Lecture 2 – Program flow, Conditionals, Loops
https://cw.fel.cvut.cz/wiki/courses/be5b33prg/start

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• Problem formulation (input / output)
• Formalism (math?)
• Algorithm (the idea!)
• Implementation (engineering)
• Testing (are we good?)
DATA TYPES

- Integers (**int**) 1, 10, 124
- Strings (**str**) "Hello, World!"
- Float (**float**) 1.0, 9.999

- Strings in Python can be enclosed in either single quotes (') or double quotes ('"'), or three of each (''''' or '"''"')

source [http://openbookproject.net/thinkcs/python/english3e/variables_expressions_statements.html](http://openbookproject.net/thinkcs/python/english3e/variables_expressions_statements.html)
• We use variables to **remember** things!
• The assignment statement gives a value to a variable
• Do not confuse = and == !
  
  = is **assignment** token such that \textit{name\_of\_variable} = \textit{value}
  
  == is operator to **test equality**
• Key property of a variable that **we can change its value**
• Naming convention: **with freedom comes responsibility!**
The longer life the longer name: `very_long_name_of_my_var`

The more important the longer name

Meaningful name does not add the meaning just by itself, the code must do this!

Illegal name causes a syntax error

Capitals: Variable vs variable

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• Python keywords have **special** purpose
• Always choose names **meaningful** to human readers
• Use **comments (#)** and **blank lines** to improve readability

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# BUILT-IN FUNCTIONS

<table>
<thead>
<tr>
<th>abs()</th>
<th>dict()</th>
<th>help()</th>
<th>min()</th>
<th>setattr()</th>
</tr>
</thead>
<tbody>
<tr>
<td>all()</td>
<td>dir()</td>
<td>hex()</td>
<td>next()</td>
<td>slice()</td>
</tr>
<tr>
<td>any()</td>
<td>divmod()</td>
<td>id()</td>
<td>object()</td>
<td>sorted()</td>
</tr>
<tr>
<td>ascii()</td>
<td>enumerate()</td>
<td>input()</td>
<td>oct()</td>
<td>staticmethod()</td>
</tr>
<tr>
<td>bin()</td>
<td>eval()</td>
<td>int()</td>
<td>open()</td>
<td>str()</td>
</tr>
<tr>
<td>bool()</td>
<td>exec()</td>
<td>isinstance()</td>
<td>ord()</td>
<td>sum()</td>
</tr>
<tr>
<td>bytearray()</td>
<td>filter()</td>
<td>issubclass()</td>
<td>pow()</td>
<td>super()</td>
</tr>
<tr>
<td>bytes()</td>
<td>float()</td>
<td>iter()</td>
<td>print()</td>
<td>tuple()</td>
</tr>
<tr>
<td>callable()</td>
<td>format()</td>
<td>len()</td>
<td>property()</td>
<td>type()</td>
</tr>
<tr>
<td>chr()</td>
<td>frozenset()</td>
<td>list()</td>
<td>range()</td>
<td>vars()</td>
</tr>
<tr>
<td>classmethod()</td>
<td>getattr()</td>
<td>locals()</td>
<td>repr()</td>
<td>zip()</td>
</tr>
<tr>
<td>compile()</td>
<td>globals()</td>
<td>map()</td>
<td>reversed()</td>
<td><strong>import</strong>()</td>
</tr>
<tr>
<td>complex()</td>
<td>hasattr()</td>
<td>max()</td>
<td>round()</td>
<td></td>
</tr>
<tr>
<td>delattr()</td>
<td>hash()</td>
<td>memoryview()</td>
<td>set()</td>
<td></td>
</tr>
</tbody>
</table>

- Built-in functions have **special** purpose
- Study [https://docs.python.org/3.4/library/functions.html](https://docs.python.org/3.4/library/functions.html)

source [http://openbookproject.net/thinkcs/python/english3e/variables_expressions_statements.html](http://openbookproject.net/thinkcs/python/english3e/variables_expressions_statements.html)
• OPERAND OPERATOR OPERAND
• Operators are **special tokens** that represent computations like addition, subtraction, multiplication, division etc
• The values the operator uses are called **operands**
• When a variable name appears in the place of an operand, it is replaced with its value before the operation is performed
• Division `/` vs **floor** division `//`

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• Functions, `int()`, `float()` and `str()` convert their arguments into types `int`, `float` and `str` respectively.
• The type converter `float()` can turn an `integer`, a `float`, or a syntactically legal `string` into a float
• The type converter `str()` turns its argument into a string
• One symbol can have different meaning depending on the data type(s) - try & explore & understand

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Evaluation depends on the rules of precedence:

1. Parentheses (for order, readability)
2. Exponentiation
3. Multiplication and Division
4. Addition and Subtraction

Order **left-to-right** evaluation on the same level, with the exception of exponentiation (**)

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You cannot perform mathematical operations on strings, even if the strings look like numbers.

