CTU

CZECH TECHNICAL
UNIVERSITY
IN PRAGUE

PRG – PROGRAMMING ESSENTIALS

Lecture 2 – Program flow, Conditionals, Loops

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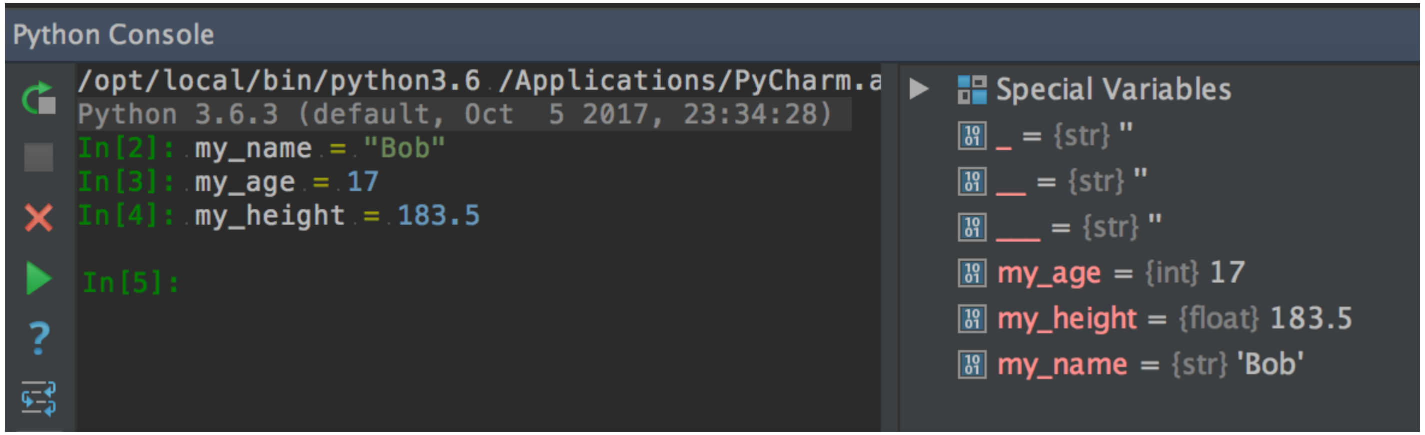
PROBLEM SOLVING!

- Problem formulation **(input / output)**
- Formalism **(math?)**
- Algorithm **(steps)**
- Implementation **(engineering)**
- Testing **(are we good?)**

VARIABLES



```
/opt/local/bin/python3.6 /Applications/PyCharm.a
Python 3.6.3 (default, Oct  5 2017, 23:34:28)
In[2]: my_name = "Bob"
In[3]: my_age = 17
In[4]: my_height = 183.5

In[5]:
```

```
_ = {str} ''
__ = {str} ''
___ = {str} ''
my_age = {int} 17
my_height = {float} 183.5
my_name = {str} 'Bob'
```

- We use variables to **remember** things!
- The assignment statement gives a value to a variable
- Do not confuse **=** and **==** !

  = is **assignment** token such that *name_of_variable* = *value*

  == is operator to **test equality**
- Key property of a variable that **we can change its value**
- Naming convention: **with freedom comes responsibility!**

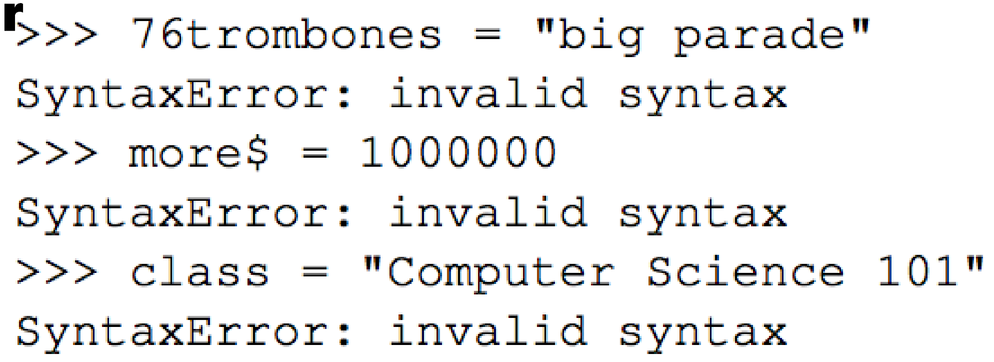
source http://openbookproject.net/thinkcs/python/english3e/variables_expressions_statements.html

VARIABLES

cannot begin with a number

this $ is illegal character

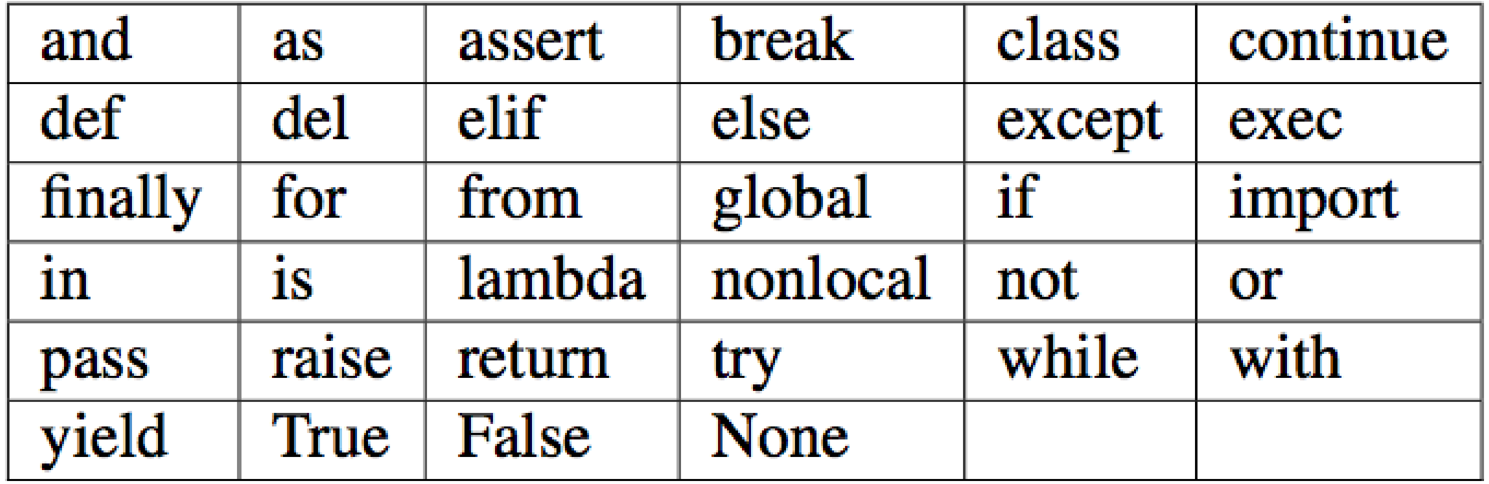
class is reserved keyword



```
>>> 76trombones = "big parade"
SyntaxError: invalid syntax
>>> more$ = 1000000
SyntaxError: invalid syntax
>>> class = "Computer Science 101"
SyntaxError: invalid syntax
```

- 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**

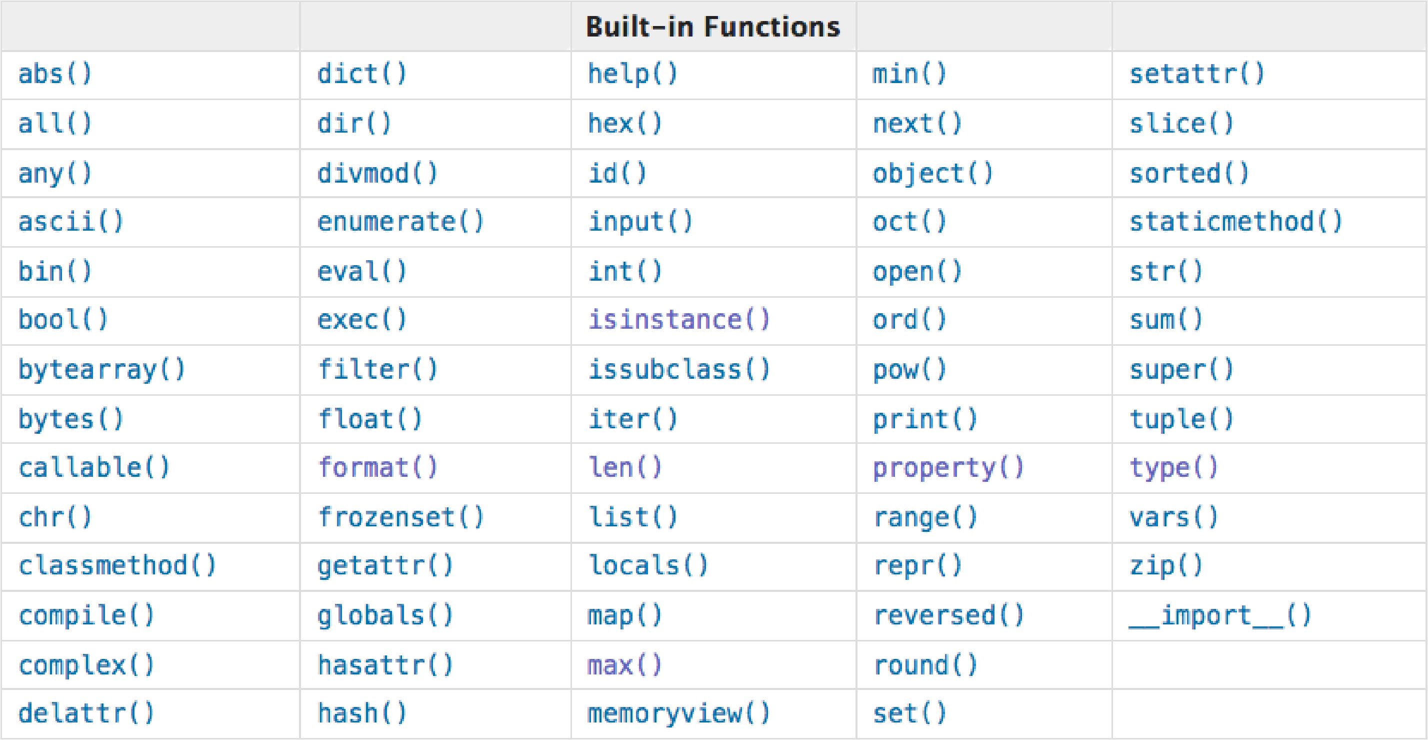
KEYWORDS



and	as	assert	break	class	continue
def	del	elif	else	except	exec
finally	for	from	global	if	import
in	is	lambda	nonlocal	not	or
pass	raise	return	try	while	with
yield	True	False	None		

