Course overview: Introduction to programming concepts

- What is a program?
- The Python programming language
- First steps in programming
- Program statements and data
- Designing programs
- Python and the web.

This course will give an introduction to general programming concepts, and to the Python programming language.

Textbook and web

- We recommend a basic Python textbook such as “Python in easy steps” (Mike McGrath)
- Python can be downloaded for free from *http://python.org/downloads*
- In this course the computers already have Python installed.

What is a program?

- A program is a set of instructions which control a computer (laptop, desktop, tablet, etc)
- Programs can be written for huge variety of tasks: performing complex computations; financial trading; computer graphics and games; medical diagnosis and data processing; aircraft autopilot, etc
- Programs can read data from computer keyboard, mouse movements and actions, from data files, databases and any other sensors/data sources on the computer – and from internet if connected.
- Programs can present information graphically on computer screen, can write to text files, or update any other device connected to computer – if permitted to do so.

What is a program?

A set of instructions, in a particular order.

Example of simple program (expressed in English, not a programming language):

```
read a number X
read a number Y
calculate Z = (X + Y) divided by 2
display Z
```

This computes average of two numbers, eg: for X = 203, Y = 1965, displays 1084.

What is a program?

- Another name for programs is *software* – as opposed to *hardware*, the physical computer and devices.
- Programs are written in text files in the format of some *programming language*
- The most widely-used programming languages are C, C++, C#, Java and Python.
- We'll use Python, as it's simplest of the popular languages.
- Python is intended to be simple language for learning programming – but can be used for real applications also.

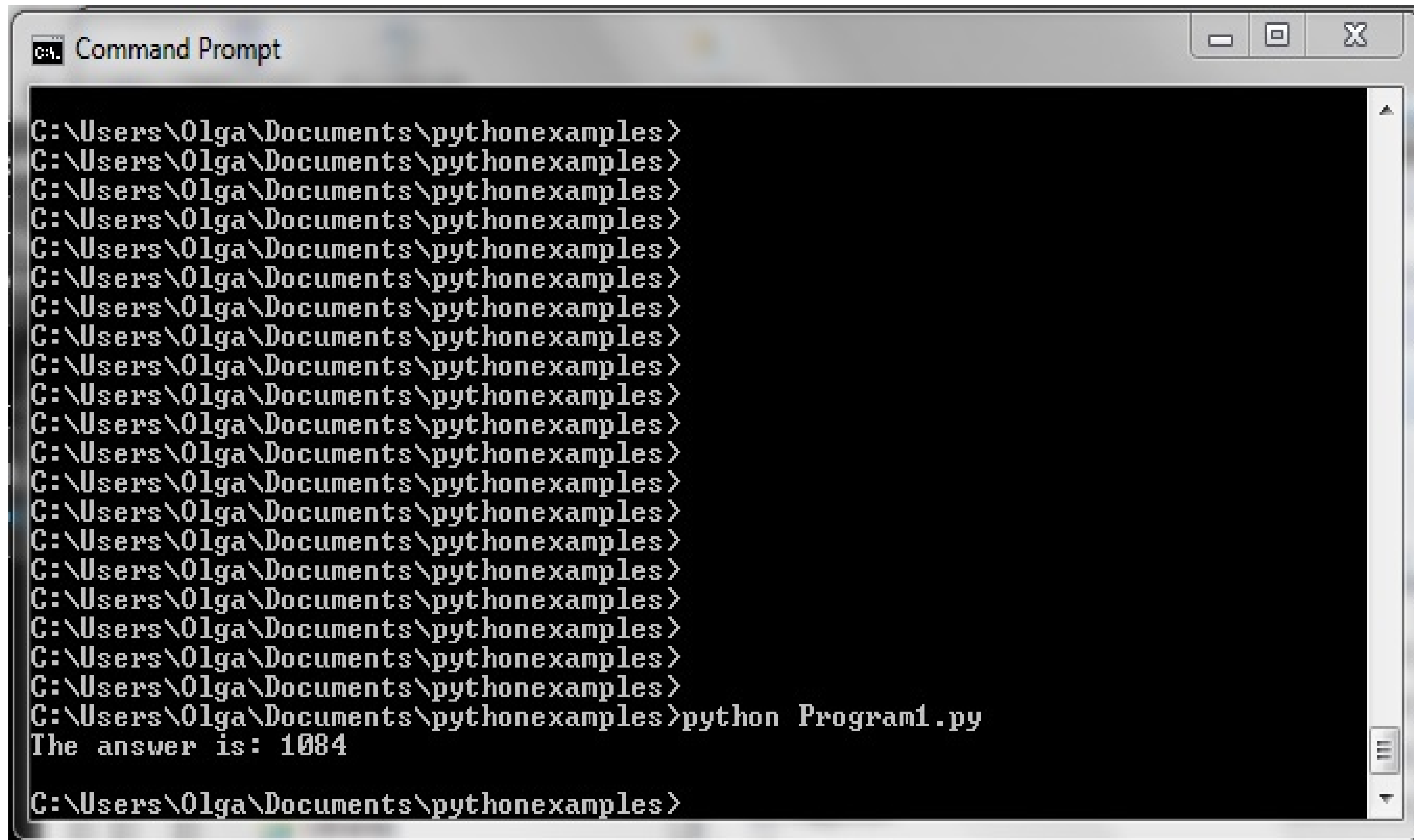
The Python programming language

- We write Python programs in text files (eg., using WordPad or Notepad), with .py file extension, eg.: *Program1.py*

```
X = 203
Y = 1965
Z = (X + Y)//2
print("The answer is: " + str(Z))
```

Here, three integer-valued variables X, Y, Z are declared. X and Y are given values 203 and 1965, then Z is calculated from them, and then displayed.

