COMP1730/COMP6730
Programming for Scientists

Functional Abstraction (with robots)

Lecture Outline

* Announcements
* The Warehouse Robot
* Functional Abstraction
* The Python Language: First Steps.

Important TODOs

* Complete the **demographic information questionnaire**.
* **Sign up to a lab group**.
  - If there is no place free in any lab at any time that you can attend:
    - don't sign up to a group you cannot attend;
    - email `comp1730@anu.edu.au` with your ANU ID, a complete list of all groups that you can attend, and any preference.
  - Labs start in week 2 (next week).
  - In-lab assessment starts in semester week 3.

* To activate your account on the CSIT computers, you must log into STREAMS:

1. `https://cs.anu.edu.au/streams/`;
2. log in with your ANU user id and password;
3. log out again.

   Do this **at least 24 hours** before your first lab.

Student Course Representatives

* Develop skills sought by employers, including interpersonal, dispute resolution, leadership and communication skills.
* Become empowered. Play an active role in determining the direction of your education.
* Become more aware of issues influencing your University and current issues in higher education.
* Ensure students have a voice to their course convener, lecturer, tutors, and college.

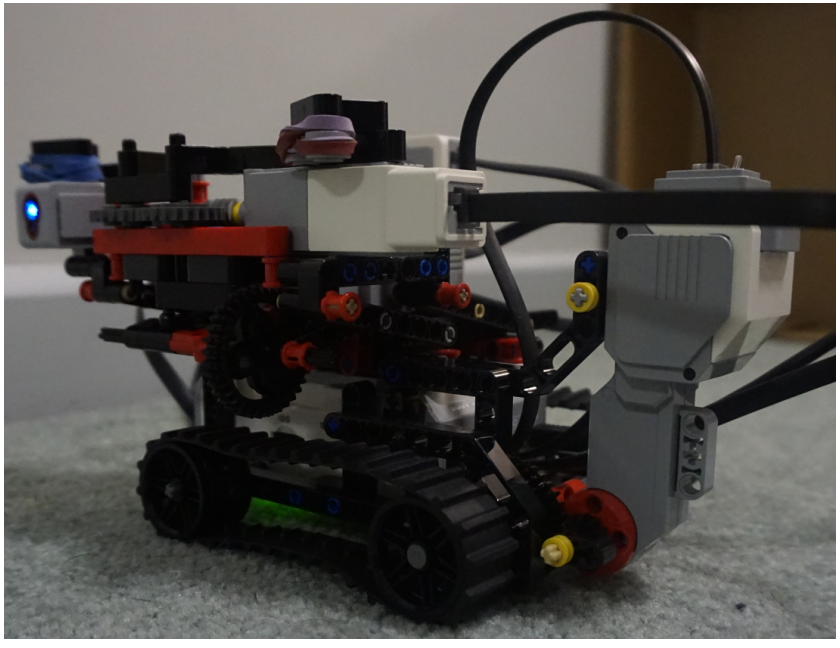
Roles and Responsibilities

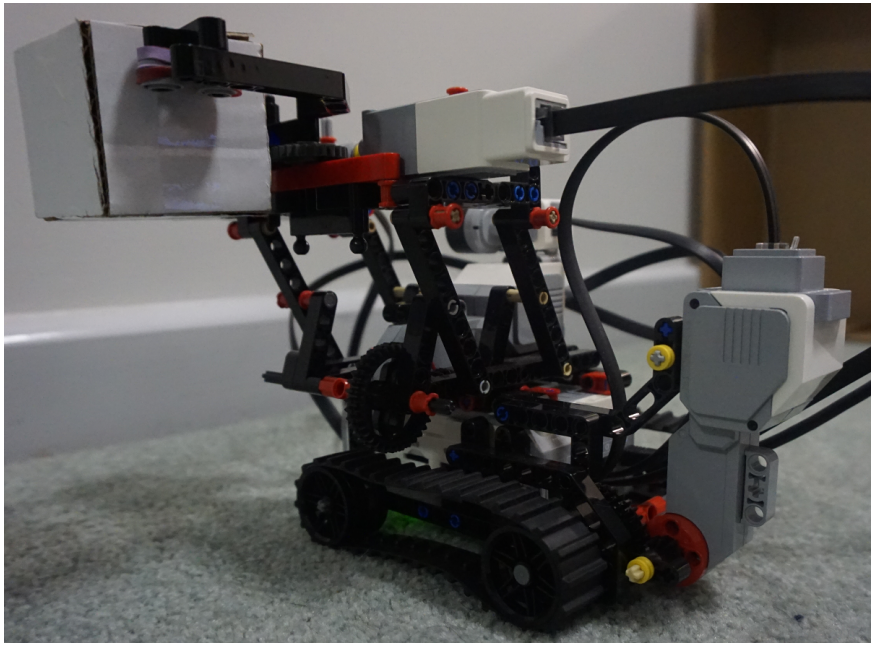
* Act as the official liaison between your peers and convener.
* Be creative, available and proactive in gathering feedback from your classmates.
* Attend regular meetings, and provide reports on course feedback to your course convener and the Associate Director (Education).
* Close the feedback loop by reporting back to the class the outcomes of your meetings.

Nomination Process

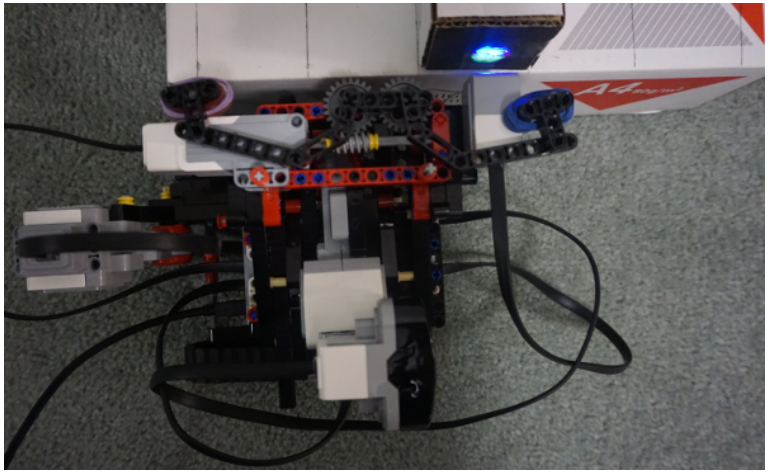
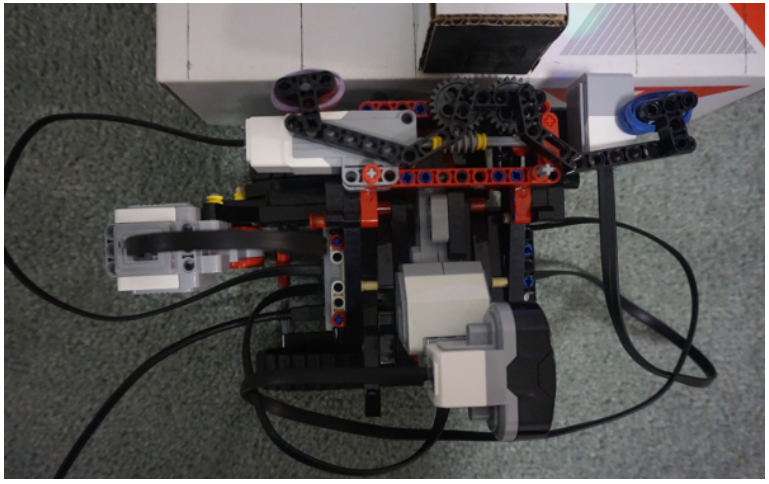
* Please contact me by 4th March to nominate yourself as a course representative.
* Alternatively e-mail: comp1730@anu.edu.au
* ANUSA and PARSA offer course representative training on 12th March to give you skills to be an effective course representative.
* Contact ANUSA President, Eleanor Kay, for more information: sa.president@anu.edu.au