The `+` operator represents concatenation, not addition.

The `*` operator also works on strings; it performs repetition (one of the operands has to be a string; the other has to be an integer).
• Built-in function to get input from a user:

    ```python
    input("Message to the user!")
    ```

• User input is stored as **string**
• Combine with type conversion

**source** http://openbookproject.net/thinkcs/python/english3e/variables_expressions_statements.html
• Combination of the elements of a program: variables, expressions, statements, and function calls
• One of the most useful features of programming languages
• Take small building blocks and compose them into larger chunks

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The modulus operator works on **integers** (integer expressions)
- Definition: modulus is the **remainder** when the first number is divided by the second
- Modulus operator is a percent sign `%`
- Syntax is the same as for other operators
- The same **precedence** as the **multiplication** operator

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• The variable `friend` at line 1 is the loop variable
• Lines 2 and 3 are the loop body
• The loop body is always indented
• The indentation determines exactly what statements are “in the body of the loop”
• At the end of each execution of the body of the loop, Python returns to the `for` statement, to see if there are more items to be handled, and to assign the next one to the loop variable

source [http://openbookproject.net/thinkcs/python/english3e/hello_little_turtles.html](http://openbookproject.net/thinkcs/python/english3e/hello_little_turtles.html)
On each iteration or pass of the loop:

- Check to see if there are still more **items to be processed**
- If there are none left (the **terminating condition** of the loop) the loop has finished
- If there are items still to be processed, the **loop variable is updated** to refer to the next item in the list
- Program execution **continues at the next statement** after the loop body
- To explore: early **break**, or **for – else** loop

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• Control flow (control of the flow of execution of the program)
• As program executes, the interpreter always keeps track of which statement is about to be executed
• Control flow until now has been strictly top to bottom, one statement at a time, the for loop changes this!

source http://openbookproject.net/thinkcs/python/english3e/hello_little_turtles.html
Test conditions and **change the program behavior** depending on the outcome of the tests

- Boolean value is either **True** or **False**
- Named after the British mathematician, **George Boole**, who first formulated Boolean algebra
Boolean expression is an expression that evaluates to produce a result which is a **Boolean value**

Six common **comparison operators** which all produce a bool result (different from the mathematical symbols)

source: [http://openbookproject.net/thinkcs/python/english3e/conditionals.html](http://openbookproject.net/thinkcs/python/english3e/conditionals.html)
• three logical operators, **and**, **or**, and **not**, that allow to build more complex expressions from simple Boolean expressions

• semantics (**meaning**) of these operators is similar to natural language equivalent

source [http://openbookproject.net/thinkcs/python/english3e/conditionals.html](http://openbookproject.net/thinkcs/python/english3e/conditionals.html)
**Short-circuit evaluation:**

- **OR** – if the expression on the left of the operator yields *True*, Python does not evaluate the expression on the right.
- **AND** – if the expression on the left yields *False*, Python does not evaluate the expression on the right.
- **Truth table** – list of all the possible inputs to give the results for the logical operators.

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**source** [http://openbookproject.net/thinkcs/python/english3e/conditionals.html](http://openbookproject.net/thinkcs/python/english3e/conditionals.html)
**BOOLEAN ALGEBRA**

\[ n \times 0 = 0 \]

\[
\begin{align*}
\text{x and False} &= \text{False} \\
\text{False and x} &= \text{False} \\
\text{y and x} &= \text{x and y} \\
\text{x and True} &= \text{x} \\
\text{True and x} &= \text{x} \\
\text{x and x} &= \text{x}
\end{align*}
\]

\[
\begin{align*}
\text{x or False} &= \text{x} \\
\text{False or x} &= \text{x} \\
\text{y or x} &= \text{x or y} \\
\text{x or True} &= \text{True} \\
\text{True or x} &= \text{True} \\
\text{x or x} &= \text{x}
\end{align*}
\]

\[ \text{not (not x)} = \text{x} \]