Python statements are written on successive text lines in text file *Program1.py*. // is used to divide integers. str(Z) converts number Z to a string.



Running Program1.py

First steps in programming

- Open the Windows console (Start; All Programs; Accessories; Command Prompt)
- In the Windows console, cd to the directory *cllexamples* where Program1.py is (on memory stick)
- Run the program with python:

  ```
  python Program1.py
  ```

Note that *python* is lowercase *P* here.

X

Y

Z

add, then divide
sum by 2

Data in computer

First steps in programming

- A Python program in a file *Name.py* can have any number of statements, written on successive lines.

- *Give programs meaningful names:* Average.py would be better name for our first program.

- *Program statements:* individual instructions and steps the computer should take.

  Eg.: `X = 203` "Introduce an integer variable called X, and assign the value 203 to it".

  `Z = (X + Y)//2` "Introduce an integer variable called Z, and assign (X + Y) divided by 2 to it".

Try changing the values assigned to X, Y and re-run using *python*.

First steps in programming

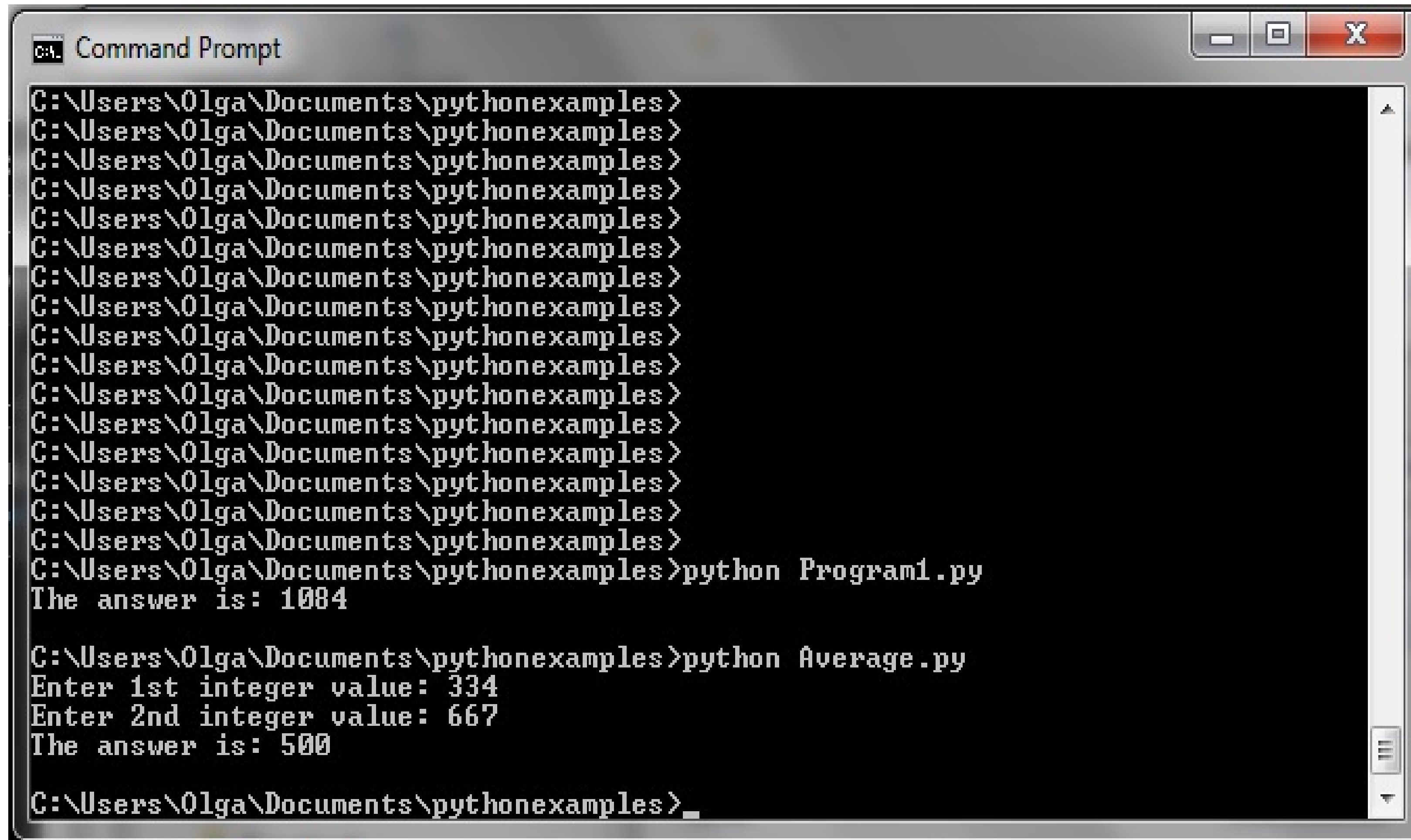
- Of course, a more useful program is one that can read inputs from user:

```
xvalue = input("Enter 1st integer value: ")
X = int(xvalue)
yvalue = input("Enter 2nd integer value: ")
Y = int(yvalue)
Z = (X + Y)//2
print("The answer is: " + str(Z))
```