The Robot

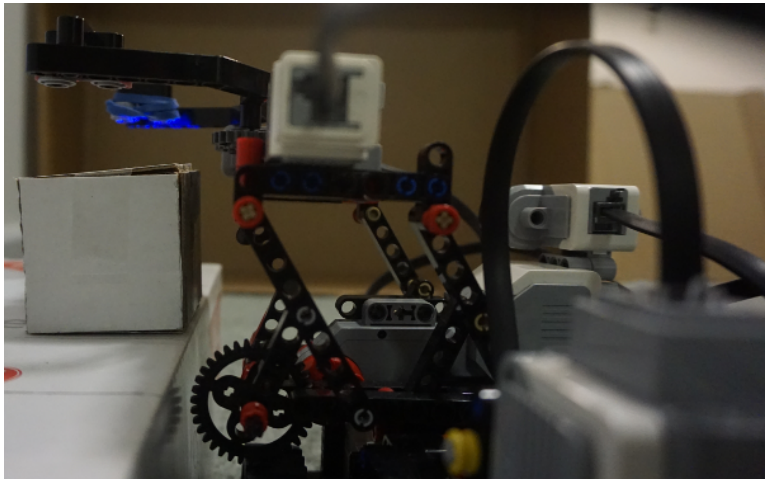
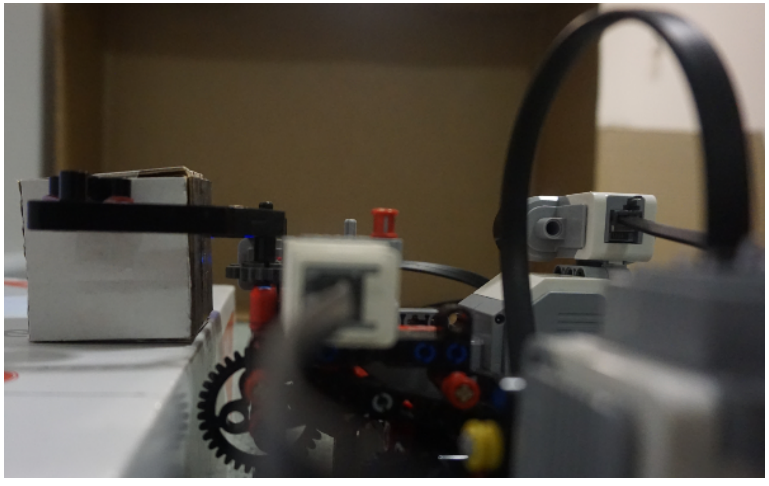




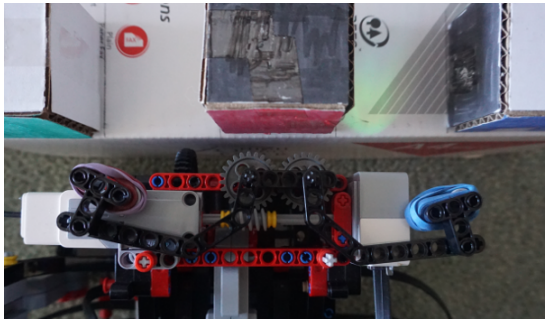
* Drive left/right along the shelf:

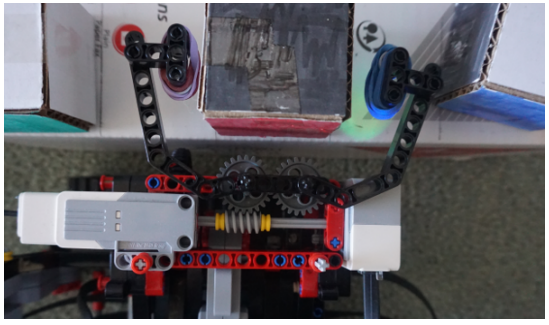
* Move lift up/down:

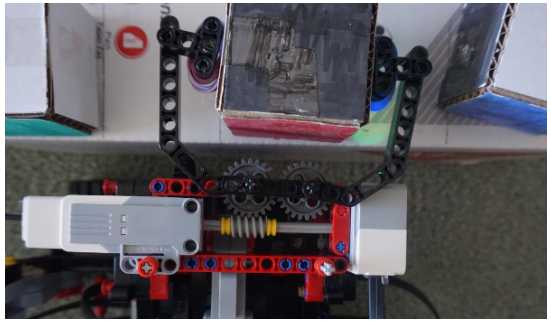
* Change position of the gripper:



folded



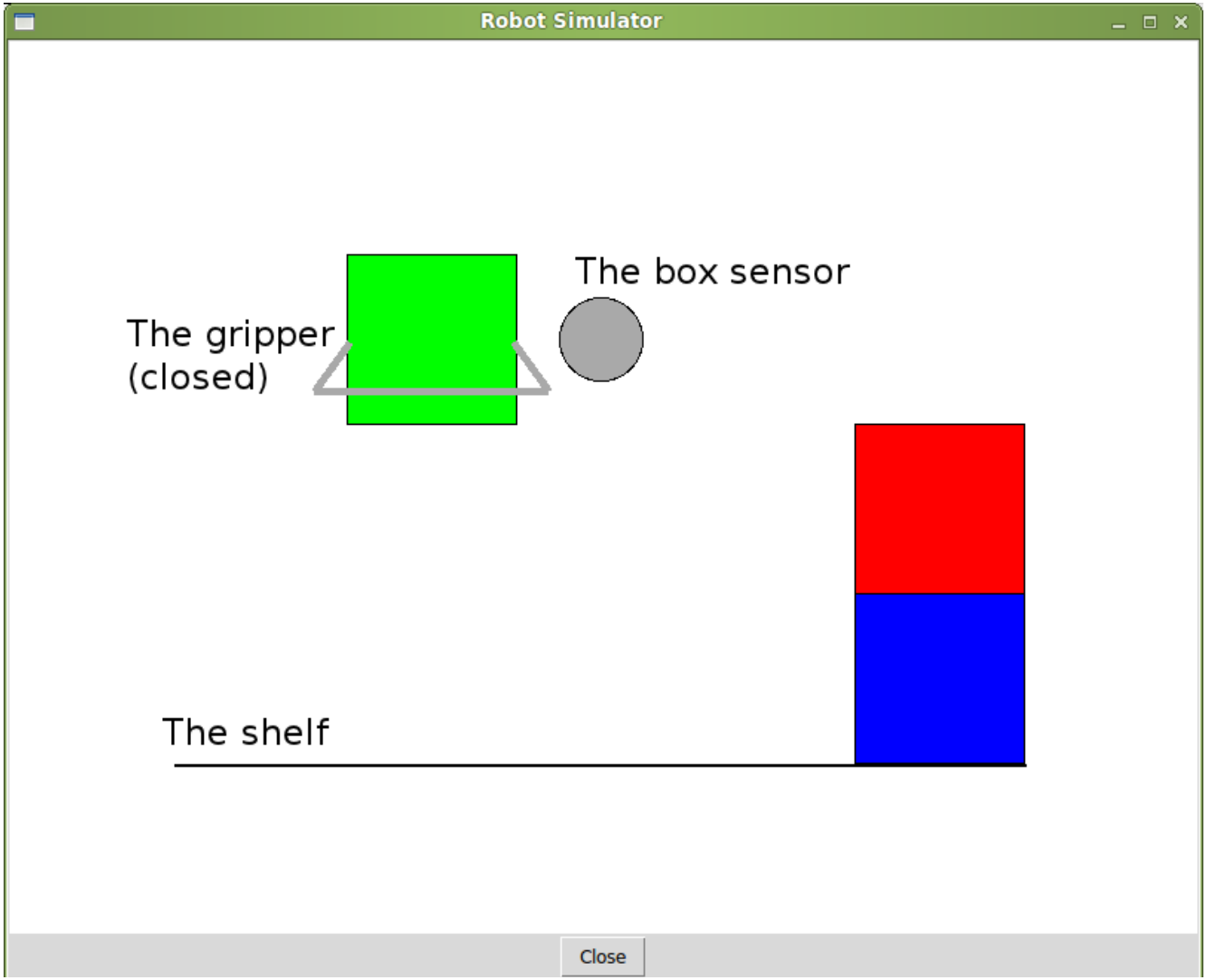
open



closed

* Moving sideways or down, the gripper may hit boxes if it is not folded.
* Folding/unfolding the gripper may hit boxes in adjacent stacks.

The robot simulator



```
>>> import robot
```

Start new simulation:

```
>>> robot.init()
```

Start simulation with larger area:

```
>>> robot.init(width = 11, height = 6)
```

Start simulation with random boxes:

```
>>> robot.init(width = 11, height = 6,
                boxes = "random")
```

Drive right/left one step:

```
>>> robot.drive_right()
>>> robot.drive_left()
```

Move the lift up one step:

```
>>> robot.lift_up()
```

Move the lift down one step:

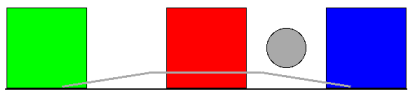
```
>>> robot.lift_down()
```

Change gripper position:

```
>>> robot.gripper_to_open()
>>> robot.gripper_to_closed()
