香港中文大學(深圳)
The Chinese University of Hong Kong, Shenzhen

Introduction to Computer Science: Programming Methodology

Lecture 3 Flow Control

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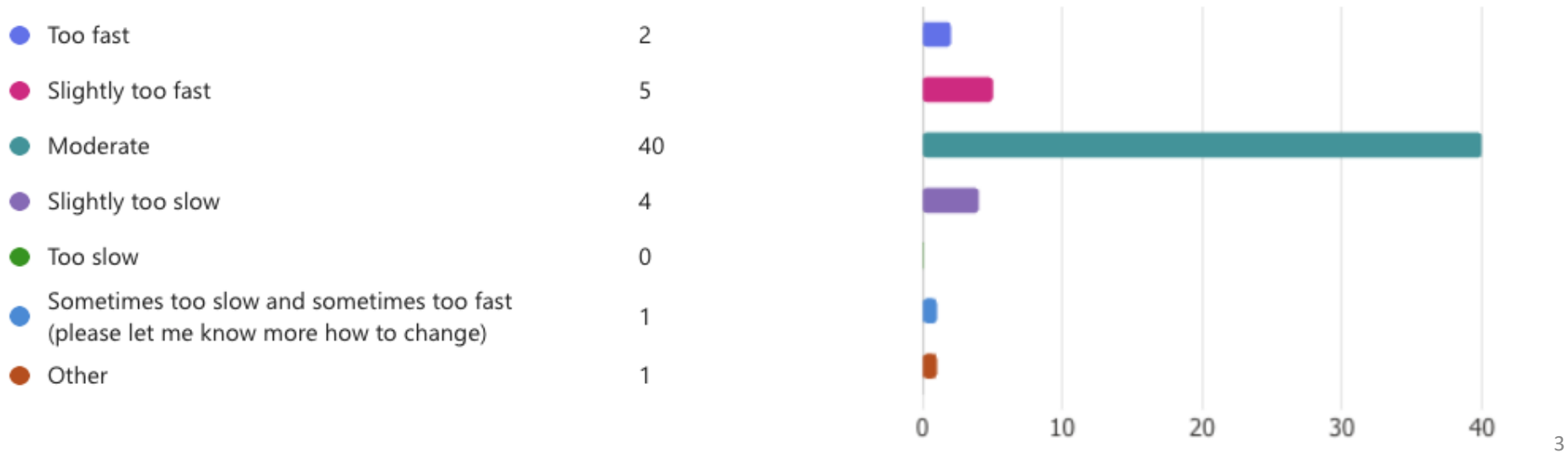
School of Data Science

Summary of feedback

Pace

- “please give some time to code on computer with you”

1. Is the pace of the lectures

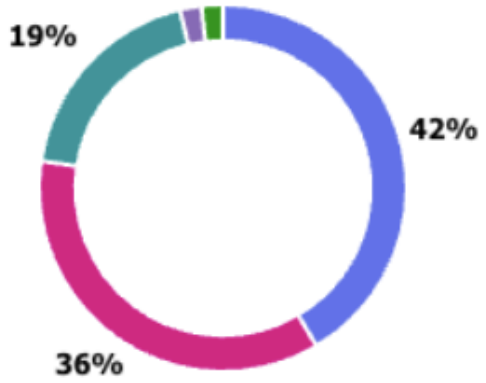


Engagement

- “Sometimes feeling sleepy because it’s nap time”

4. Do you feel engaged in the class?

Yes	22
Yes but not enough	19
No but that's OK	10
No and I want more engagement	1
Other	1

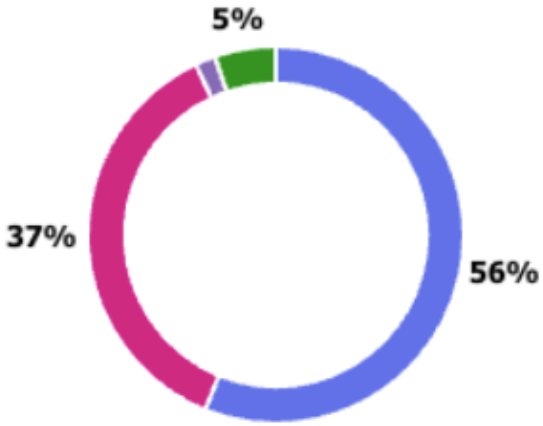


Running code in the class

- “I can't remember what you have done”

5. Do you find it helpful when I run code live during class?

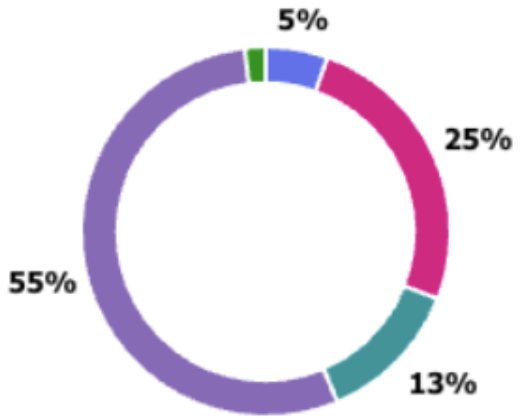
Yes, and you should do more	32
Yes, and current form is good	21
No, I prefer to go through the slides	0
No, I can't remember what you have done	1
Other	3



Office hours

8. Would you prefer a different office hour time?

Yes, and I would prefer a specific time (please specify below)	3
Yes, and I hope it could be more flexible	14
No, I don't need an office hour	7
No, current time is good	30
Other	1



Summary of feedback

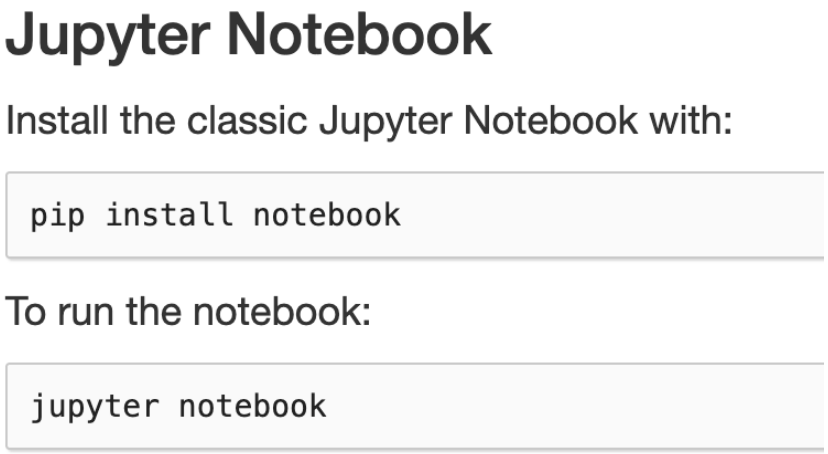
- More engagement!
- More practice and coding in the class
- Please share the code
- I prefer VS code
- Some good words & more long suggestions…

-> thank you very much!

Let's try something new!

