PROGRAMMING IN PYTHON I

Comments, Variables, Console

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A Python Program

- Python program code is stored in text files
- Standard filename suffix indicating a Python file: `.py`
  - Example filename: `myfile.py`
- See file `01_comments_variables_console.py` for an example Python file
- We will use Python in version $\geq$ 3.9

Python Code Execution

- Python program code is executed **line by line (from first line to last line)**
- **Expressions** are **evaluated from left to right**

  ```
  a + b + c
  ```

  - Is equivalent to `(a + b) + c`
- **Assignments** are **evaluated from right to left**

  ```
  x = a + b
  ```

  - Is equivalent to `x = (a + b)`
- Different **operators have different precedence**

  ```
  x = a + b / c
  ```

  - Is equivalent to `x = (a + (b / c))`
  - https://docs.python.org/3/reference/expressions.html#operator-precedence

Python Style

- Python will not force you to follow a certain style but there are recommendations (as you will see later)
- Adhering to conventions helps to achieve easier maintainability and consistency, and it will aid programmers in understanding other people's code more quickly
- Recommendation details (naming conventions, comment styles, formatting):
  `https://www.python.org/dev/peps/pep-0008/`
- If you follow the style presented in the lecture/exercise, you will be on the right track

Comments

- Parts of the program code which are **not executed**
- Used for **documenting code**
- Start with **hashtag character** #
- Have no effect on the behavior of the program
- **Good comments** will make your life much easier!

Comments: Examples

- The following line only contains a comment:

```
# This is a comment
```

- The following line contains an assignment operation, followed by a comment:

```
var = "hello"  # This is a comment
```

  For execution, this it is equivalent to:

```
var = "hello"
```

Data Types

- We can use a group of bits to encode a value
- There are different ways to encode values as bits (=**data types**)
- Our main data types will be

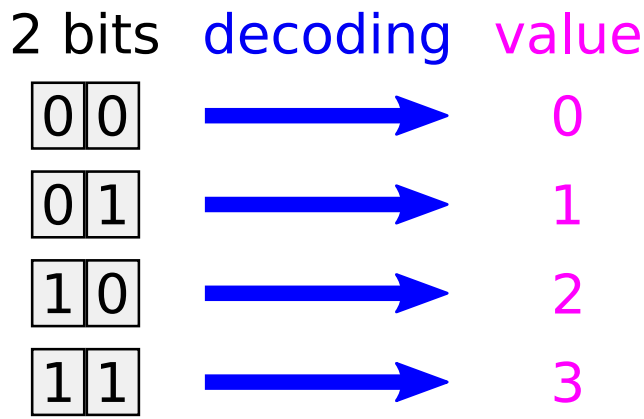
bool	Boolean – Either False or True
int	Integer – Integral numbers
float	Float – Floating point numbers
str	String – (String of) characters

Data Types: Boolean (Example: `var = True`)

- Often, we want to check conditions $\rightarrow$ for convenience, data type **boolean**
- Can only store two values: **False** or **True**
- In Python, this is actually an integer (see next slide):
  - 0 = False
  - 1 = True

Data Types: Integer (Example: `var = 3`)

- **Integer** data type assigns one bit pattern to one value
- **Precise**, there is no information lost
- **Only integral numbers** in certain range[1]



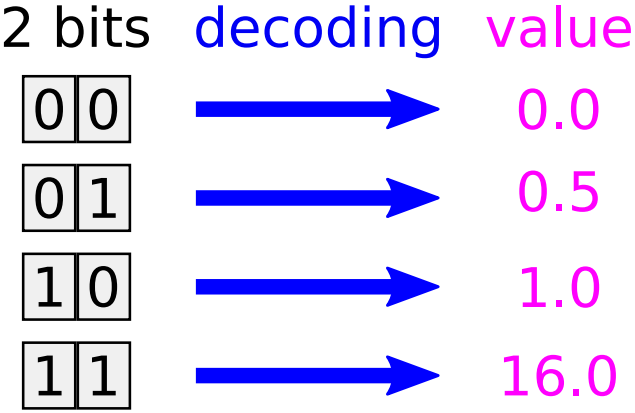
[1] In Python, integers are actually not limited by a certain fixed size (e.g., 32 bits) but are variable-length objects of arbitrary size.

