a program



Move 1 step forward

Move 1 step forward

Move 1 step forward

Move 1 step forward

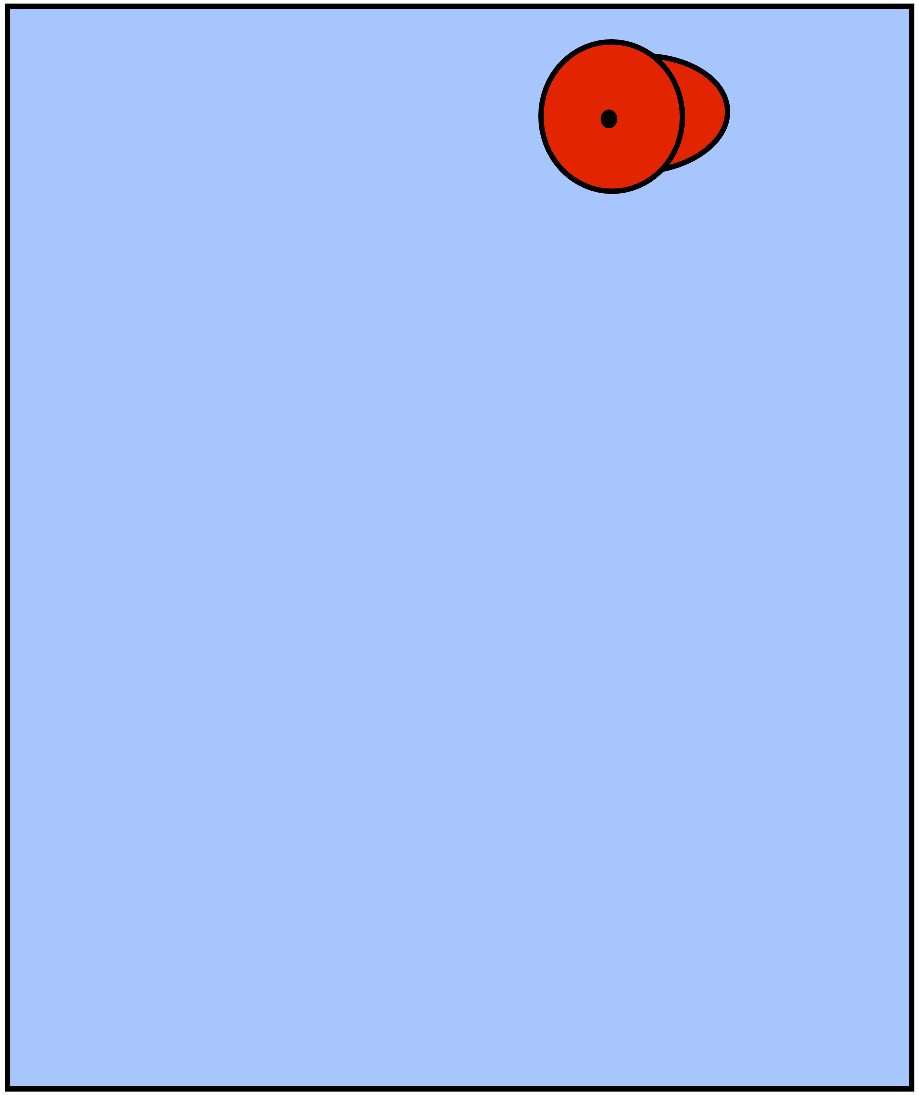
Turn right

Move 1 step forward

Move 1 step forward

Pick up coin

Example of a program



```
Repeat 4 times:
    Move 1 step forward
Turn right
Repeat 2 times:
    Move 1 step forward
Pick up coin
```

Another example: cooking

More appropriate to call this an **algorithm**.

Melt butter with olive oil.

Add garlic.

Cook until lightly browned.

Stir in green beans.

Season with salt and pepper.

Cook until beans are tender.

Sprinkle with parmesan cheese.

In this course:

This course is about learning to write programs for:

You will be their master.

Wait a minute!
Are you telling me Angry Birds is just a set of instructions?

Examples of Programs

Operating Systems

Windows
MacOS
Unix

Applications

Internet Explorer
iTunes
Warcraft

Web Sites

Facebook
Twitter
Wikipedia

There are thousands (sometimes millions) of lines of code (instructions) that tell the computer **exactly** what to do and when to do it.

What you will learn in this course:

We will lay the foundations of programming.

