



THE HONG KONG  
POLYTECHNIC UNIVERSITY  
香港理工大學

INDUSTRIAL CENTRE  
工業中心

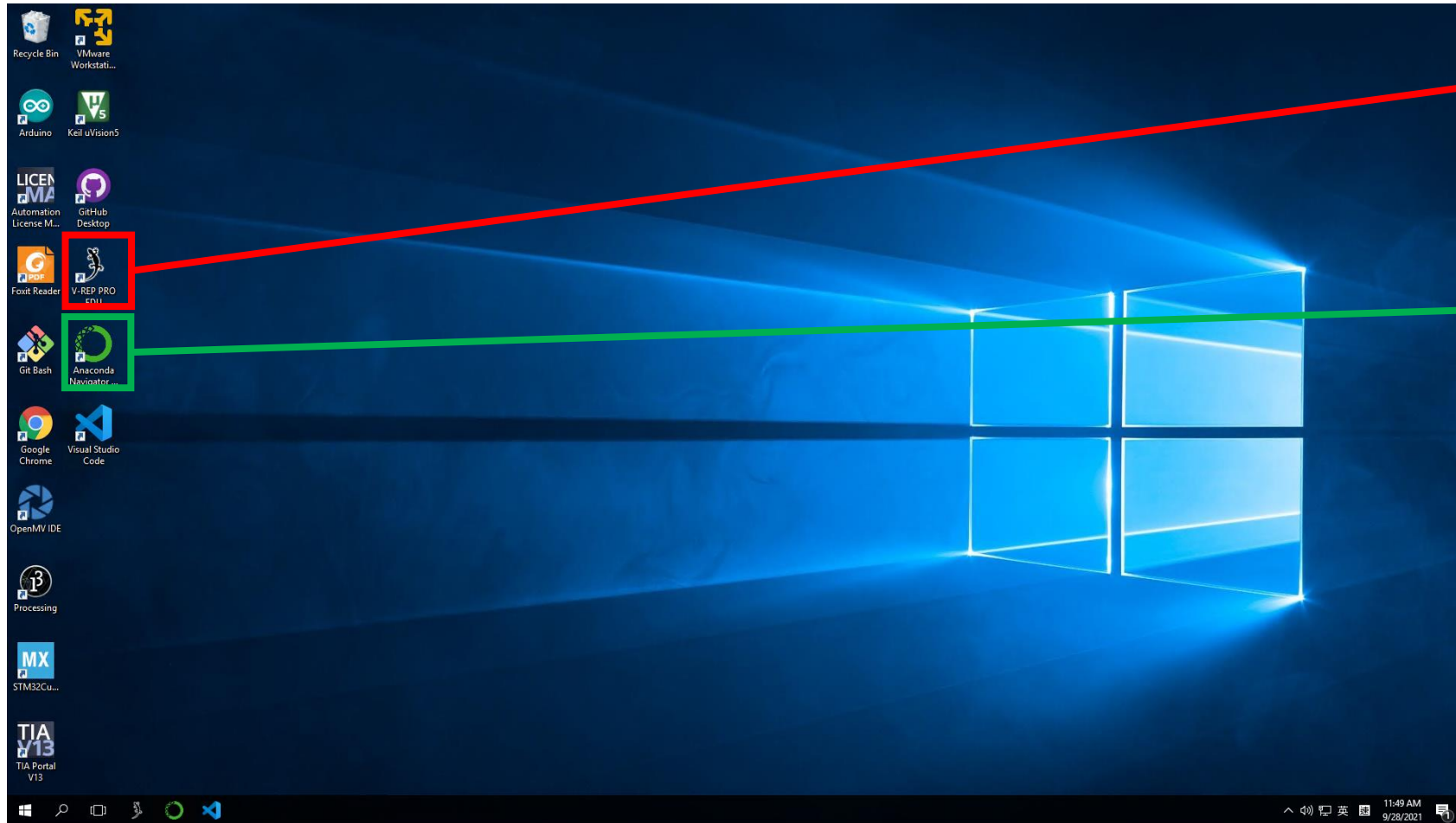
# Control and Automation IC2122 Robotics Lab with VREP

Instructor: Louis Wong

Industrial Centre

The Hong Kong Polytechnic University

# Software platform



V-REP

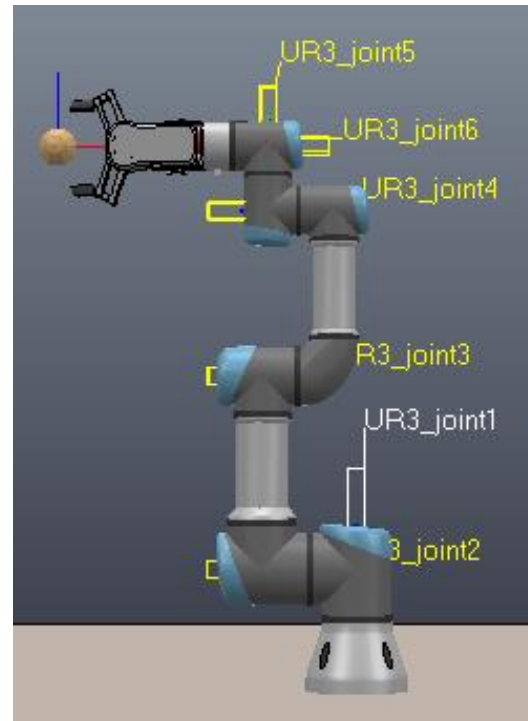
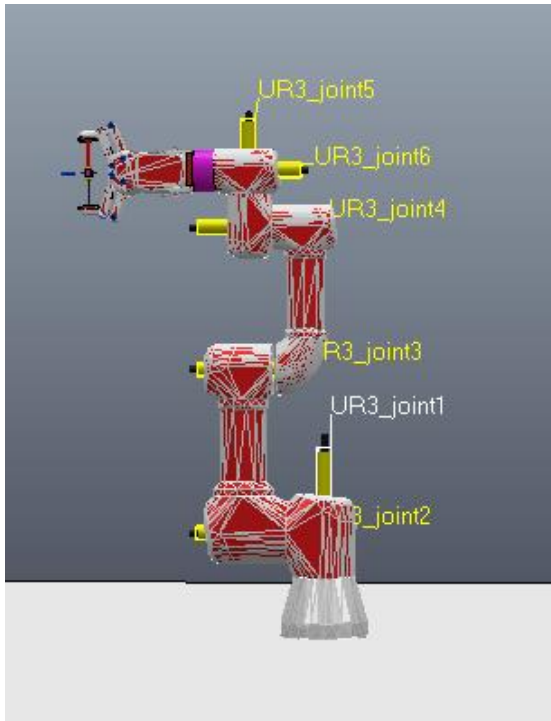
➤ Simulation platform

Anaconda

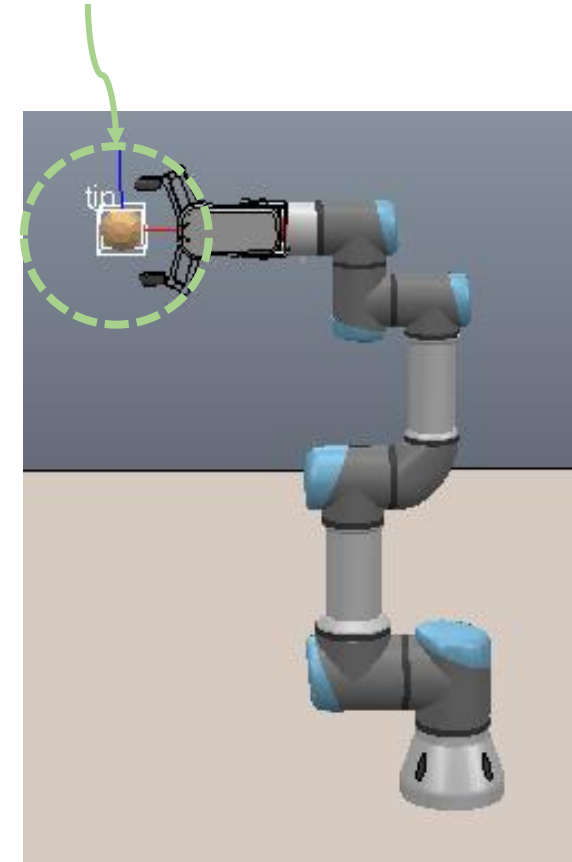
➤ Python distribution platform

# V-REP UR3

- Joints (UR3):
  - From UR3\_joint1 to UR3\_joint6



- End-effector (Tip):

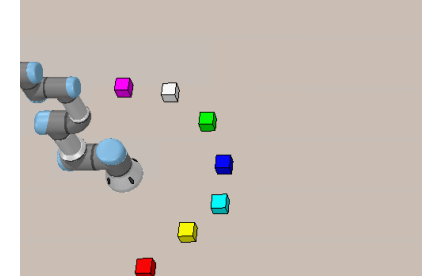
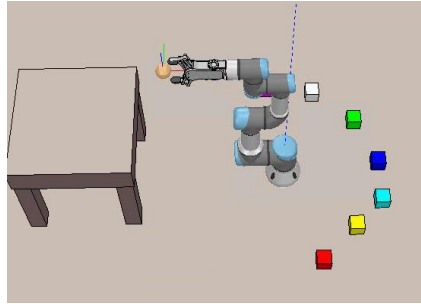


# V-REP Tools

- Camera **Pan**:



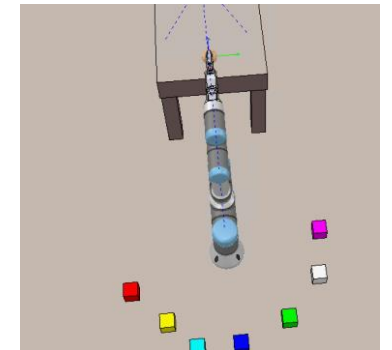
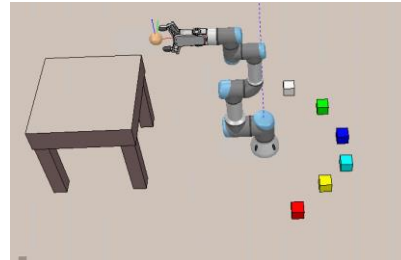
- Moving the camera