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

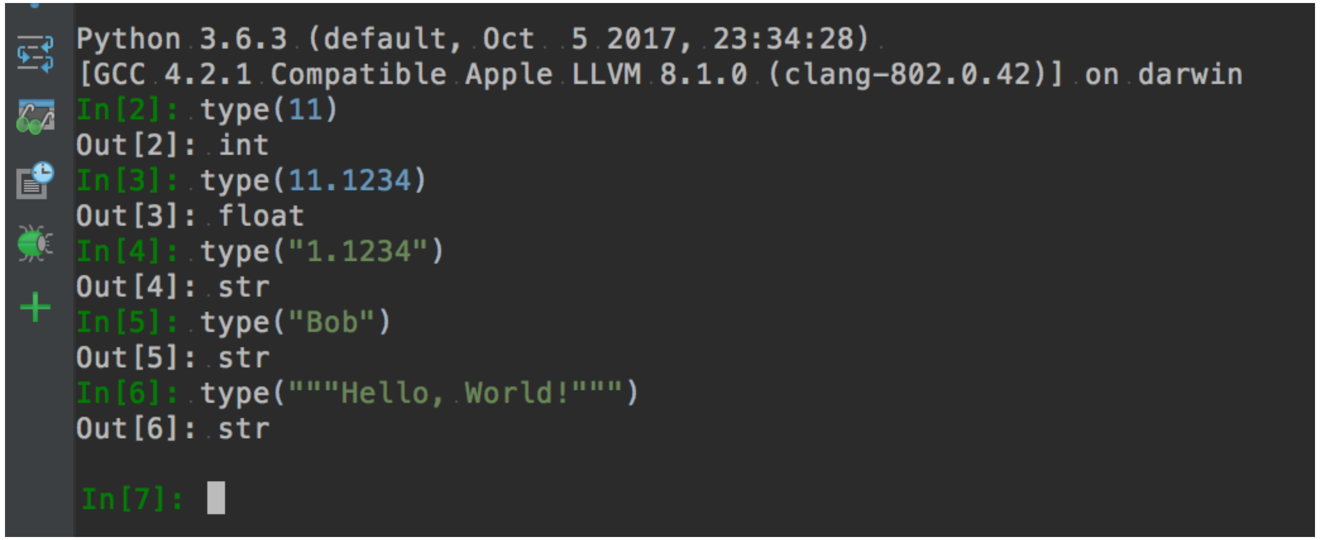
BUILT-IN FUNCTIONS



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

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

DATA TYPES

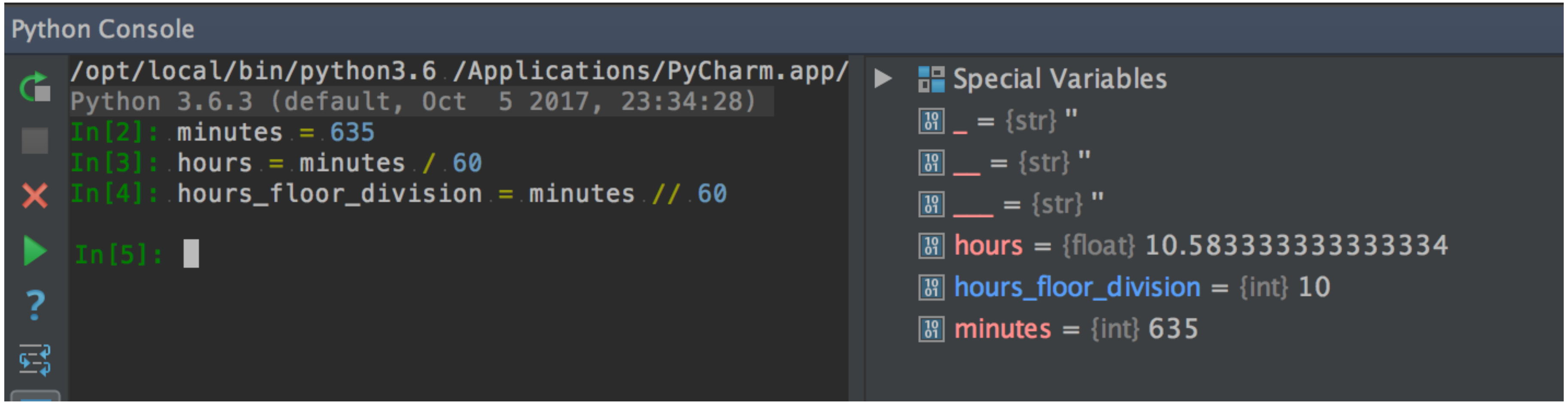


```
Python 3.6.3 (default, Oct  5 2017, 23:34:28)
[GCC 4.2.1 Compatible Apple LLVM 8.1.0 (clang-802.0.42)] on darwin
In[2]: type(11)
Out[2]: int
In[3]: type(11.1234)
Out[3]: float
In[4]: type("1.1234")
Out[4]: str
In[5]: type("Bob")
Out[5]: str
In[6]: type("""Hello, World!""")
Out[6]: str

In[7]: 
```

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 """)

OPERATORS & OPERANDS

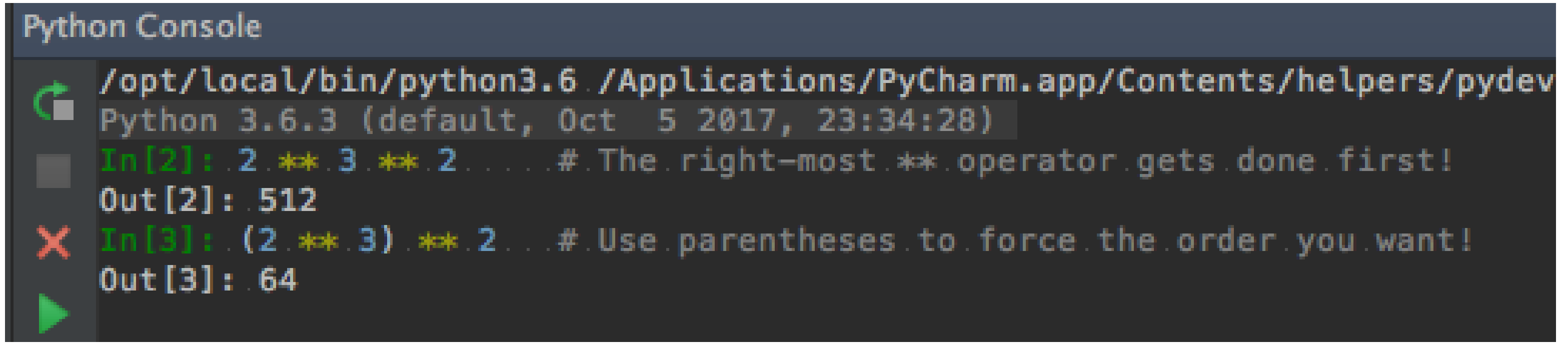

Python Console

```
/opt/local/bin/python3.6 /Applications/PyCharm.app/
Python 3.6.3 (default, Oct  5 2017, 23:34:28)
In[2]: minutes = 635
In[3]: hours = minutes / 60
In[4]: hours_floor_division = minutes // 60

In[5]:
```

```
Special Variables
_ = {str} ''
__ = {str} ''
___ = {str} ''
hours = {float} 10.583333333333334
hours_floor_division = {int} 10
minutes = {int} 635
```

- **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 **//**

ORDER OF OPERATIONS – PEMDAS



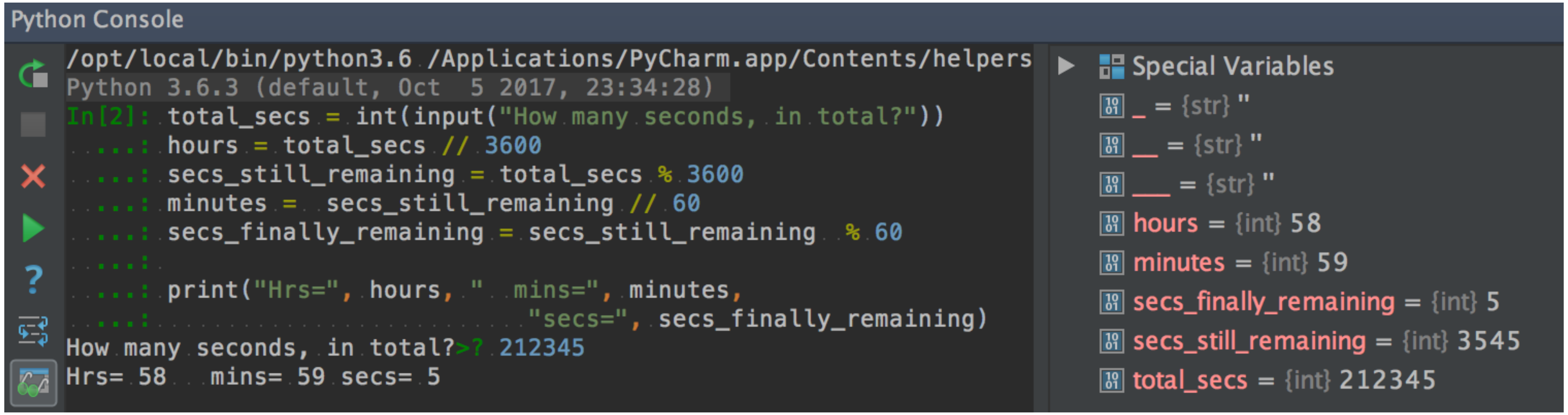
```
/opt/local/bin/python3.6 /Applications/PyCharm.app/Contents/helpers/pydev
Python 3.6.3 (default, Oct  5 2017, 23:34:28)
In[2]: 2 ** 3 ** 2     # The right-most ** operator gets done first!
Out[2]: 512
In[3]: (2 ** 3) ** 2   # Use parentheses to force the order you want!
Out[3]: 64
```

