Lecture 2: Objects, Expressions & Variables

Comp 102 (sec: A,B)

Fakhir Shaheen

Forman Christian University

Recap from Lecture 1

- **Programming** = giving instructions to computers
- **Programmatic thinking** = breaking problems into steps
- **Machine language** vs **High-level languages**
- **Syntax** (rules) and **Semantics** (meaning)
- **Objects**: Everything in Python is an object
- **Scalar** vs **Non-scalar** objects

Building Blocks of Programming

Today's Agenda

Building Blocks of Programming

1. Scalar Objects & Types

2. Expressions

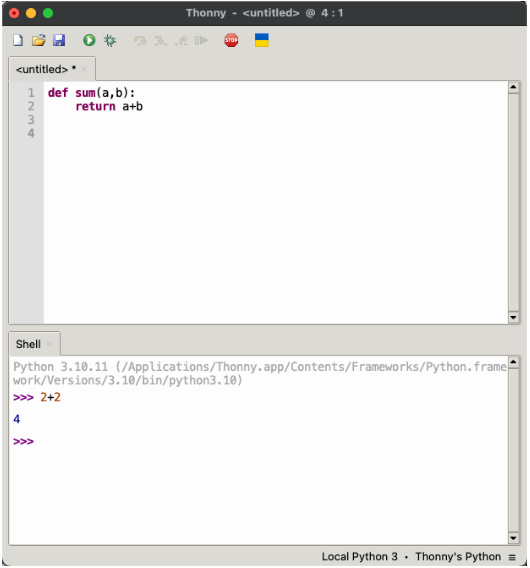
Math Expressions

Call Expressions

3. Variables

Programming Environment

Thonny



Editor

Shell

Scalar Objects

Scalar Objects *(can't be subdivided)*

- `int` - *represents integers:* 5, -100 *etc*
- `float` - *represents real numbers:* 3.27, 2.0 *etc*
- `bool` - `True`, `False`
- `NoneType` - *special, has only one value:* `None`

int

0, 1, 2, …
300, 301 …
-1, -2, -3, …
-400, -401, …

float

0.0, …, 0.21, …
1.0, …, 3.14, …
-1.22, …, -500.0 , …

bool

True
False

NoneType

None

Use `type()` to see type of an object:

```
>>> type(5)
int
>>> type(3.0)
float
```

This is what you type in the Python shell

This is what Python console outputs

You Try

Step 1: Predict the type of each WITHOUT using the computer:

Step 2: Verify your predictions in Python console:

1. `1234`
2. `8.99`
3. `9.0`
4. `True`
5. `False`
6. `None`

Type Conversions *(a.k.a Type Casting)*

- You can **convert object of one type to another**
  - `float(3)` casts the int 3 to a `float` 3.0
  - `int(3.9)` casts the float 3.9 to an `int` 3
    (note the truncation!)

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  - `int(3.9)` casts the `float` 3.9 to an `int` 3
    (note the truncation!)

- Some operations perform **implicit casts** *(automatic conversions)*
  - `round(3.9)` returns the `int` 4

You Try

First: Predict the type & value WITHOUT using the computer.

Then: Verify in Python console:

- `float(123)`
- `round(7.9)`
- `float(round(7.9))`
- `int(7.2)`
- `int(7.9)`

Expressions

Math Expressions

(a.k.a Arithmetic Expressions)

Combine Objects and Operators to form **Expressions**

$$\underset{\textit{object}}{1} \overset{\textit{operator}}{+} \underset{\textit{object}}{2}$$

Combine Objects and Operators to form **Expressions**

operator

$$\mathbf{1} + \mathbf{2}$$

object *object*

Syntax:

<object> <operator> <object>

Examples:

```
>>> 1 + 2
3
>>> 5 / 2
2.5
```

Examples:

```
>>> 1 + 2
3
>>> 5 / 2
2.5
>>> (4 + 2) * 6 - 1
```

evaluate from left to right

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$\underbrace{4 + 2}_{6}$

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6

36

evaluate from left to right

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2.5
>>> (4 + 2) * 6 - 1
```

$\underbrace{\underbrace{(\underbrace{4 + 2}_{6}) * 6}_{36} - 1}_{35}$

evaluate from left to right

Examples:

```
>>> 1 + 2
3
>>> 5 / 2
2.5
>>> (4 + 2) * 6 - 1
```

6

36

35

evaluate from left to right

```
>>> 35
```

You Try:

Predict the answer FIRST, then verify with Python!