- Camera **Rotate**:



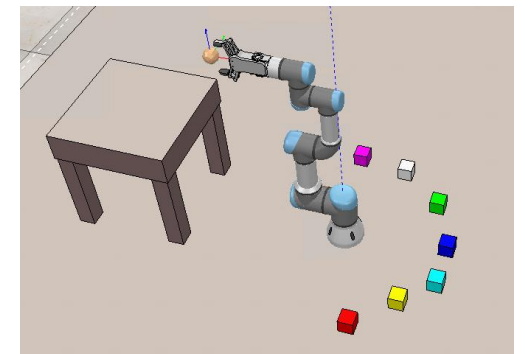
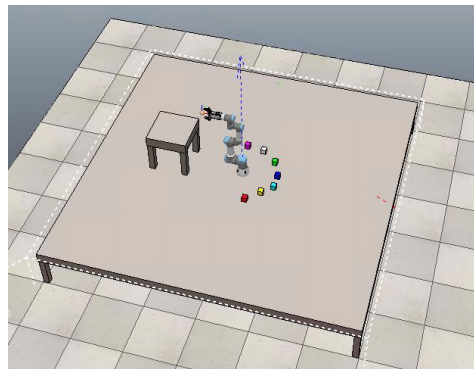
- Rotating the camera



- Camera **Shift**:



- Zoom in or Zoom out



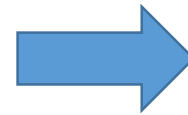
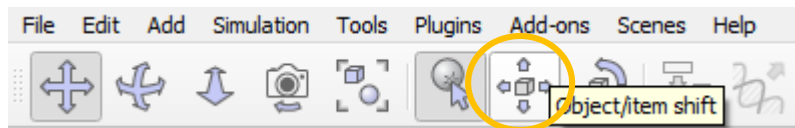
# V-REP Tools

- Object Position:

1. Select the object

2. Click

3. Position: X, Y, Z



Object/Item Translation/Position

Mouse Translation Position Translation Pos. Scaling

Relative to: ☒ World ☐ Parent frame

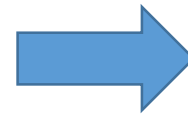
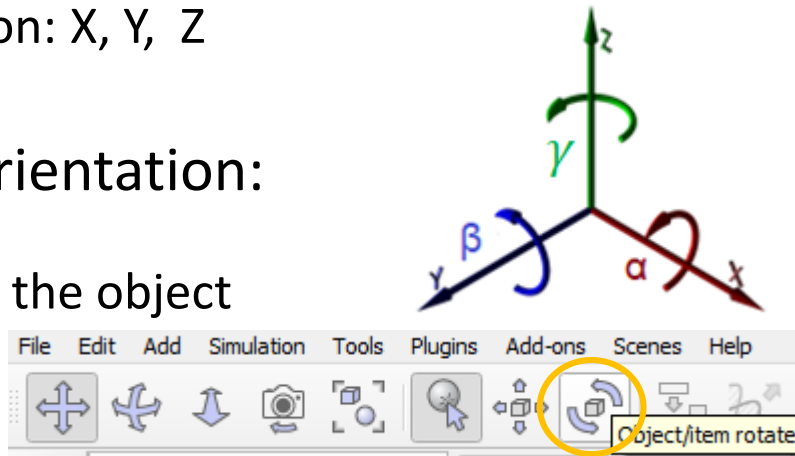
X-coord. [m]	+1.2500e-01	Apply X to sel.	Apply to selection
Y-coord. [m]	-3.5000e-01	Apply Y to sel.	
Z-coord. [m]	+4.3500e-01	Apply Z to sel.	

- Object Orientation:

1. Select the object

2. Click

3. Orientation: Alpha ( $\alpha$ ), Beta ( $\beta$ ), Gamma( $\gamma$ )

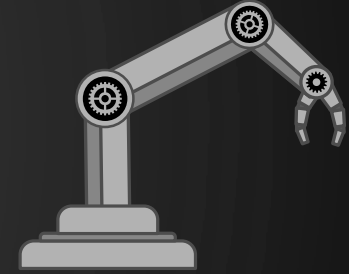


Object/Item Rotation/Orientation

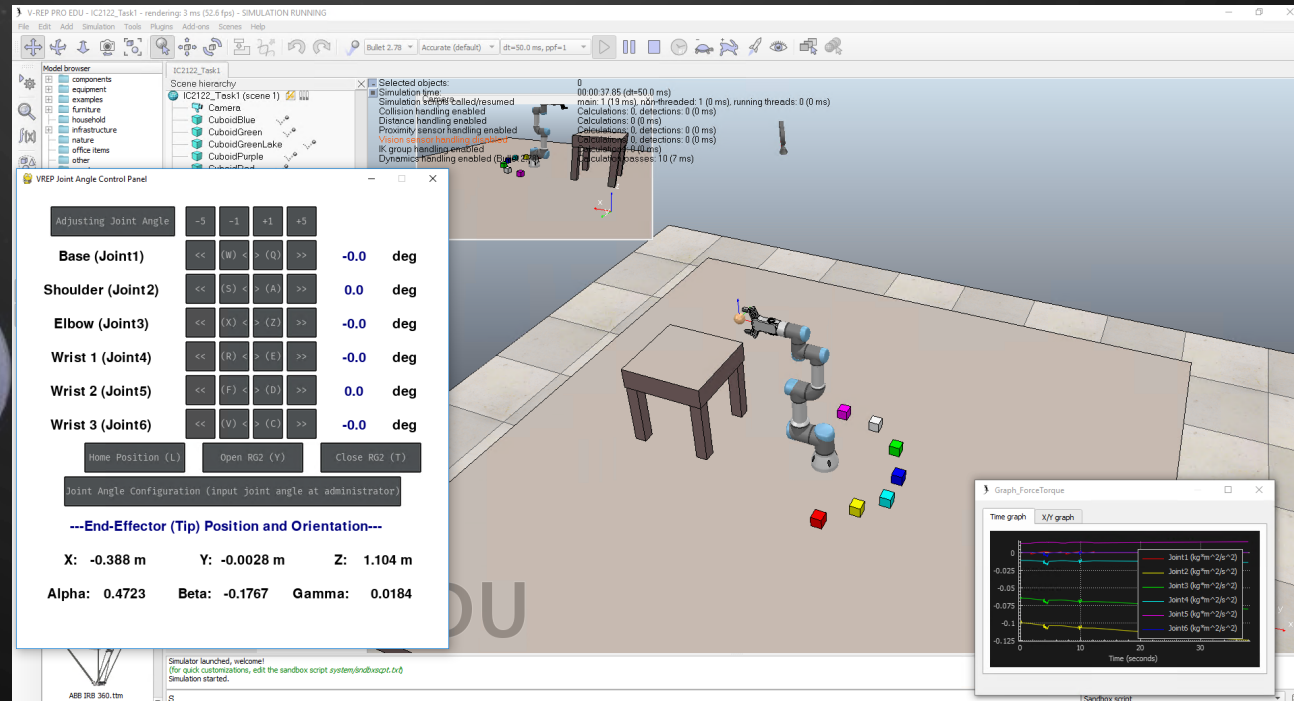
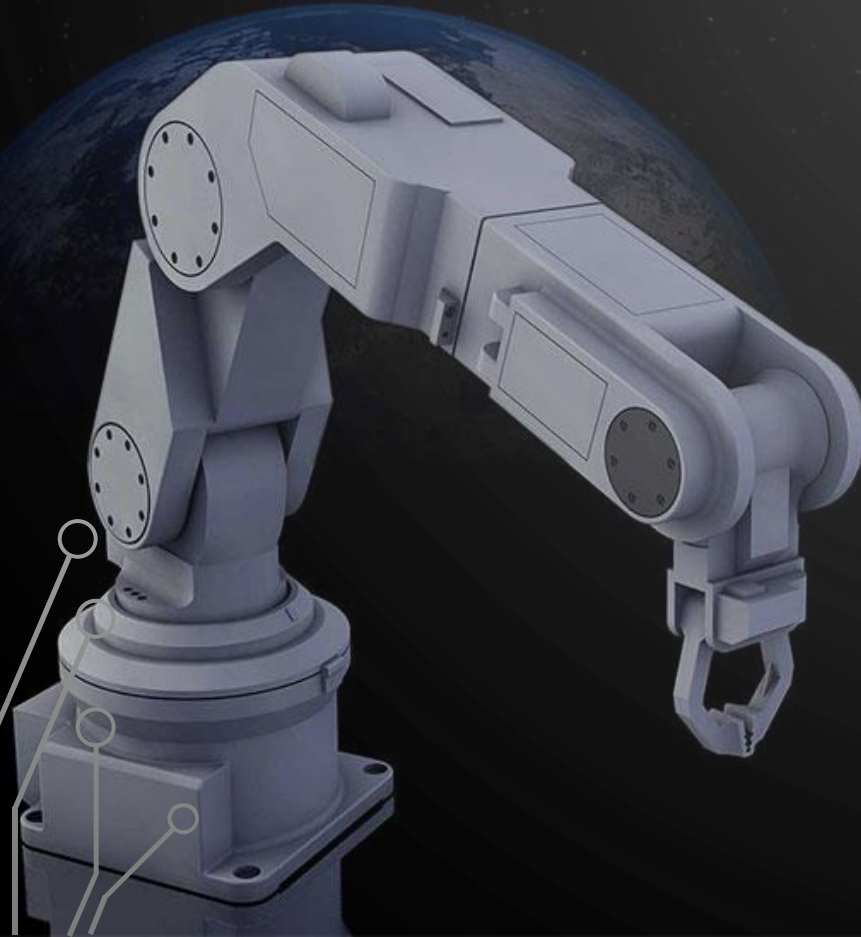
Mouse Rotation Orientation Rotation

Relative to: ☒ World ☐ Parent frame

Alpha [deg]	+8.2224e-07	Apply to selection
Beta [deg]	-1.1953e-06	
Gamma [deg]	-7.3521e-15	