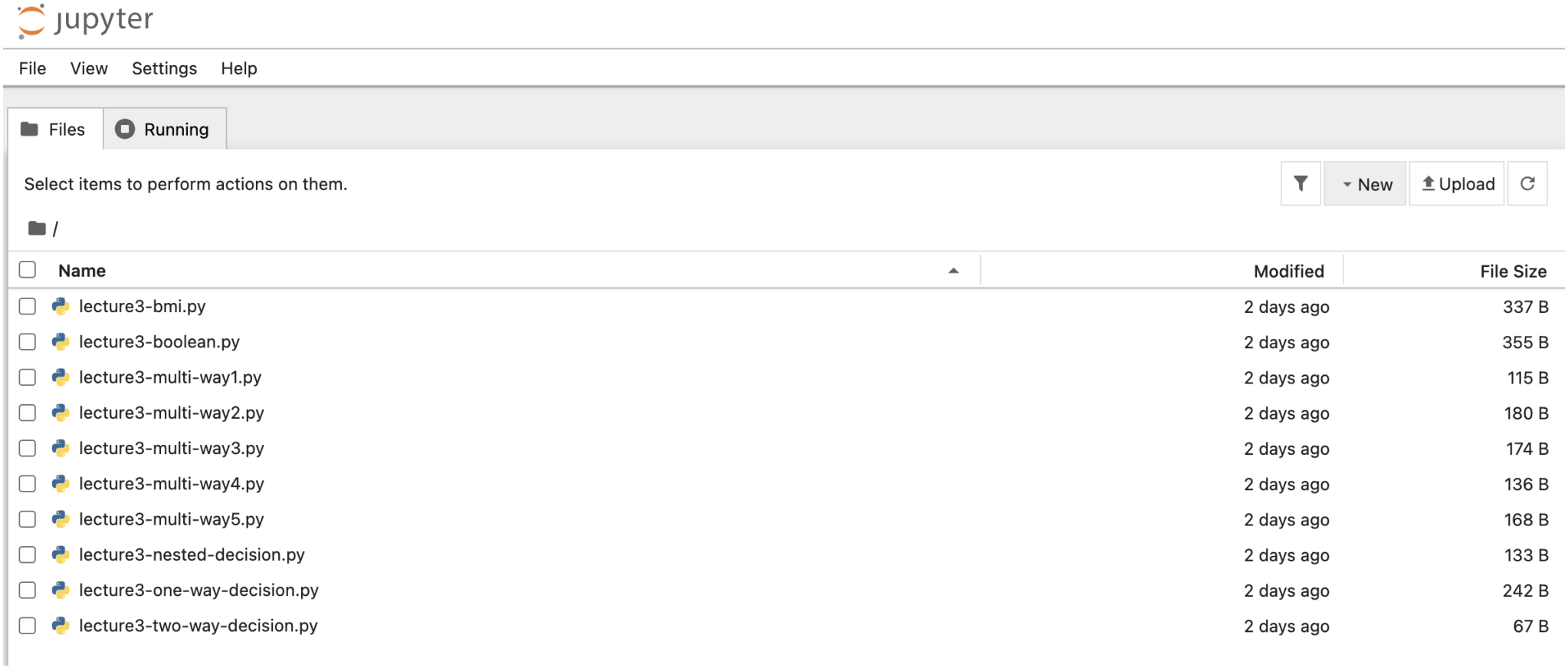
A new interactive interface of Python

- Jupyter notebook allows you to easily store and replicate all commands used in the interactive mode
- Widely used in AI and many research communities to allow others to easily replicate what they've done
- How to install? -> https://jupyter.org/install



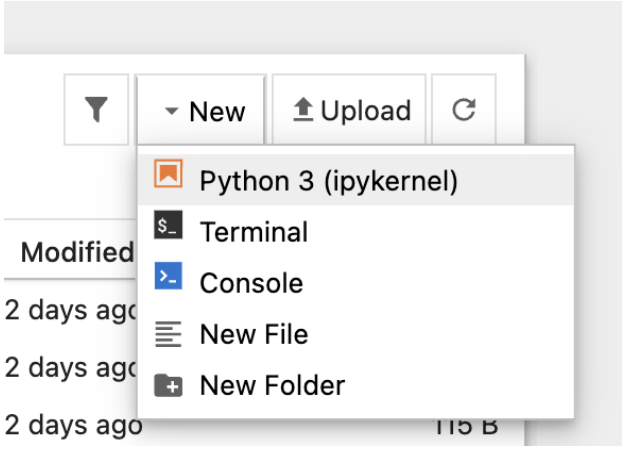
Usage

- Type `jupyter notebook` in the command line/Terminal



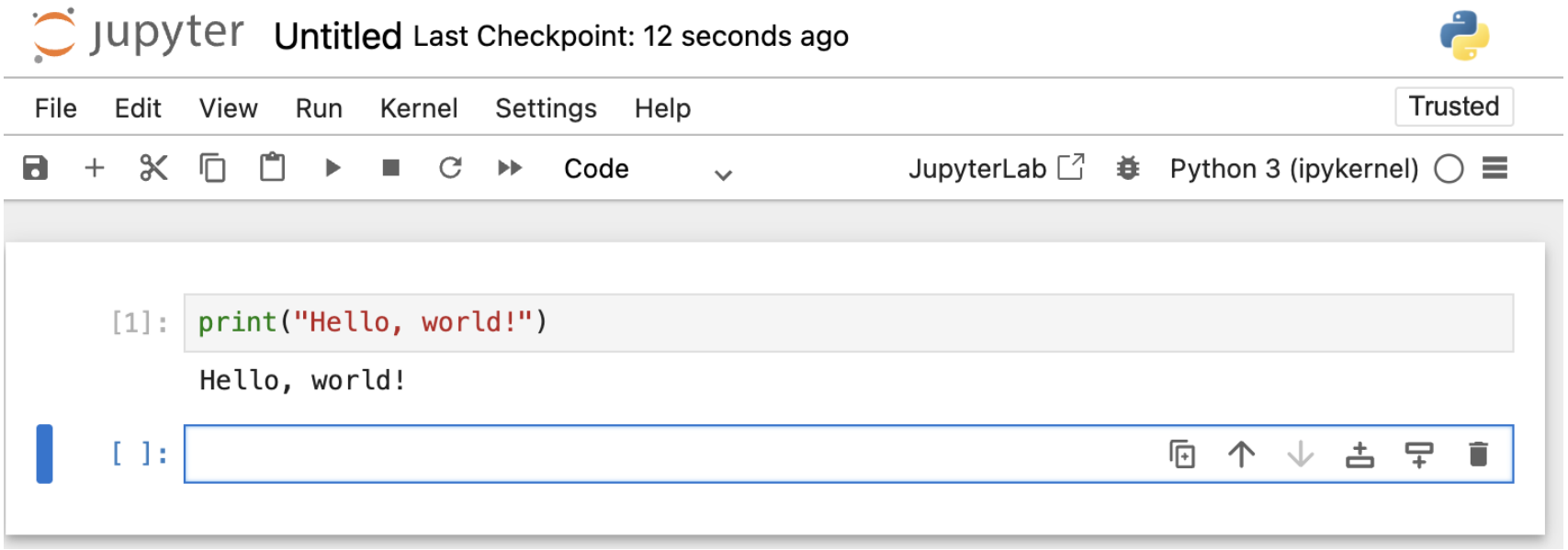
Usage

- Create a new interactive notebook, or open any existing notebooks/scripts



Interactive notebook

- Execute code block by block, and in each block, you can
  - Put in multiple lines that serve the same purpose
  - Try multiple times until the output is expected!