The dialogs prompt user for the X, Y values.

Input from user is stored in String variables xvalue, yvalue – these store pieces of text.

Then converted to numbers by int(value). Eg., string “334” is converted to number 334.



Average.py input dialog

First steps in programming

- If we enter some wrong data (not integers), our program crashes – a professional program should be robust & continue despite errors
- The *User Interface* of a program consists of the visual components used to exchange data between program and users – in this case the input dialog and command window. Also called *Graphical User Interface* (GUI).

Program Statements

- Programs consist of *program statements* – individual processing instructions, operating on variables and values
- *Assignment statements* assign a value to a variable:

  ```
  X = 530
  ```

  These also declare/introduce the variable, so that it can be used in following statements:

  ```
  X = 530
  Y = X*X
  ```

- *Conditional statements* enable decisions to be made: if a condition is true, one behaviour is executed; if condition is false another behaviour is executed.

Max.py:

```
xvalue = input("Enter 1st integer value: ")
X = int(xvalue)
yvalue = input("Enter 2nd integer value: ")
Y = int(yvalue)
Z = 0
if X < Y :
  Z = Y
else :
  Z = X
print("The largest value is: " + str(Z))
```

The statement

```
if X < Y :
  Z = Y
else :
  Z = X
```

tests the condition $X < Y$, ('is X less than Y?'), if this is true then the statement $Z = Y$ is executed, otherwise (if X equals Y or is larger than Y), the statement $Z = X$ is executed.

Effect is to always set Z to be the larger of X and Y.

Indent sub-statements such as $Z = X$ at least 2 spaces from their parent statement (here, the if-else statement).

Multiple decisions

Conditions can be as complex as needed, and multiple conditions can be tested (StudentMarks.py):

```
markvalue = input("Enter the student's mark: ")
mark = int(markvalue)
if mark < 40 :
  result = "Fail"
else :
  if mark >= 40 and mark < 50 :
    result = "Pass -- grade D"
  else :
    if mark >= 50 and mark < 60 :
      result = "Pass -- grade C"
    else :
      if mark >= 60 and mark < 70 :
        result = "Pass -- grade B"
```

```
    else :
      result = "Pass -- grade A"
print("The student's result is: " + result)
```

For each nested statement, indent a further 2 (or more) spaces.

The "and" keyword combines two conditions by conjunction.

result is a String variable – it stores a piece of text.

Conditional Statements

Examples of different cases:

Input	*Output*
10	“Fail”
42	“Pass – grade D”
55	“Pass – grade C”
67	“Pass – grade B”
70	“Pass – grade A”

Try executing StudentMarks.py with other example input values.

Loop Statements

- Loop statements repeat some instructions over & over again until a task is completed
- *for statements* loop for a fixed number of times:

```
for i in range(a,b+1) :
  statements
```

means ‘execute the *statements* with i = a, then with i = a+1, i = a+2, ..., then with i = b’

- If $a > b$, does nothing
- If a equals b, just one iteration, for $i = a$.

Loop Statements

SumNumbers.py:

```
nvalue = input("Enter the number to sum: ")
n = int(nvalue)
sum = 0
for i in range(1,n+1) :
  sum = sum + i
print("The sum is: " + str(sum))
```

calculates sum of numbers from 1 to n.

Results for different input values:

n	sum
0	0
1	1
2	3
3	6
4	10
5	15
6	21
7	28
8	36
9	45
10	55

- Simple program structure as list of statements
- Variables of integer type (`X = 0`) – these can store values of integers, eg.: -214, 0, 1, 55, 1000, 500000, etc.
- Variables of String type (`s = ""`) – these can store strings/text, eg.: "Result", "Enter a value"
- Assignment statements $var = value$
- Conditional statements

```
if Condition :
  statement1
else :
  statement2
```

- Bounded loops:

```
for var in range(a, b) :
  statement
```

More advanced Python

- `float` variables (rational numbers)
- Unbounded loops (`while` statements)
- What is programming?
- Functions and recursion
- List variables.

Calculations with rational numbers

- `float` variables can store fractional values: 0.5, 2.25, 0.0001, etc.
- Python provides functions for square root: `math.sqrt(d)`, x to power y, etc: `math.pow(x,y)`
- These functions return float values in general – but integers can be used as floats (1.0, -3.0, etc).