Data Types: Float (Example: `var = 0.5`)

- **Float** data type uses the formula

$$value = significand \times base^{exponent}$$

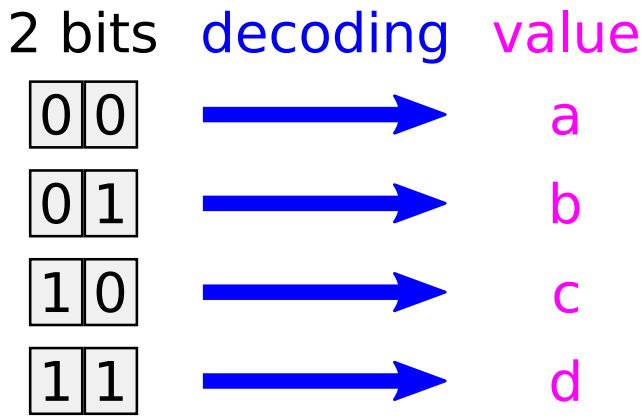
  where $significand$ and $exponent$ are integers extracted from the bit pattern, and $base$ is fixed (e.g., 2)
- **Not precise** because values are approximated
- Allows for **floating point numbers** in very large range[2]



[2] In Python, we typically have double-precision floats (64 bits), which can represent numbers between about $\pm 2.2 \cdot 10^{-308}$ and $\pm 1.8 \cdot 10^{308}$.

Data Types: String (Example: `var = "a"`)

- **Character** data type assigns one bit pattern (typically a byte) to one **character/letter**
- Such characters are concatenated, which gives the data type **string** (we will see more about this later)[3]
- Different encoding formats: UTF-8, ASCII, ...



[3] In Python, a single character is also represented as a string.

Variables

- A **variable** is something that **can hold a changeable value** and has a **name** for accessing this value
- We can **store (assign), access and modify** the information in the variable
- Example in Python:
  - Assign integer `5` to variable `var`:

    ```
    var = 5
    ```

  - Modify content of existing variable `var`:

    ```
    var = 6
    ```

  - Assigning to variable `var2` by accessing/reading `var`:

    ```
    var2 = var - 5
    ```

- How do we know what type of data is stored in a variable?

Variables: Static and Dynamic Typing

- **Static typing**:
  - Data type of variable is known at **compile time**
  - **Variable itself is associated with data type**
  - Example: In Java, a variable uses a fixed data type that has to be set when defining the variable

    ```
    int var = 5;
    ```
- **Dynamic typing**:
  - Variable data type is determined during **run time**
  - **Data type is associated with value** itself, not with variable
  - Example: In Python, a variable is a reference to an object (value) which itself stores the information about the type

    ```
    var = 5  # 5 is an integer object
    ```

Variables in Python

- Variables in Python are just references to objects that are generated, stored and managed automatically in the background, i.e., they are essentially only **names** or **identifiers** that are **bound to objects** – they themselves do not store any information
- These actual **objects** hold information on the **data type** and what kind of data is stored in your memory
- Example: `var = 5`
  - Variable/name/identifier `var` is bound to `5`
  - `5` is a Python integer object with numerical value 5
- What is an object in Python? **Everything!**

Variables in Python

- Assigning to a variable that does not exist yet, creates this variable (name is bound to the object)
- Variable names must start with characters that are not digits and not operators
- Variable names are case sensitive
- Variable names are by convention in lower case format and words are separated with an underscore. Example:
  `my_variable_name`
- Certain names (**keywords**) are reserved and cannot be used, e.g., `if`, `while`, `for`, `def`, `class`, etc.[4]

[4] https://docs.python.org/3/reference/lexical_analysis.html#keywords

Example

- Consider the following Python code:[5]

```
x = 42
y = x
```

  How often is 42 stored in memory? Once! `x` and `y` refer to the same integer object with value 42.