```
>>> (2 + 3) - 1

>>> 2 + (3 - 1)

>>> 3 / 2

>>> 3 ** 2

>>> type(3 ** 2)
```

You Try:

Predict the answer FIRST, then verify with Python!

`>>> (2 + 3) - 1`	**5 - 1 → 4**
`>>> 2 + (3 - 1)`	**2 + 2 → 4** *(brackets first)*
`>>> 3 / 2`	**1.5**
`>>> 3 ** 2`	**9**
`>>> type(3 ** 2)`	**int**

Warning:

Do not use other types of brackets in expressions.

Use **ONLY** parenthesis: ( )

Do **NOT** use brackets: [ ] **or** braces: { }

✓ `2 + (3 - 1)`

✗ `2 + [3 - {1}]`

Math Operators

`i+j` → **sum**

`i-j` → **difference**

`i*j` → **product**

*if both are **int**, the result is **int***
*if either or both are **float**, result is **float***

`i/j` → **division** *result is always a **float***

`i//j` → **floor division**

`i%j` → the **remainder** when `i` is divided by `j`

`i**j` → `i` to the **power** of `j` (i^j)

You Try:

IMPORTANT: Write your predictions on paper FIRST!

Then evaluate in console to check:

1. `(14-2) / (12*2)`
2. `type(4 * 3)`
3. `type(4.0 * 3)`
4. `3 // 2`
5. `5 % 2`
6. `2 ** 5`

You Try:

IMPORTANT: Write your predictions on paper FIRST!

Then evaluate in console to check:

1. `(14-2) / (12*2)` `0.5`
2. `type(4 * 3)` `int`
3. `type(4.0 * 3)` `float`
4. `3 // 2` `1`
5. `5 % 2` `1`
6. `2 ** 5` `32`

Big Idea

All "*arithmetic expressions*" evaluate to a **single value**.

Call Expressions

(a.k.a Function Calls)

Call Expressions

```
>>> max(3, 5)
5
```

Call Expressions

```
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5
```

$$\underbrace{\boxed{\mathbf{max}}}_{\substack{\textit{operator}\\ \textit{(function name)}}}\,(\,\underbrace{\boxed{\mathbf{3}}}_{\textit{object}}\,,\,\underbrace{\boxed{\mathbf{5}}}_{\textit{object}}\,)$$

Multiple objects can be passed to a function:

```
>>> max(3, 5, 7)
7
>>> min(3, 5, 7, 1)
1
```

(comma separated)

Multiple objects can be passed to a function:

```
>>> max(3, 5, 7)
7
>>> min(3, 5, 7, 1)
1
```

(comma separated)

Order of objects is important:

```
>>> pow(10, 2)
100
>>> pow(2, 10)
1024
```

Importing Library Functions

- Python has a large number of functions, **unavailable** by default.
- You must import functions from a **package (a.k.a module)** to use them:

```
>>> from math import sqrt
>>> sqrt(16)
4.0
```

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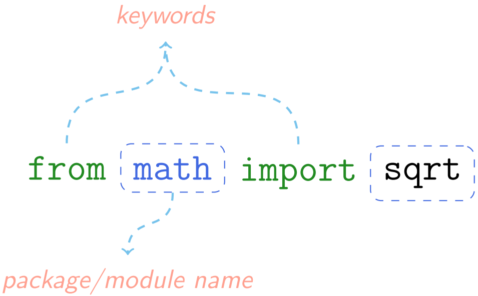

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keywords

`from` $\boxed{\texttt{math}}$ `import` $\boxed{\texttt{sqrt}}$

package/module name *function name*

Call Expression Examples