# Task 1: Forward Kinematics





# Start-up – V-REP

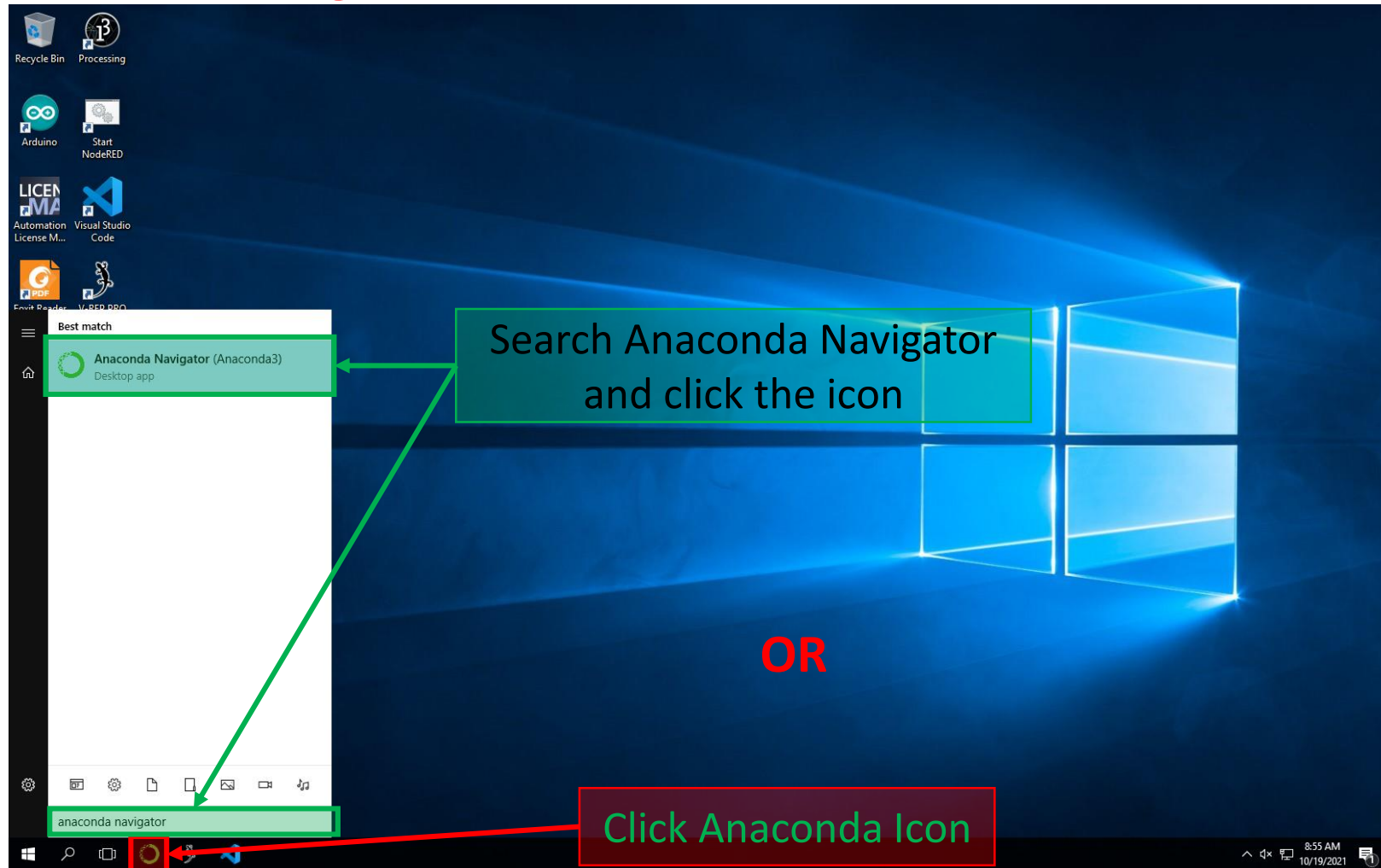
- Start the V-REP (Task1\_vrep.bat)

The screenshot shows a Windows File Explorer window titled 'IC2122-Robotics'. The address bar displays the path: This PC > DATA (D:) > 01-Home > IoT > IC2122-Robotics. A green box highlights the address bar, and a green callout box contains the text 'D:\01-Home\IoT\IC2122-Robotics'. The left sidebar shows the navigation pane with 'DATA (D:)' selected. The main pane displays a list of files and folders. The file 'Task1\_vrep' is highlighted with a purple box, and a purple callout box with the text 'Double-Click' points to it.

Name	Date modified	Type	Size
Task1	10/18/2021 9:43 AM	File folder	
Task2	10/18/2021 9:43 AM	File folder	
Task3	10/18/2021 9:44 AM	File folder	
Task4	10/18/2021 9:42 AM	File folder	
IC2122_Task1_r4	10/18/2021 9:41 AM	Microsoft PowerP...	8,301 KB
IC2122_Task2_r4	10/18/2021 9:41 AM	Microsoft PowerP...	6,613 KB
IC2122_Task3_r3	10/18/2021 9:41 AM	Microsoft PowerP...	7,015 KB
IC2122_Task4_r2	10/18/2021 9:41 AM	Microsoft PowerP...	8,072 KB
IC21122-Robotics-Task1-2	10/11/2021 5:21 PM	Microsoft Word 9...	73 KB
IC21122-Robotics-Task3-4	10/12/2021 3:58 PM	Microsoft Word 9...	76 KB
README	9/23/2021 8:53 AM	Markdown Source...	8 KB
Task1_vrep	10/5/2021 9:55 AM	Windows Batch File	1 KB
Task2_vrep	10/5/2021 4:35 PM	Windows Batch File	1 KB
Task2c_vrep	10/5/2021 4:35 PM	Windows Batch File	1 KB
Task3_vrep	10/11/2021 11:30 ...	Windows Batch File	1 KB
Task4a_vrep	10/11/2021 11:31 ...	Windows Batch File	1 KB
Task4b_vrep	10/11/2021 11:31 ...	Windows Batch File	1 KB
Task4c_vrep	10/11/2021 11:31 ...	Windows Batch File	1 KB

# Start-up – Anaconda Navigator

- Start the **Anaconda Navigator** on Taskbar or search Windows



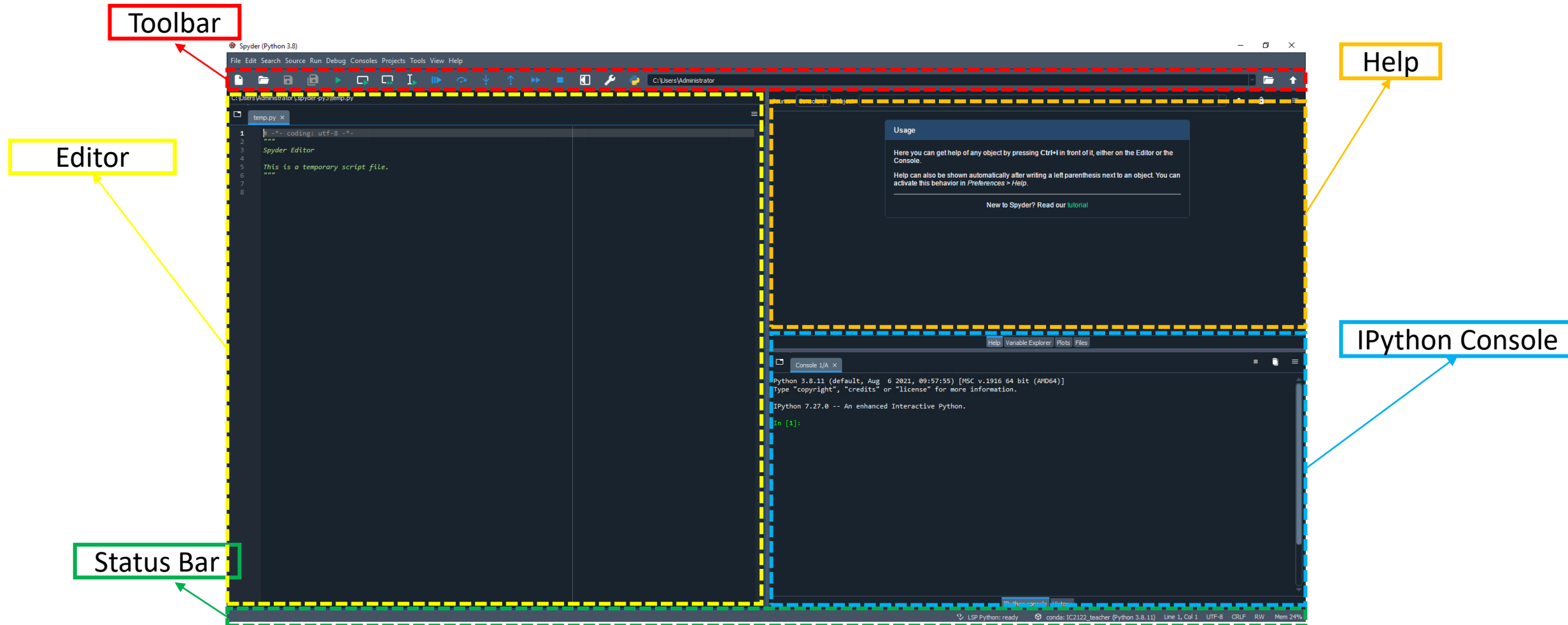


# Start-up – Spyder

- Launch Spyder

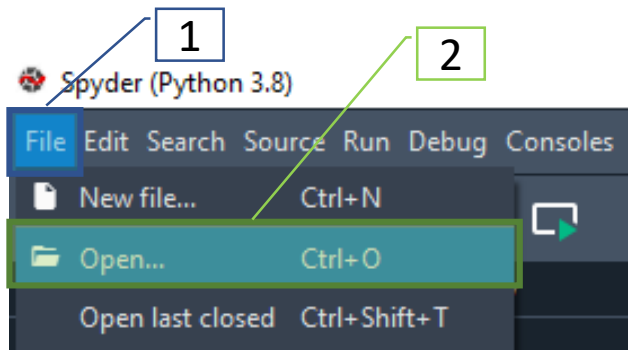
The screenshot displays the Anaconda Navigator application window. The interface includes a top menu bar with 'File' and 'Help', and a left sidebar with navigation options: 'Home' (highlighted with a blue box and callout 1), 'Environments', 'Learning', and 'Community'. The main area is titled 'Applications on' and features a dropdown menu for environment selection (callout 2) showing 'IC2122' and 'base (root)', with 'IC2122' selected (callout 3). Below the dropdown, four application cards are visible: 'Datalore', 'IBM Watson Studio Cloud', 'Qt Console', and 'Spyder'. The 'Spyder' card is highlighted with a yellow box and callout 4, showing its version (5.0.5) and a 'Launch' button. The 'Spyder' card also includes a description: 'Scientific PYTHON Development Environment. Powerful Python IDE with advanced editing, interactive testing, debugging and introspection features'.