1. How to think like a computer scientist.

2. Principals of good programming.

3. Programming language: Python

What you will learn in this course:

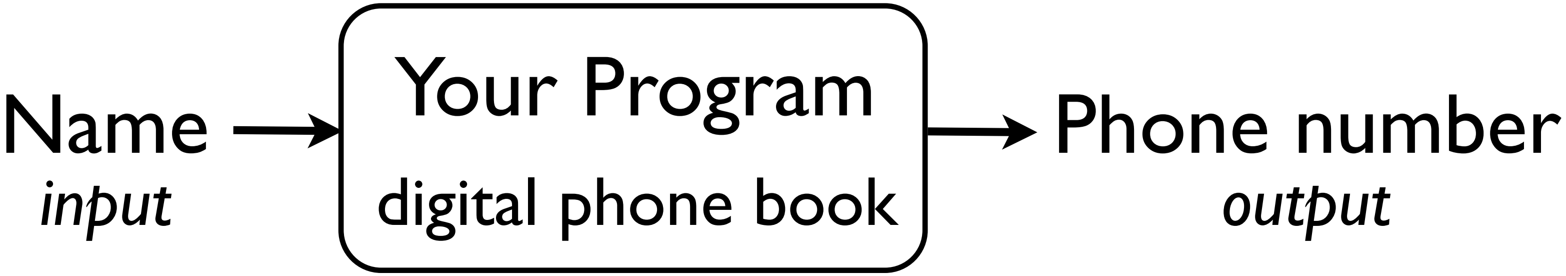
1. How to think like a computer scientist.

Solving problems.

- use instructions a machine can understand.
- divide the problem into smaller manageable parts.

Finding an efficient (preferably most efficient) solution.

EXAMPLE



Name
input

Your Program
digital phone book

Phone number
output

- *How do you solve it using instructions the computer can understand? (Can't just say "find phone number")*

- *How do you solve the problem efficiently?*

What you will learn in this course:

We will lay the foundations of programming.

1. How to think like a computer scientist.

2. Principals of good programming.

3. Programming language: Python

What you will learn in this course:

2. Principals of good programming.

Most important properties of a program:

- Does your program work correctly?

- Is it efficient?

*But these are **not** the only important things:*

- Is your program (code) easy to read? easy to understand?

- Can it be reused easily? extended easily?

- Is it easy to fix errors (bugs)?

- Are there redundancies in the code?

What you will learn in this course:

We will lay the foundations of programming.

1. How to think like a computer scientist.

2. Principals of good programming.

3. Programming language: Python

What you will learn in this course:

3. Programming language: Python

There are many human languages.
Can give instructions in English or Spanish or French, etc.

Similarly, there are many programming languages.

- Mix of math and English.
- Lots of similarities between different languages, but also important differences.

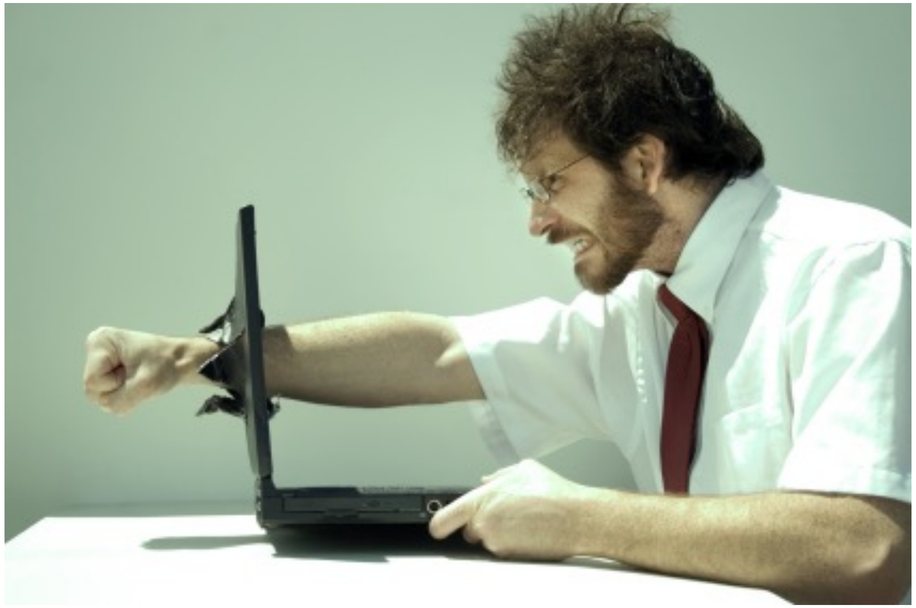
Programming is awesome!