```
>>> pow(2,3)
8
```

already available, no need to import

Call Expression Examples

```
>>> pow(2,3)
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>>> from math import sqrt
>>> sqrt(256)
16.0
```

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Call Expression Examples

```
>>> pow(2,3)
8
>>> from math import sqrt
>>> sqrt(256)
16.0
>>> from operator import add, sub, mul
>>> add(1, 1)
2
```

already available, no need to import

equivalent to → 1 + 1

Call Expression Examples

```
>>> pow(2,3)        already available, no need to import
8
>>> from math import sqrt
>>> sqrt(256)
16.0
>>> from operator import add, sub, mul
>>> add(1, 1)       equivalent to → 1 + 1
2
```

The operator module provides functions for arithmetic operations such as +, −, ∗, / etc.

Big Idea

All ”*call expressions*” evaluate to a **single value**.

Evaluating Nested Expressions

"Evaluation Tree":

```
sub(10, mul(3, add(1, 2)))
```

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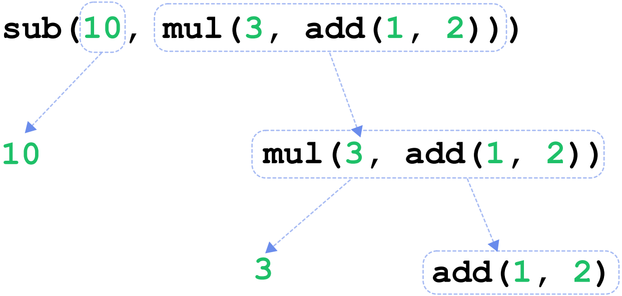

Evaluating Nested Expressions

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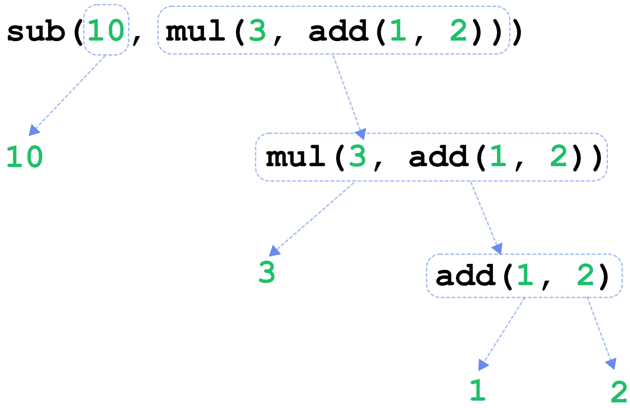

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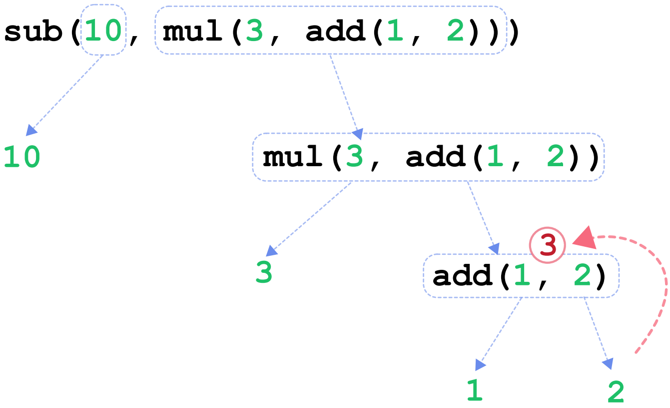

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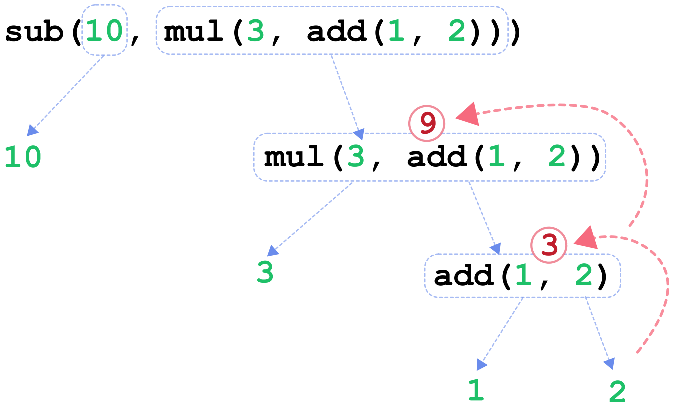

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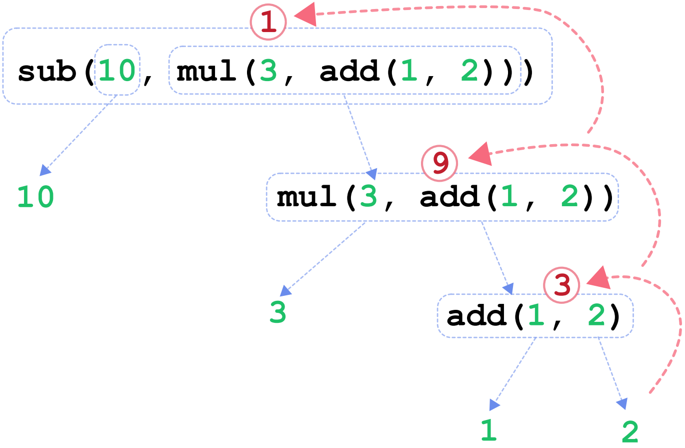

You Try:

Trace through each expression step-by-step on paper!