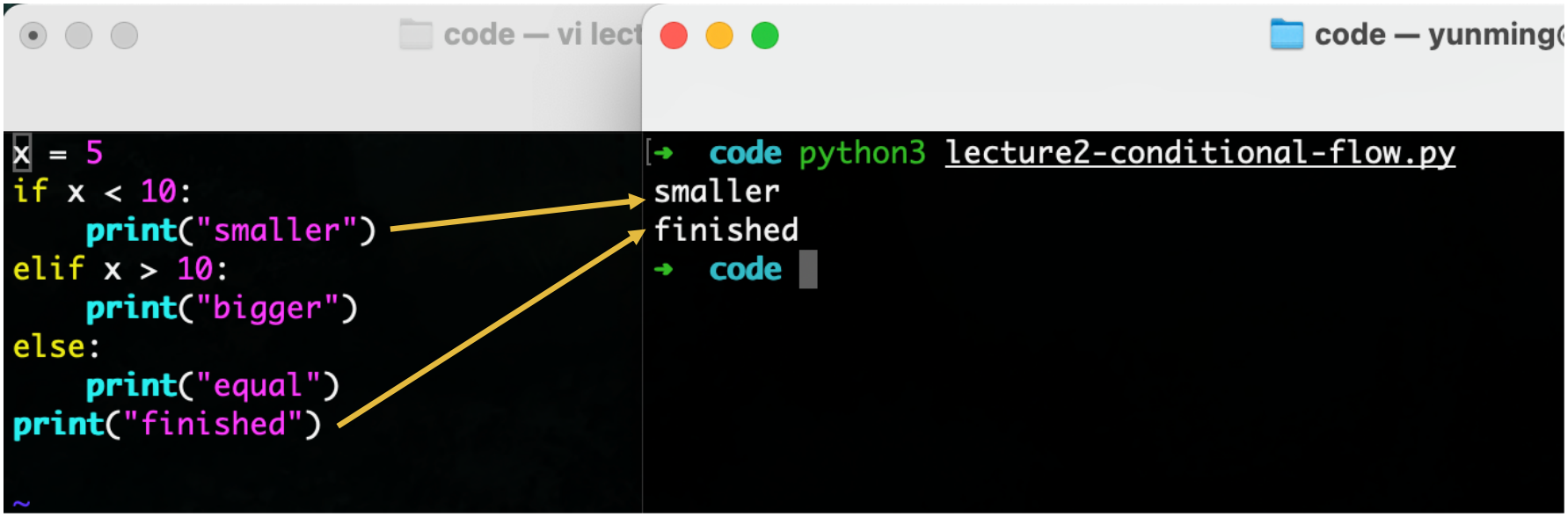


The real class starts from here

Conditional flow

Program

Outputs



Comparison operators

- Boolean expressions ask a question and produce a Yes/No result, which we use to control program flow

- Boolean expressions use comparison operators to evaluate Yes/No or True/False

`x < y`	Is x less than y?
`x <= y`	Is x less than or equal to y?
`x == y`	Is x equal to y?
`x >= y`	Is x greater than or equal to y?
`x > y`	Is x greater than y?
`x != y`	Is x not equal to y?

- Comparison operators check variables but do not change the values of variables

- Careful!! "=" is used for assignment

Examples of comparison

```
>>> 5 > 7
False
>>> x, y = 45, -3.0
>>> x > y
True
>>> result = x > y + 50
>>> result
False
...     print("I think this should print.")
...
I think this should print.
>>> "hello" > "Bye"
True
>>> "AAB" > "AAC"
False
>>>
```

- Python 3 uses the **lexicographic** (dictionary) order for strings
- Capital letters are **always before** lower case letters

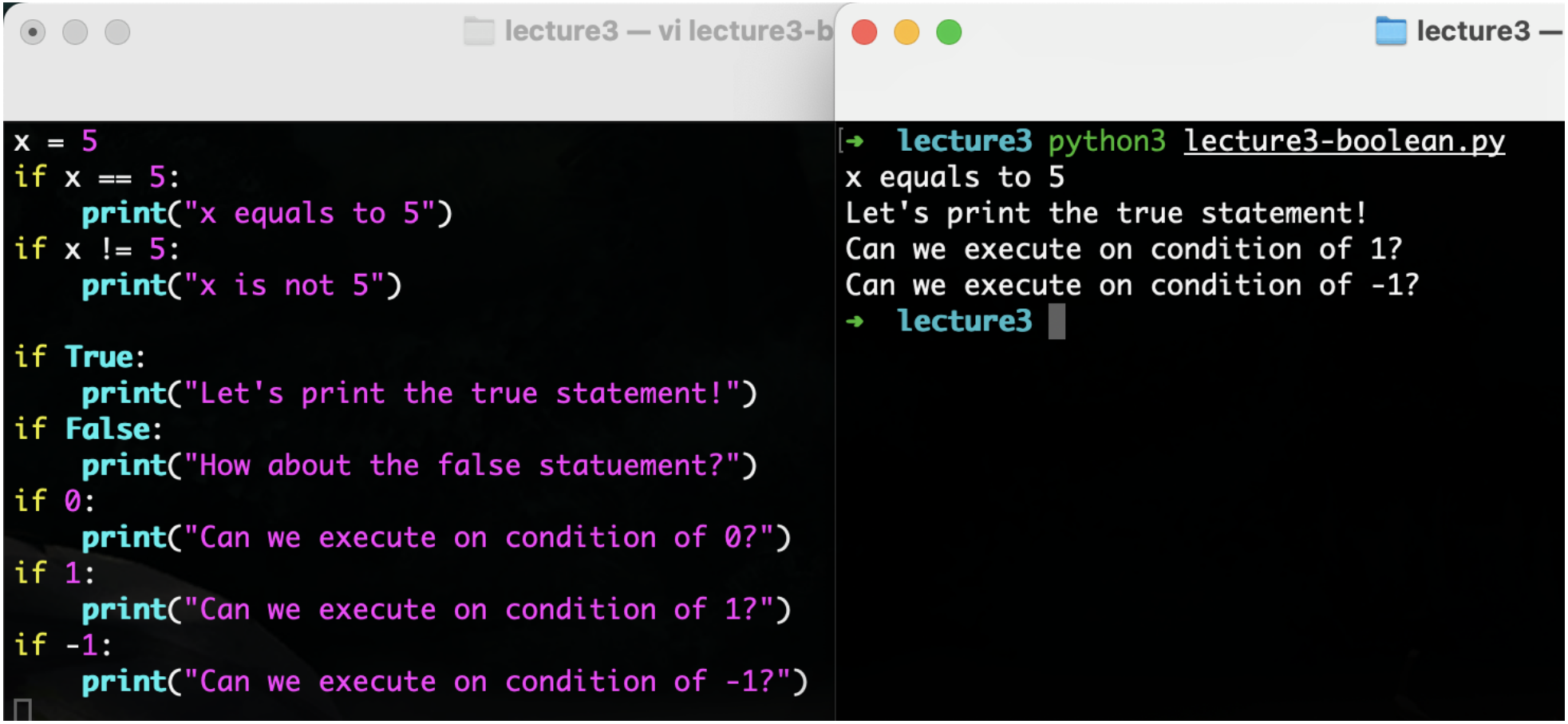
Examples of comparison

```
>>> 7 == 7.0
True
>>> x = 0.1
>>> 1 == 10 * x
True
>>> 1 == x + x + x + x + x + x + x + x + x + x
False
>>> x + x + x + x + x + x + x + x + x + x
0.9999999999999999
>>> 7 != "7"
True
>>> "A" == 65
False
>>>
```

Boolean type

- Python contains a built-in Boolean type, which takes two values True/False
- Number 0 can also be used to represent False. All other numbers represent True
- Reversely, True is considered as 1 if involved in numerical calculation, and False is considered as 0

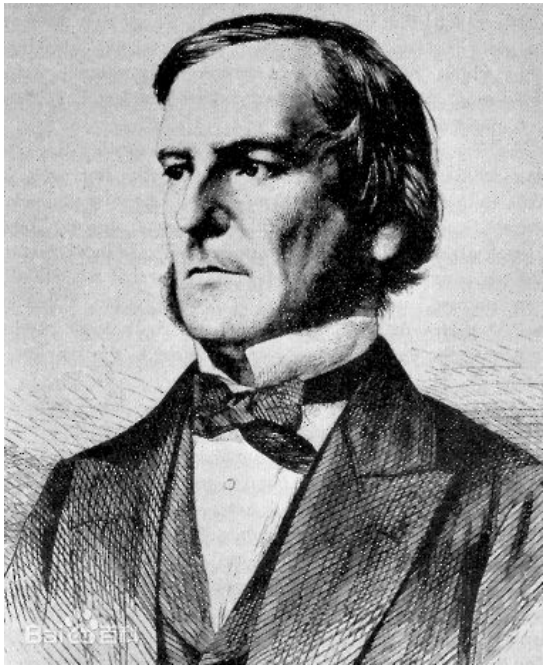
Boolean type in conditional flow



Bool()