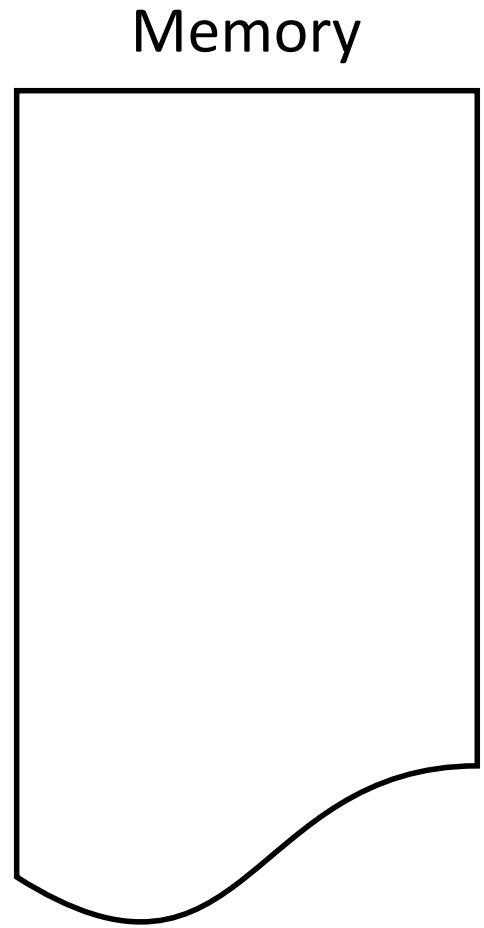
- Next we do:

```
y = 3
```

  What is the value of `x` now? Still 42! If a value is assigned to a variable, it refers to a new object, i.e., it does not overwrite the object it referred to before the assignment.

[5] For a longer discussion of this example, click here

Example Visualization



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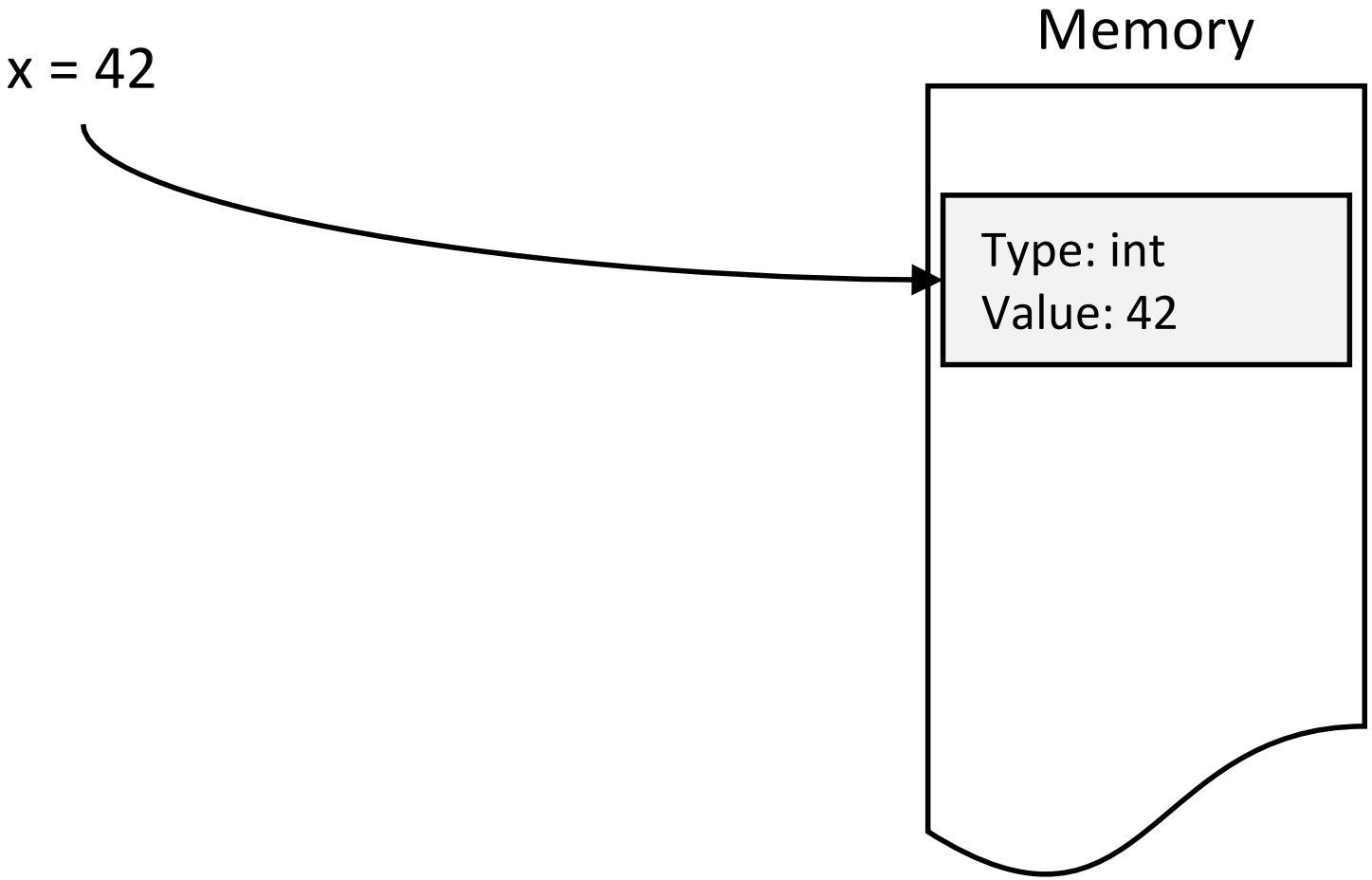