- Evaluation depends on the rules of precedence:

1. **P**arentheses (for order, readability)
2. **E**xponentiation
3. **M**ultiplication and **D**ivision
4. **A**ddition and **S**ubtraction

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

MODULUS OPERATOR



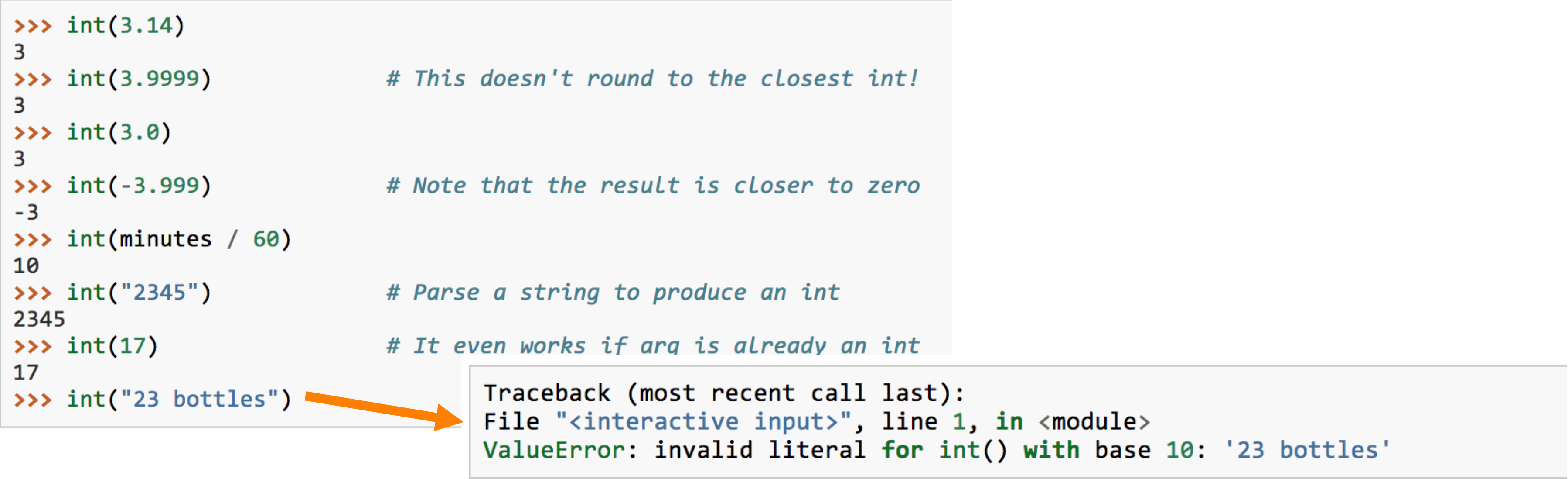
Python Console

```
/opt/local/bin/python3.6 /Applications/PyCharm.app/Contents/helpers
Python 3.6.3 (default, Oct  5 2017, 23:34:28)
In[2]: total_secs = int(input("How many seconds, in total?"))
  ...: hours = total_secs // 3600
  ...: secs_still_remaining = total_secs % 3600
  ...: minutes =  secs_still_remaining // 60
  ...: secs_finally_remaining = secs_still_remaining  % 60
  ...: 
  ...: print("Hrs=", hours, "  mins=", minutes,
  ...:                         "secs=", secs_finally_remaining)
How many seconds, in total?>? 212345
Hrs= 58   mins= 59 secs= 5
```

```
Special Variables
_ = {str} ''
__ = {str} ''
___ = {str} ''
hours = {int} 58
minutes = {int} 59
secs_finally_remaining = {int} 5
secs_still_remaining = {int} 3545
total_secs = {int} 212345
```

- 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

TYPE CONVERSION

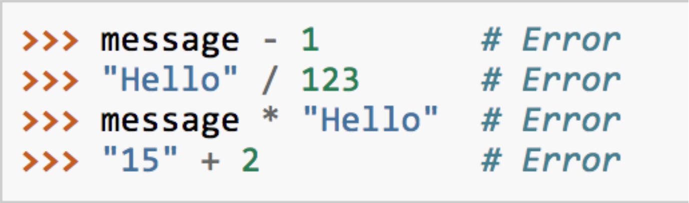


```
>>> int(3.14)
3
>>> int(3.9999)             # This doesn't round to the closest int!
3
>>> int(3.0)
3
>>> int(-3.999)             # Note that the result is closer to zero
-3
>>> int(minutes / 60)
10
>>> int("2345")             # Parse a string to produce an int
2345
>>> int(17)                 # It even works if arg is already an int
17
>>> int("23 bottles")
```

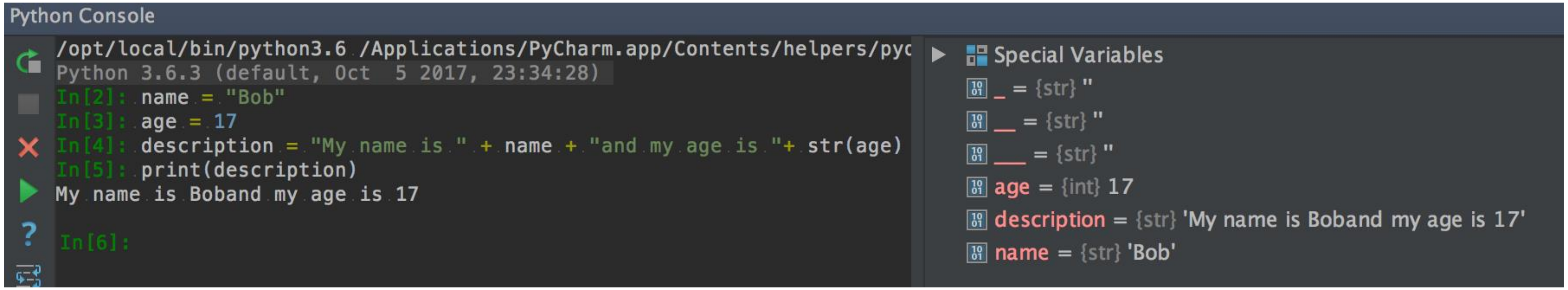
```
Traceback (most recent call last):
File "<interactive input>", line 1, in <module>
ValueError: invalid literal for int() with base 10: '23 bottles'
```

- 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**

OPERATIONS ON STRINGS



```
>>> message - 1          # Error
>>> "Hello" / 123        # Error
>>> message * "Hello"    # Error
>>> "15" + 2             # Error
```

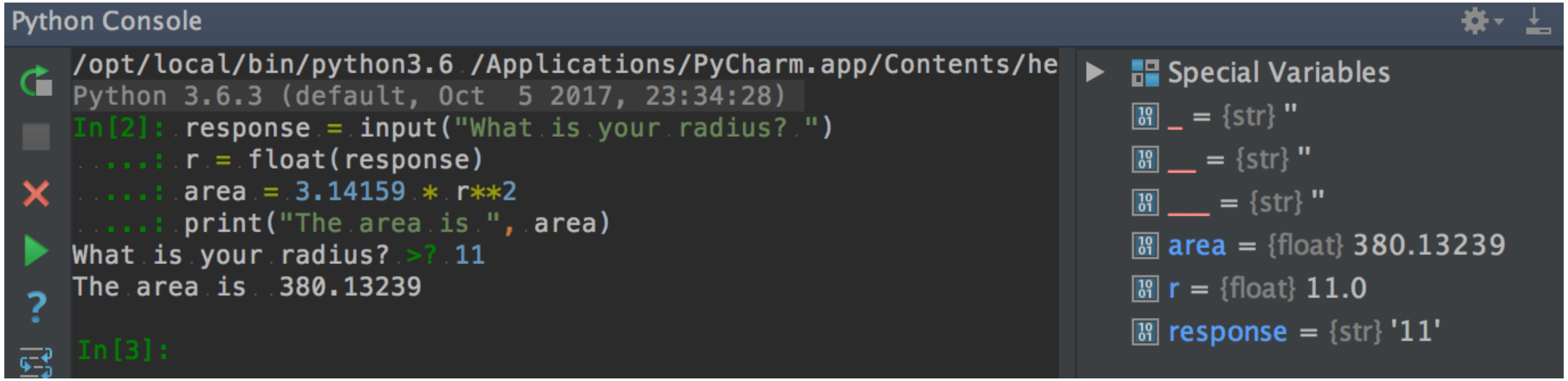


```
/opt/local/bin/python3.6 /Applications/PyCharm.app/Contents/helpers/pyc
Python 3.6.3 (default, Oct  5 2017, 23:34:28)
In[2]: name = "Bob"
In[3]: age = 17
In[4]: description = "My name is " + name + "and my age is "+ str(age)
In[5]: print(description)
My name is Boband my age is 17

In[6]:
```

```
Special Variables
_ = {str} ''
__ = {str} ''
___ = {str} ''
age = {int} 17
description = {str} 'My name is Boband my age is 17'
name = {str} 'Bob'
```

- 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)

INPUT



```
/opt/local/bin/python3.6 /Applications/PyCharm.app/Contents/he
Python 3.6.3 (default, Oct  5 2017, 23:34:28)
In[2]: response = input("What is your radius? ")
  ...: r = float(response)
  ...: area = 3.14159 * r**2
  ...: print("The area is ", area)
What is your radius? >? 11
The area is  380.13239

In[3]:
```