>>> robot.gripper_to_folded()
```

* If the robot hits a box, no command works until a new simulation is started.

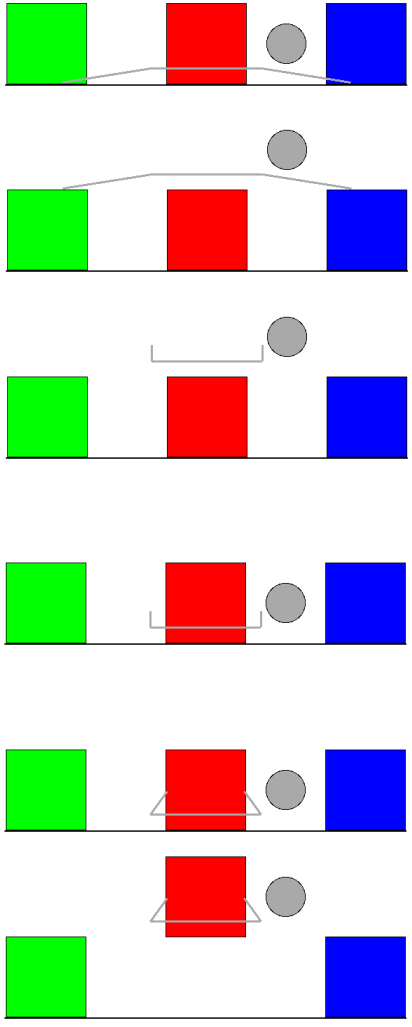
* How to pick up a box without hitting the box(es) next to it?



* How to pick up a box without hitting the box(es) next to it?

```
robot.lift_up()
robot.gripper_to_open()
robot.lift_down()
robot.gripper_to_closed()
robot.lift_up()
```

* A *program* is a sequence of instructions.



Libraries, modules, namespaces

* *Library* is a generic term for a collection of (useful) functions, data structures, etc.
* In python, libraries are called *modules*.
* *Importing* a module,

```
import math
import robot
```

makes its content available to use.

* Imported names are prefixed with the module name, as in `math.pi`, `robot.lift_up`, etc.
  - They are placed in a separate *namespace* (more about namespaces later in the course).