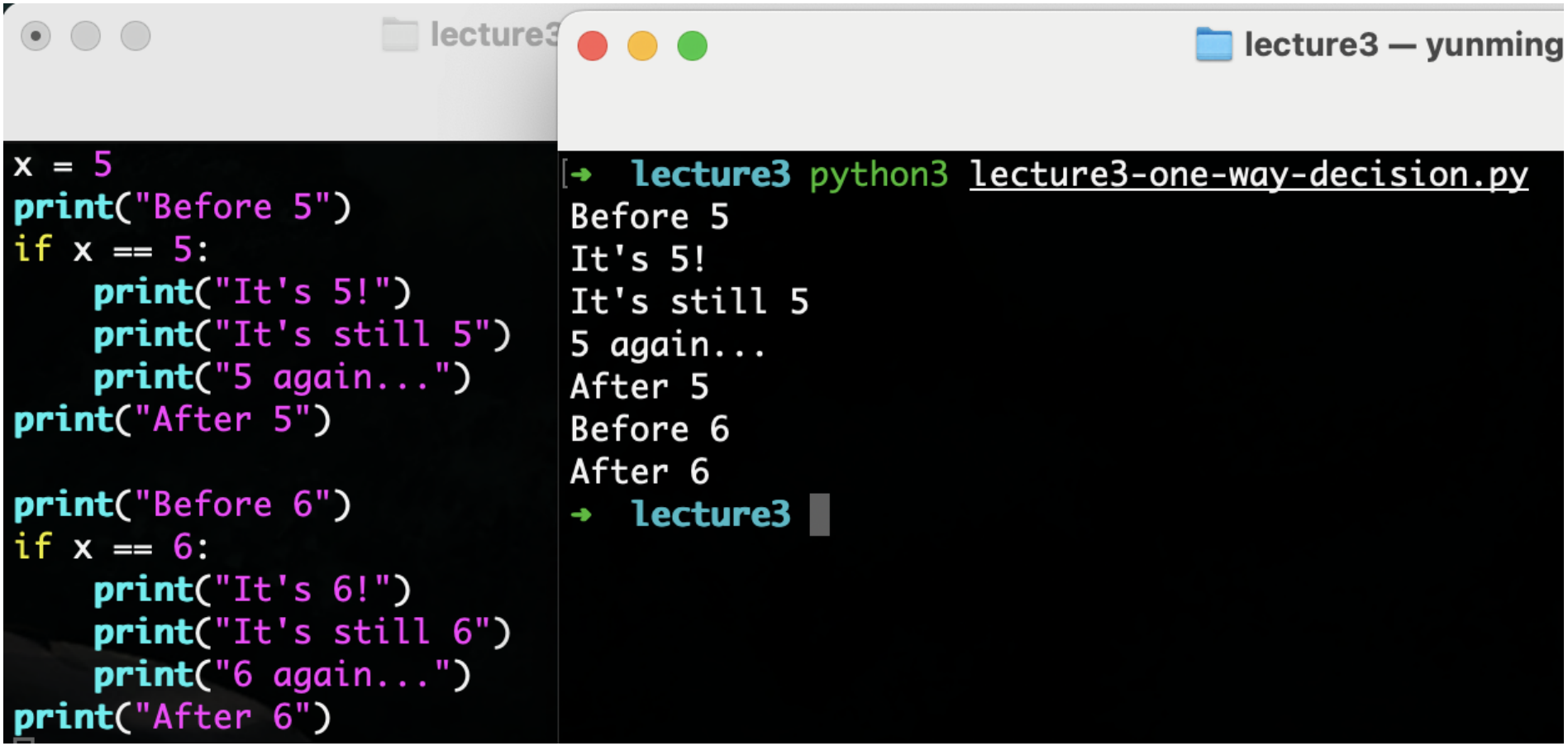
```
>>> x = 0; y = 0.0; z = 0 + 0j
>>> bool(x), bool(y), bool(z)
(False, False, False)
>>> x = -1; y = 1.e-10; z = 0 + 1j
>>> bool(x), bool(y), bool(z)
(True, True, True)
>>> x = []; y = [0]; z = "0"
>>> bool(x), bool(y), bool(z)
(False, True, True)
>>>
>>> 42 + True
43
>>> 42 - False
42
```

Boolean type



George Boole (1815 - 1864): Mathematician, inventor of mathematical logic, significant contributions to differential and difference equations

One-way decisions

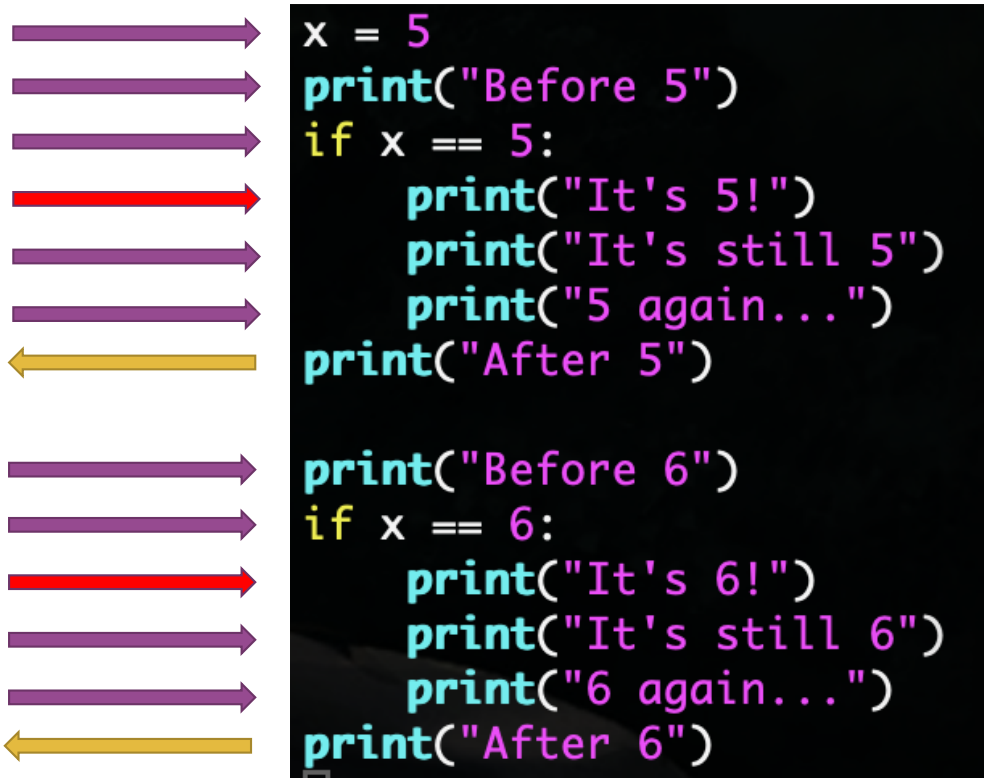


Indentation

- Increase indent: indent after an if or for statement (after :)
- Maintain indent: to indicate the scope of the block (which lines are affected by the if/for)
- Decrease indent: to back to the level of the if statement or for statement to indicate the end of the block
- Blank lines are ignored – they do not affect indentation
- Comments on a line by themselves are ignored w.r.t. indentation

Increase/maintain/decrease

- Increase/maintain after if/for statements
- Decrease to indicate the end of a block
- **Blank lines** and **comments** are ignored