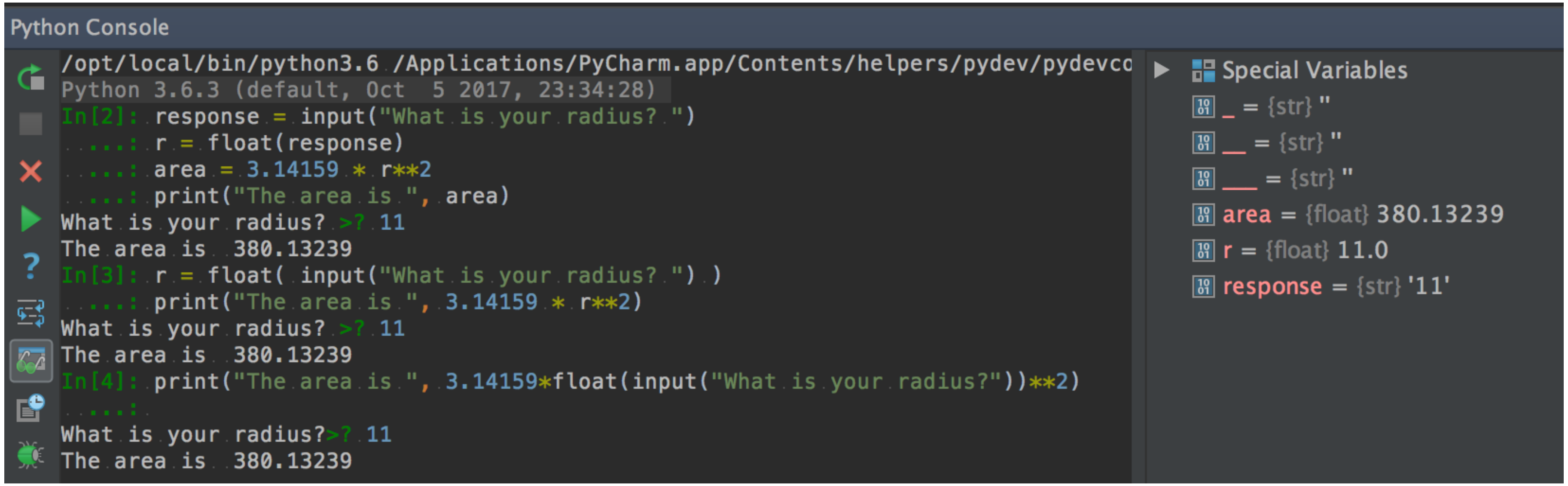
```
Special Variables
_ = {str} ''
__ = {str} ''
___ = {str} ''
area = {float} 380.13239
r = {float} 11.0
response = {str} '11'
```

- Built-in function to get input from a user:

  input(”Message to the user!”)

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

COMPOSITION



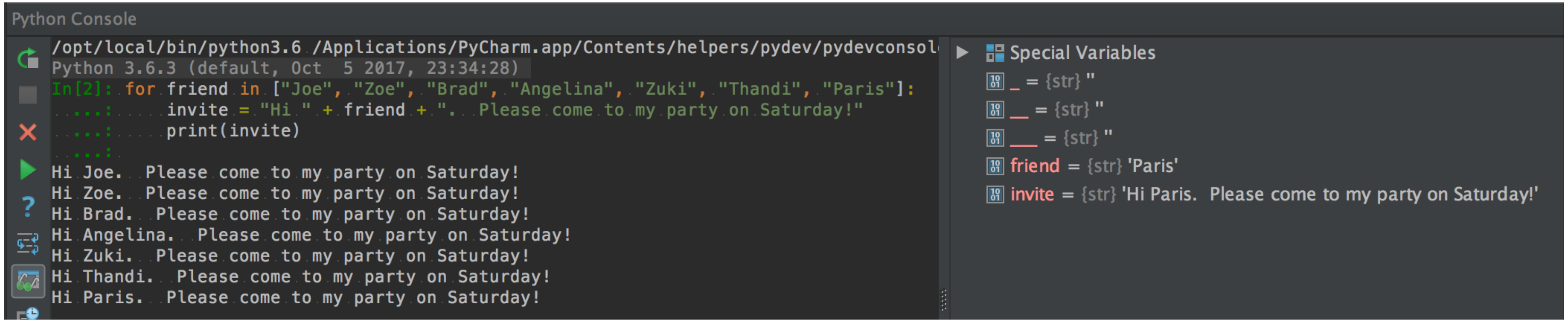
Python Console

```
/opt/local/bin/python3.6 /Applications/PyCharm.app/Contents/helpers/pydev/pydevco
Python 3.6.3 (default, Oct  5 2017, 23:34:28)
In[2]: response = input("What is your radius? ")
  ...: r = float(response)
  ...: area = 3.14159 * r**2
  ...: print("The area is ", area)
What is your radius? >? 11
The area is  380.13239
In[3]: r = float( input("What is your radius? ") )
  ...: print("The area is ", 3.14159 * r**2)
What is your radius? >? 11
The area is  380.13239
In[4]: print("The area is ", 3.14159*float(input("What is your radius?"))**2)
  ...: 
What is your radius?>? 11
The area is  380.13239
```

```
Special Variables
_ = {str} ''
__ = {str} ''
___ = {str} ''
area = {float} 380.13239
r = {float} 11.0
response = {str} '11'
```

- 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

THE FOR LOOP



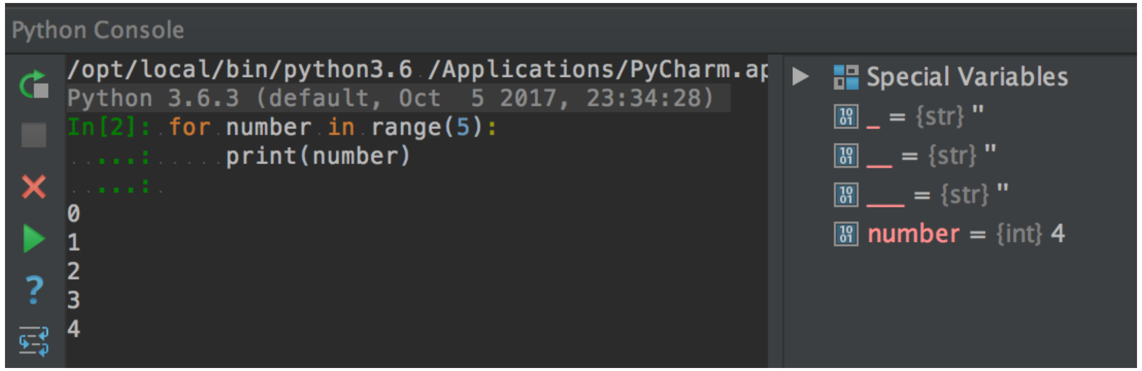
Python Console

```
/opt/local/bin/python3.6 /Applications/PyCharm.app/Contents/helpers/pydev/pydevconsol
Python 3.6.3 (default, Oct  5 2017, 23:34:28)
In[2]: for friend in ["Joe", "Zoe", "Brad", "Angelina", "Zuki", "Thandi", "Paris"]:
   ...:     invite = "Hi " + friend + ".  Please come to my party on Saturday!"
   ...:     print(invite)
   ...: 
Hi Joe.  Please come to my party on Saturday!
Hi Zoe.  Please come to my party on Saturday!
Hi Brad.  Please come to my party on Saturday!
Hi Angelina.  Please come to my party on Saturday!
Hi Zuki.  Please come to my party on Saturday!
Hi Thandi.  Please come to my party on Saturday!
Hi Paris.  Please come to my party on Saturday!
```

```
Special Variables
_ = {str} ''
__ = {str} ''
___ = {str} ''
friend = {str} 'Paris'
invite = {str} 'Hi Paris.  Please come to my party on Saturday!'
```

- 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

THE FOR LOOP



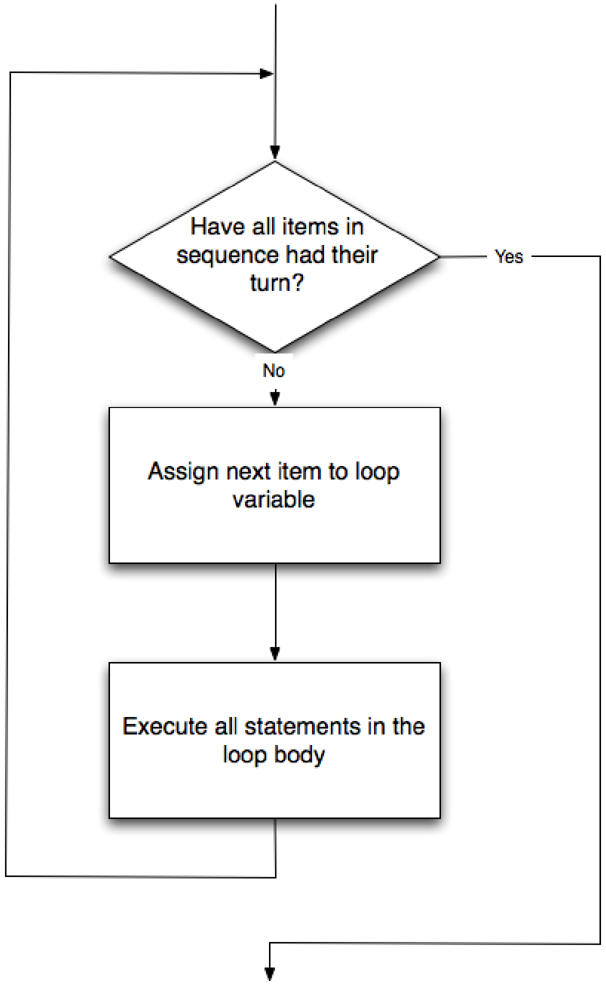
```
/opt/local/bin/python3.6 /Applications/PyCharm.ap
Python 3.6.3 (default, Oct  5 2017, 23:34:28)
In[2]: for number in range(5):
   ...:     print(number)
   ...: 
0
1
2
3
4
```

```
Special Variables
_ = {str} ''
__ = {str} ''
___ = {str} ''
number = {int} 4
```