# Start-up – Spyder

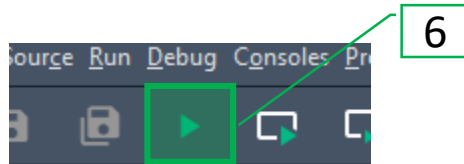


# Start-up – Spyder

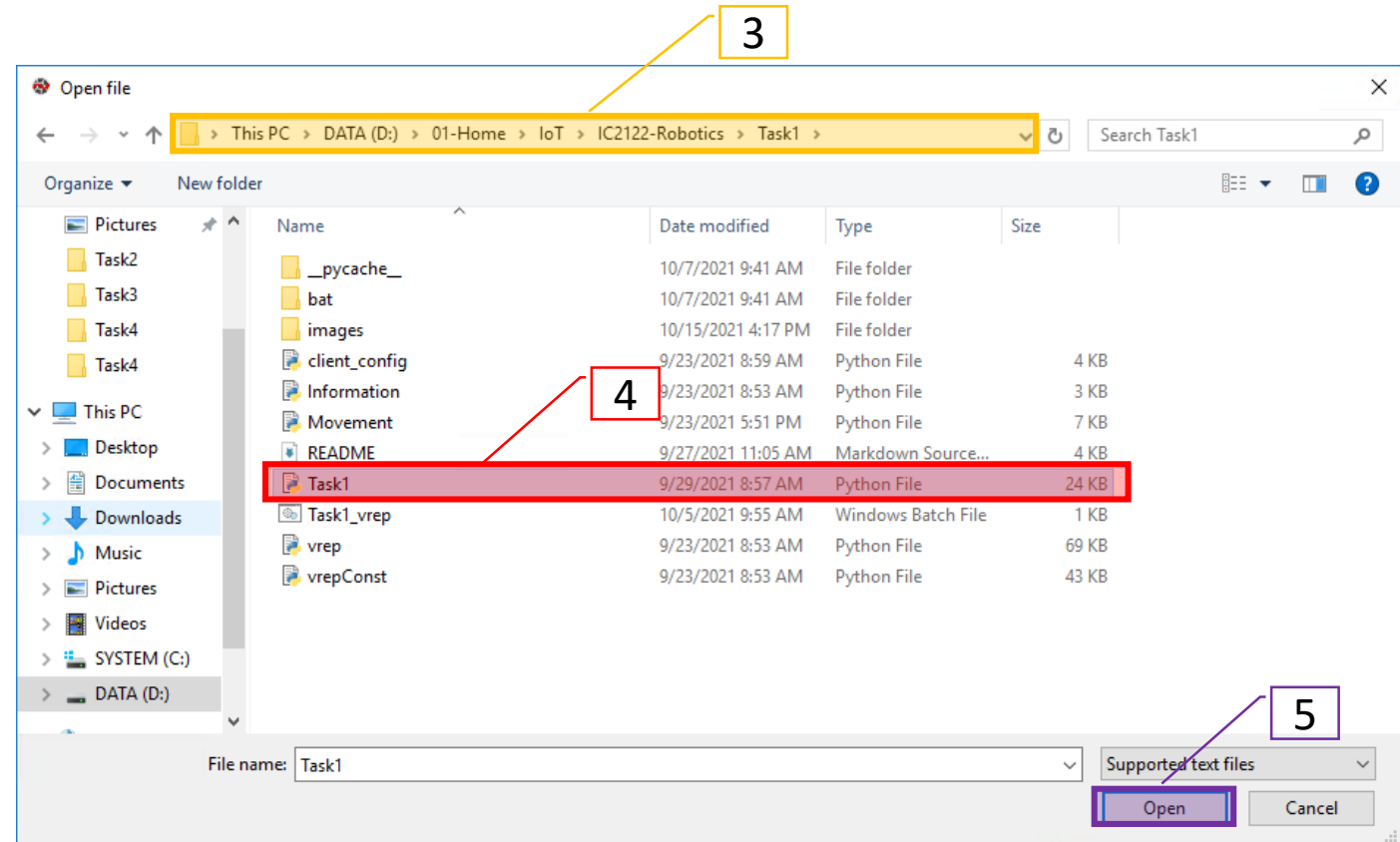
- **Open** Python file at editor



- **Run** the program at Spyder



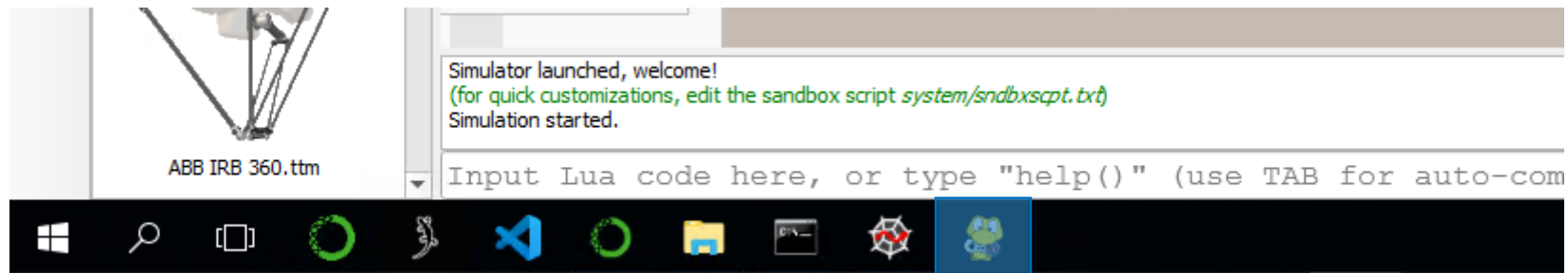
D:\01-Home\IoT\IC2122-Robotics\Task1



# Start-up – Control panel window

---

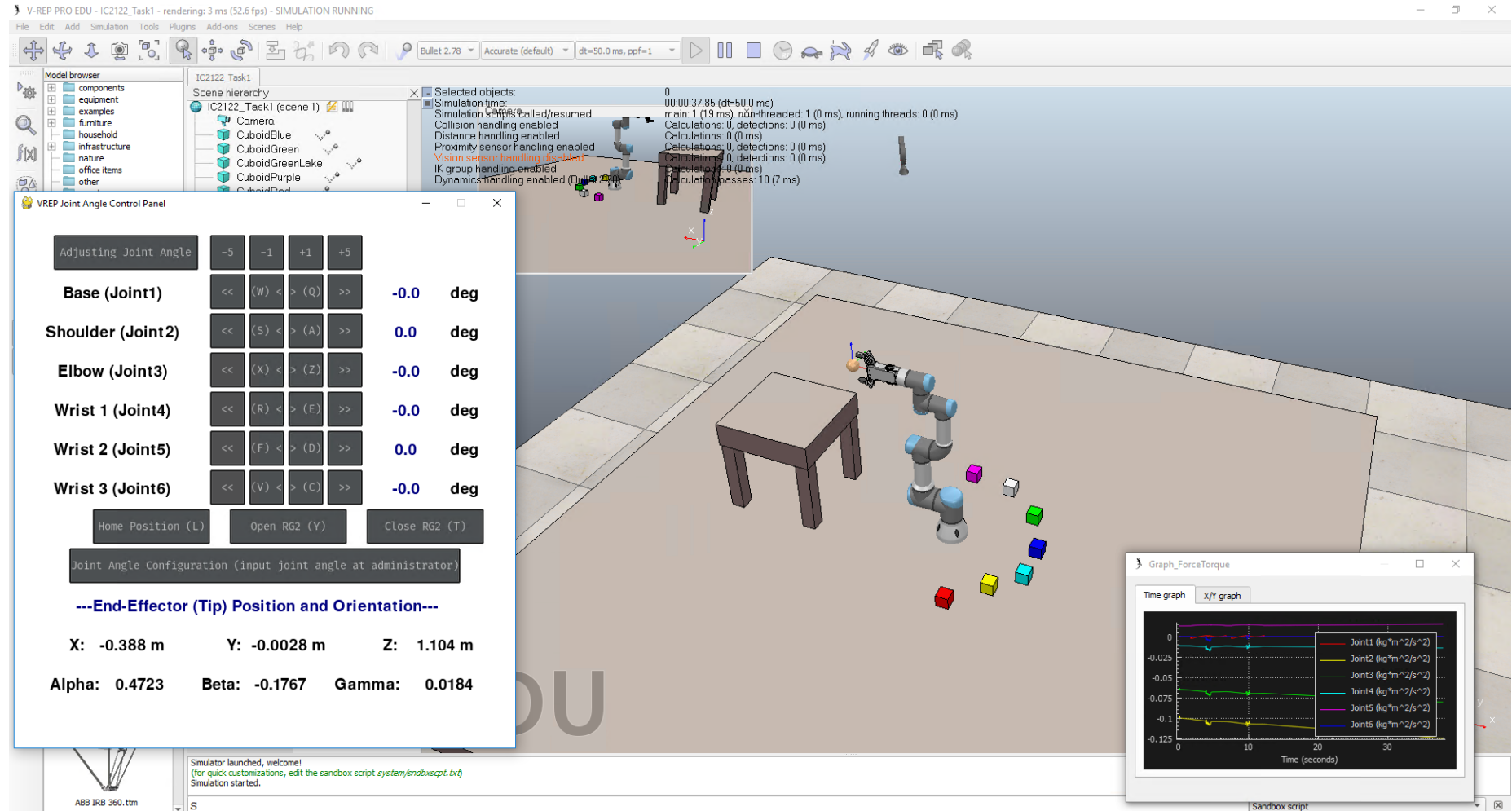
- Control panel window will be appeared after running the program
- After switching to the V-REP, the control panel window will be hidden
- **Click** the Control panel window icon to open it.