Sky is the limit.

Combines technical skill and creativity.

When your program does what it is supposed to do:

When it doesn’t:



The destination

Term Projects

Keys to success in this course

How do you learn programming? **By doing!**

Understand the method: learning by immersion.

Understand the challenge. Embrace the challenge.

Time management!

Help us help you!

Ask questions in class, in office hours, on Piazza.

You will learn the most from your CAs. Use them.

Keys to success in this course

Most importantly:

Have fun!

Course Webpage

http://www.cs.cmu.edu/~112/m16/

Let’s start.

How do you create and run Python programs?

1. Install Python: *www.python.org/download*
   version 3.5.x

2. To type your code and run it, you need an IDE:

   a. Install and use IEP (now called Pyzo).

   or

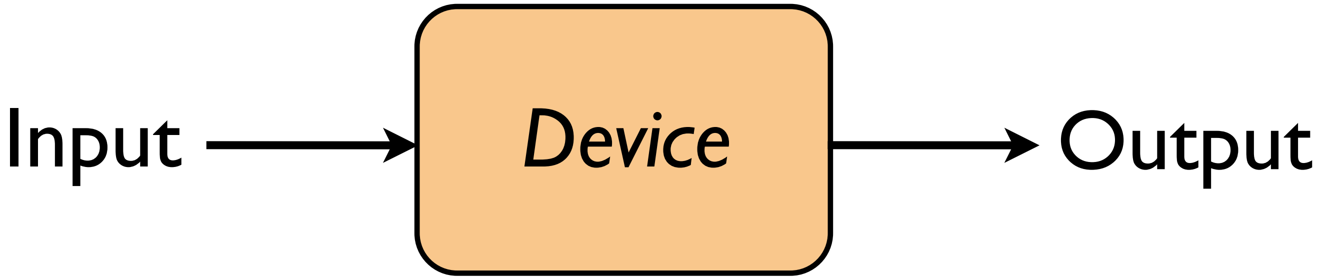
   b. Install Sublime or Komodo Edit
   or some other program.

What we know so far:

What is a computer?

A programmable device that manipulates data/information

Usually



What is a computer program ?

A set of instructions that tells the computer how to manipulate data/information.

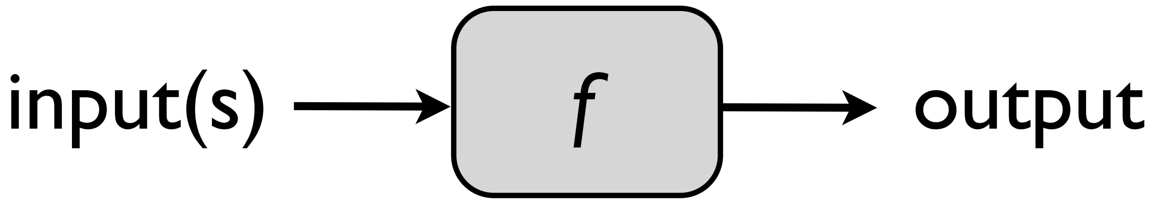
This Lecture (and next, and next, and next…)

How do these instructions look like?
(What kind of instructions are allowed?)

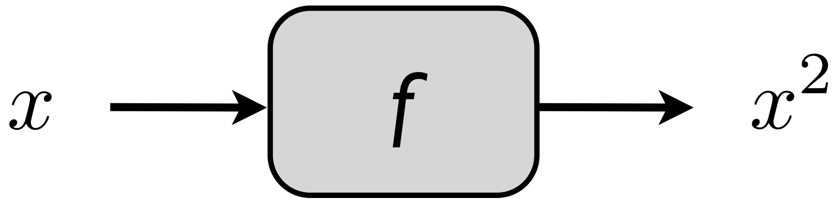
How can I use these instructions to write programs?
(How do I approach programming, where do I start?)