<u>On each iteration or pass of the loop</u>:

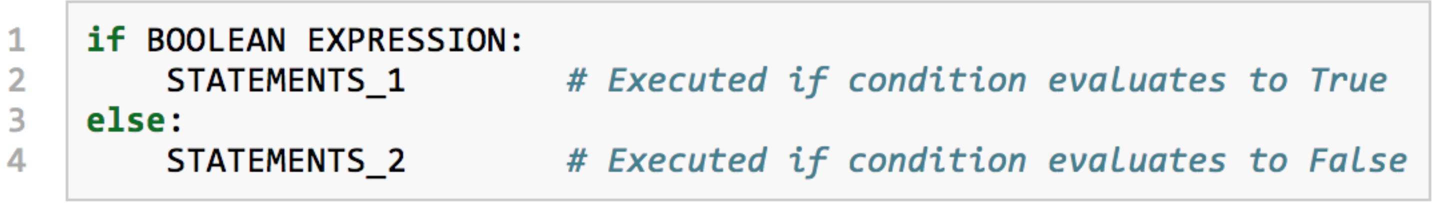
- Check to see if there are still more **items to be processed**
- If there are none left (the **terminating condition** of the loop) the loop has finished
- If there are items still to be processed, the **loop variable is updated** to refer to the next item in the list
- Program execution **continues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

THE FOR LOOP – CONTROL FLOW

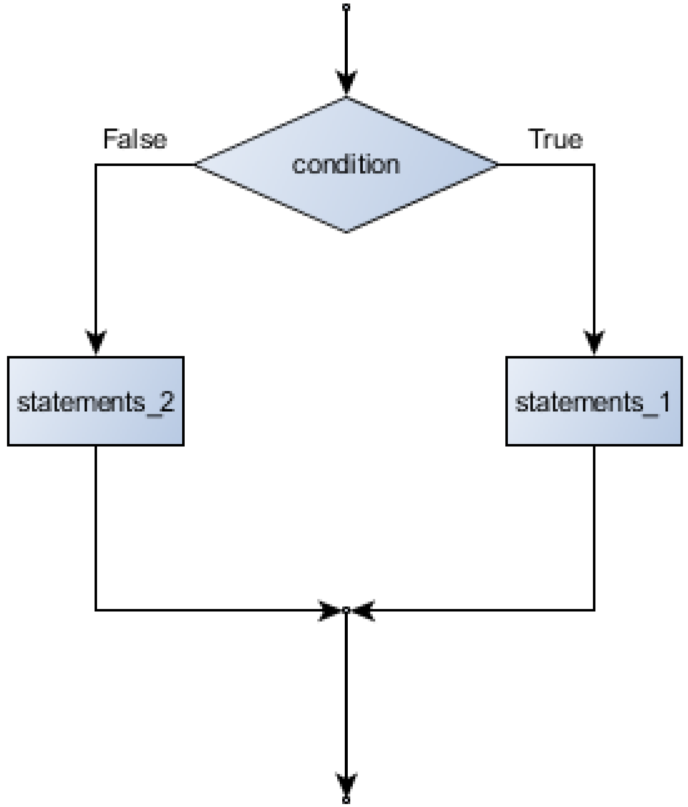

Have all items in sequence had their turn?
Yes
No
Assign next item to loop variable
Execute all statements in the loop body

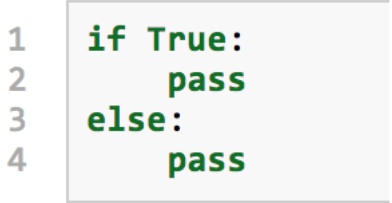
- Control flow (control of the flow of execution of the program)
- As program executes, the interpreter **always keeps track** of which statement is about to be executed
- Control flow until now has been strictly **top to bottom**, one statement at a time, **the for loop changes this!**

CONDITIONAL EXECUTION



```
if BOOLEAN EXPRESSION:
    STATEMENTS_1        # Executed if condition evaluates to True
else:
    STATEMENTS_2        # Executed if condition evaluates to False
```

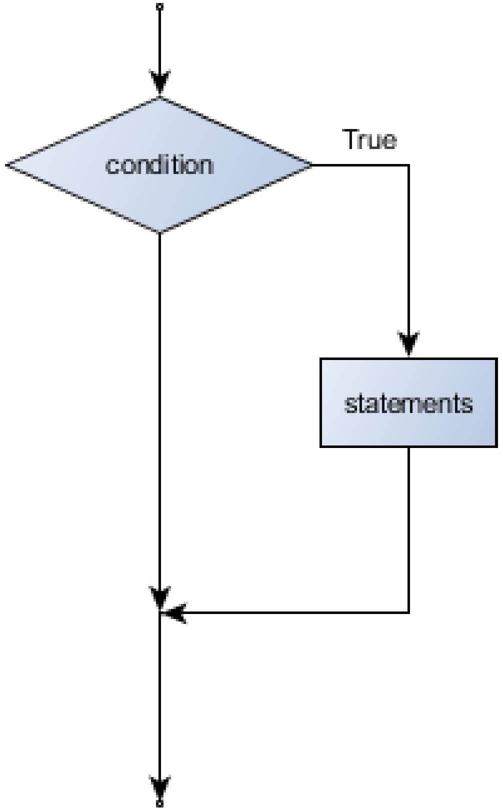




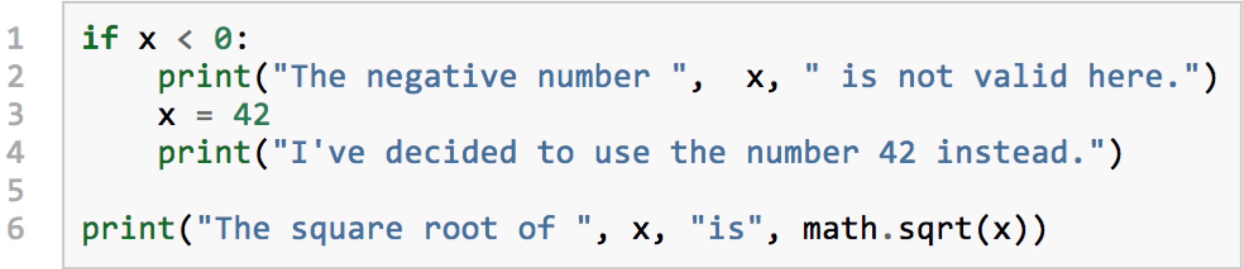
```
if True:
    pass
else:
    pass
```

- Condition **IF – ELSE**
- Conditional statement – the ability to check conditions and change the behavior of the program accordingly

CONDITIONAL EXECUTION



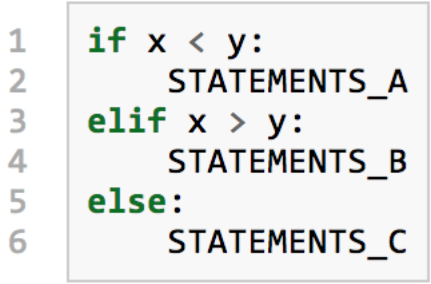
- Condition **IF only**
- No ELSE statement
- To control flow only for specific condition



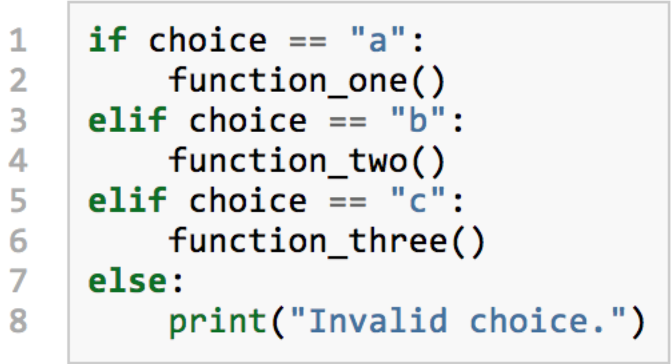
```python
if x < 0:
    print("The negative number ",  x, " is not valid here.")
    x = 42
    print("I've decided to use the number 42 instead.")

print("The square root of ", x, "is", math.sqrt(x))
```

source http://openbookproject.net/thinkcs/python/english3e/conditionals.html

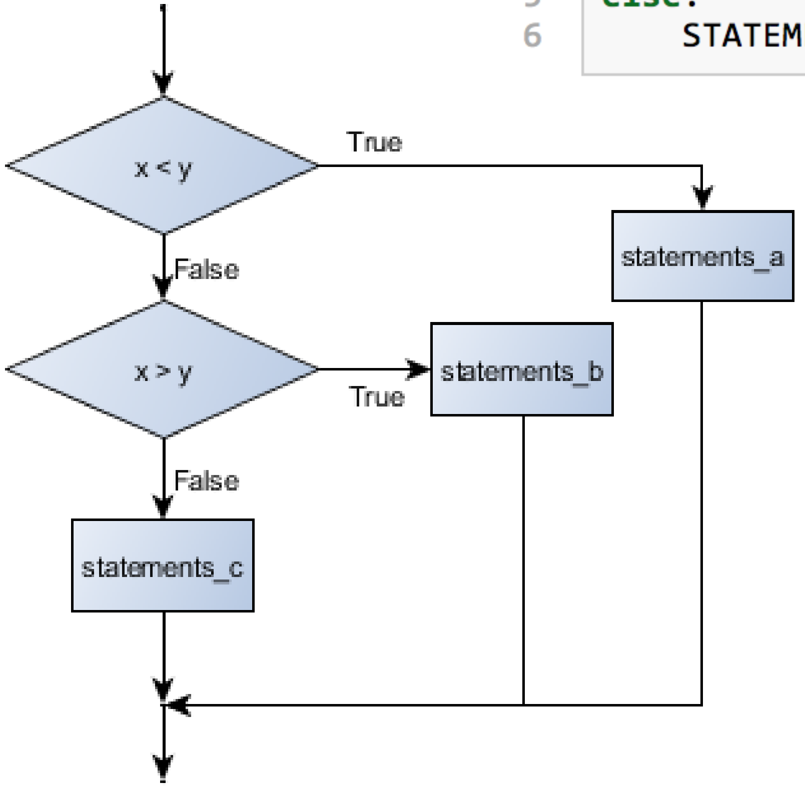
CONDITIONAL EXECUTION



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

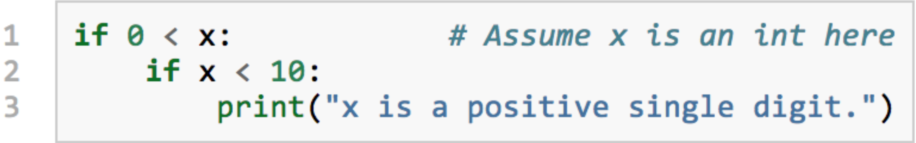


```
if choice == "a":
    function_one()
elif choice == "b":
    function_two()
elif choice == "c":
    function_three()
else:
    print("Invalid choice.")
```