Click this icon

# Start-up

- V-REP interface :



# V-REP Joint Angle - Keyboard Control

- **Joint Movement ( +/- 1 degree)**

Joint Name	Keyboard	
	-1 degree	+1 degree
Joint 1	(W)	(Q)
Joint 2	(S)	(A)
Joint 3	(X)	(Z)
Joint 4	(R)	(E)
Joint 5	(F)	(D)
Joint 6	(V)	(C)

- **Pose:**

- (L): Home Position

- Return all of the joint angles as 0 degrees

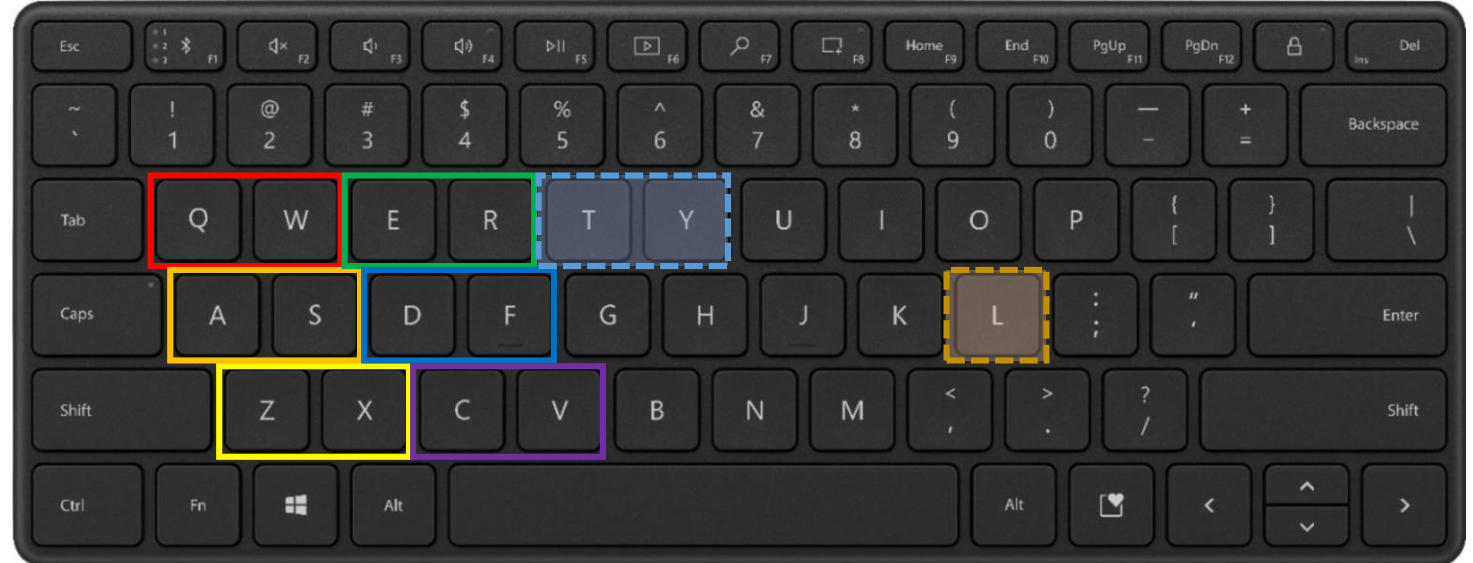
- **Gripper (RG2):**

- (Y): Close RG2

- Grip object

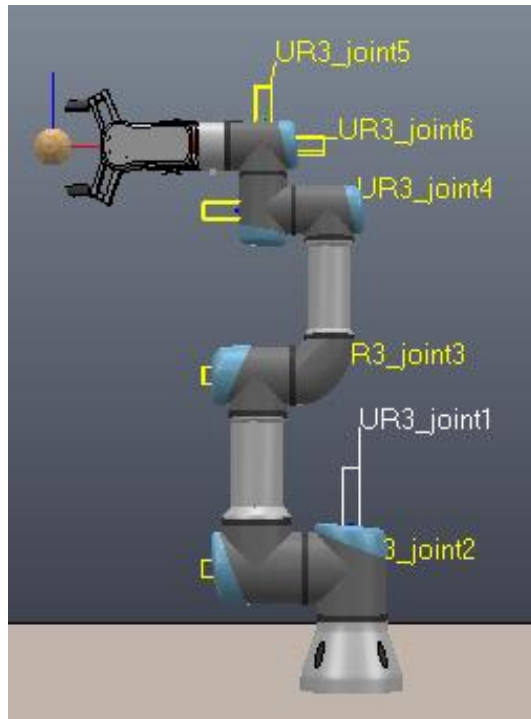
- (T): Open RG2

- Release object





# V-REP Joint Angle - Control Panel



Joint Name

VREP Joint Angle Control Panel

Adjusting Joint Angle

Base (Joint1)	<<	(W) <	> (Q)	>>	0.0	deg
Shoulder (Joint2)	<<	(S) <	> (A)	>>	0.0	deg
Elbow (Joint3)	<<	(X) <	> (Z)	>>	0.0	deg
Wrist 1 (Joint4)	<<	(R) <	> (E)	>>	0.0	deg
Wrist 2 (Joint5)	<<	(F) <	> (D)	>>	0.0	deg
Wrist 3 (Joint6)	<<	(V) <	> (C)	>>	0.0	deg

Home Position (L)    Open RG2 (Y)    Close RG2 (T)

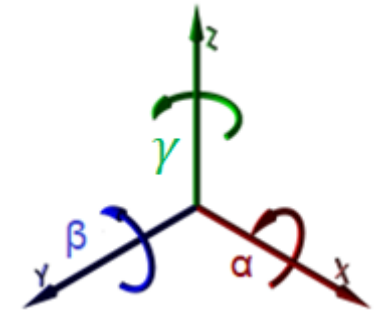
Joint Angle Configuration (input joint angle at administrator)

---End-Effector (Tip) Position and Orientation---

X: 1.1205 m    Y: -1.8998 m    Z: 1.0797 m

Alpha: -110.933    Beta: -28.703    Gamma: 169.59

Joint Angle



End-effector Position

End-effector Orientation

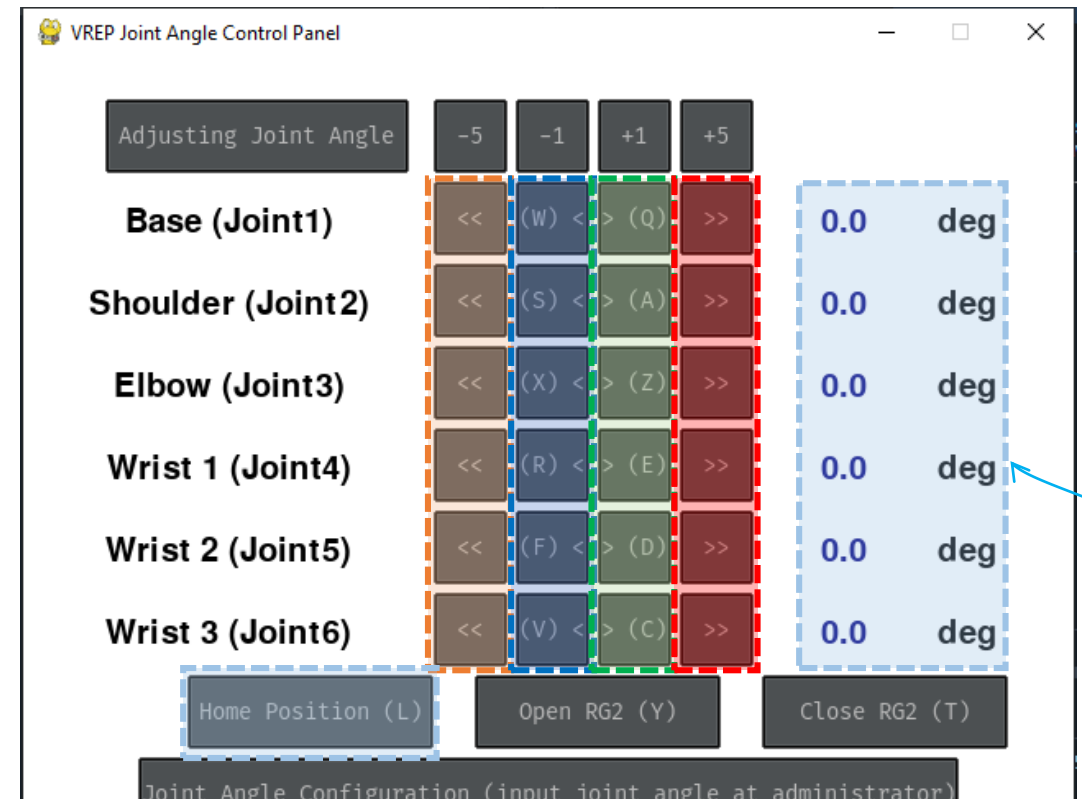
# V-REP Joint Angle - Control Panel

- Joint Angle Movement:

1. - 5 degrees of Joint angle
2. - 1 degrees of Joint angle
3. + 1 degrees of Joint angle
4. + 5 degrees of Joint angle

- Home Position:

1. Return all of the joint angles as 0 degrees

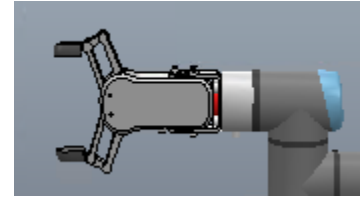


# V-REP Joint Angle - Control Panel

- Gripper (RG2):

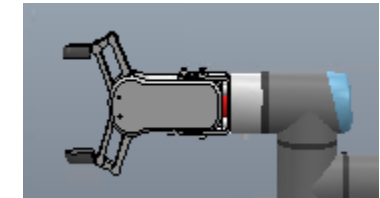
1. **Close** RG2 to Grip object

Close RG2 (T)



2. **Open** RG2 to Release object

Open RG2 (Y)



- Joint Angle Configuration

1. Set all of the joint angles in the IPython Console

(Input value and press enter  
at Spyder IPython Console )