```
>>> from operator import add, sub, mul

>>> 1 + add(2,3)

>>> pow(2, sub(3,1))

>>> mul(2*(3+1),add(1,2))
```

You Try:

Trace through each expression step-by-step on paper!

```
>>> from operator import add, sub, mul

>>> 1 + add(2,3)                1 + 5 → 6

>>> pow(2, sub(3,1))            pow(2,2) → 4

>>> mul(2*(3+1),add(1,2))       mul(8,3)→ 24
```

Variables

Bind names to objects:

temp = 100.4

a = 2

go = True

b = -0.3

flag = False

x = 123

n = 17

small = 0.001

Assignment Statement:

assignment operator

$$\mathbf{pi} = \mathbf{3.14}$$

variable *value*

Assignment Statement:

$$\underset{\textit{variable}}{\boxed{\mathbf{pi}}} \overset{\textit{assignment operator}}{=} \underset{\textit{value}}{\boxed{\mathbf{3.14}}}$$

<u>WARNING</u>: This is NOT Equal Sign! You are NOT comparing!

Math variables vs CS variables

Math Variables

1. = means equality

CS Variables

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2. can represent many values:
   $y = x^2$

CS Variables

1. = means assignment
2. bound to a single value
   `g = 9.81`

Math variables vs CS variables

Math Variables

1. = means equality
2. can represent many values: $y = x^2$
3. `b = (3+2)*1.5` Comparing `b` with the right side

CS Variables

1. = means assignment
2. bound to a single value `g = 9.81`
3. `b = (3+2)*1.5` `b` is bound to an expression *(which will evaluate to a single value)*

You Try:

Predict first: Which are allowed in Python?

Then verify in the console:

1. `x = 6`
2. `6 = x`
3. `x * y = 3 + 4`
4. `xy = 3 + 4`

You Try:

Predict first: Which are allowed in Python?

Then verify in the console:

1. `x = 6` ✓
2. `6 = x` ✗
3. `x * y = 3 + 4` ✗
4. `xy = 3 + 4` ✓

Expression Abstraction

Why give names to values and expressions?

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Why give names to values and expressions?

- to reuse names instead of values
- to make code easier to read and modify

```
# Compute approximate value for pi
pi = 355/113
radius = 2.2
area = pi * (radius ** 2)
circumference = 2 * pi * radius
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assignment operator

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```

comment
*is **not** a part of the program*

Choose variable names wisely:

- You'll be fine if you stick to **letters** and **underscores**
- Just **don't** start the name with numbers

You Try:

Which of the following are valid variable names?