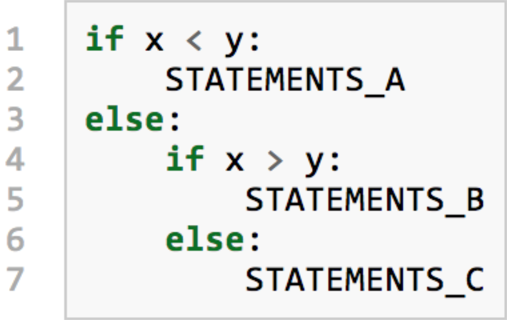


- Condition chaining
  IF – ELIF – ELSE
- Recommendation: handle all distinctive options by separate condition, use else to handle all other

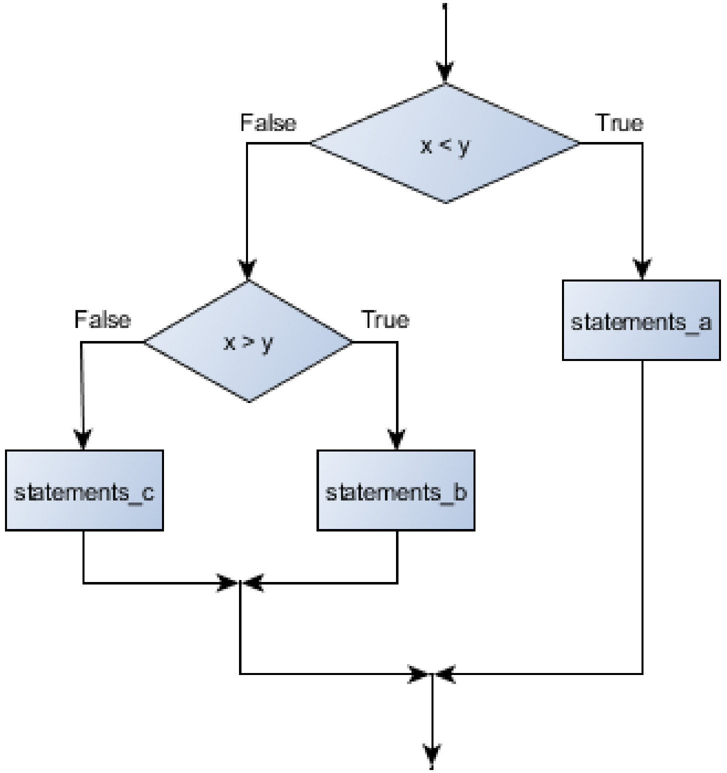
CONDITIONAL EXECUTION



```python
if 0 < x:                        # Assume x is an int here
    if x < 10:
        print("x is a positive single digit.")
```

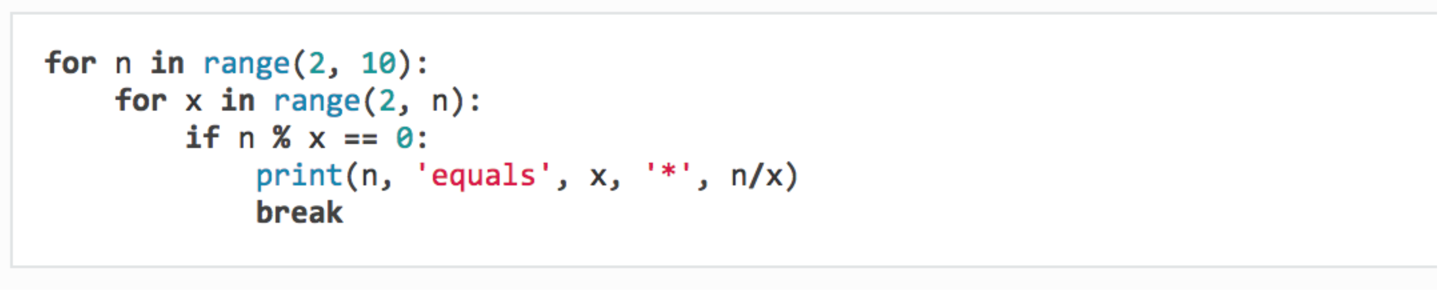


```python
if x < y:
    STATEMENTS_A
else:
    if x > y:
        STATEMENTS_B
    else:
        STATEMENTS_C
```

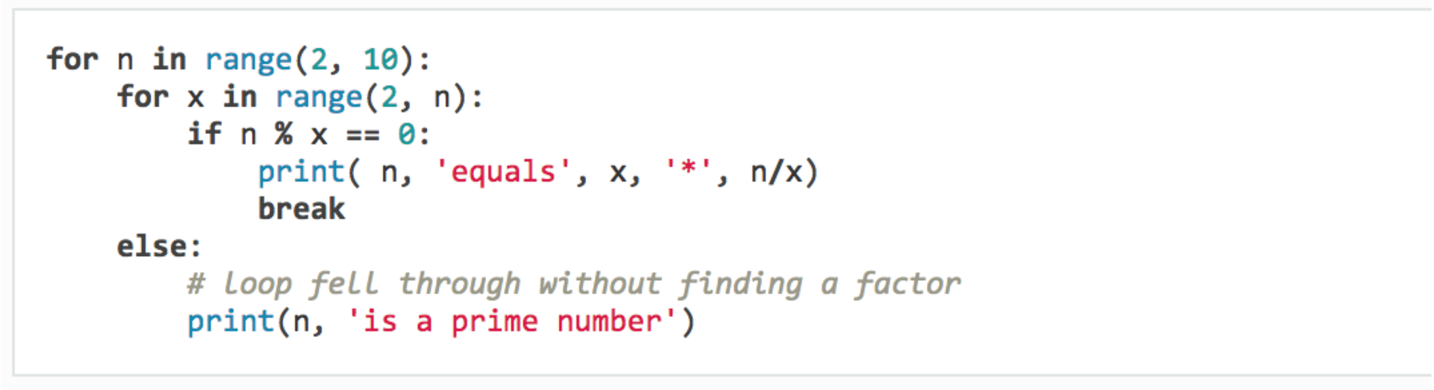


- Nesting conditions builds hierarchy of decisions (decision trees)
- Nesting may reduce readability and clarity

CONDITIONAL EXECUTION



```python
for n in range(2, 10):
    for x in range(2, n):
        if n % x == 0:
            print(n, 'equals', x, '*', n/x)
            break
```

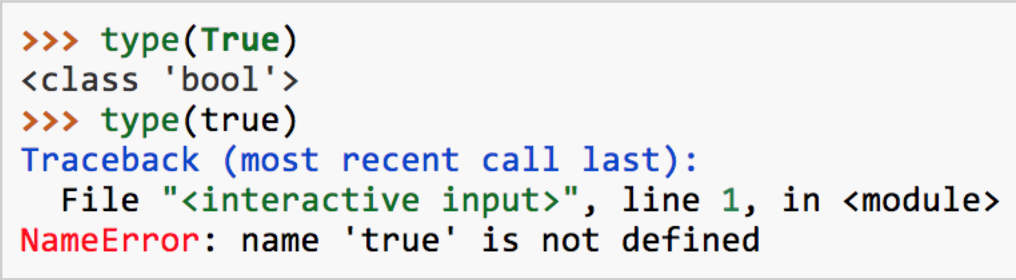


```python
for n in range(2, 10):
    for x in range(2, n):
        if n % x == 0:
            print( n, 'equals', x, '*', n/x)
            break
    else:
        # loop fell through without finding a factor
        print(n, 'is a prime number')
```

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

source http://book.pythontips.com/en/latest/for_-_else.html

BOOLEAN VALUES & EXPRESSIONS

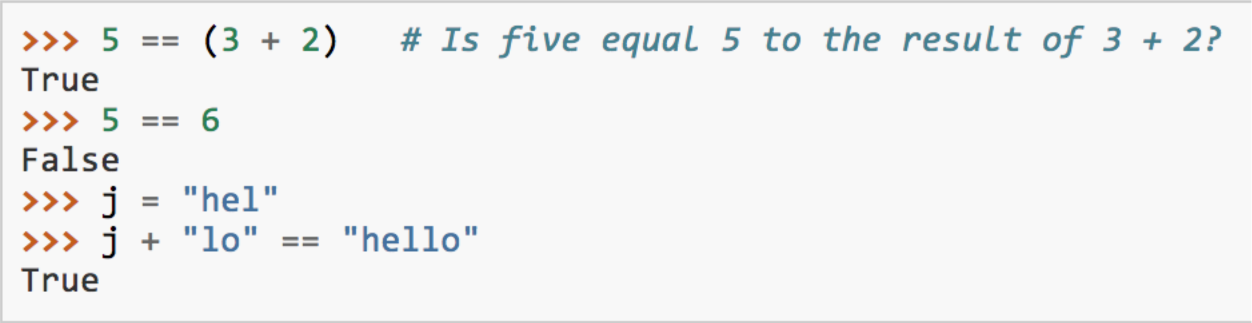


```
>>> type(True)
<class 'bool'>
>>> type(true)
Traceback (most recent call last):
  File "<interactive input>", line 1, in <module>
NameError: name 'true' is not defined
```