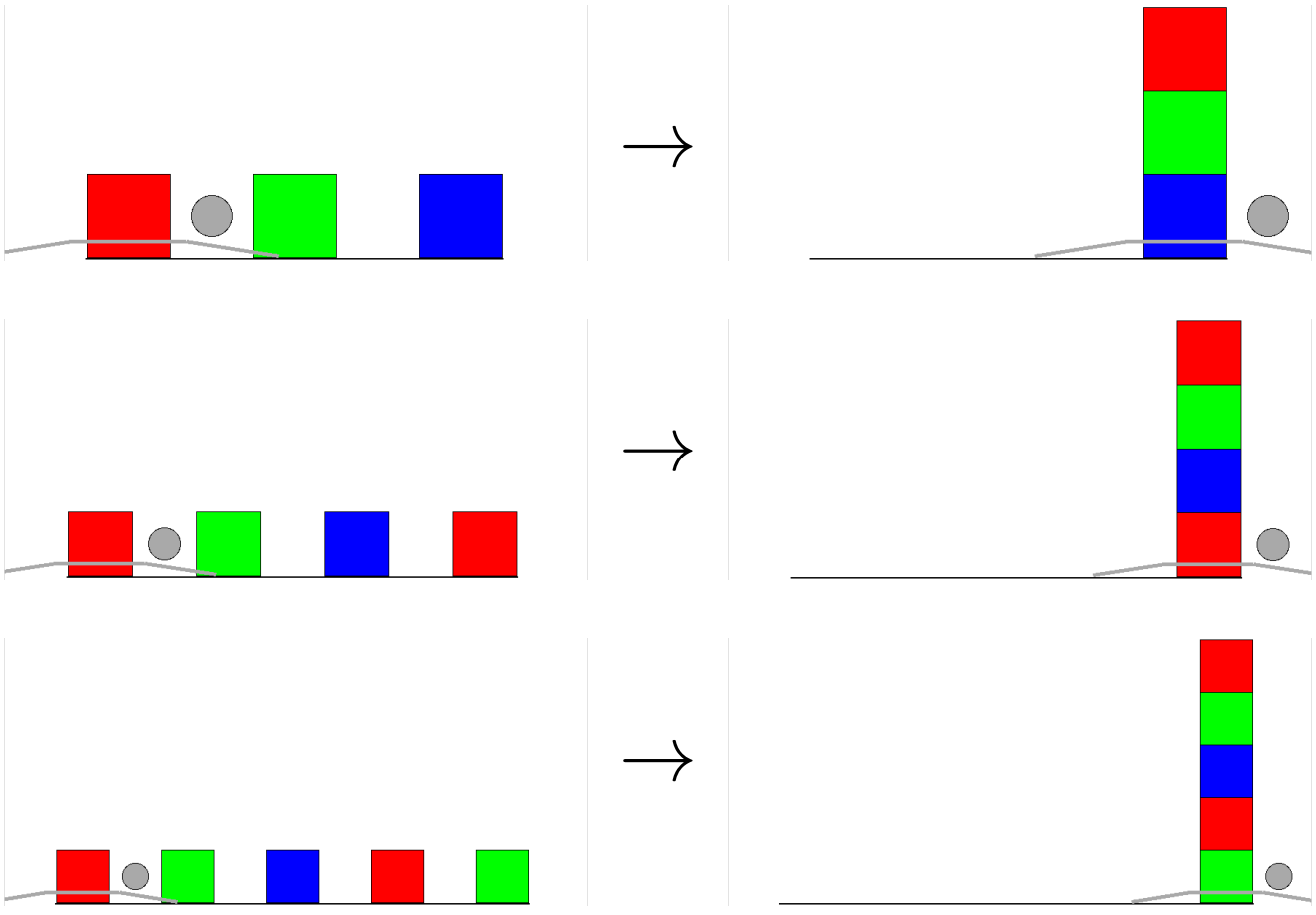
* How does python find modules?
  - Standard modules (e.g., `math`) are installed in a specific location on the file system.
  - Non-standard modules (e.g., `robot`) must be in the *current working directory* (cwd).

```
>>> import os
>>> os.getcwd()
'/Users/jeffrey/COMP1730/Lecture2'
```

* When running a program, the cwd is (normally) the directory where the file is.