Example: calculate total amount earned if invest *deposit* (eg, £100) for n years at interest rate *rate* (eg. 5%, or 0.05).

Calculating compound interest

deposit grows with interest to: $total = deposit * (1 + rate)^n$ after n years at rate *rate*.

```
import math
# The math library is needed for pow

amount = 100.0  # total money
deposit = 100.0  # original investment
rate = 0.05  # interest rate

for year in range(1,11) :
  amount = deposit * math.pow(1.0 + rate, year)
  print("After " + str(year) +
        " years, total is: " + str(amount))
```

Notice that comments are written following the # character.

Amounts after n years:

n	$amount$
1	105.0
2	110.25
3	115.763
4	121.551
5	127.628
6	134.01
7	140.71
8	147.746
9	155.133
10	162.889

Calculating compound interest

How many years does it take for investment to double?

Need `while` loop:

```
import math

amount = 100.0  # total money
deposit = 100.0  # original investment
rate = 0.05  # interest rate

year = 1
while amount < 2*deposit :
  amount = deposit * math.pow(1.0 + rate, year)
  print("After " + str(year) + " years, total is: " +
        str(amount))
  year = year + 1
```

```
while E:
  C
```

repeats C until E is false – but may run forever!

Here, termination when `year = 15`.

Try changing the rate and see the effect on the result.

What is Programming?

- Given: a *problem* ("find how many years it takes to double an investment at 5% interest")
- First: *idea for solution*
- Second: *plan an algorithm* to carry out the solution
- Third: *code up algorithm* in a programming language (Python or another)
- Fourth: *test/correct* your code.

What is Programming?

- Problem to “find number of years until investment doubles”
- Idea for solution: calculate total amount earned for successive years, stopping when this amount is at least twice the original deposit
- Algorithm: compute total earned to *year* by

  $$amount = deposit * (1.0 + rate)^{year}$$

  for year = 1, 2, 3, ... stopping when $amount \geq 2 * deposit$
- Code in Python: use *while* loop to repeat calculation until the stopping condition is true
- Test with different rates and deposits.

Reading data from files

- Programs can read data from files (usually, text files)
- Eg.: to read student marks and classify these into grades
- Idea is that program reads lines of text from file (should be numbers), and converts each to a grade, until end of file (eof) is reached.

MarksFile.py:

```
file = open("marks.txt", "r")
for line in file :
  mark = int(line)
  if mark < 40 :
    result = "Fail"
  else :
    if mark >= 40 and mark < 50 :
      result = "Pass -- grade D"
    else :
      if mark >= 50 and mark < 60 :
        result = "Pass -- grade C"
      else :
        if mark >= 60 and mark < 70 :
          result = "Pass -- grade B"
        else :
          result = "Pass -- grade A"
```

```
  print("The student's result is: " + result)
file.close()
```

The file *marks.txt* is opened for reading, and for each line of the file, its grade is calculated and displayed. Finally *marks.txt* is closed.

Defining functions

- So far we've written all code in one file as sequence of statements.
- Also possible to write several operations in a program, called from main code: factorial example.
- For larger programs, best to create separate files + call their code from main file.

Calculating factorials

For integer $n > 0$, its factorial is product: $n * (n-1) * ... * 1$.

Factorial.py:

```
def fact(n) :
  if n <= 1 :
    return 1
  else :
    return n*fact(n-1)



# Main program uses fact function:


for n in range(1,14) :
  print("Factorial " + str(n) + "! = " + str(fact(n)))
```

fact calls itself – this is *recursion*. Provides another way of looping: *fact*(5) calls *fact*(4), which calls *fact*(3), etc. `return e` ends the call and returns value of e to the caller.

Program design: lottery example

- Problem to "Carry out lottery with three numbers in range 1 to 30 for user to guess with five guesses"
- Idea for solution: generate random numbers, ask user to guess these, and count correct guesses
- Algorithm:

```
Generate 3 random integers in 1..30
Ask user for 5 guesses
Count and display the correct guesses
```

- Code in Python: use *random* package and $sample(range(1, 31), 3)$ to generate the random numbers
- Test with different cases of correct/incorrect guesses.

Lottery.py:

```
import random  # to generate random numbers

balls = random.sample(range(1,31),3)
correct = 0
for i in range(1,6) :
  sguess = input("Enter your guess: ")
  guess = int(sguess)
  if guess in balls :
    print("Correct guess of a ball")
    correct = correct + 1
  else :
    print("Sorry, wrong guess!")
print("You guessed " + str(correct) + " correct");
```

