Computational Thinking

Discrete Mathematics

Topic 01 : Computational Thinking

Lecture 01 : Fundamentals of Computation

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Number Theory

Logic

Graphs and Networks

Collections

Enumeration

Relations & Functions

Outline

- Using PyTutor with Colab
- Python Fundamentals
- Storing data and data types, Making decisions, Looping, Functions

Outline

Using PyTutor with Colab

Before we start covering Python we want to show you PyTutor in action. The following slides shows screenshots of the process but you should verify the steps yourself on your phone/tablet.

Step 1 — Click/Scan on QR Code

The following code outputs powers of 2, don't worry about the actual code, just make sure that you can open and use PyTutor . . .

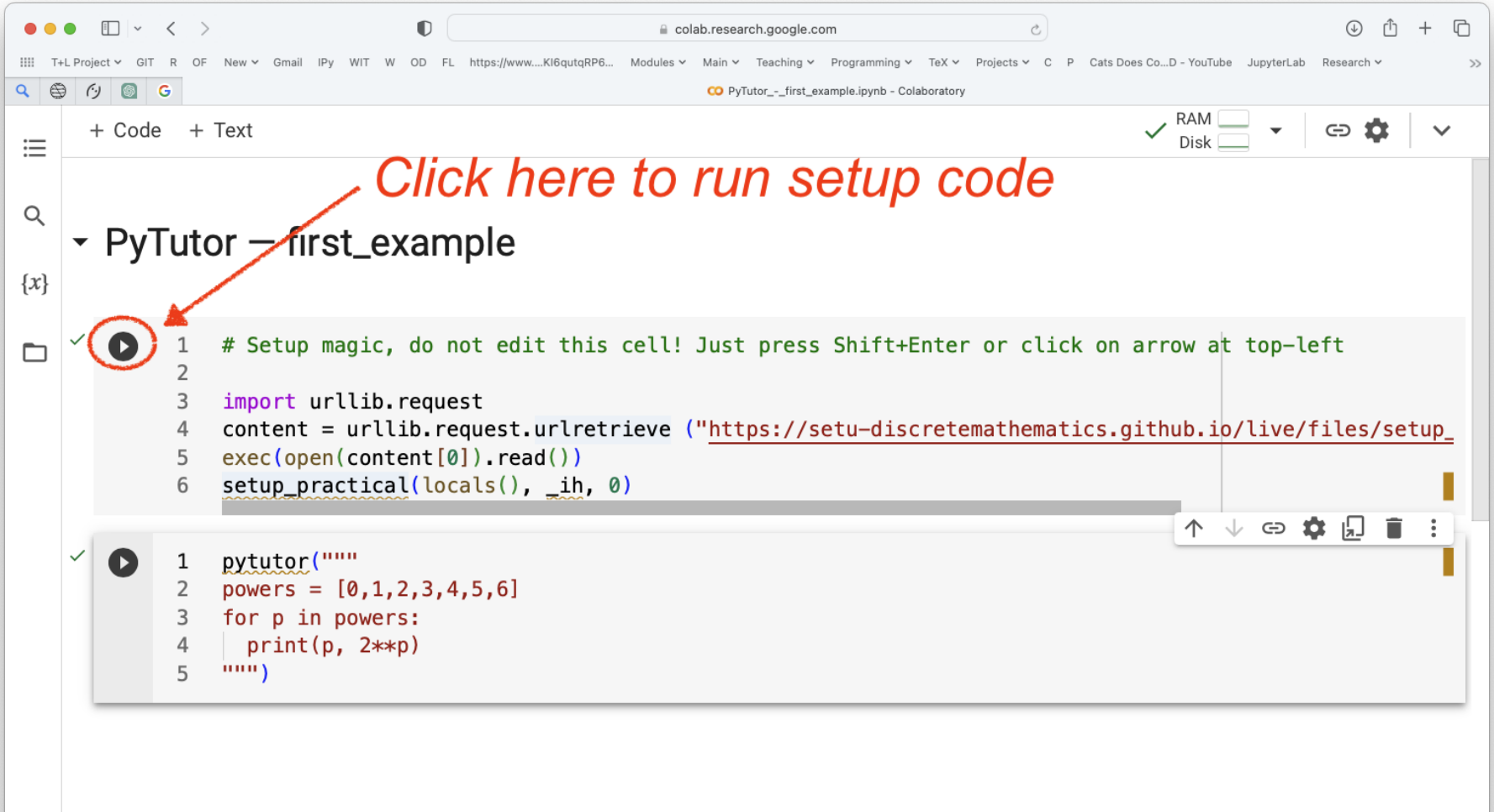
```
1 powers = [0,1,2,3,4,5,6]
2 for p in powers:
3   print(p, 2**p)
```

```
0 1
1 2
2 4
3 8
4 16
5 32
6 64
```

