Technical University of Lodz
Institute of Electronics

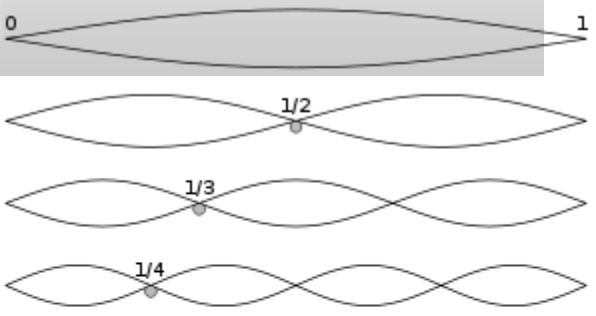
Algorithms and Data Structures

4. Loops and Boolean Expressions

Łódź 2018

$$\sum_{n=1}^{\infty} \frac{1}{n} = 1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \cdots$$

Exercise – Harmonic Sum



Wikipedia

- Type in the program code
- Save it as **harmonic.py**
- Run the script using ***IPython***

```
1  # harmonic.py
2
3  def harmonic(n):
4      # Compute the sum of 1/k for every k from 1 to n.
5      total = 0.0
6      for k in range(1, n + 1):
7          total += 1.0 / k
8      return total
9
10 def main():
11     n = input('Enter a positive integer: ')
12     print "The sum of 1/k for k = 1 to %d is %.6f" % (n, harmonic(n))
13
14 main()
15
```

- This program uses the **for** loop, the **range()** function and **+=** operator.

for Loops

- The **for** loop is used to repeat the calculations in cases one knows ahead of time how many times the loop needs to run.

Syntax:

```
for <variable> in <sequence>:
    <body>
```

- For each item in the **<sequence>**, the **<variable>** is assigned the value of that item and the the **<body>** is executed.

- A **sequence** in Python is an ordered set of elements. An example is the **list** whose elements are listed in square brackets, e.g. [12, -3, 5, 0.5].

```
In[1]: for x in [12, -3, 5, 0.5]:
In[2]:     print ( x, x**2)
```

- What is the body of the above loop? How many times a body is executed in the general case?

range Function

- This is a built-in function that creates a sequence of integers.

Syntax:

range(stop)	Begin at **0**. Take steps of **1**. End just before **stop**.
range(start, stop)	Begin at **start**. Take steps of 1. End just before **stop**.
range(start, stop, step)	Begin at **start**. Take steps of **step**. End just before **stop**.

- The variables **start**, **stop** and **step** are integers.

```
In[1]: range(9)
In[2]: range(-2, 12)
In[3]: x = 5
In[4]: range(3, x+7)
In[5]: range(3, x-2)
In[6]: range(3, x-1)
In[7]: range(5, 2, -1)
```

Accumulation Loops

- Script ***harmonic.py*** contains an accumulator variable **total** which gradually accumulates some quantities as the loop runs.

Syntax:

```
<accumulator> = <starting value>
loop:
        <accumulator> += <value to add>
```

- The **x += v** is a *shorthand assignment* equivalent to **x = x + v**

-Accumulation loops may accumulate also through other operations, e.g. subtraction, multiplication and division (**x -= v**, **x *= v**, **x /= v**) rather than addition.

Do not use **sum** as an accumulator variable name, because **sum()** is a built-in Python function.

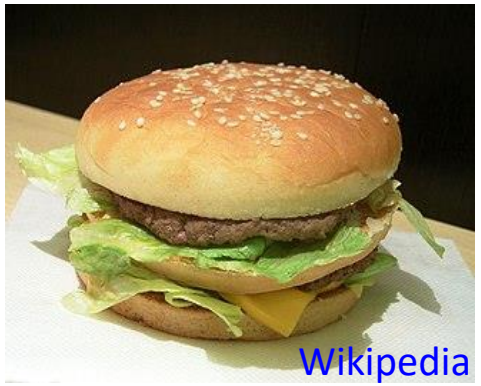
```
In[1]: x = range(6)
In[1]: print ( sum ( x ) )
```

- For many repetitions, the program may run much too long. To break the loop, use **CTRL-D** or restart ***IPython*** shell.