1. `lunchPrice`
2. `fried rice`
3. `greek-salad`
4. `chilli_sauce`
5. `7up`

You Try:

Which of the following are valid variable names?

1. `lunchPrice` ✓ *valid variable name, note the camel case*
2. `fried rice` ✗ *invalid variable name, spaces are not allowed*
3. `greek-salad` ✗ *this is a subtraction expression*
4. `chilli_sauce` ✓ *valid variable name*
5. `7up` ✗ *variable names cannot start with numbers*

Which one is the Best Code Style?

```
# do calculations
a = 355/113 * (2.2 ** 2)
c = 355/113 * (2.2 * 2)
```

```
p = 355/133
r = 2.2
# multiply p with r squared
a = p*(r**2)
# multiply p with r times 2
c = p*(r*2)
```

```
# calculate area and circumference of a circle
# using an approximation of pi
pi = 355/113
radius = 2.2
area = pi * (radius ** 2)
circumference = pi * (radius * 2)
```

Which one is the Best Code Style?

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```

Horrible...

- unclear comments,
- single letter variable names,
- not assigning names to expressions

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Still Bad

- atleast the comments are meaningful,
- expressions are bound to variables,
- variable names are still not very descriptive

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```

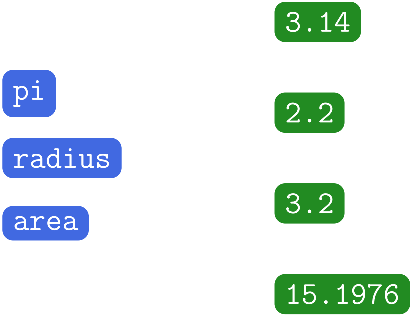
Best!

- very descriptive comments throughout the code,
- expressions are bound to variables,
- variable names are very descriptive

Change Bindings

- Variables can **re-bind** to other values

```
pi = 3.14
radius = 2.2
area = pi*(radius**2)
radius = 3.5
print(area)
```



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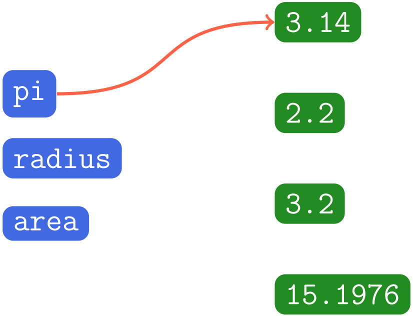

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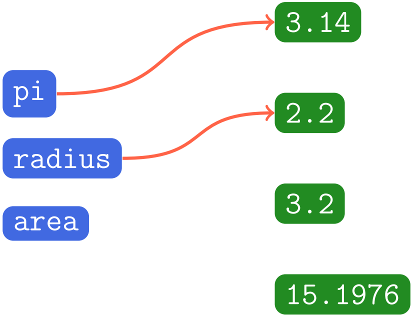

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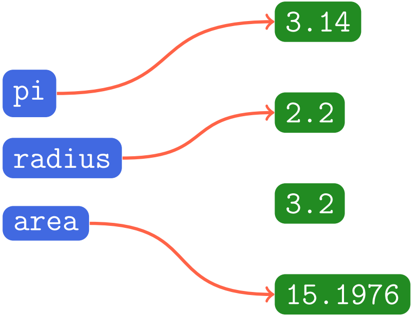