Using PyTutor with Colab II

This should open in Colab the following notebook.
Unlike our practical notebooks, don't bother clicking on File → Save a copy in Drive.

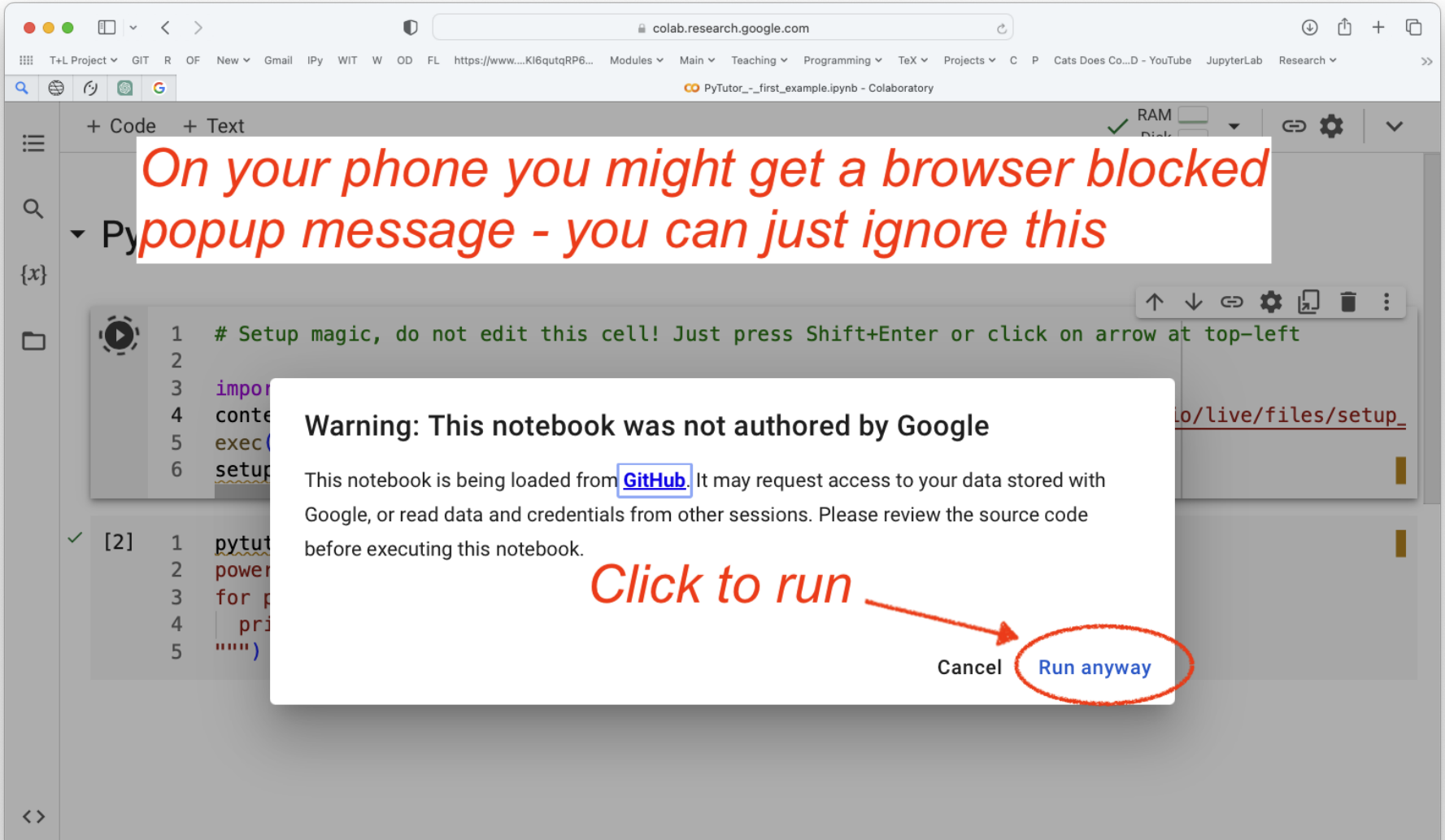
Step 2 — Execute the first cell to setup notebook.