List variables

balls is a *list* variable, holds collection of values. Membership test

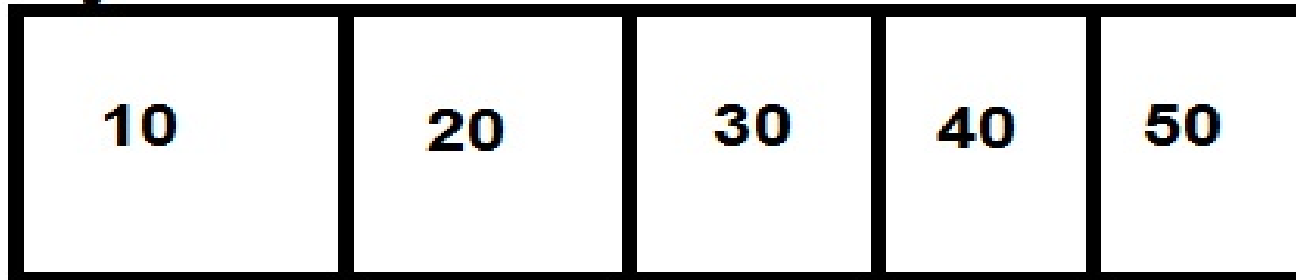
```
guess in balls
```

checks if value of *guess* is a member of *balls*.

- Previously, we saw variables that store single items – an individual integer, rational, string, or class instance
- Sometimes useful to have one variable storing group of items – such as the 3 balls in lottery game
- *List variables* store group of items of same kind. Eg.:

  ```
  balls = [23,11,17]
  ```

  declares *balls* as a list of 3 integers.
- Individual items are written as *balls*[0], *balls*[1], *balls*[2].




```
arrayX = []
arrayX.append(10)
arrayX.append(20)
arrayX.append(30)
arrayX.append(40)
arrayX.append(50)

or:
arrayX = [10,20,30,40,50]
```

Data in list variables

List variables

A loop of form

```
for x in array :
   ... code for x ...
```

is often used to process lists.

Size of list *array* is $len(array)$. Notice that numbering of elements starts from 0, so ends at $len(array) - 1$.

Set value of $array[i]$ by statement

```
array[i] = value
```

Summary

- Program structure as list of statements
- Variables of integer, rational, string, class instance types
- List variables
- Assignment, conditional, loop statements
- Functions and recursion.

Python and the web

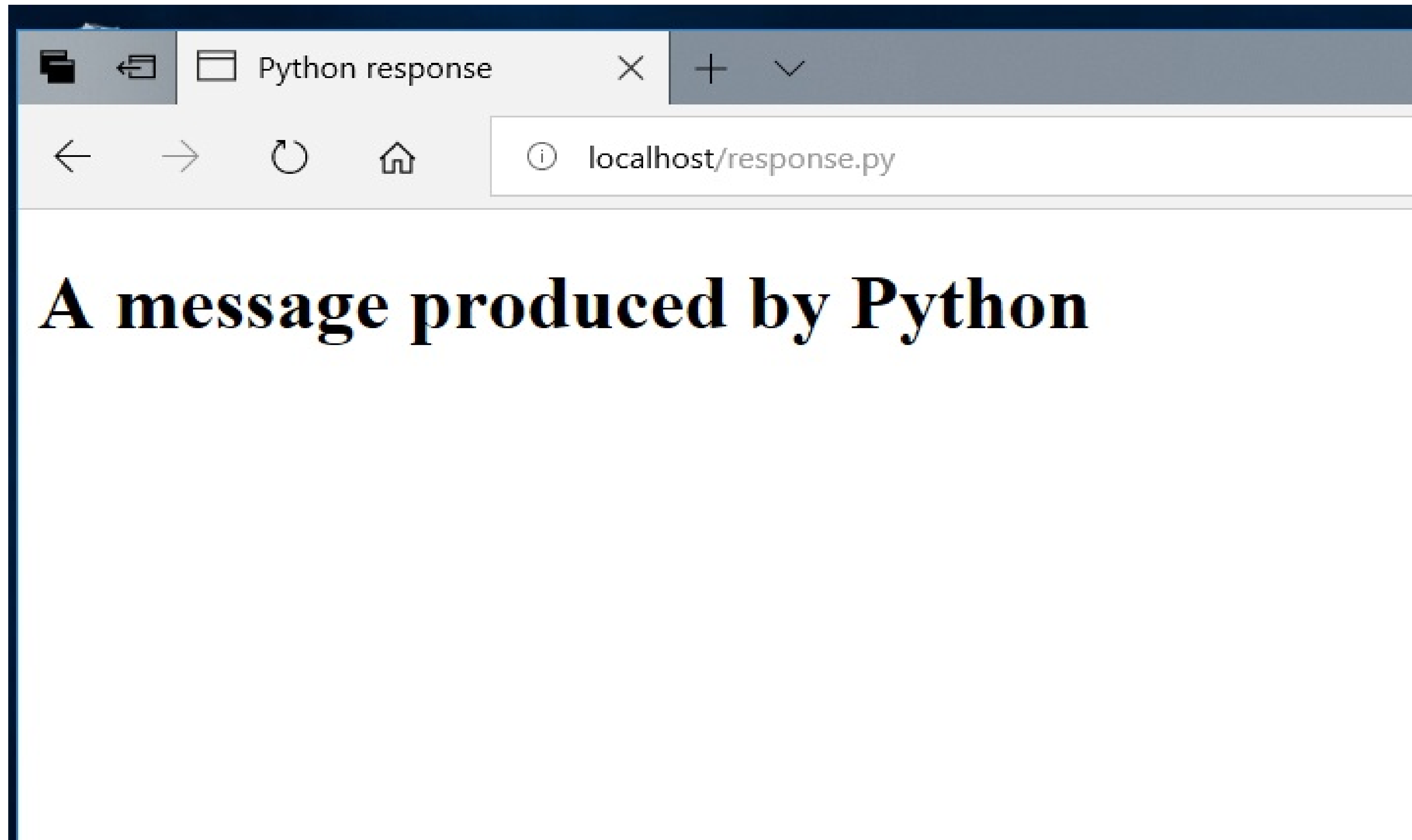
- Python can be used to create *web applications* – software that can be executed via a Web browser
- Python programs can read data you enter in a Web page (eg., in a form)
- Results of program can be displayed in browser.