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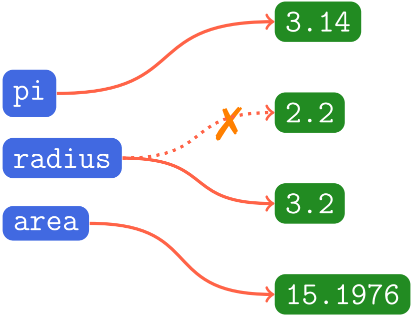

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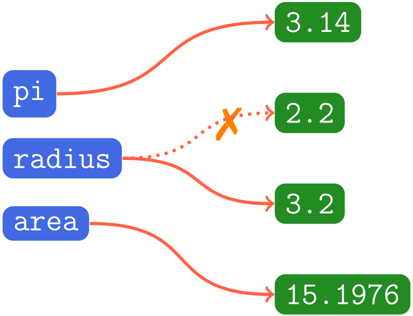


the area is still **15.1976**
have to calculate the area again!

Big Idea

Lines are evaluated one after the other.

No skipping around, yet.

We'll see how lines can be skipped/repeated later.

You Try:

Step 1: Trace through this code BY HAND.

What are the values of **meters** and **feet** after each line?

```
meters = 100
feet = 3.2808 * meters
meters = 200
```

Step 2: Verify with PythonTutor

- Follow along with this Python Tutor LINK

Where did we tell Python to (re)calculate feet?

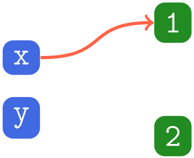
You Try:

Swap values of x and y without binding the numbers directly.

Debug (a.k.a fix) this code:

```
x = 1
y = 2

y = x
x = y
```



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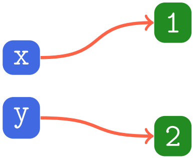

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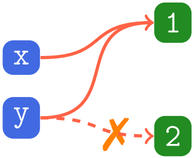

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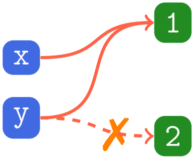

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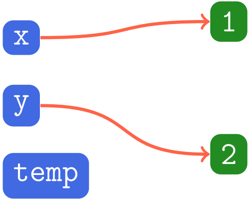

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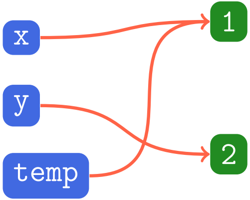

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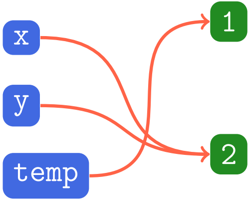

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You Try:

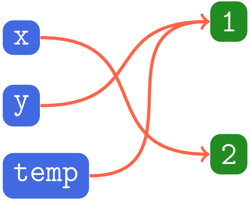
Swap values of x and y without binding the numbers directly.

Debug (a.k.a fix) this code:

```
x = 1
y = 2

y = x
x = y
```

Hint:



Python Tutor to the rescue ?

From the Shell to a Script

Two Ways to Talk to Python

Shell *(bottom window)*

- Type **one line**, press Enter
- Python answers **immediately**
- Perfect for quick experiments
- Nothing is saved

Editor *(top window)*

- Type **many lines**: a whole program
- **Save** it in a file, e.g. `area.py`
- **Run** it: green button, or `F5`
- Lines run **top to bottom**

A saved program is called a **script**.

Your First Script

1. **File** → **New**: an empty editor tab

Editor: `area.py`

Shell

Your First Script

1. **File** → **New**: an empty editor tab
2. Type the program
   (no >>> this time!)