Using PyTutor with Colab III

On executing the first cell you will get the following message. Click on Run anyway.

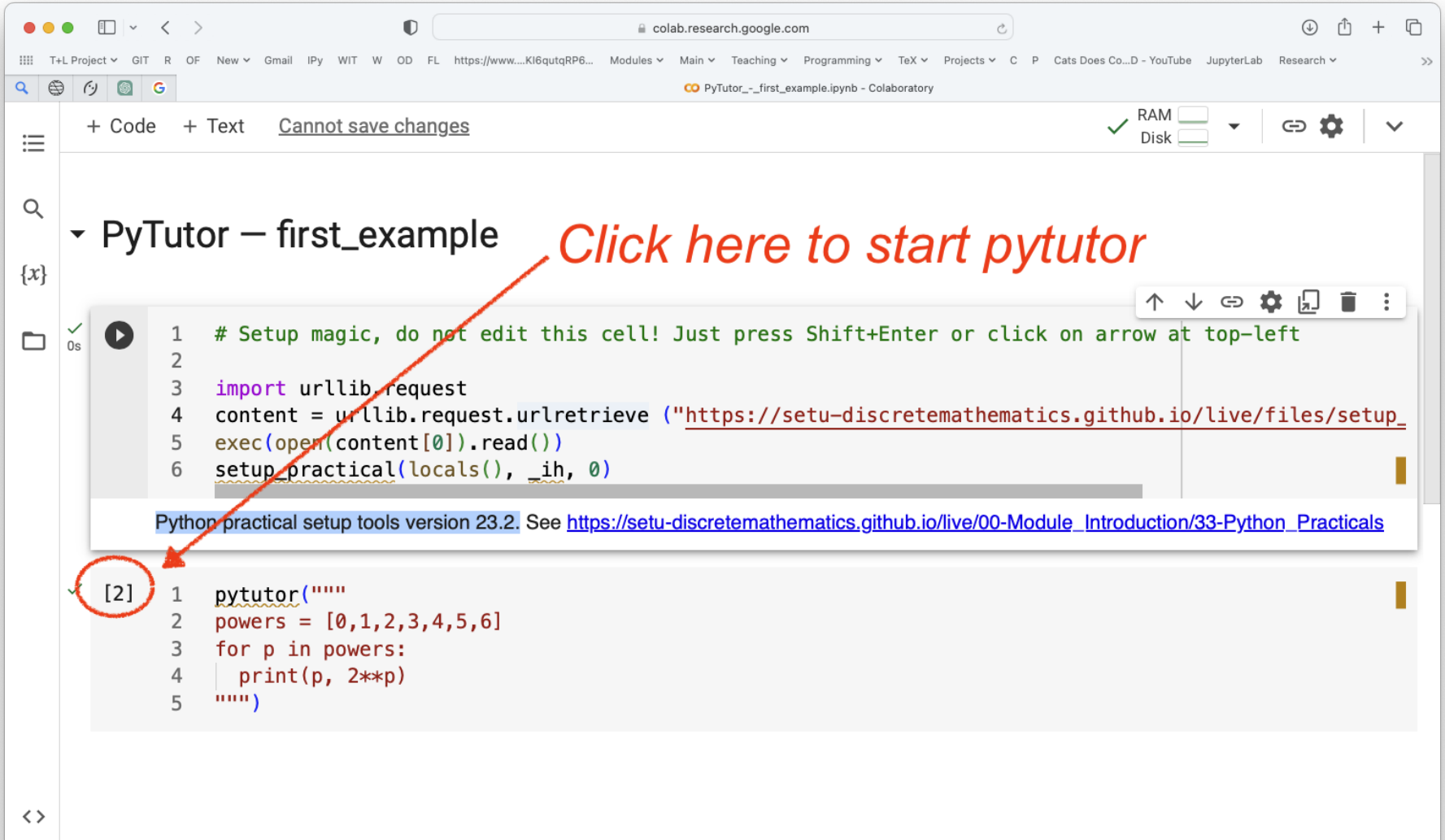
Step 3 — Click on Run anyway



Using PyTutor with Colab IV

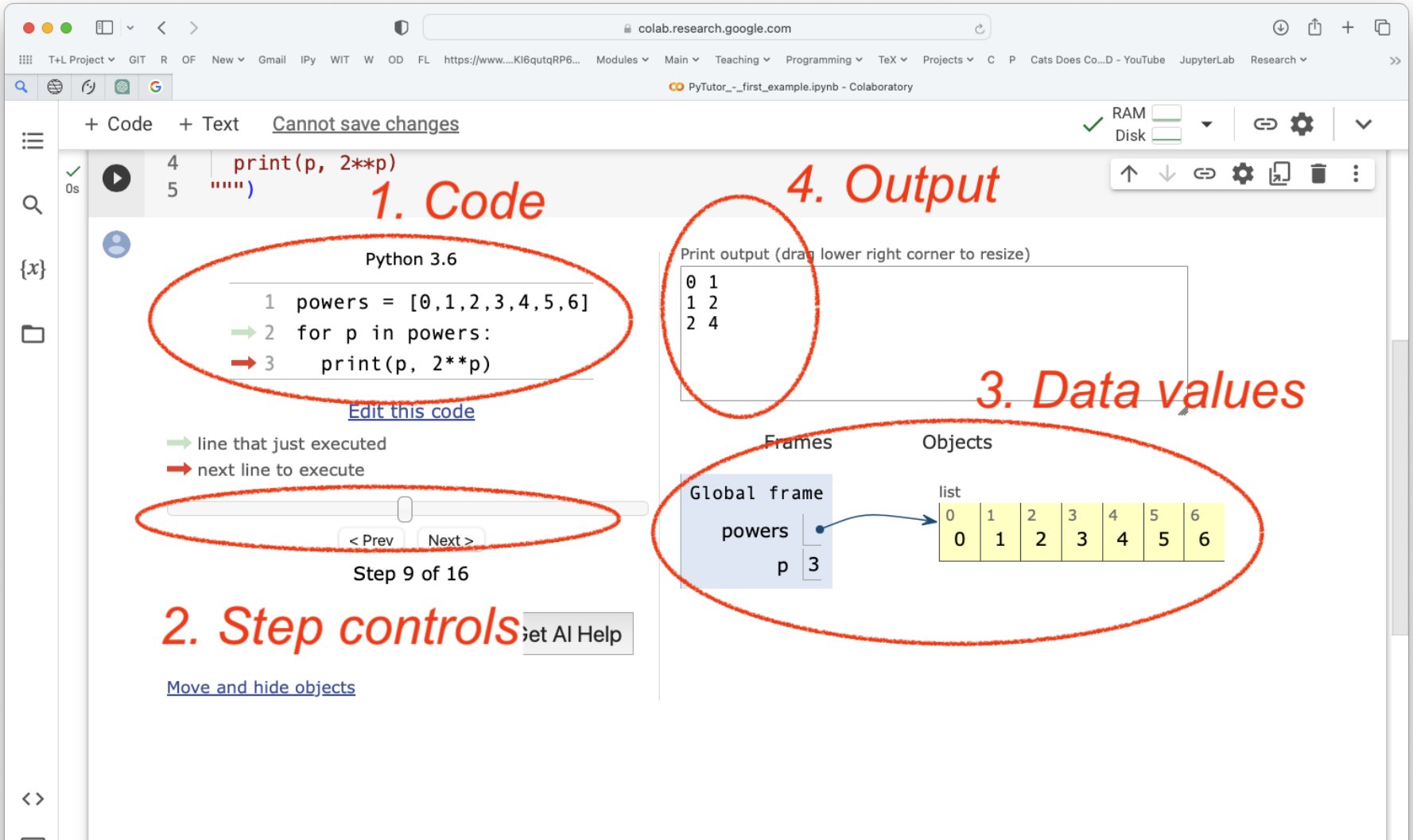
After executing the first cell you will get the usual "Python practical setup tools version 23.2".

Step 4 — Click on second cell to run code in PyTutor



Using PyTutor with Colab

You can now use PyTutor, to step back/forward through the code and see the current data values and resultinig output.