Python and the web

Server-side Python code to generate a Web page (as text):

```
print('Content-type:text/html\r\n\r\n')
print('<!DOCTYPE HTML>')
print('<html lang="en">')
print('<head>')
print('<title>Output page from Python</title>')
print('</head>')
print('<body>')
print('<h1>Output from Python</h1>')
print('</body>')
print('</html>')
```

Returns a simple web page to any browser that connects to server.



Result of simple Python script

Python and the web

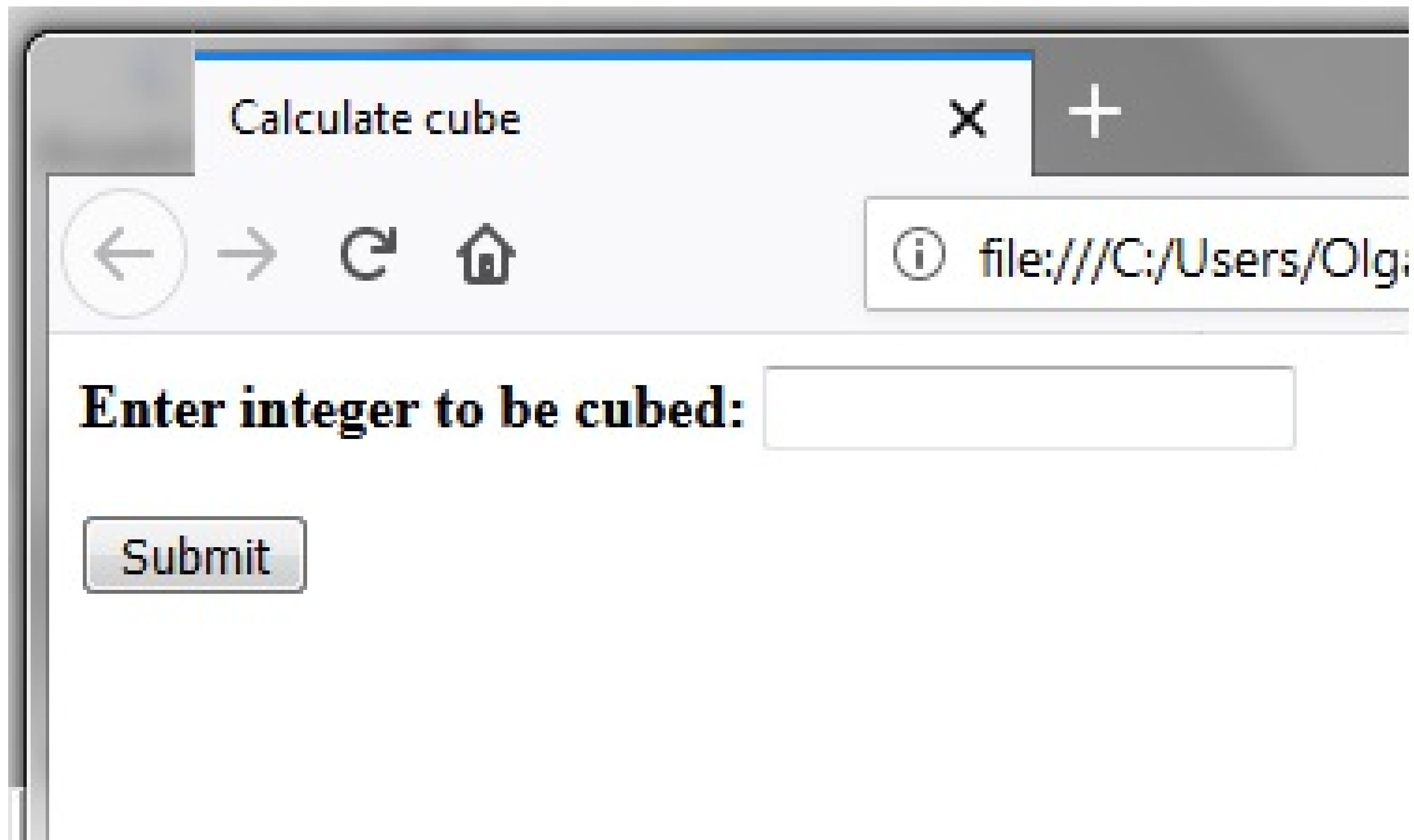
- Programs can read form information sent over internet
- Data accessed using the form field names
- Arbitrary processing can be carried out by server script
- Results returned in Web result page.