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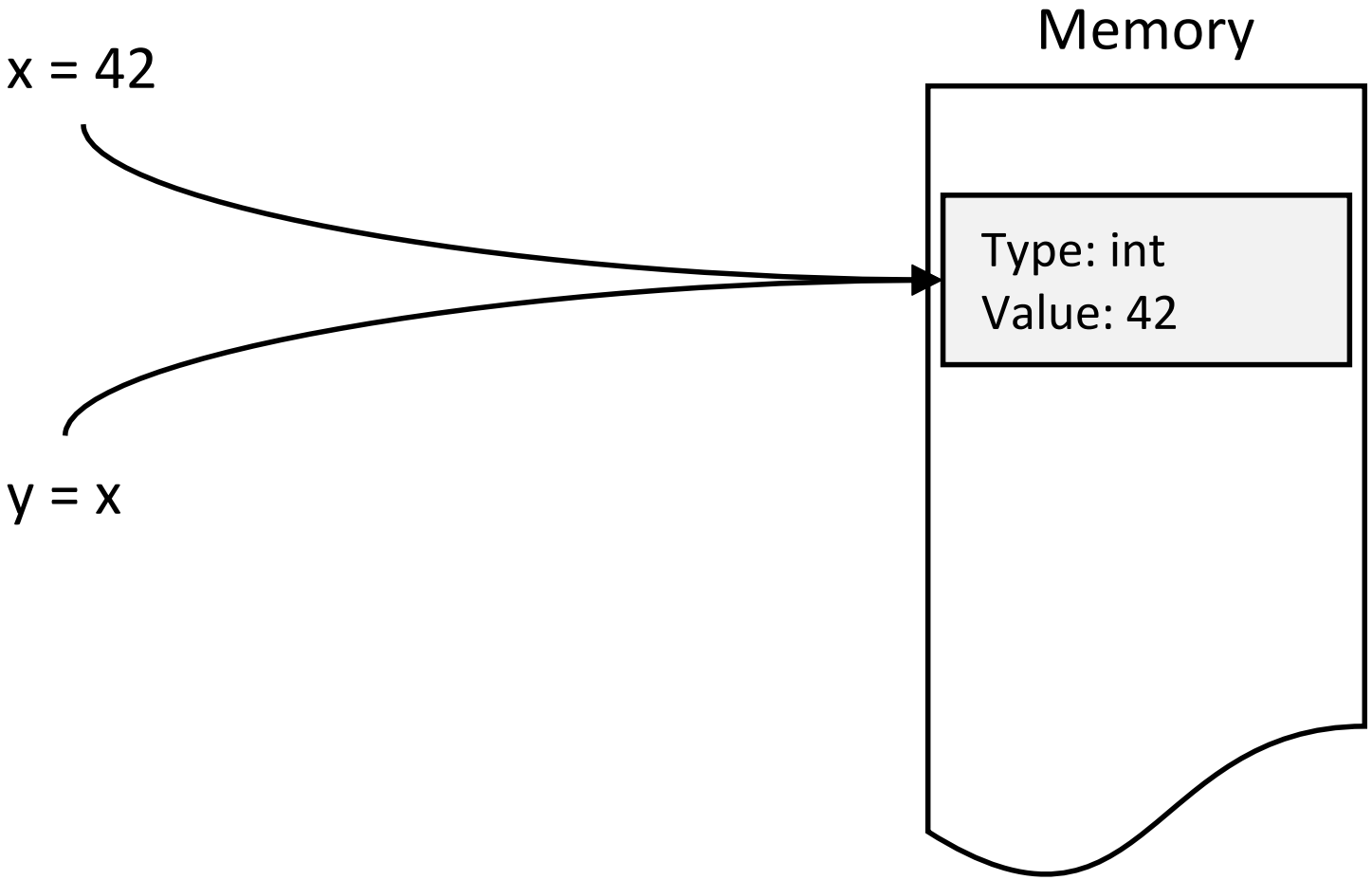
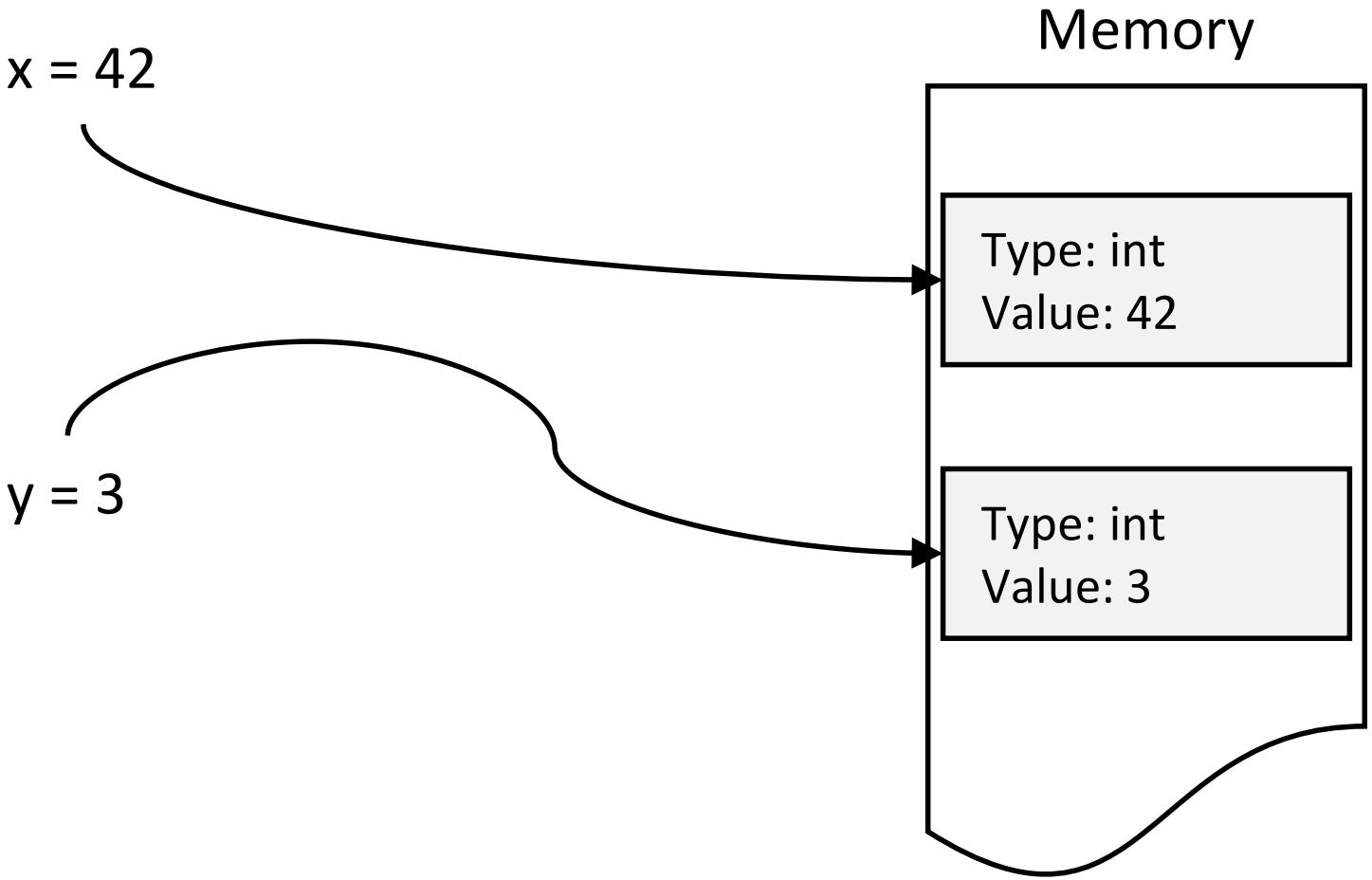


Example Visualization



Console Input and Output

- The **console** is the primary default **input** and **output device**
- Output (printing something to the console):

```
print("Hello, World!")
print(123)
```

- Input (reading user input from the console):

```
var = input("Please enter something: ")
```

  The read input will be a string, so data type conversion must be done manually $\rightarrow$ see the accompanying code file for more details