Outline

Brief History of Python

- Invented in the Netherlands, early 90s by Guido van Rossum.

  "Python is an experiment in how much freedom programmers need. Too much freedom and nobody can read another's code; too little and expressiveness is endangered."

  – Guido

- Named after Monty Python.
- Scalable, object oriented and functional from the beginning.
- Python 3.0 was released in 2008, to rectify certain flaws in Python 2.*.
- Most popular language for machine learning and data mining.

Python's Benevolent Dictator For Life

First Look at Python Code

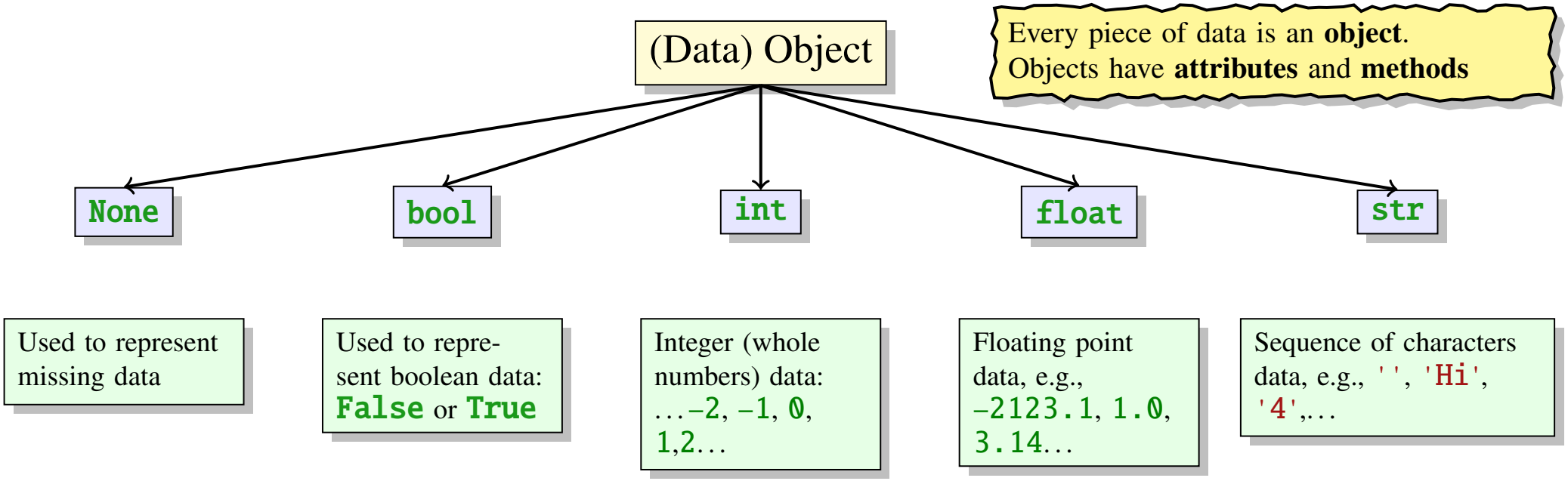
To get an idea of Python, we will take a small piece of code*

```
2
1  # Solution to Euler problem 2
2
3  # Calculate the sum of the even-values in the Fibonacci sequence
4  #    1, 2, 3, 5, 8, 13, 21, 34, 55, 89, ...
5  # value that do not exceed four million,
6
7  last = 1
8  current = 2
9
10 answer = 0
11 while current <= 4_000_000:
12     if current % 2 == 0:
13         answer += current
14     last, current = current, last + current
15
16 print(answer)
```

*This is a solution to the Euler Problem 2, at the programming competition site, projecteuler.net.

Data and Data Types

Python has 5 main primitive data types:



- An **Object** stores data in its **attributes**, and **methods** are used to change an object.
- In Python, the type of the data is automatically determined (unlike Processing).
- The type determines what you are allowed to do to a piece of data.
- Function `type` will return the type of a piece of data.