Joint Angle Configuration (input joint angle at administrator)

```
pygame 2.0.1 (SDL 2.0.14, Python 3.8.11)
Hello from the pygame community. https://www.pygame.org/contribute.html
Simulation started
connect successfully
Simulation start

Input Joint 1 Angle: 0
Input Joint 2 Angle: 0
Input Joint 3 Angle: 0
Input Joint 4 Angle: 0
Input Joint 5 Angle: 0
Input Joint 6 Angle: |
```

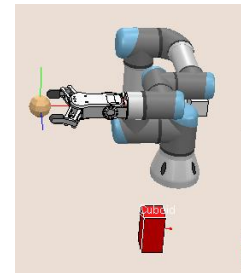
Input your value

# V-REP Joint Angle – Example 1

- Example 1: **Move** the end-effector on top of the **RED** rectangle.
- Steps:
  1. Switch to the “**V-REP Control Panel**” window and observe the UR3’s movement when clicking the button to adjust joint angle (**synchronizing with V-REP**)

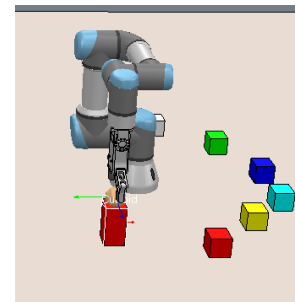
2. Tune **Joint 3** angle as **-90 degree**  
(Press "X" or click button "<" / "<<" to adjust)

Elbow (Joint3)    << (X) < > (Z) >>    **-90.01**    deg

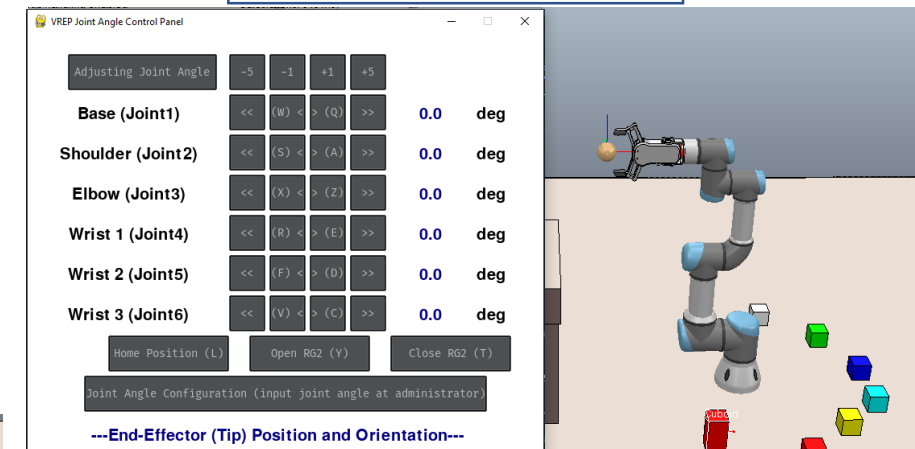


3. Tune **Joint 5** angle as **+90 degree**  
(Press "D" or click button ">" / ">>" to adjust)

Wrist 2 (Joint5)    << (F) < > (D) >>    **+90.0**    deg

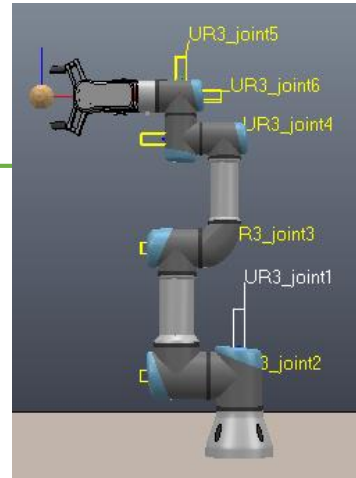


Home position



# IC2122 – Task 1a

- Task 1a: **Move** the end-effector to the **RED** block using **Forward Kinematics** and write down the joint angles.



Red Block Position:	Position X	Position Y	Position Z
	0.125 m	-0.35 m	0.435 m

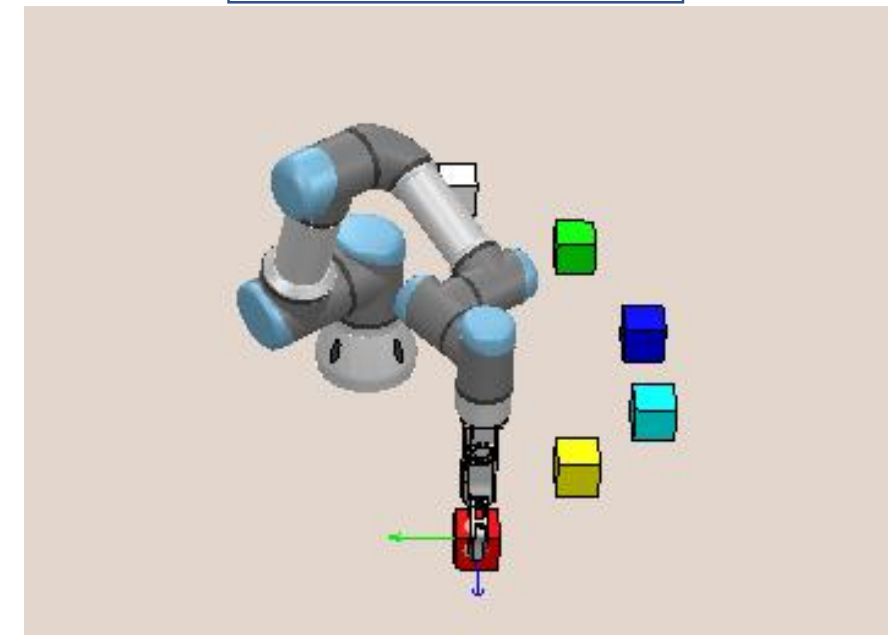
End-effector information

---End-Effector (Tip) Position and Orientation---

X: 0.1254 m      Y: -0.3579 m      Z: 0.4514 m

Alpha: 86.2592      Beta: -0.1106      Gamma: 90.527

Final Goal

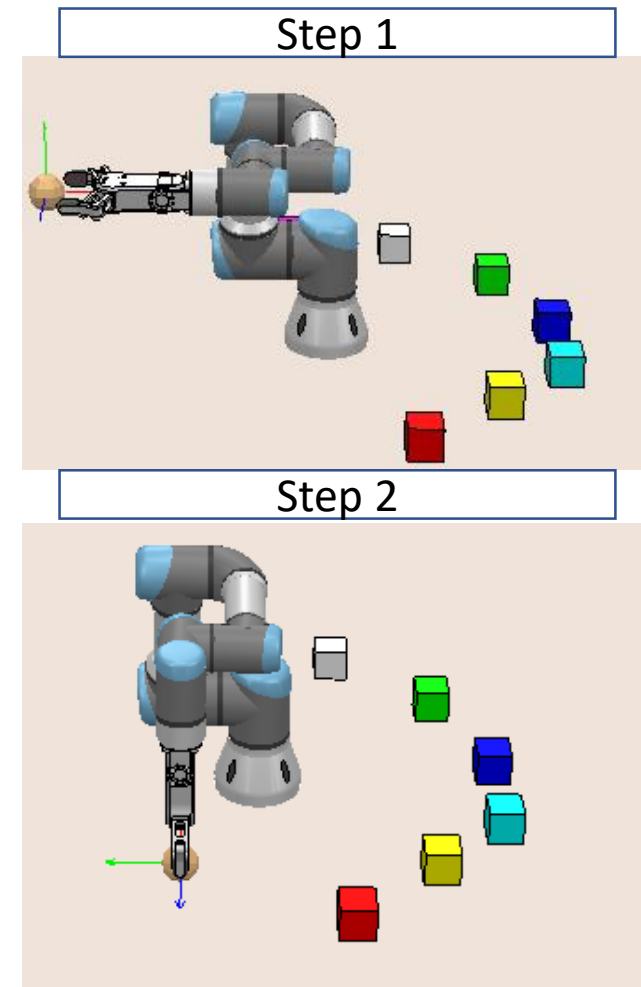


# IC2122 – Task 1a (Hints)

- Task 1a: **Move** the end-effector to the **RED** block using **Forward Kinematics** and write down the joint angles.

(Hints: Adjust the joint angles one by one)

- Step 1: Adjust **two** joint angles
  - Make the RG2 **parallel** to the table
- Step 2: Adjust **one** joint angle
  - Make the end-effector **vertically** to the ground





# IC2122 – Task 1a (Hints)

- Task 1a: **Move** the end-effector to the **RED** block using **Forward Kinematics** and write down the joint angles.



(Hints: Adjust the joint angles one by one)

- Step 3: Adjust the joint angles to reach the **RED** block

(End-effector's position  $\approx$  Red block's position)

---End-Effector (Tip) Position and Orientation---

**X: 0.1254 m**

**Y: -0.3579 m**

**Z: 0.4514 m**

**Alpha: 86.2592**

**Beta: -0.1106**

**Gamma: 90.527**



# IC2122 – Task 1b

- Task 1b: **Move** the end-effector to the **YELLOW** block using **Forward Kinematics** and write down the joint angles.