Calculation as computation

We can express calculation as a math function:



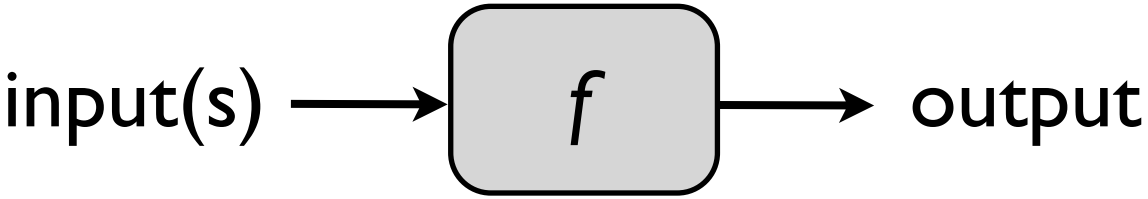
$$f(x) = x^2$$



$f(2) + f(5)$ evaluates to 29

Calculation as computation

We can express calculation as a math function:

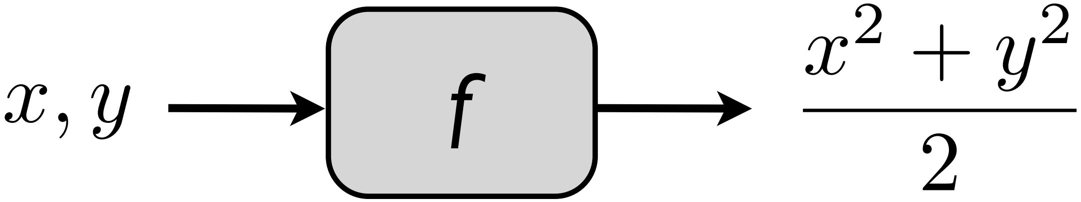


input(s)

f

output

$$f(x, y) = \frac{x^2 + y^2}{2}$$



x, y

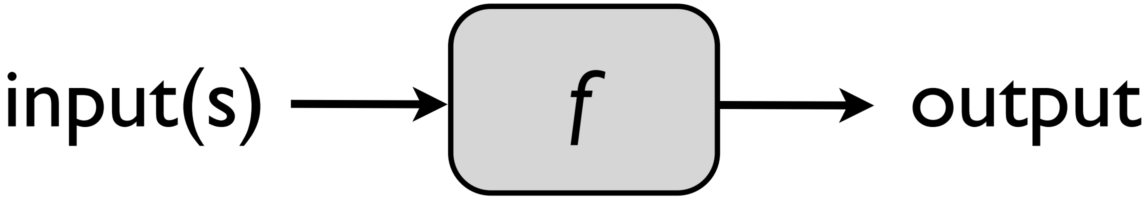
f

$$\frac{x^2 + y^2}{2}$$

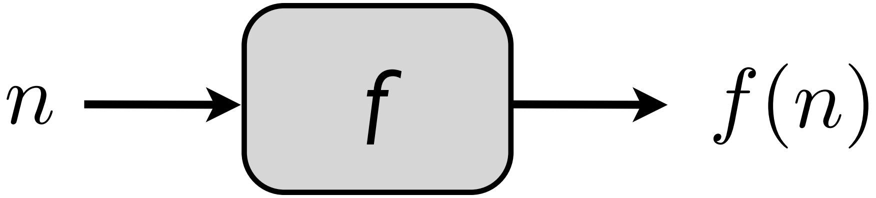
$f(2, 4) + 5$ evaluates to 15

Calculation as computation

We can express calculation as a math function:



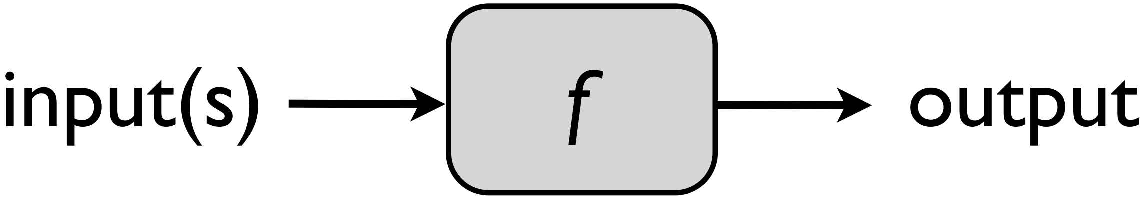
$$f(n) = \text{n'th prime number}$$



Often, there will be no formula for the output.

Calculation as computation

We can express calculation as a math function:



The most important part of calculation/computation is:

specifying how to go from the input to the output.

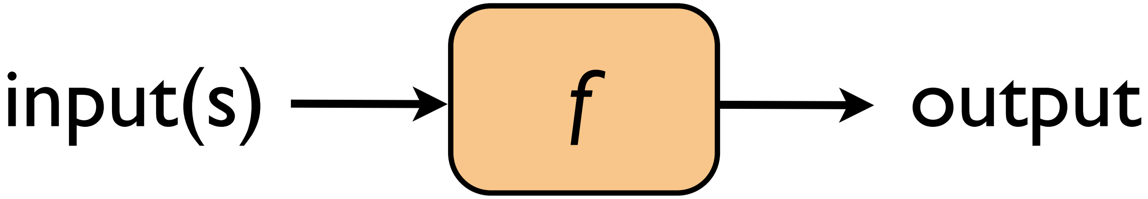
- This specification/description is called:

  > algorithm, if a human can follow it;

  > computer program (or code), if a computer can follow it.