Form that submits to Python

```
<html> <head>
<title>Calculate cube</title>
</head>

<body>
<form name = "form1" action = "cube.py">

<strong>Enter integer to be cubed:</strong>
<input name = "field1" type = "text"><br>
<p><input type = "submit"
 value = "Submit"></p>
</form>
</body></html>
```

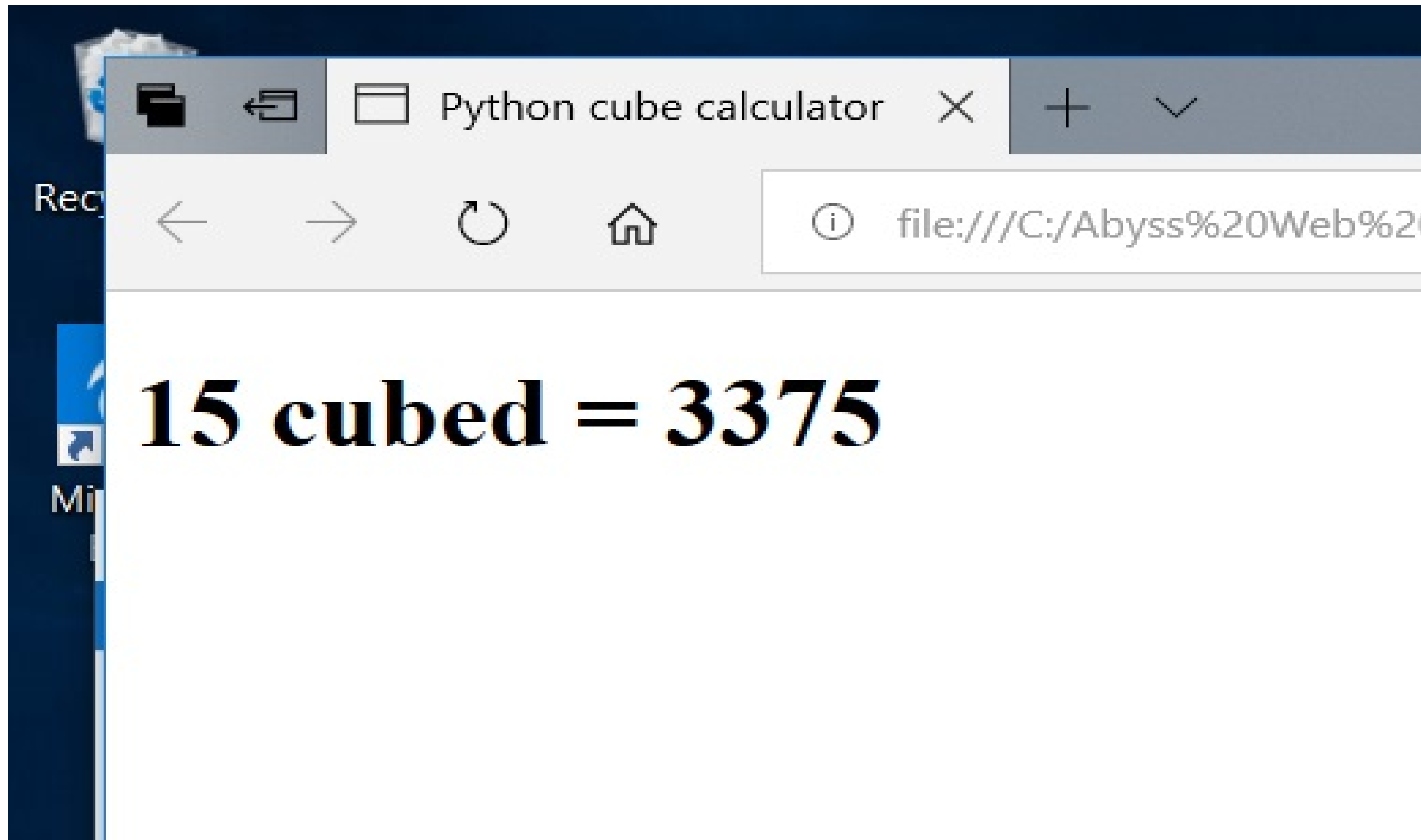


Cube form

Python code of *cube.py*:

```
import cgi
data = cgi.FieldStorage()
x = data.getvalue('field1')
y = int(x)
print('Content-type:text/html\r\n\r\n')
print('<!DOCTYPE HTML>')
print('<html lang="en">')
print('<head>')
print('<title>Python cube calculator</title>')
print('</head>')
print('<body>')
print('<h1>' + x + ' cubed = ' + str(y*y*y) + '</h1>')
print('</body>')
print('</html>')
```

Can submit different x by pressing Back in brower.