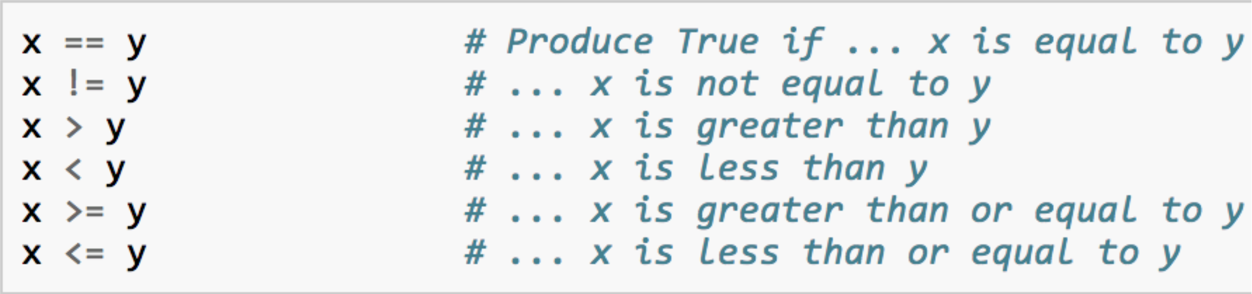
- Test conditions and **change the program behavior** depending on the outcome of the tests
- Boolean value is either **True** or **False**
- Named after the British mathematician, **George Boole**, who first formulated Boolean algebra

source http://openbookproject.net/thinkcs/python/english3e/conditionals.html

BOOLEAN VALUES & EXPRESSIONS



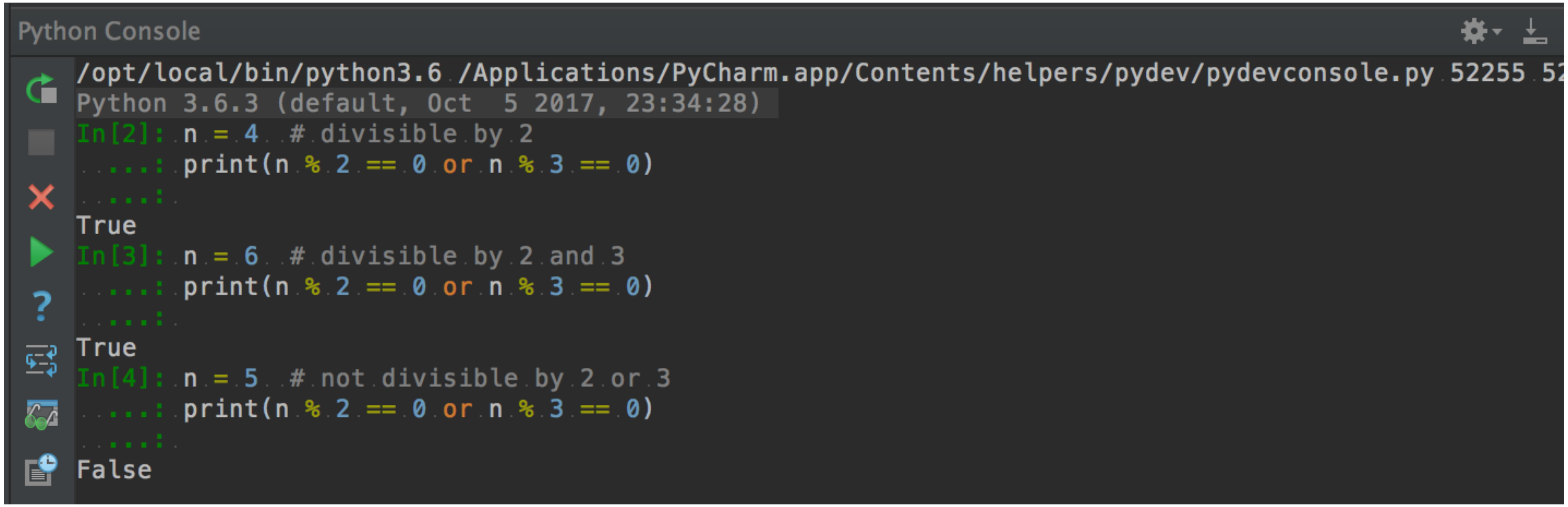
```
>>> 5 == (3 + 2)   # Is five equal 5 to the result of 3 + 2?
True
>>> 5 == 6
False
>>> j = "hel"
>>> j + "lo" == "hello"
True
```



```
x == y               # Produce True if ... x is equal to y
x != y               # ... x is not equal to y
x > y                # ... x is greater than y
x < y                # ... x is less than y
x >= y               # ... x is greater than or equal to y
x <= y               # ... x is less than or equal to y
```

- 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)

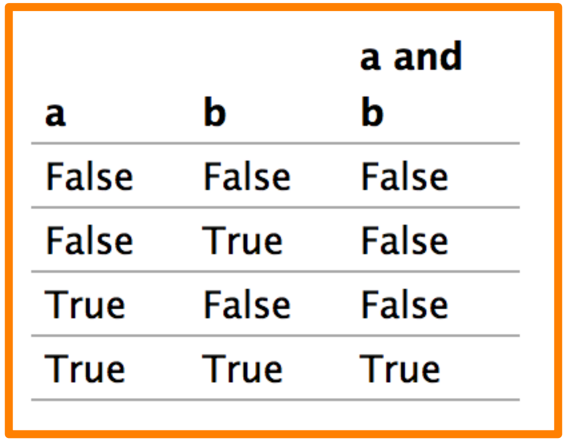
LOGICAL OPERATORS



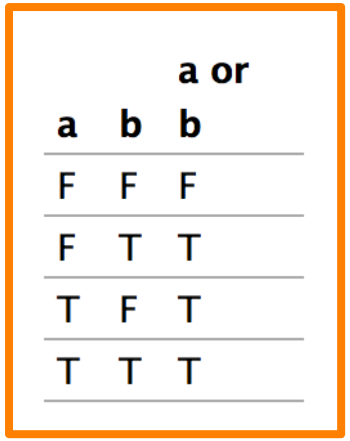
```
/opt/local/bin/python3.6 /Applications/PyCharm.app/Contents/helpers/pydev/pydevconsole.py 52255 52
Python 3.6.3 (default, Oct  5 2017, 23:34:28)
In[2]: n = 4  # divisible by 2
   ...: print(n % 2 == 0 or n % 3 == 0)
   ...: 
True
In[3]: n = 6  # divisible by 2 and 3
   ...: print(n % 2 == 0 or n % 3 == 0)
   ...: 
True
In[4]: n = 5  # not divisible by 2 or 3
   ...: print(n % 2 == 0 or n % 3 == 0)
   ...: 
False
```

- 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

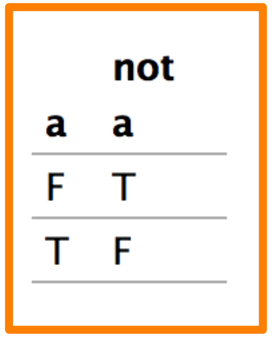
TRUTH TABLES



a	b	a and b
False	False	False
False	True	False
True	False	False
True	True	True



a	b	a or b
F	F	F
F	T	T
T	F	T
T	T	T

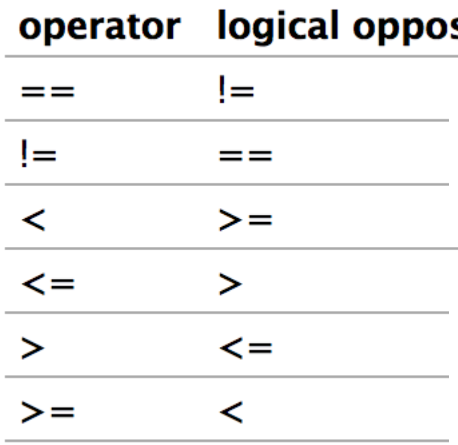


a	not a
F	T
T	F

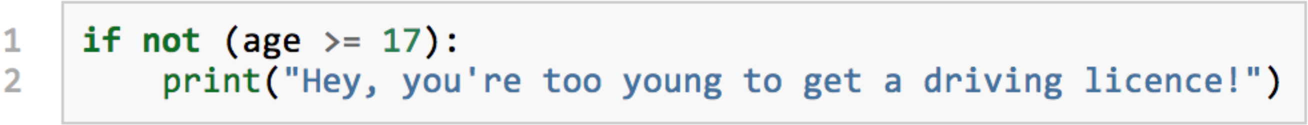
Short-circuit evaluation:

- **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

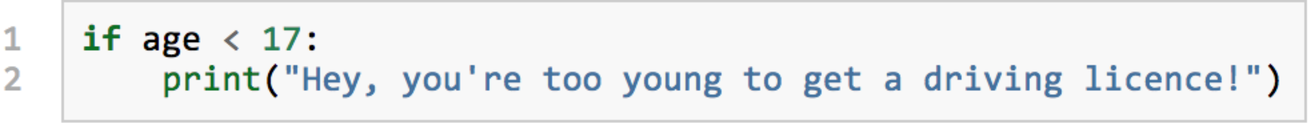
BOOLEAN ALGEBRA – LOGIC OPPOSITES



operator	logical opposite
==	!=
!=	==
<	>=
<=	>
>	<=
>=	<



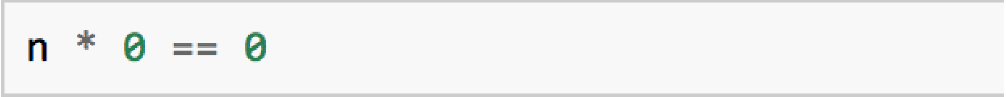
```
if not (age >= 17):
    print("Hey, you're too young to get a driving licence!")
```