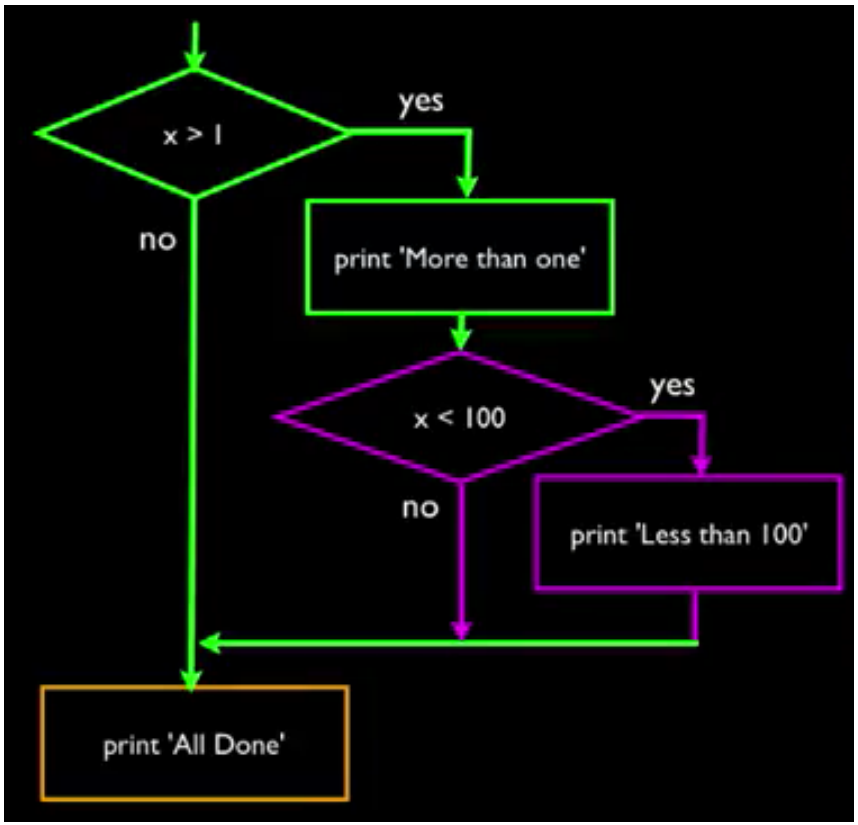


```
x = 5
print("Before 5")
if x == 5:
    print("It's 5!")
    print("It's still 5")
    print("5 again...")
print("After 5")

print("Before 6")
if x == 6:
    print("It's 6!")
    print("It's still 6")
    print("6 again...")
print("After 6")
```

Nested decisions

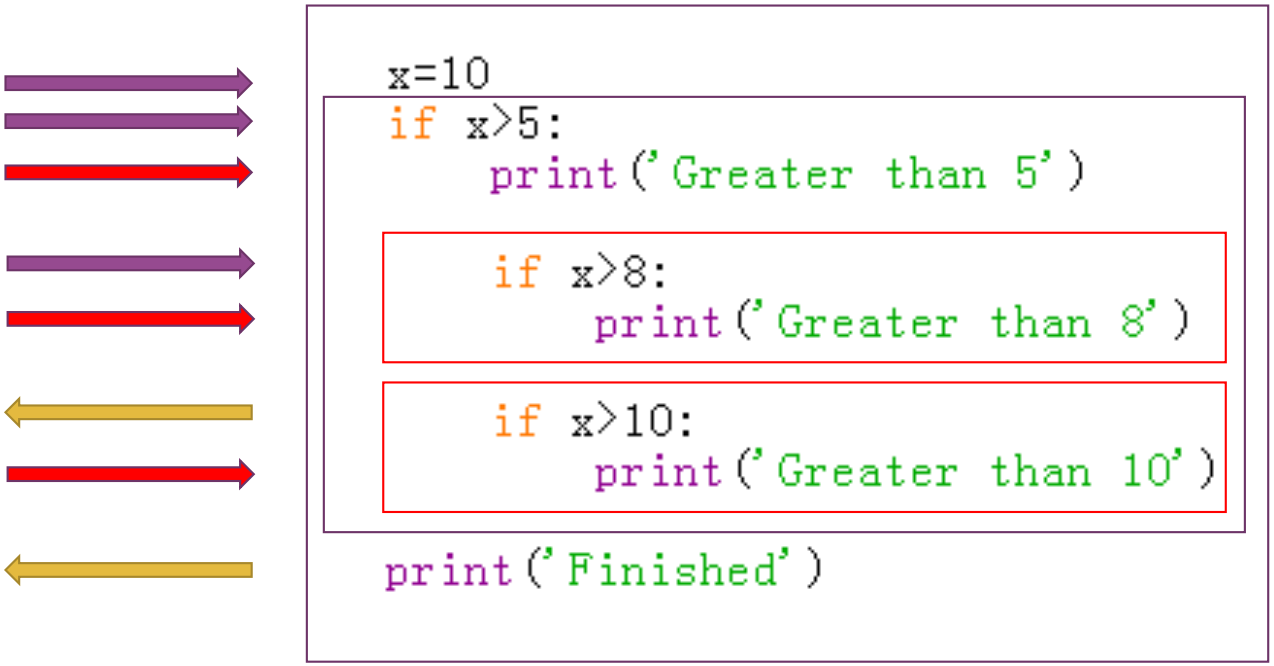
Example

```
x = 42  # What about 101? -1?
if x > 1:
    print("More than 1")

    if x < 100:
        print("Less than 100")

print("Finished")
```



Flow chart

Mental begin/end



Too many nested decisions will be a disaster…

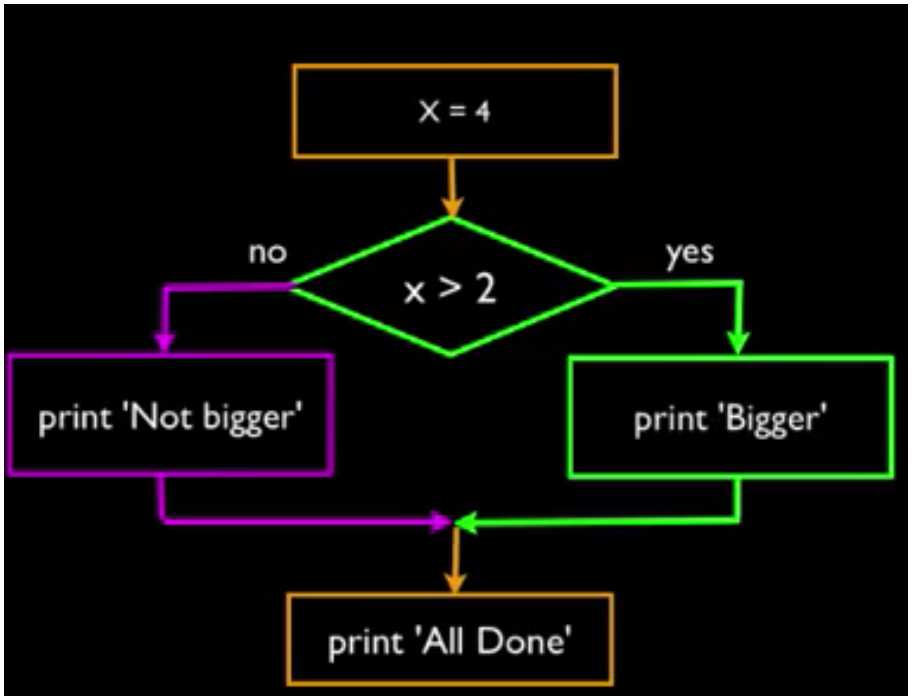
```php
function register()
{
    if (!empty($_POST)) {
        $msg = '';
        if ($_POST['user_name']) {
            if ($_POST['user_password_new']) {
                if ($_POST['user_password_new'] === $_POST['user_password_repeat']) {
                    if (strlen($_POST['user_password_new']) > 5) {
                        if (strlen($_POST['user_name']) < 65 && strlen($_POST['user_name']) > 1) {
                            if (preg_match('/^[a-z\d]{2,64}$/i', $_POST['user_name'])) {
                                $user = read_user($_POST['user_name']);
                                if (!isset($user['user_name'])) {
                                    if ($_POST['user_email']) {
                                        if (strlen($_POST['user_email']) < 65) {
                                            if (filter_var($_POST['user_email'], FILTER_VALIDATE_EMAIL)) {
                                                create_user();
                                                $_SESSION['msg'] = 'You are now registered so please login';
                                                header('Location: ' . $_SERVER['PHP_SELF']);
                                                exit();
                                            } else $msg = 'You must provide a valid email address';
                                        } else $msg = 'Email must be less than 64 characters';
                                    } else $msg = 'Email cannot be empty';
                                } else $msg = 'Username already exists';
                            } else $msg = 'Username must be only a-z, A-Z, 0-9';
                        } else $msg = 'Username must be between 2 and 64 characters';
                    } else $msg = 'Password must be at least 6 characters';
                } else $msg = 'Passwords do not match';
            } else $msg = 'Empty Password';
        } else $msg = 'Empty Username';
        $_SESSION['msg'] = $msg;
    }
    return register_form();
}
```