(Remark: end-effector should be located inside the **YELLOW** block)

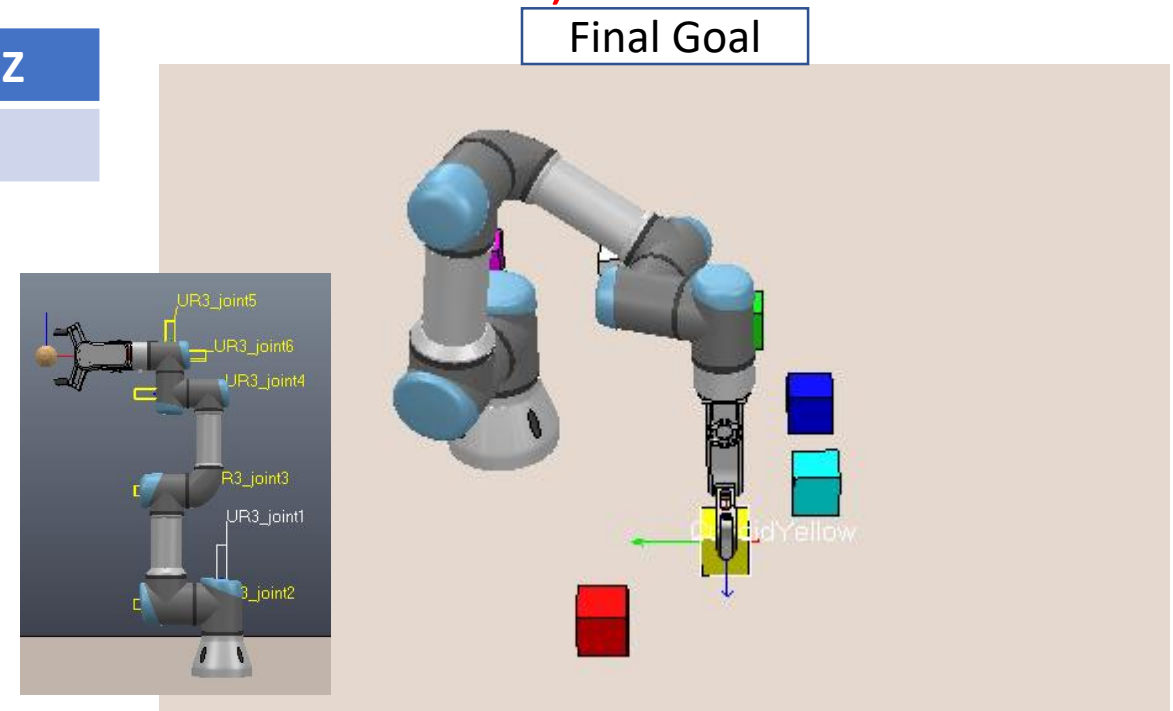
Yellow Block Position:	Position X	Position Y	Position Z
	0.25 m	-0.225 m	0.435 m

End-effector information

---End-Effector (Tip) Position and Orientation---

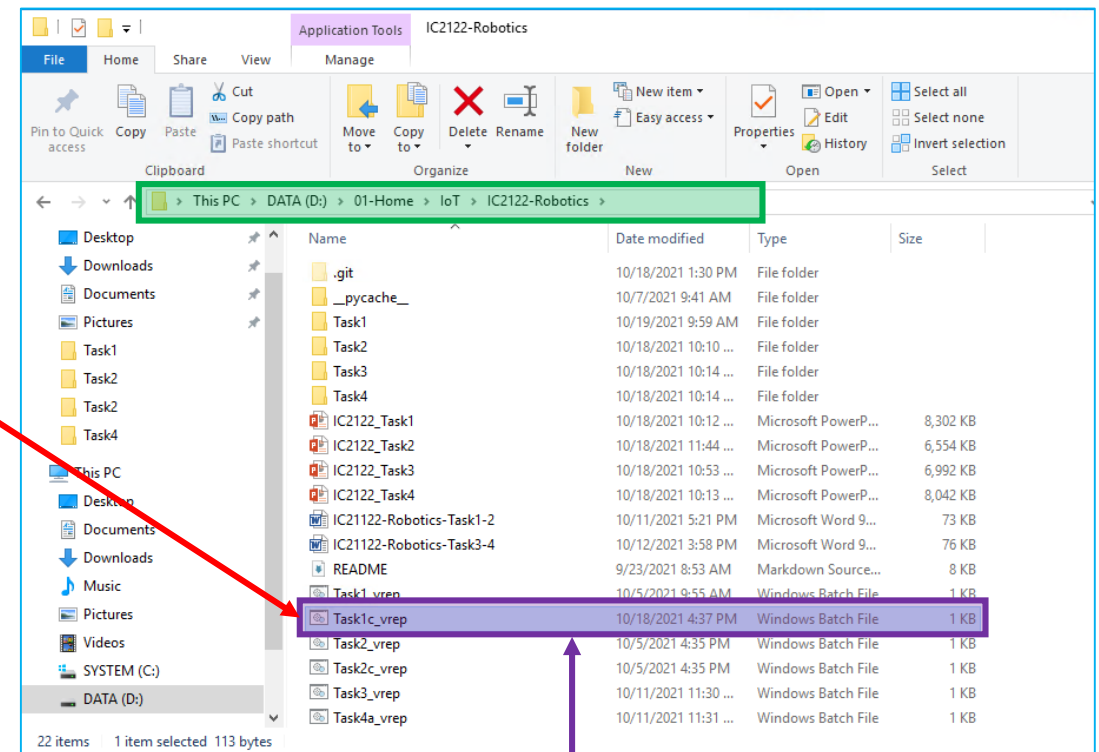
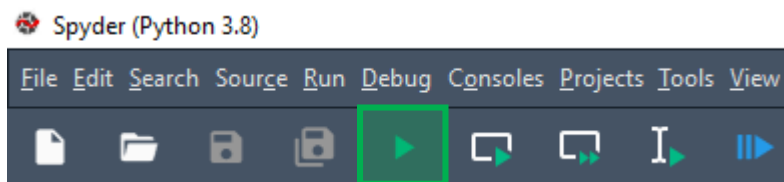
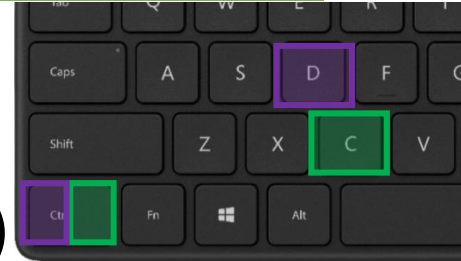
X: 0.2516 m      Y: -0.2261 m      Z: 0.4374 m

Alpha: 86.8039      Beta: -0.0816      Gamma: 90.324



# IC2122 – Task 1c

- Stop the program by holding “Ctrl” and clicking “C” (IPython console)
- Open a new console by holding “Ctrl” and clicking “D” (IPython console)
- Close the previous V-REP
- Start a new V-REP (Task1c\_vrep.bat)
- Run the Task1.py program (Spyder)



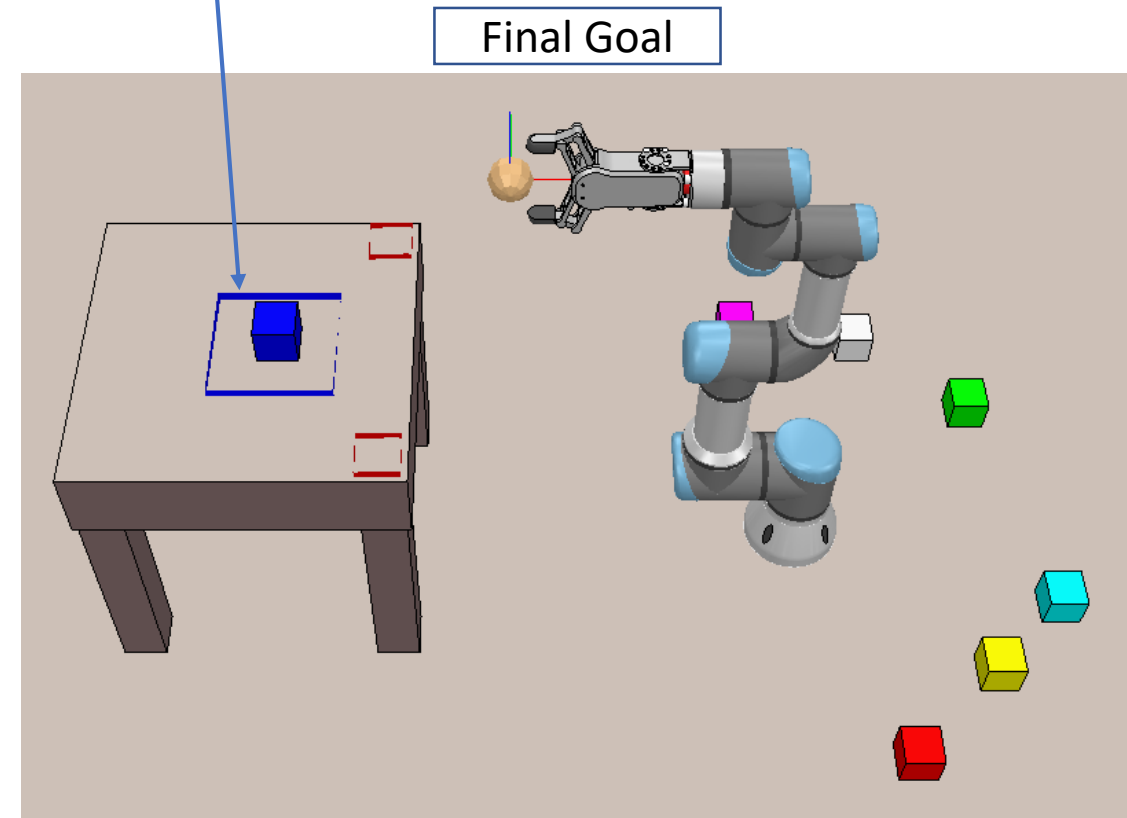
# IC2122 – Task 1c

- Task 1c: **Place** the **BLUE** block on the table (inside Blue colour area) using **Forward Kinematics** and write down the procedure.