Computation using Python

We can express computation as a Python function:


input(s) → *f* → output

But now, inputs and output can be any type of data.

Examples:

```
def f(x):
    y = x*x
    return y
```

```
def f(x, y):
    z = (x**2 + y**2)/2
    return z
```

```
def nthPrime(n):
    …
```

more complicated.

Basic Building Blocks

Statements

Tells the computer to do something. An instruction.

Data Types

Data is divided into different types.

Variables

Allows you to store data and access stored data.

Operators

Allows you to manipulate data.

Functions

Programs are structured using functions.

Conditional Statements

Executes statements if a condition is satisfied.

Loops

Execute a block of code multiple times.

Basic Building Blocks

Statements

```
print(“Hello World”)
```

In Python3, this is technically a function.

```
Hello World
```

```
print(911)
```

```
911
```

```
print(1, 2, 3)
```

```
1 2 3
```

```
print(3.14, “is not an integer”)
```

```
3.14 is not an integer.
```

Basic Building Blocks

Assignment Statements and Variables

variable-name = value

```
x = 5
y = “Hello World”
print(x)
print(y)
```

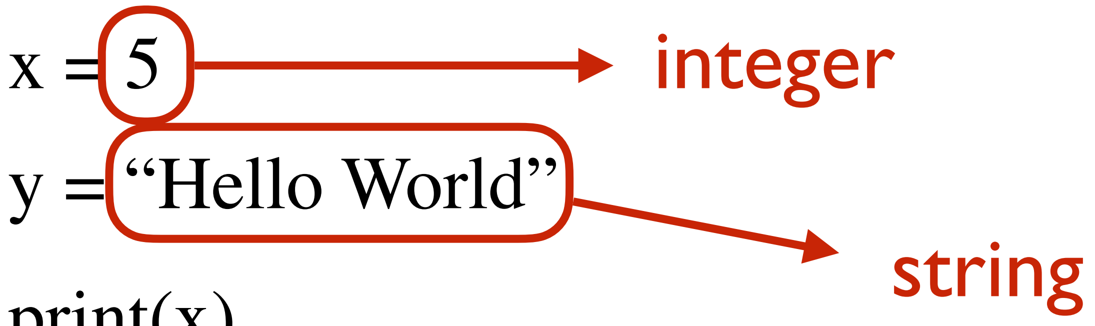
```
x = 3.14
y = x
x = 0
print(y)
```

In an **assignment statement:**

1. Evaluate RHS.
2. Assign the value to the variable.

Basic Building Blocks

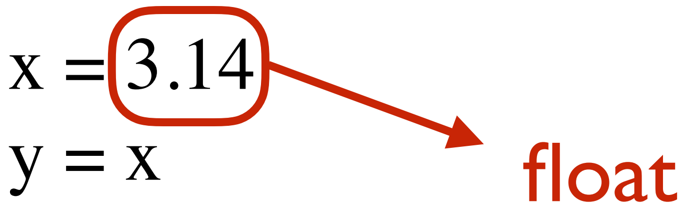
Data/value types



```
x = 5
y = “Hello World”
print(x)
print(y)
```

integer

string



```
x = 3.14
y = x
x = 0
print(y)
```

float

Data Types

Python name	Description	Values
int (integer)	integer values	-2^{63} to $2^{63}-1$
long	large integer values	all integers
float	fractional values	e.g. 3.14
str (string)	text	e.g. "Hello World!"
bool (boolean)	Boolean values	True, False
NoneType	absence of value	None

•••

Basic Building Blocks

Operators

```
x = 3 + 5                                   x stores 8
print(“Hello” + “ World”)                   Hello World
print(1.5 + 1.5)                            3.0
x = 2 * x + 2**3                            x stores 24
print(x > 25)                               False
print((x < 25) and (x >= 0))                True
x = “Hi!” * 2                               x stores “Hi!Hi!”
```

What an operator does depends on the types of data it’s acting on.

Expression: - a valid combination of data and operators

- evaluates to a value

Expressions are evaluated first!