Programming and functional abstraction

Problem: Building a tower



```
robot.init(width = 7, boxes = "flat")
robot.drive_right()
robot.lift_up()
robot.gripper_to_open()
robot.lift_down()
robot.gripper_to_closed()
robot.lift_up()
robot.drive_right()
robot.drive_right()
robot.gripper_to_open()
robot.lift_down()
robot.gripper_to_closed()
robot.lift_up()
robot.drive_right()
robot.drive_right()
robot.gripper_to_open()
robot.lift_down()
⋮
```

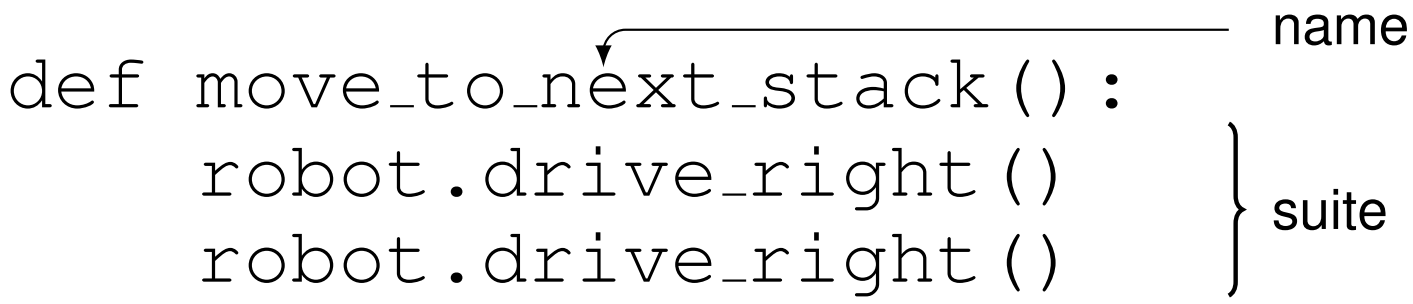
Functional abstraction

* In programming, a *function* (also known as “procedure” or “subroutine”) is a piece of the program that is given a name.
  - The function is *called* by its name.
  - A function is defined once, but can be called any number of times.

* Why use functions?
  - **Abstraction**: To use a function, we only need to know *what* it does, *not how*.
  - Break a complex problem into smaller parts.

"*Engineering succeeds and fails because of the black box*"
Kuprenas & Frederick, "101 Things I Learned in Engineering School"

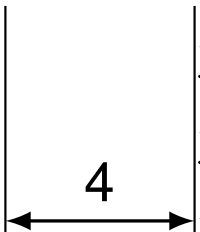
Function definition in python



* `def` is a python keyword (“reserved word”).
* The *function’s name* is followed by a pair of parentheses and a colon.
  - Inside the parentheses are the function’s parameters (more on this in coming lectures).
* The *function suite* is the sequence of statements that will be executed when the function is called.

Function definition in python

```
def grasp_box_on_shelf():
    robot.lift_up()
    robot.gripper_to_open()
    robot.lift_down()
    robot.gripper_to_closed()
    robot.lift_up()
```



* In python, a suite is delimited by *indentation*.
  - All statements in the suite **must be preceded by the same number of spaces/tabs** (standard is 4 spaces).

Function definition in python

```
def release_and_pickup_next():
    robot.gripper_to_open()
    robot.lift_down()
    robot.gripper_to_closed()
    robot.lift_up()
```

* The `def` statement only *defines* the function – it does not execute the suite.
* The whole definition is itself a statement.