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• Condition **IF — ELSE**
• Conditional statement – the ability to check conditions and change the behavior of the program accordingly
• Condition **IF only**
• No ELSE statement
• To control flow only for specific condition

```python
if x < 0:
    print("The negative number ", x, " is not valid here.")
    x = 42
    print("I've decided to use the number 42 instead.")
print("The square root of ", x, " is", math.sqrt(x))
```
**CONDITIONAL EXECUTION**

- Condition chaining
  - **IF – ELIF – ELSE**
- Recommendation: handle all distinctive options by separate condition, use else to handle all other

```python
if x < y:
    STATEMENTS_A
elif x > y:
    STATEMENTS_B
else:
    STATEMENTS_C
```

```python
if choice == "a":
    function_one()
elif choice == "b":
    function_two()
elif choice == "c":
    function_three()
else:
    print("Invalid choice.")
```

source [http://openbookproject.net/thinkcs/python/english3e/conditionals.html](http://openbookproject.net/thinkcs/python/english3e/conditionals.html)
Nesting conditions builds hierarchy of decisions (decision trees)

Nesting may reduce readability and clarity

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• Early return / early break
• Can be used to speed-up code execution
• Special condition: FOR – ELSE

Each of the six relational operators has a **logical opposite**

- Recommendation: **not** operators may reduce readability, use logical opposites instead

```python
  if not (age >= 17):
      print("Hey, you're too young to get a driving licence!")

  if age < 17:
      print("Hey, you're too young to get a driving licence!")
```

<table>
<thead>
<tr>
<th>operator</th>
<th>logical opposite</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>==</code></td>
<td><code>!=</code></td>
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<tr>
<td><code>!=</code></td>
<td><code>==</code></td>
</tr>
<tr>
<td><code>&lt;</code></td>
<td><code>&gt;</code></td>
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<td><code>&lt;=</code></td>
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<tr>
<td><code>&gt;=</code></td>
<td><code>&lt;</code></td>
</tr>
</tbody>
</table>
De Morgan’s laws rules allow the expression of **conjunctions** and **disjunctions** in terms of each other via **negation**

**Example**: suppose we can slay the dragon only if our magic sword is charged to 90% or higher **and** we have 100 or more energy units in our protective shield

```python
if not ((sword_charge >= 0.90) and (shield_energy >= 100)):
    print("Your attack has no effect, the dragon fries you to a crisp!")
else:
    print("The dragon crumples in a heap. You rescue the gorgeous princess!")
```

source: [http://openbookproject.net/thinkcs/python/english3e/conditionals.html](http://openbookproject.net/thinkcs/python/english3e/conditionals.html)
DE MORGAN’S LAWS

• **Example**: suppose we can slay the dragon only if our magic sword is charged to 90% or higher *and* we have 100 or more energy units in our protective shield

```python
if (sword_charge < 0.90) or (shield_energy < 100):
    print("Your attack has no effect, the dragon fries you to a crisp!")
else:
    print("The dragon crumples in a heap. You rescue the gorgeous princess!")

if (sword_charge >= 0.90) and (shield_energy >= 100):
    print("The dragon crumples in a heap. You rescue the gorgeous princess!")
else:
    print("Your attack has no effect, the dragon fries you to a crisp!")
```

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### Example

<table>
<thead>
<tr>
<th>p</th>
<th>q</th>
<th>r</th>
<th>(not (p and q)) or r</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>F</td>
<td>F</td>
<td>?</td>
</tr>
<tr>
<td>F</td>
<td>F</td>
<td>T</td>
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</tbody>
</table>

**Example:** complete the table ..

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This lecture re-uses selected parts of the OPEN BOOK PROJECT
Learning with Python 3 (RLE)
http://openbookproject.net/thinkcs/python/english3e/index.html
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• Version date: October 2012
• by Peter Wentworth, Jeffrey Elkner, Allen B. Downey, and Chris Meyers (based on 2nd edition by Jeffrey Elkner, Allen B. Downey, and Chris Meyers)
• Source repository is at https://code.launchpad.net/~thinkcspy-rle-team/thinkcspy/thinkcspy3-rle
• For offline use, download a zip file of the html or a pdf version from http://www.ict.ru.ac.za/Resources/cspw/thinkcspy3/