C#论坛
www.ibcibc.com

Two-way decisions

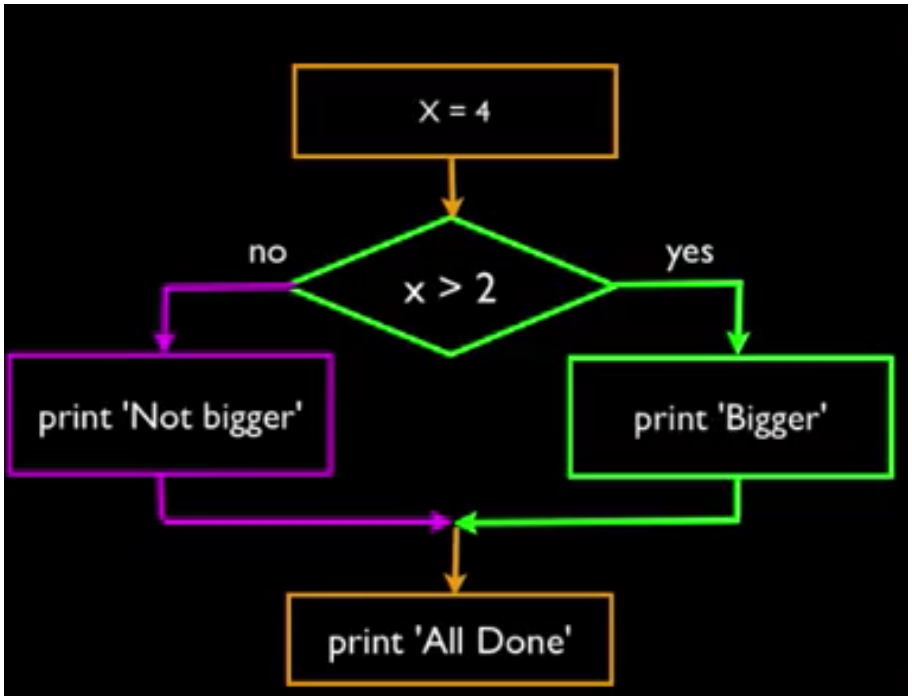
- Sometimes we want to do one thing when the logical expression is true, and another thing when it is false

- It is like a fork in the road, we need to choose one or the other path, but not both



Two-way decisions

```
x = 4
if x > 2:
    print("Larger")
else:
    print("Not larger")
```



Pay attention to indentation!

```
x = 4
if x > 2:
    print("Larger")
else:
    print("Not larger")
```

```
x = 4
if x > 2:
    print("Larger")
    else:
    print("Not larger"
```

- Else must come after if
- Use indentation to match if and else

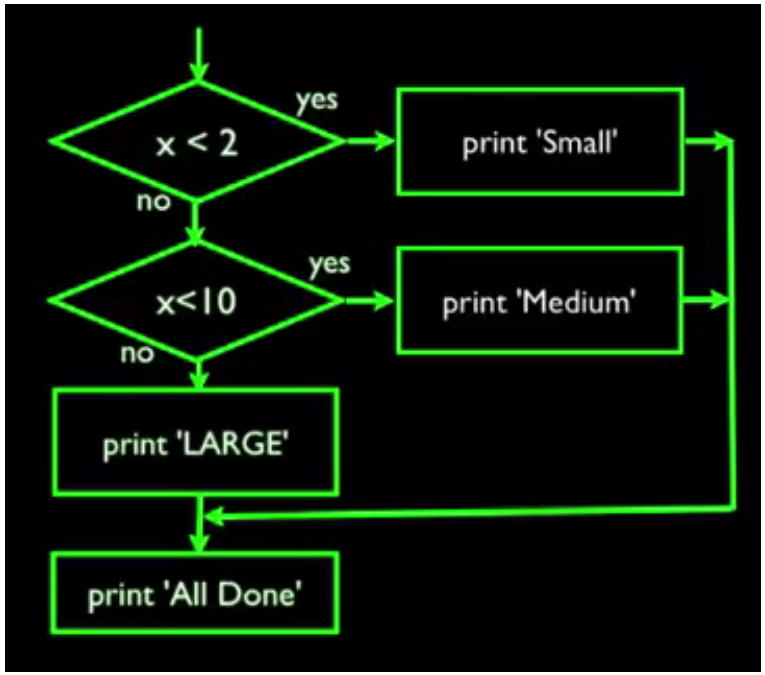
More example

```
x = 3
if x > 2:
    if x > 4:
        print("Larger")
    else:
        print("Smaller")

print("Finished")
```

```
x = 3
if x > 2:
    if x > 4:
        print("Larger")
else:
    print("Smaller")

print("Finished")
```

Multi-way decisions

```
x = 5
if x < 10:
    print("smaller")
elif x > 10:
    print("bigger")
else:
    print("equal")
print("finished")

~
```



Multi-way decisions

```
x = 5
if x < 10:
    print("smaller")
elif x > 10:
    print("bigger")
print("finished")
```

- We can live without “else”

Multi-way decisions

```
x = 42
if x < 2:
    print("Small")
elif x < 8:
    print("bigger")
elif x < 32:
    print("Large")
elif x < 128:
    print("Huge")
else:
    print("Ginormous")
print("Finished")
```

```
x = 42
if x < 2:
    print("Small")
if x < 8:
    print("bigger")
if x < 32:
    print("Large")
if x < 128:
    print("Huge")
else:
    print("Ginormous")
print("Finished")
```

- What's the difference?

Any wasted code?

```
x = eval(input())
if x <= 2:
    print("Below 2")
elif x > 2:
    print("Above 2")
else:
    print("Something else")
print("Finished")
```

```
x = eval(input())
if x < 2:
    print("Below 2")
elif x < 8:
    print("Below 8")
elif x < 4:
    print("Below 4")
else:
    print("Something else")
print("Finished")
```

Logical operators

- Logical operators can be used to combine several logical expressions into a single expression

- Python has three logical operators: not, and, or

Examples of logical operators

```
>>> not True
False
>>> False and True
False
>>> not False and True
True
>>> (not False) and True
True
>>> True or False
True
>>>
```

Examples of logical operators

```
>>> not False or True
True
>>> not (False or True)
False
>>> False and False or True
True
>>> False and (False or True)
False
```

Let's handle errors!

- Codes need to face all kinds of possible scenarios/inputs

```
➜  lecture2 python3 lecture2-bmi.py
This is a program to calculate the MBI
Please type in your weight in kilograms:
123abc
Traceback (most recent call last):
  File "/Users/yunming/Documents/CUHKSZ/Courses/CSC1001-25fall
/code/lecture2/lecture2-bmi.py", line 8, in <module>
    weight = float(weight)
ValueError: could not convert string to float: '123abc'
➜  lecture2
```

A software tester walks into a bar…

- Runs into a bar.
- Crawls into a bar.
- Dances into a bar.
- Flies into a bar.
- Jumps into a bar.

- And orders:
- a beer.
- 2 beers.
- 0 beers.
- 99999999 beers.
- a lizard in a beer glass.
- -1 beer.
- "qwertyuiop" beers.

- Testing complete.
- A real customer walks into the bar and asks where the bathroom is.
- The bar goes up in flames.