Building a tower of 5 boxes

```
robot.init(width = 9, boxes = "flat")
robot.drive_right()
grasp_box_on_shelf()
move_to_next_stack()
release_and_pickup_next()
move_to_next_stack()
release_and_pickup_next()
move_to_next_stack()
release_and_pickup_next()
move_to_next_stack()
robot.gripper_to_folded()
robot.lift_down()
```

The python language: First steps

Syntax

* The *syntax* of a (programming) language is the rules that define what is a valid program.
* A python program is a sequence of *statements*:
  - defining a function:
```
def move_twice():
    robot.drive_right()
    robot.drive_right()
```
  - calling a function:
```
move_twice()
robot.lift_up()
```
  - importing a module:
```
import robot
```
  - ...and a few more.

Whitespace

* Spaces, tabs and end-of-line are known as *whitespace*.
* The whitespace before a statement is called *indentation*.
* In python, whitespace has two special roles:
  - end-of-line marks the end of a statement (some exceptions, more later in the course);
  - indentation defines the extent of a *suite* of statements.
* Other than this, whitespace is ignored.

Permitted names in python

* A function name in python may contain letters, numbers and underscores (_), but must begin with a letter or undescore.

Allowed	Not allowed
`moverighttwice`	`move right twice`
`move_right_2`	`2_steps_right`
`is_box_red`	`is_box_red?`
`imPort`	`import`

* Reserved words cannot be used as names.
* Names are *case sensitive*: upper and lower case letters are not the same.

Comments

* A hash sign (#) marks the beginning of a *comment*; it continues to end-of-line.

```
robot.init(width = 7) # use a wider shelf
# grasp the first box:
robot.lift_up()
...
```

* Comments are ignored by the interpreter.
  - Comments are for *people*.
  - Use comments to state what is not obvious.
* If it was hard to write, it's probably hard to read. Add a comment. (Punch & Enbody, Rule 6)

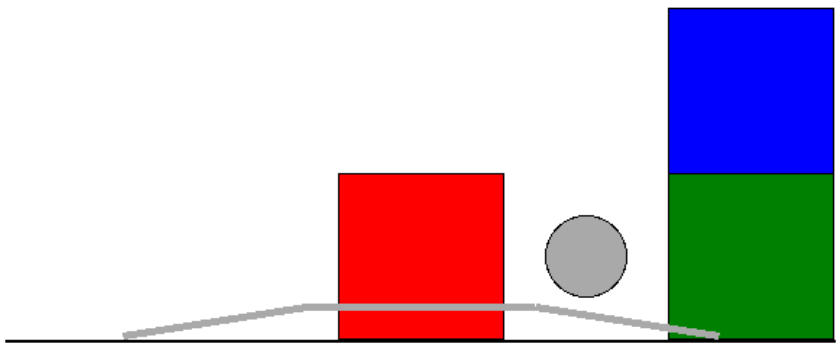
* Write comments to describe *what* a function does, and *when* it should be expected to work.

```
# Pick up a box from the shelf, without
# hitting adjacent boxes.
# Assumptions: The robot (gripper) is in
# front of the box; the gripper is folded
# and the lift is down.
def grasp_box_on_shelf():
    ...
```

Testing and debugging

Test, test, test

* How do we know our program works?
  - Specify the assumptions under which the program (or function) is meant to work.
  - Test it with a variety of cases that fall under those assumptions.
  - Particularly, “edge cases”.



Errors

```
Traceback (most recent call last):
  File "stack-3-v1.py", line 35, in <module>
    robot.lift_up()
  File "/.../robot.py", line 40, in lift_up
    _robot.lift_up()
  File "/.../robot.py", line 600, in lift_up
    + " and can't go any higher!")
robot.RobotError: Robot Error: The lift is at level 1 and can't go any higher!
```

* Errors will happen.
* Read the error message!

* Some common errors:
  - `SyntaxError`:
    You have broken the rules of python syntax.
  - `NameError` or `AttributeError`:
    You have used a (function) name that doesn't exist. Check for typos.
  - `IndentationError`:
    Too much or too little indentation.
    - All statements in a function suite must have the same indentation.
    - All statements outside function definitions must have no indentation.