Editor: `area.py`

```
pi = 355 / 113
radius = 2.2
area = pi * (radius ** 2)
print(area)
```

Shell

Your First Script

1. **File** → **New**: an empty editor tab
2. Type the program

   (no >>> this time!)
3. **File** → **Save**, name it `area.py`

Editor: `area.py`

```
pi = 355 / 113
radius = 2.2
area = pi * (radius ** 2)
print(area)
```

Shell

Your First Script

1. **File** → **New**: an empty editor tab
2. Type the program
   (no >>> this time!)
3. **File** → **Save**, name it `area.py`
4. Press the green **Run** button
   (or F5)

Editor: `area.py`

```
pi = 355 / 113
radius = 2.2
area = pi * (radius ** 2)
print(area)
```

Shell

Your First Script

1. **File** → **New**: an empty editor tab
2. Type the program
   (no >>> this time!)
3. **File** → **Save**, name it `area.py`
4. Press the green **Run** button
   (or F5)
5. The output appears in the **Shell**

Editor: `area.py`

```
pi = 355 / 113
radius = 2.2
area = pi * (radius ** 2)
print(area)
```

Shell

```
>>> %Run area.py
15.205309734513278
```

Big Idea

A script shows **nothing**
unless you `print()` it.

Shell *echoes every value*

```
>>> area
15.205309734513278
```

Script *stays silent*

```
area
```

(computed, then thrown away)

You Try:

Step 1: This script is saved and run with `F5`. What appears in the Shell? Predict on paper first.

```
x = 6
x * 2
print(x + 1)
x = 10
print(x)
```

Step 2: Type it in the <u>editor</u>, save it as `first.py`, run it.

You Try:

Step 1: This script is saved and run with `F5`. What appears in the Shell? Predict on paper first.

```
x = 6
x * 2
print(x + 1)
x = 10
print(x)
```

```
7
10
```

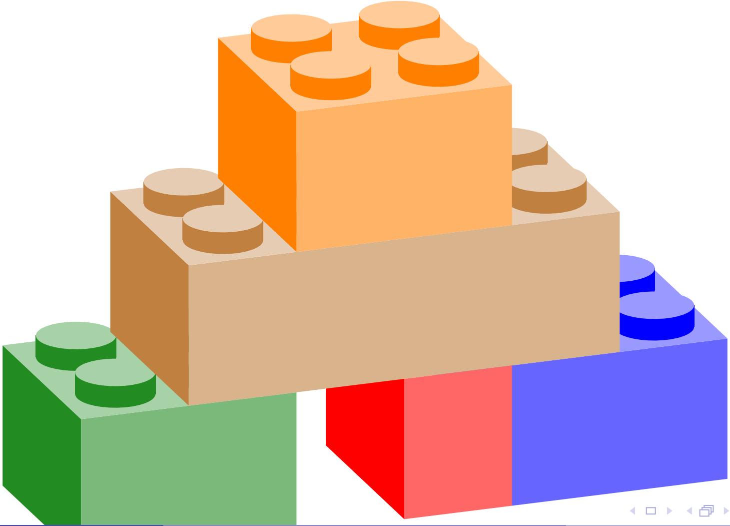
$x * 2$ is evaluated and forgotten: nobody asked to print it.

Step 2: Type it in the editor, save it as `first.py`, run it.

Summary

- **Programming Environment**
  - Thonny IDE: Shell vs. Editor
  - Save a script, run it with `F5`
  - Scripts only show what they `print()`
- **Scalar Objects**
  - `int`, `float`, `bool`, `NoneType`
  - `type()`
- **Type Casting**
  - `int()`, `float()`
- **Expressions**
  - Math expressions
  - Call expressions
  - All evaluate to single value
- **Variables**
  - Assignment statements
  - Variable naming
  - Re-binding values

Building Blocks of Programming



Questions ?

Exit Ticket

Today's question *(2 minutes)*

```
a = 4
b = a * 2
a = 10
```

(a) What is the value of `b` ?

(b) What is the value of `a / 4` ?

COMP 102 — Exit Ticket #2

Name: ____________________

Roll #: __________ Date: ________

Answer:

Hand it to me on your way out.
No name, no attendance.