Try/except structure

- You surround a dangerous part of code with try/except
- If the code in try block works, the except block is skipped
- If the code in try block fails, the except block will be executed

Use try/except structure to capture errors

```
print("Please type in your weight in kilograms:")
weight = input()
try:
    weight = float(weight)
except:
    print("Invalid input! Now I assume you have 68kg")
    weight = 50.0
```

- If the conversion succeeds, it just skips the except block
- If the conversion fails, it just jumps into the except block, and the program continues

Practice

- Write a program to instruct the user to input the working hours and hourly rate, and then output the salary. If the working hours exceed 40 hours, then the extra hours received 1.5 times pay.
- If the working hour input is invalid, set it to be 0
- If the hourly rate is invalid, set it to X (minimum by law)

Practice

- Write a program to instruct a user to input a date (both month and day), and then output the new month and day when the inputted date is advanced by one day (leap years are ignored)
- If the month input is invalid, set it to be 9
- If the day input is invalid, set it to 16

Break

Repeated flow

Program

```
n = 5
while n > 0:
    print(n)
    n = n - 1
print("finished")
```

Outputs

```
code python3 lecture2-repeated-flow.py
5
4
3
2
1
finished
code
```

- Loops (repeated steps) have iterative variables that change each time through a loop
- Often these iterative variables go through a sequence of numbers

A problematic loop

```
n = 5
while n > 0:
    print("Wash")
    print("Rinse")
n = n - 1
print("Dry off!")
```

- What's wrong with this program?

Another problematic loop

```
n = 0
while n > 0:
    print("Wash")
    print("Rinse")
    n = n - 1
print("Dry off!")
```

- What's wrong with this program?

Breaking out of a loop

- The break statement ends the current loop, and jumps to the statement which directly follows the loop

```
while True:
    line = input("Enter a word:")
    if line == "done":
        break
    print(line)
print("Finished")
```

Finishing an iteration with continue

- The continue statement ends the current iteration, and start the next iteration immediately

```
while True:
    line = input("Enter a word:")
    if line[0] == "#":
        continue
    if line == "done":
        break
    print(line)
print("Finished")
```

Indefinite loop

- While loops are called “indefinite loops”, since they keep going until a logical condition becomes false
- Till now, the loops we have seen are relatively easy to check whether they will terminate
- Sometimes it can be hard to determine whether a loop will terminate

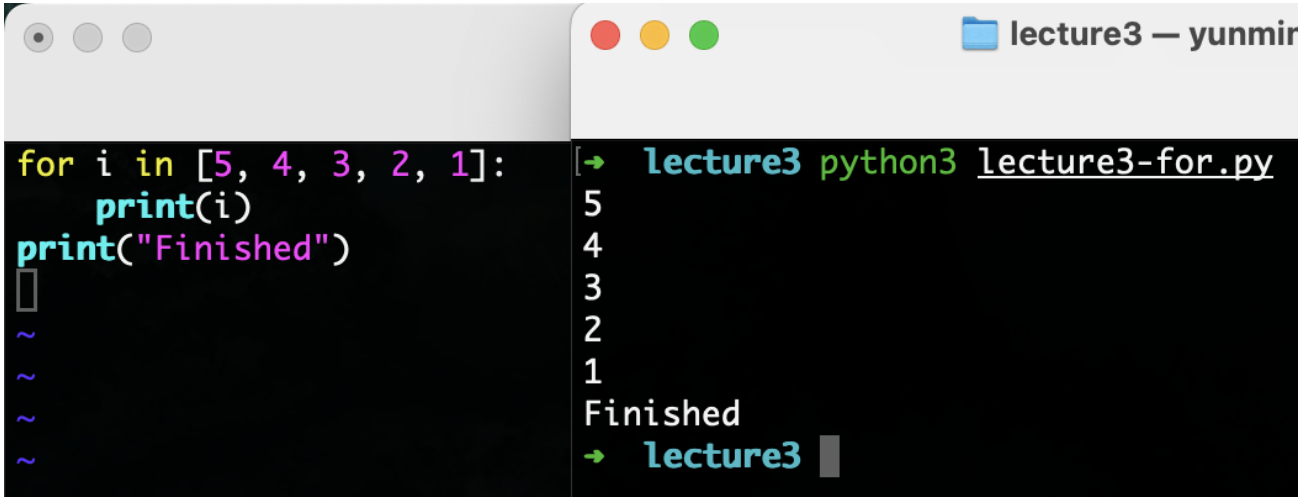
Definite loop

- Quite often we have a finite set of items
- We can use a loop, each iteration of which will be executed for each item in the set, using the for statement
- These loops are called “definite loops” because they execute an exact number of times
- It is said that “definite loops iterate through the members of a set”