Data and Data Types II

```
3
1  w = None
2
3  x = 4
4  y = '4'
5  z = 4.0
6
7  print(type(w), type(x), type(y), type(z))
8
9  x = x * 10
10 y = y * 10
11 z = z * 10
12
13 x = x * 1_000_000_000
14 z = z * 1_000_000_000
15
16 x = x / 1_000_000_000
17 z = z / 1_000_000_000
18
19 print(type(w), type(x), type(y), type(z))
```

Collections: `set`, `list`

We will cover collections in more detail later, but for now we have:

Sets

- A `set` is collection of **distinct**, **unordered** values.
  - **distinct** means a set cannot hold the same piece of data more than once.
  - **unordered** means we cannot sort the elements of a set of ask "what element is first?" etc.
  - We can manipulate sets using union `|`, intersection `&`, and set minus `-` operations.

Lists

- A `list` is collection of **ordered** values.
  - **ordered** means the values appear in a sequence (i.e., have position). So we can talk about which value appears before (or after) another value. (**ordered** $\neq$ **sorted**)
  - Data values do not have to be distinct.
  - The position of a data value in a list is called its **index**. Since Python is a **zero-based language**, the position starts at 0.
  - Lists are a BIG DEAL in python and we have many operations to manipulate them (more later).

Collections: set

```
4
1  z = set() # creating a empty set
2
3  # defining sets by stating values
4  a = {1,3,1,2,1,5,4}
5  b = {1,'a',3}
6
7  print(len(a)) # size of set
8
9  c = a & b # intersection
10 print(c)
11
12 c = a | b # union
13 print(c)
14
15 c = a - b # set difference
16 print(c)
17
18 c = b - a # set difference
19 print(c)
```

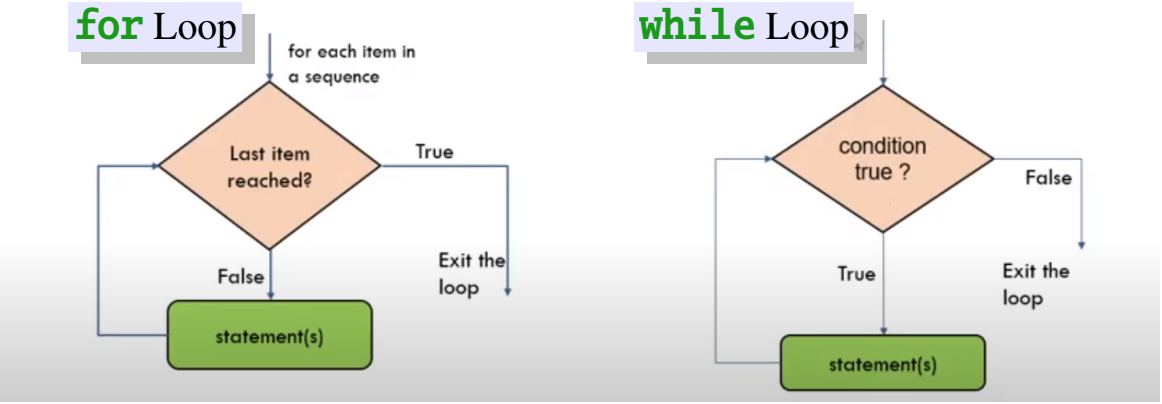
Collections: `list`

```
5
1  z = []  # creating a empty list
2
3  # defining lists by stating values
4  a = [1,3,1,2,1,5,4]
5  b = [1,3]
6
7  print(len(a)) # size of list
8
9  c = a + b # appending lists
10 print(c)
11
12 value = c[2] # list indexing ZERO-BASED
13 print(value)
14
15 d = c[2:5] # slicing SEMI-OPEN notation
16 print(d)
17
18 value = c[-4] # negative indexing
19 print(value)
```

Looping: `for`, `while`

`for` — Looping when you know how many times you want to repeat

- Python `for` loop is actually a **for-each** loop.
  - In a for-each loop you loop over values in a collection. This is considered to be less error prone than standard for loops. (They are more likely to have off-by-one errors.)
  - Python has function `range` to efficiently build collections to be used in `for` loops.



`while` — Looping when you don't know how many times you want to repeat

- In a `while` loop, since we don't know how many times to loop, we have to define a **stopping condition**.
  - A `while` loop will keep repeating a block of code **while** the **condition** calculates to a `True` value.