Cube result page

Other form elements can be used with Python:

- Checkboxes:

```
<input type="checkbox" name="agree"
    value="agreed-terms-conditions">
```

Test with

```
if data.getvalue('agree'):
  activate()
```

- Radio buttons:

```
Agree? <input type="radio" name="agree"
      value="agreed-terms">
Disagree? <input type="radio" name="agree"
      value="not-agreed">
```

Test with

```
answer = data.getvalue('agree')
if answer == 'agreed-terms':
  ...
else:
  ...
```

Python and the web

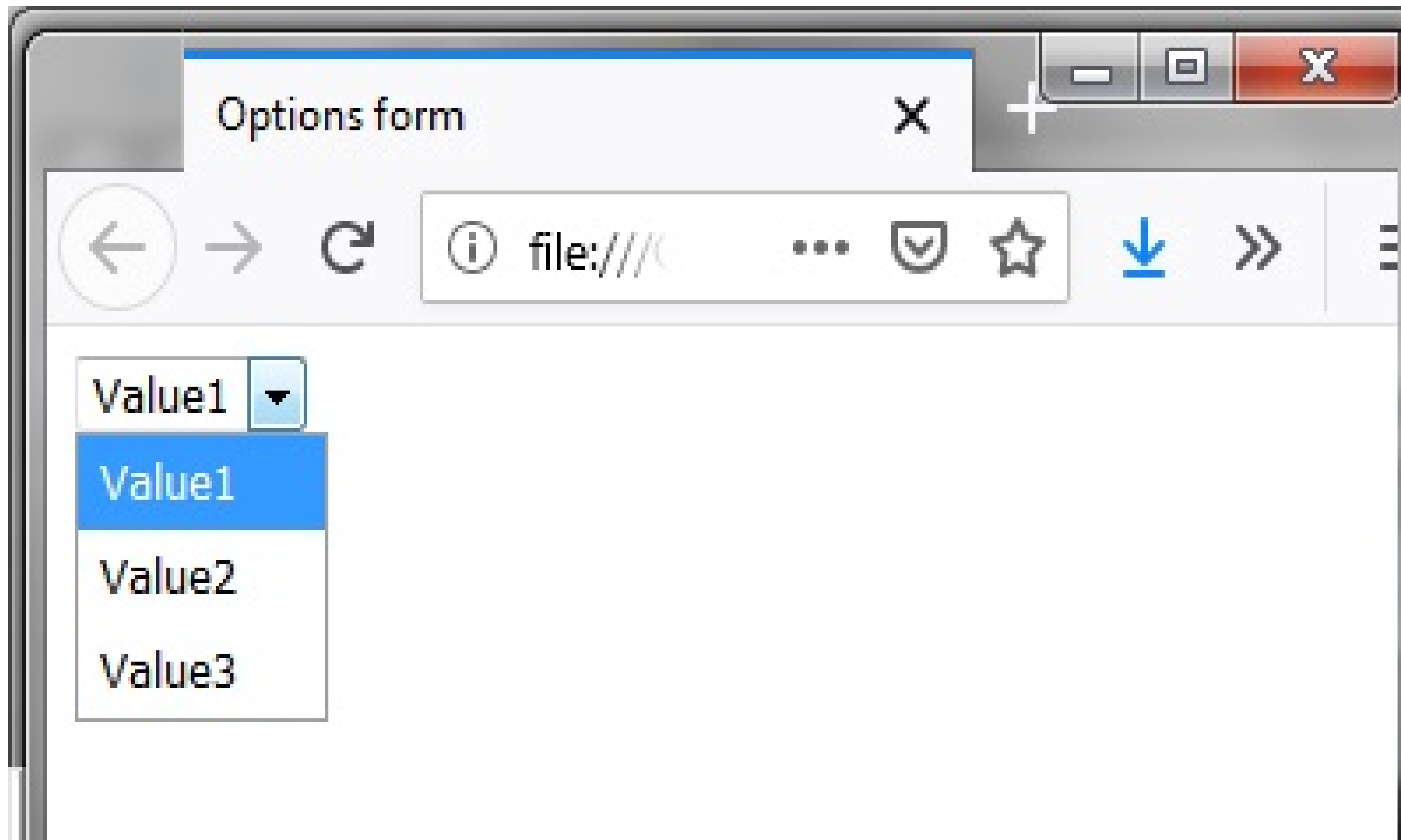
For selection lists:

```
<select name="options">
<option value="value1">Value1</option>
<option value="value2">Value2</option>
<option value="value3">Value3</option>
</select>
```

Test with

```
opt = data.getvalue('options')
```

opt will have value *value*1, *value*2 or *value*3, depending on which option was selected in the form.



Form with selection list

Further resources

We hope you have enjoyed this course. The following are useful for further study:

- Python can be downloaded from:
  `http://python.org/downloads`

  Choose the option appropriate for your computer and operating systems.

- The examples used in this course are at:
  `www.nms.kcl.ac.uk/kevin.lano/cllpython`