Body Mass Index Revisited

- Make the script using ***Kate***, save as **bmi_evaluation.py** and run in ***IPython.***

$$\mathrm{BMI} = \frac{\mathrm{masa_{kg}}}{\mathrm{wzrost_m^2}}$$




```
1   # BMI.py
2
3   YourName = str(input("Enter your name: "))
4   var = int(input("Enter your height in cm: "))
5   YourHeight = var / 100.0
6   YourMass = float(input("Enter your mass in kg: "))
7   BMI = YourMass / (YourHeight * YourHeight)
8   print("\n")
9   print("Hello " + YourName + "!")
10  if (BMI < 18.5):
11      print("Your Body Mass Index is %4.1f (possible underweight)." % (BMI))
12  elif (BMI >= 18.5) and (BMI < 25.0):
13      print("Your Body Mass Index is %4.1f (correct weight)." % (BMI))
14  else:
15      print("Your Body Mass Index is %4.1f (possible overweight)." % (BMI))
```

Boolean (Logic) Expressions

- Another type of data in Python is **boolean**. Variables that hold this type have only 2 possible values: **True** or **False**.
- Python has the following **comparison operations** that return boolean values:

x == y	Equal.
x != y	Not equal.
x < y	Less than.
x > y	Greater than.
x <= y	Less than or equal.
x >= y	Greater than or equal.

Avoid using **==** or **!=** to compare floats!

```
In[1]: x = 3
In[2]: y = 2
In[3]: P = x == y   #P is a Boolean variable
In[4]: print (P)
```

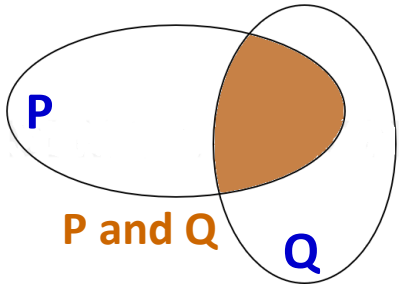
```
In [5]: a = 0.1+0.2
DEMO VERSION
In [6]: a == 0.3
```

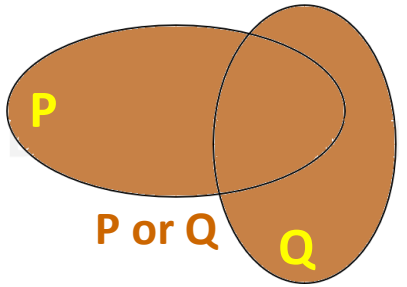
Boolean (Logic) Expressions

- Boolean expressions may be combined with this **boolean operations**:

P and Q	**True** if both P and Q are **True**; otherwise **False**.
P or Q	**True** if either P or Q are **True**; otherwise **False**.
not P	**True** if P is **False**; otherwise **False**.

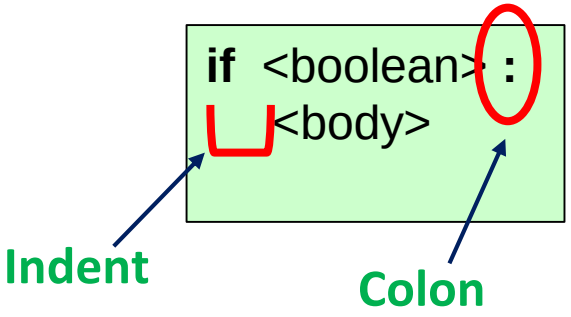
```
In[1]: x = 3
In[2]: y = 2
In[3]: P = not ((x == y) or (y == 2))
In[4]: print (P)

In[5]: P = True
In[6]: Q = False
In[7]: R = P and Q
In[8]: print R
```





if Statement

Perhaps all programming languages have some form of **if** statement.
In Python, it has essentially 3 forms.




```
if <boolean> :
    <body1>
else:
    <body2>
```

```
if <boolean1> :
    <body1>
elif <boolean2> :
    <body2>
elif <boolean3> :
    <body3>
…
else :
    <bodyN>
```

```
In[1]: YourGender = 'Female'
In[2]: if YourGender == 'Male' :
In[3]:     print ('Good day, Mister!')
In[4]: else:
In[5]:     print('Nice to see you, Madame!')
```

while Loops

- The **while** loops allow program to repeat the calculations without knowing in advance how many times the loop will run.

Syntax:

```
while <boolean> :
    <body>
```

-The **<boolean>** expression is evaluated, and if it is **True**, then the **<body>** is executed. After that, the **<boolean>** is checked again and if it is still **True**, the **<body>** executes again. This is repeated until the boolean expression is **False**.