A simple definite *for* loop

Program

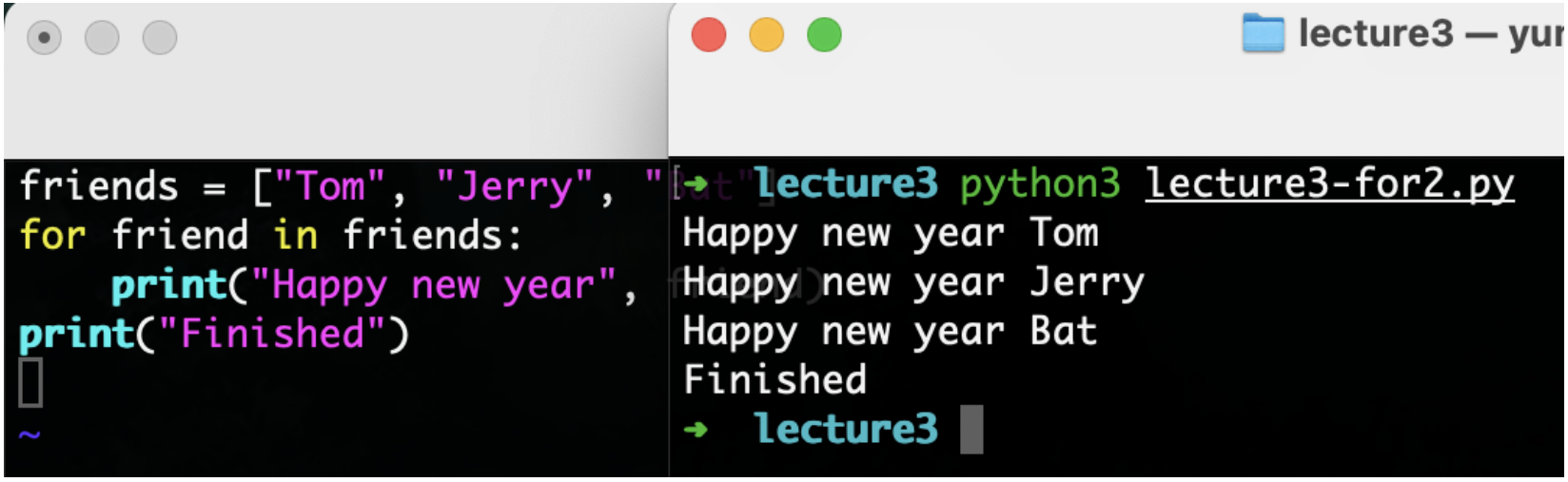
Outputs



A simple definite *for* loop

Program

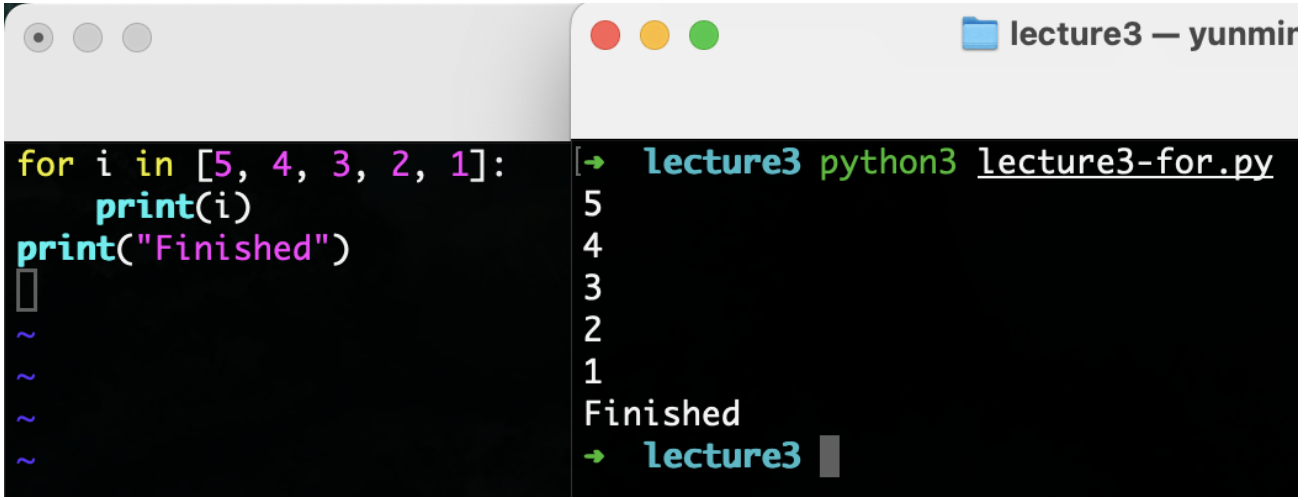
Outputs



For loop

Program

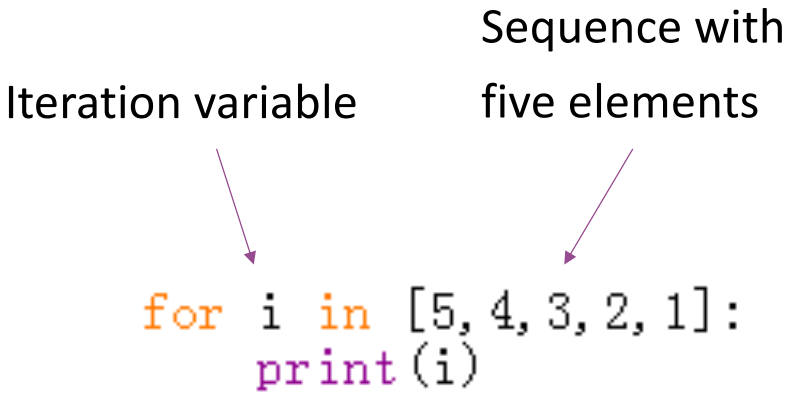
Outputs



- For loops (definite loops) have explicit iteration variables that change each time through a loop.
- These iteration variables move through a sequence or a set

For loop

- The iteration variable "iterates" through a sequence (ordered set)
- The block (body) of the code is executed once for each value in the sequence
- The iteration variable moves through all of the values in the sequence



Loop patterns

- Note: though these examples are simple, the patterns apply to all kinds of loops

Making “smart” loops

- The trick is “knowing” something about the whole loop when you are stuck writing code that only sees one entry at a time

Set some variables to initial values

for things in data:

Look for something or do something to each entry respectively

Update a variable

Check out the variables

Looping through a list

Program

```
print("Before")
for thing in [3, 5, 100, 34, 6, 87]:
    print(thing)
print("After")
```

Outputs

```
lecture3 — yunmin
→  lecture3 python3 lecture3-for-list.py
Before
3
5
100
34
6
87
After
```

- For loops (definite loops) have explicit iteration variables that change each time through a loop.
- These iteration variables move through a sequence or a set

Example: finding the largest number

Program

```
largest_so_far = -1
print("Before", largest_so_far)

for num in [9, 39, 21, 98, 4, 5, 100, 65]:
    if num > largest_so_far:
        largest_so_far = num
    print(largest_so_far, num)

print("After", largest_so_far)
```

Outputs

```
[➜  lecture3 python3 lecture3-for-find-largest.py
Before -1
9 9
39 39
39 21
98 98
98 4
98 5
100 100
100 65
After 100
```

- Use a variable to store the largest number we have seen so far
- If the current number is larger, we assign it to the store variable

Counting in a loop

Program

```
count = 0
print("Before", count)
for thing in [3, 4, 98, 38, 9, 10, 199, 78]:
    count += 1
    print(count, thing)
print("After", count)
```

Outputs

```
lecture3 — yunming@M
..co
[➜  lecture3 python3 lecture3-for-counting.py
Before 0
1 3
2 4
3 98
4 38
5 9
6 10
7 199
8 78
After 8
```

- To count how many times we have executed a loop, we can introduce a counting variable, which increases itself in each iteration

Practice

- Given a set of numbers, write a program to calculate their sum using for loop

Practice

- Given a set of numbers, write a program to calculate their average using for loop

Filtering in a loop

Program

```
print("Before")

for value in [23, 3, 39, 80, 111, 99, 3]:
    if value > 50:
        print("Large value", value)

print("After")
```

Outputs

```
lecture3 — yunming@M
..cod
[➜  lecture3 python3 lecture3-for-filtering.py
Before
Large value 80
Large value 111
Large value 99
After
➜  lecture3
```

- We can use an if statement in a loop to catch/filter the values we are interested at

Search using a Boolean variable

Program

```
found = False

print("Before", found)

for value in [9, 41, 12, 3, 74, 15]:
    if value == 74:
        found = True
    print(found, value)

print("After", found)
```

Outputs

```
lecture3 — yunming@MacB
..code/le
➜  lecture3 python3 lecture3-search-boolean.py
Before False
False 9
False 41
False 12
False 3
True 74
True 15
After True
➜  lecture3
```

- If we want to search in a set and double check whether a specific number is in that set
- We can use a Boolean variable, set it to False at the beginning, and assign True to it as long as the target number is found

Alternative: search using break

Program

```
found = False

print("Before", found)

for value in [9, 41, 12, 3, 74, 15]:
    if value == 74:
        break
    print(found, value)

print("After", found)
```

Outputs

```
lecture3 — yunming@M
..co
➜  lecture3 python3 lecture3-search-break.py
Before False
False 9
False 41
False 12
False 3
After False
➜  lecture3
```

- We can also use break to finish this task

Example: finding the largest number

Program

```
largest_so_far = -1
print("Before", largest_so_far)

for num in [9, 39, 21, 98, 4, 5, 100, 65]:
    if num > largest_so_far:
        largest_so_far = num
    print(largest_so_far, num)

print("After", largest_so_far)
```

Outputs

```
[➜  lecture3 python3 lecture3-for-find-largest.py
Before -1
9 9
39 39
39 21
98 98
98 4
98 5
100 100
100 65
After 100
```

- Use a variable to store the largest number we have seen so far
- If the current number is larger, we assign it to the store variable

Finding the smallest number

```
smallest_so_far = -1
print("Before", smallest_so_far)

for num in [9, 39, 21, 98, 4, 5, 100, 65]:
    if num < smallest_so_far:
        smallest_so_far = num
    print(smallest_so_far, num)

print("After", smallest_so_far)
```

- Use a variable to store the smallest number we have seen so far
- If the current number is smaller, we assign it to the store variable
- What is the problem with this program?

Finding the smallest number

Program

```
smallest_so_far = None
print("Before", smallest_so_far)

for num in [9, 39, 21, 98, 4, 5, 100, 65]:
    if smallest_so_far == None:
        smallest_so_far = num
    if num < smallest_so_far:
        smallest_so_far = num
    print(smallest_so_far, num)

print("After", smallest_so_far)
```

Outputs

```
[➜  lecture3 python3 lecture3-for-find-smallest2.py
Before None
9 9
9 39
9 21
9 98
4 4
4 5
4 100
4 65
After 4
➜  lecture3
```

- In the first iteration, the smallest value is none, so we need to use an if statement to check this

The *is* and *is not* operator

- Python has a "is" operator which can be used in logical expression
- Implies "is the same as"
- Similar to, but stronger than ==
- "is not" is also an operator

```
smallest_so_far = None
print("Before", smallest_so_far)

for num in [9, 39, 21, 98, 4, 5, 100, 65]:
    if smallest_so_far == None:
        smallest_so_far = num
    if num < smallest_so_far:
        smallest_so_far = num
    print(smallest_so_far, num)

print("After", smallest_so_far)
```

The *is* and *is not* operator

```
>>> print(10 is 10)
<python-input-10>:1: SyntaxWarning:
True
>>> a = 10
>>> b = 10
>>> print(a is b)
True
>>> a = '123'
>>> b = '123'
>>> print(a is b)
True
>>> a = [1, 2, 3]
>>> b = [1, 2, 3]
>>> print(a is b)
False
```

Thanks