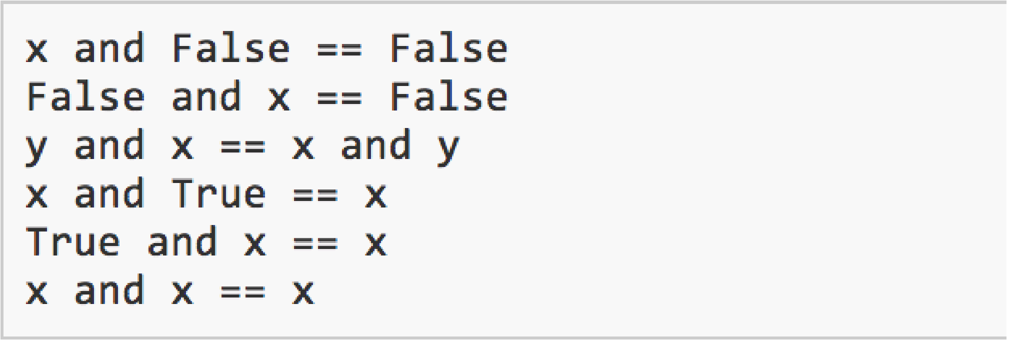
```
if age < 17:
    print("Hey, you're too young to get a driving licence!")
```

- Each of the six relational operators has a **logical opposite**
- Recommendation: **not** operators may reduce readability, use logical opposites instead

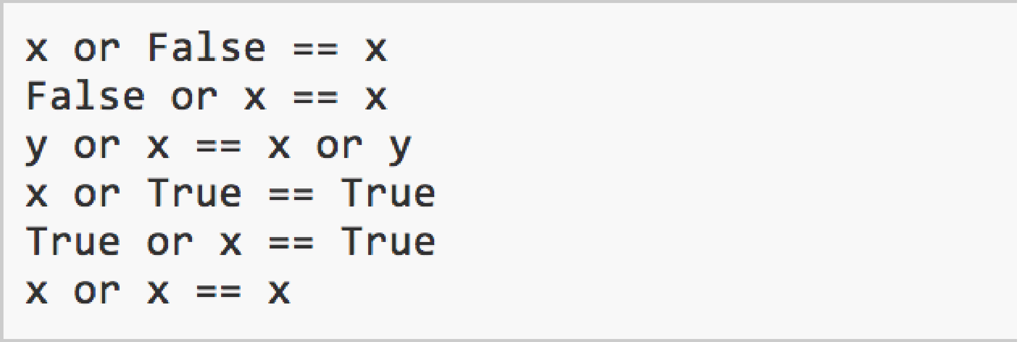
BOOLEAN ALGEBRA



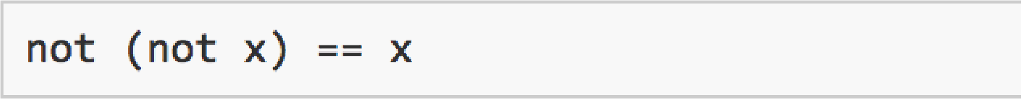
```
n * 0 == 0
```



```
x and False == False
False and x == False
y and x == x and y
x and True == x
True and x == x
x and x == x
```

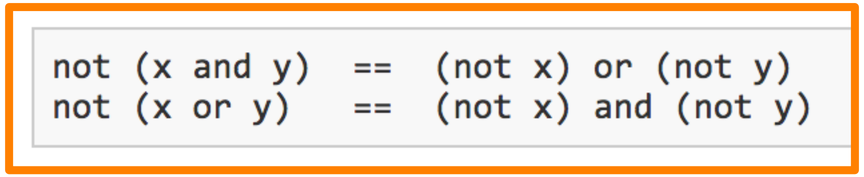


```
x or False == x
False or x == x
y or x == x or y
x or True == True
True or x == True
x or x == x
```

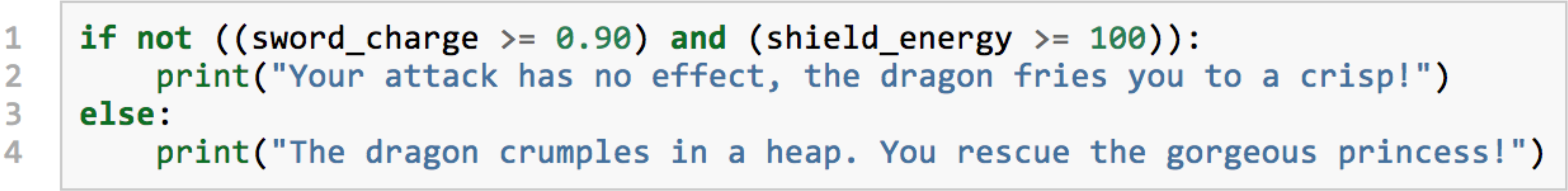


```
not (not x) == x
```

DE MORGAN'S LAWS



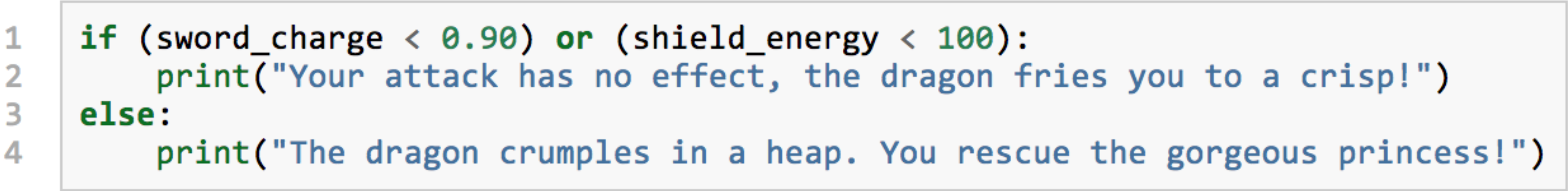
```
not (x and y)  ==  (not x) or (not y)
not (x or y)   ==  (not x) and (not y)
```



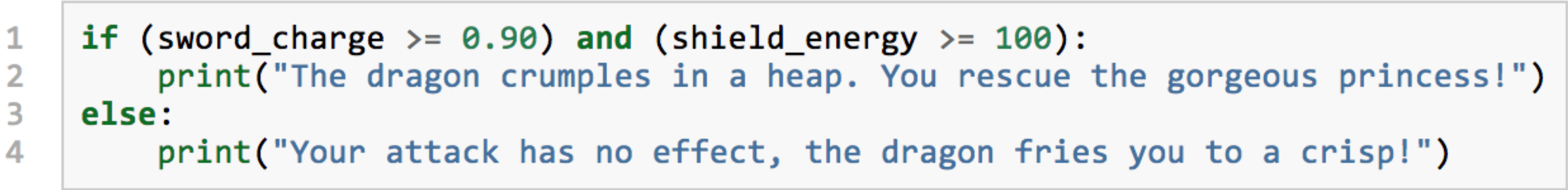
```
if not ((sword_charge >= 0.90) and (shield_energy >= 100)):
    print("Your attack has no effect, the dragon fries you to a crisp!")
else:
    print("The dragon crumples in a heap. You rescue the gorgeous princess!")
```

- 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

DE MORGAN'S LAWS



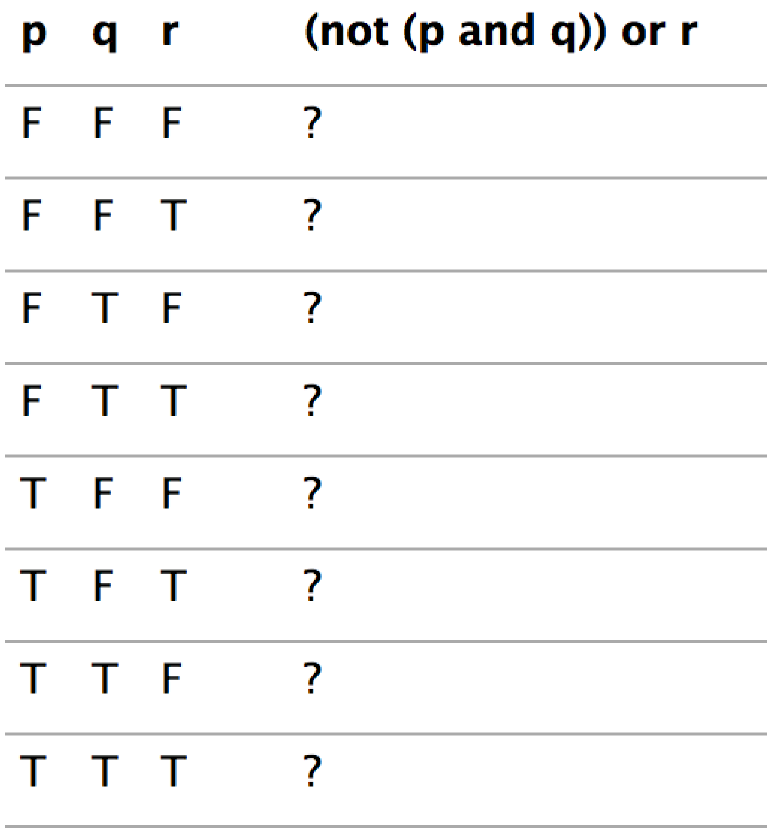
```python
if (sword_charge < 0.90) or (shield_energy < 100):
    print("Your attack has no effect, the dragon fries you to a crisp!")
else:
    print("The dragon crumples in a heap. You rescue the gorgeous princess!")
```



```python
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!")
```

- 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

EXAMPLE



p	q	r	(not (p and q)) or r
F	F	F	?
F	F	T	?
F	T	F	?
F	T	T	?
T	F	F	?
T	F	T	?
T	T	F	?
T	T	T	?

- Example: complete the table ..

REFERENCES

This lecture re-uses selected parts of the OPEN BOOK PROJECT
Learning with Python 3 (RLE)
http://openbookproject.net/thinkcs/python/english3e/index.html
available under **GNU Free Documentation License Version 1.3**)

- 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/