Blue Block original Position:	Position X	Position Y	Position Z
	0.35 m	0.025m	0.435 m

Blue Block final Position:	Position X	Position Y	Position Z
	$\approx -0.667$ m	$\approx 0$ m	0.846 m



# IC2122 – Task 1c

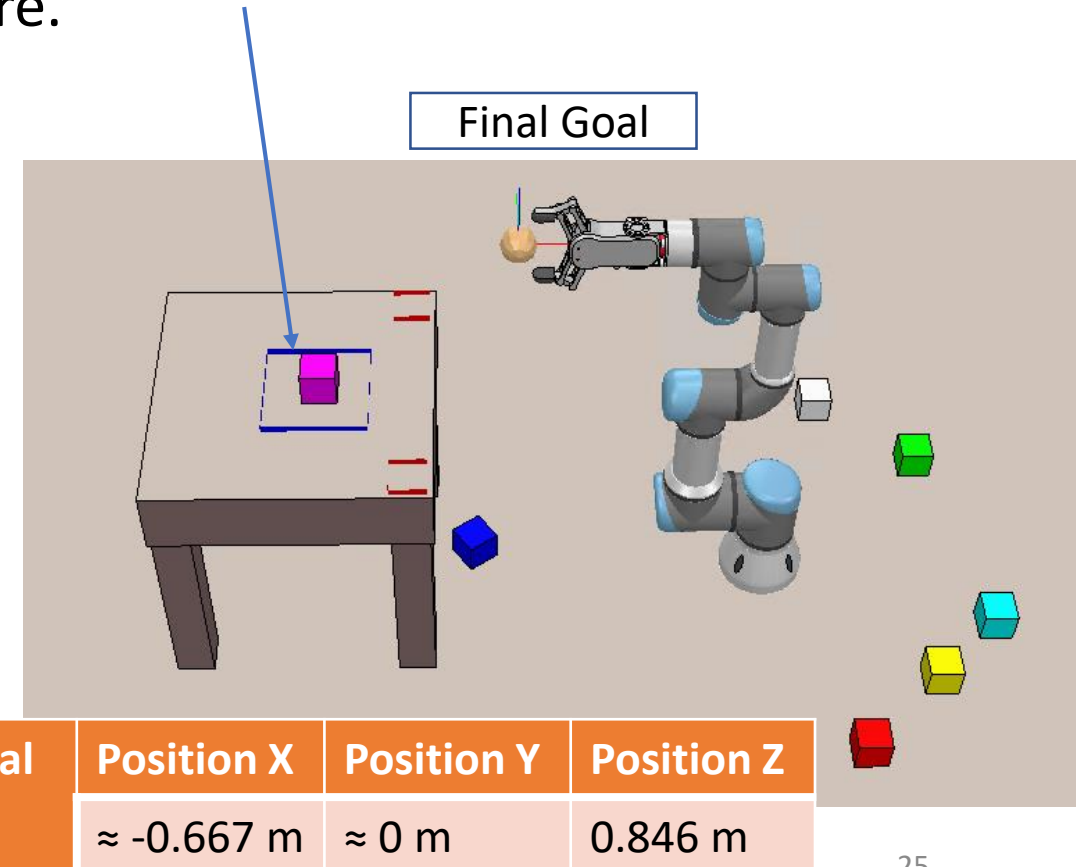
- Second chance (Failed for picking and placing BLUE block)
- Task 1c: **Place** the **PURPLE** block on the table (inside Blue colour area) using **Forward Kinematics** and write down the procedure.



- Arrive at **PURPLE** block:
  1. Click “**Home Position**”
  2. Click “**Joint Angle Configuration**” and input the following value and press enter

Base (Joint1)	<<	(W)	<	>	(Q)	>>	-10.0	deg
Shoulder (Joint2)	<<	(S)	<	>	(A)	>>	+15.0	deg
Elbow (Joint3)	<<	(X)	<	>	(Z)	>>	+100.01	deg
Wrist 1 (Joint4)	<<	(R)	<	>	(E)	>>	-22.98	deg
Wrist 2 (Joint5)	<<	(F)	<	>	(D)	>>	-90.0	deg
Wrist 3 (Joint6)	<<	(V)	<	>	(C)	>>	-10.0	deg

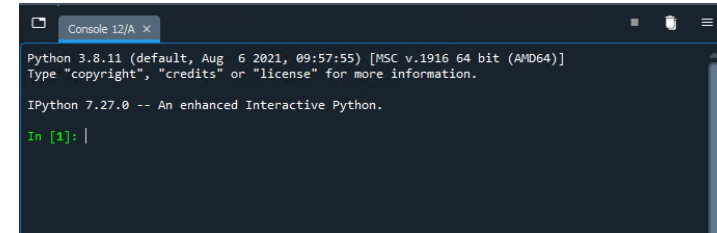
Final Goal

A 3D simulation of a robotic arm with blue joints and a grey base. The arm is positioned over a table. A purple block is on the table, highlighted by a blue dashed box. A blue arrow points from the text "Final Goal" to this box. Other colored blocks (orange, white, green, blue, yellow, red) are scattered on the floor. A table at the bottom shows the final position of the purple block.

PURPLE Block final Position:	Position X	Position Y	Position Z
	≈ -0.667 m	≈ 0 m	0.846 m

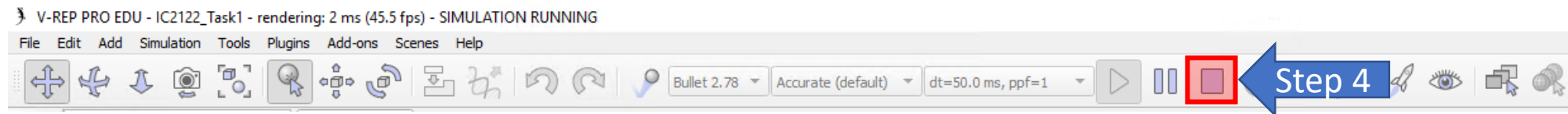
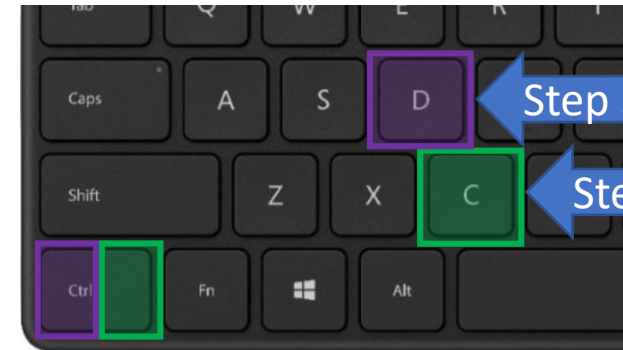
# Task1 – Troubleshoot

- Step 1: **Switch** to the Spyder IPython Console

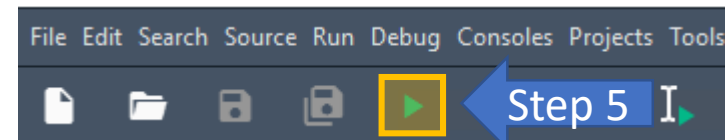


← Step 1

- Step 2: **Stop** the program by **holding** “Ctrl” and **clicking** “C”
- Step 3: **Open** a new console by **holding** “Ctrl” and **clicking** “D”
- Step 4: **Stop** the V-REP simulation



- Step 5: **Run** the program at Spyder



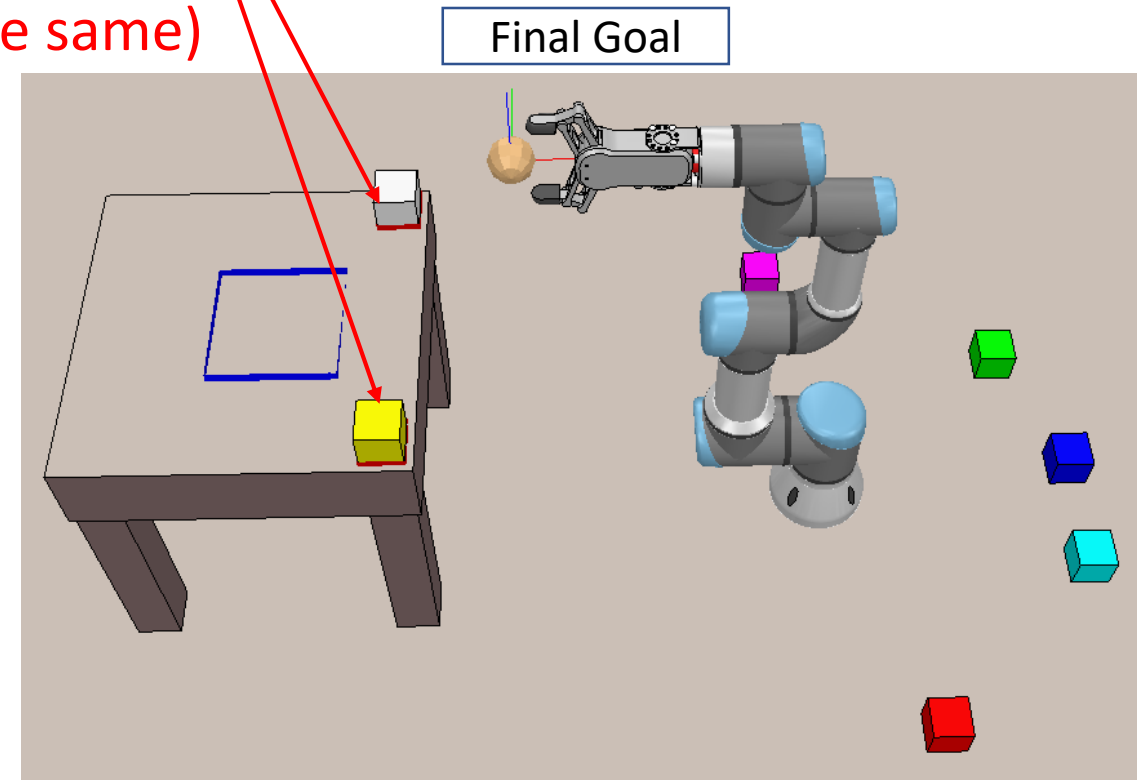


# IC2122 – Additional Task (optional)

- Place the **RED** and **WHITE** block on the table (red colour area) using **Forward Kinematics**.

(Remark: The position and orientation should be same)

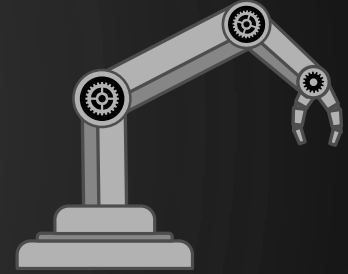
<b>WHITE</b> Block original Position:	Position X	Position Y	Position Z
	0.125 m	+0.325 m	0.435 m
<b>Yellow</b> Block original Position:	Position X	Position Y	Position Z
	0.25 m	-0.225 m	0.435 m
<b>WHITE</b> Block final Position:	Position X	Position Y	Position Z
	-0.54 m	-0.165 m	0.846 m
<b>Yellow</b> Block final Position:	Position X	Position Y	Position Z
	-0.54 m	+0.165 m	0.846 m





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# Q&A