(a) Print all positive integers up to *n*

```
In[1]: n = 5
In[2]: i = 1
In[3]: while i < n+1:
In[4]:     print i
In[5]:     i += 1
```

(b) Print even numbers up to *n*

```
In[1]: n = 10
In[2]: i = 1
In[3]: while i < n+2:
In[4]:     if i%2 == 0: print i
In[5]:     i += 1
```

Temperature Converter

- In the following **temp.py** program the while loop repeats when user enters an invalid temperature value.

```
1  # temp.py
2  # The entered temperature in Celsius
3  #    is converted to Fahrenheit degrees.
4  temp = input ( 'Enter a temperature in Celsius: ')
5  while temp<-273.15:
6      temp = input ('Impossible. Enter a valid temperature: ')
7  print "In Fahrenheit, that is", 9.0/5.0*temp+32.0
8
```

- Unlike the **for** loop, it is possible for a **while** loop to be **infinite**. Press **CTRL-D** to break calculations of an infinite loop.

```
In[1]: i = 0
In[2]: while True:
In[3]:     print(i)
In[4]:     i += 1
```

Prime numbers

- In the following **prime.py** program, the **while** loop is used to find out whether an entered number is prime or not.

```
1   # prime.py
2
3   num = input ( 'Enter an integer number: ')
4   i = 2
5   # A prime is a number that divides by 1 and itself only.
6   while i<num and num%i != 0: # num%i equals to remainder
7       i += 1
8   if i==num:
9       print "The number", num, "is prime."
10  else:
11      print "The number", num, "is not prime."
12
```

Prime numbers – tracing the code

```
In[1]: i = 2
In[1]: while i<num and num%i != 0:
In[1]:     i += 1
```

Loop terminated

num = 9:

i	*i<num*	*num%i*	Boolean expression
2	T	1	T
3	T	0	F
-	-	-	-
-	-	-	-

On termination: i = 3

i<num → not prime

num = 5:

i	*i<num*	*num%i*	Boolean expression
2	T	1	T
3	T	2	T
4	T	1	T
5	F	-	F

i = 5

i==num → prime

Exercises

4.1. Explain the use of **n+1** instead of **n** in **harmonic.py**. Conjecture what happens to the harmonic sum for very large **n**.

4.2. Assign the value of **10** to a variable **n**, run the **harmonic.py** program and enter **3** when asked for a positive integer that is assigned to the variable **n** in the program. Then print the value of **n** and explain the result. List all the local variables and describe the scope of each.

4.3. Determine a **range** expression to iterate over each of these sequences

(a) 0, 1, 2, 3 (b) 3, 2, 1, 0 (c) 1, 3, 5, 7, 9, 11
(d) 10, 27, 44, 61, …, 197 (e) 100, 90, …, 10 (f) 2, 4, 6, 8, …, 200

4.4. Write a program **myfactorial.py** that returns the product 1*2*3*…*n*. Use an accumulator; do not use the **factorial()** function from the math module.

Exercises

4.5. Write a **mymax.py** function that returns the largest of *x, y* and *z*.

4.6. Write a **median3.py** function that returns the middle value among the *x, y* and *z*.

4.7. Write a **myabs.py** function that returns the absolute value of *x*.

4.8. Find the smallest number in the list.

4.9. Find the largest number in the list.

4.10. Write a Python code example of a nested loop.

4.11. Write an infinite loop.

Exercises

4.12. Write a Python program to construct the following pattern (use a nested loop)

```
*
**
***
****
*****
****
***
**
*
```

4.13. Write a Python program that prints each item and its corresponding type from the following list (use **type()** function):

datalist = [1452, 11.23, 1+2j, True, 'w3resource', (0, -1), [5, 12], {"class":'V', "section":'A'}]

4.14. Write a Python program to calculate the sum of the elements in:

- a vector,
- a 2D matrix,
- each row of a 2D matrix,
- each column of a 2D matrix.

Exercises

4.15. Write a Python program to calculate the average of the elements in:

- a vector,
- a 2D matrix,
- each row of a 2D matrix,
- each column of a 2D matrix.

4.16. Write a program to add:

- scalar to a vector,
- two vectors to each other,
- scalar to a matrix,
- two matrices to each other.

4.17. Write a program to multiply two matrices.
(https://en.wikipedia.org/wiki/Matrix_multiplication)

Summary

1) The **for** loop is used when one knows in advance how many times calculations are to be repeated.
2) Python **list** stores an ordered sequence of items. The items (list elements) can be of any type, e.g. a_list = [10, False, ”Hi mate!”, 3.14159].
3) Python **boolean** data type can have any of two values: **True** or **False**.
4) Boolean values are returned by **comparison operations**.
5) The function **range**() produces a list of integers.
6) The **if** statement allows doing different parts of a program provided some conditions are satisfied.
7) The **while** loop is used to program repetitive computations without knowing the number of repetitions in advance.
8) Loops can sometimes be infinite.

Literature

Brian Heinold, Introduction to Programming Using Python, Mount St. Mary's University, 2012 (http://faculty.msmary.edu/heinold/python.html).

Brad Dayley, Python Phrasebook: Essential Code and Commands, SAMS Publishing, 2007 (dostępne też tłumaczenie: B. Dayley, Python. Rozmówki, Helion, 2007).

Mark J. Johnson, A Concise Introduction to Programming in Python, CRC Press, 2012.