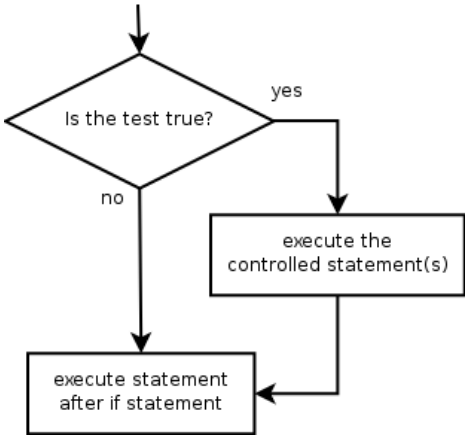
Looping: for Loop

```
6
1  # for loops runs over a collection
2
3  print('Looping over a list')
4  for letter in ['a', 'e', 'i', 'o', 'u']:
5      print(letter, 'is a vowel')
6
7  # BUT be careful if the collection is a set
8  # since a set does not have order
9  print('Looping over a set')
10 for letter in {'a', 'e', 'i', 'o', 'u'}:
11     print(letter, 'is a vowel')
12
13 # Function range is useful in creating collections
14 # NOTE Python uses SEMI-OPEN intervals !!!
15 print('Use range to build collections')
16 for x in range(5):
17     print(x)
```

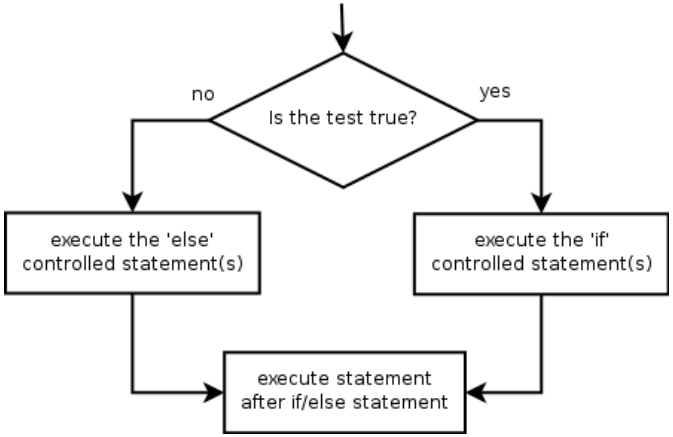
Making Decisions: `if`, `elif`, `else`

The `if` statement controls which blocks of code to execute based on given conditions. It has three variations:

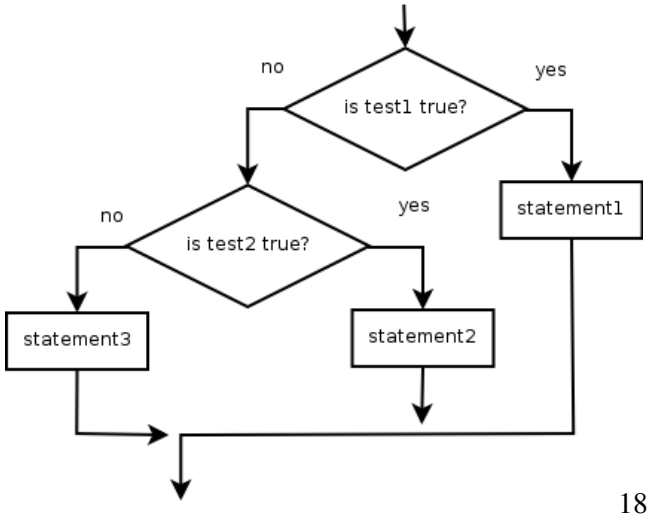
```
if test:
   statements
```




```
if test:
   if_statements
else:
   else_statements
```




```
if test_1:
   statements_1
elif test_2:
   statements_2
else:
   statements_3
```



Making Decisions: `if`, `elif`, `else`

```
7
1  # In the drinking game of fuzz-buzz players count in turn
2  # but replace multiples of 3 with 'fuzz',
3  # multiples of 5 with 'buzz',
4  # and multiples of 15 with 'fuzz buzz'
5
6  for k in range(1,21):
7      if k%15==0:  # is k a multiple of 15?
8          print("fuzz buzz")
9      elif k%3==0: # is k a multiple of 3?
10         print("fuzz")
11     elif k%5==0: # is k a multiple of 5?
12         print("buzz")
13     else:
14         print(k)
```

Functions: `def`, `return`

- In Python a function is a block of code defined with a name — this allows us to reuse code and improve code quality.
- A function is a block of code that only runs when it is called.
- You pass data, known as **parameters**, into the function. And pass data back using `return`.