Basic Building Blocks

Functions

```
def square(x):
    y = x*x
    return y
```

function definition

```
print(square(5))
```

Basic Building Blocks

Functions

```
def square(x):
    y = x*x
    return y

print(square(5))
```

function body (must be indented)

Basic Building Blocks

Functions

```
def square(x):
    y = x*x
    return y

print(square(5))
```

parameter

Basic Building Blocks

Functions

```
def square(x):
    y = x*x
    return y

print(square(5))
```

function call

Basic Building Blocks

Functions

```
def square(x):
    y = x*x
    return y

print(square(5))
```

argument

Basic Building Blocks

Functions

```
def square(x):
    y = x*x
    return y
```

```
def square(x):
    return x*x
```

```
def square(x):
    return x**2
```

Functions can have multiple inputs

```
def f(x, y):
    return (square(x) + square(y))/2

print(f(2, 3))
```

Basic Building Blocks

Functions

```
def greetUser(name):
    print(“Hello”, name)

greetUser(“David”)
```

```
Hello David
```

Does this function return anything?

It actually returns None. Same as:

```
def greetUser(name):
    print(“Hello”, name)
    return None

print(greetUser(“David”))
```

```
Hello David
None
```

Basic Building Blocks

Functions

Functions don’t have to take any input

```
def greetEveryone():
    print(“Hello everyone!”)

greetEveryone()                        Hello everyone!

greetEveryone(“David”)                 ERROR
```

```
def isPositive(x):
    return (x > 0)

print(isPositive(-1))                  False
```

Basic Building Blocks

Functions

```
def isPositive(x):
    print(“Hello.”)
    return (x > 0)
    print(“Bye.”)

print(isPositive(-1))
```

```
Hello.
False
```

```
def celsiusToFahrenheit(degrees):
    return degrees * (9 / 5) + 32

def fahrenheitToCelsius(degrees):
    return (degrees - 32) * (5 / 9)
```

Basic Building Blocks

Functions

There are various built-in functions:

```
print(abs(-5))
print(max(2, 3))
print(min(2, 3))
print(pow(2, 3))
print(round(-3.14))

print(type(5))
print(type(“hello”))
print(type(True))

print(int(2.8))
```

Basic Building Blocks

Statements
Tells the computer to do something. An instruction.

Data Types
Data is divided into different types.

Variables
Allows you to store data and access stored data.

Operators
Allows you to manipulate data.

Functions
Programs are structured using functions.

Conditional Statements
Executes statements if a condition is satisfied.

Loops
Execute a block of code multiple times.

Basic Building Blocks

Conditional Statements

```
def absoluteValue(n):
    if (n < 0):
        n = -n
    return n

print(absoluteValue(-5))        5
print(absoluteValue(3))         3
```

Basic Building Blocks

Conditional Statements

```
def absoluteValue(n):
    if (n < 0):
        return -n
    return n

print(absoluteValue(-5))            5
print(absoluteValue(3))             3
```

Basic Building Blocks

Conditional Statements

```
def degreeConverter(degrees, option):
    if (option == 1):
        result = degrees * (9 / 5) + 32
    else:
        result = (degrees - 32) * (5 / 9)
    return result

print(degreeConverter(100, 1))
```

Basic Building Blocks

Loops

```
for i in range(5):
    print("Hello!")
```

```
Hello!
Hello!
Hello!
Hello!
Hello!
```

Basic Building Blocks

Loops

```
def printHello(n):
    for i in range(n):
        print("Hello!")
```

```
printHello(7)
```

```
Hello!
Hello!
Hello!
Hello!
Hello!
Hello!
Hello!
```

Basic Building Blocks

Loops

```
def printHello(n):
    i = 0
    while (i < n):
        print(“Hello!”)
        i = i + 1

printHello(7)
```

```
Hello!
Hello!
Hello!
Hello!
Hello!
Hello!
Hello!
```

Careful: Easy to make errors!

Try to modify the examples:

- Misspell some of the words.
- Write in upper case.
- Put two statements on one line.
- Divide one statement over two lines.
- ...

Try to run and see what kind of errors you get.

Types of Programming Errors (Bugs)

3 types

Syntax errors (compile-time errors):

The compiler finds problems with syntax

e.g. typed "Print" rather than "print"

Run-time errors:

A problem occurs during program execution, and causes the program to terminate abnormally (*crash*).

e.g. division by 0.

Logical errors:

The program runs, but produces incorrect results.

e.g. maybe in your program you used a wrong formula:

```
celsius = (5 / 9) * fahrenheit - 32
```

One of the most important parts of programming is debugging!