RAMNIRANJAN JHUNJHUNWALA COLLEGE
GHATKOPAR (W), MUMBAI - 400 086

DEPARTMENT OF
INFORMATION TECHNOLOGY

2021 - 2022

M.Sc. (I.T.) Part II (Sem - 3)

Subject: Robotics

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Hindi Vidya Prachar Samiti's

RAMNIRANJAN JHUNJHUNWALA COLLEGE

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CERTIFICATE

This is to certify that **Miss. Sneha Ramchandra Pawar** with Roll No. **18** has successfully completed the necessary course of experiments in the subject of **Robotics** during the academic year **2021 – 2022** complying with the requirements of **RAMNIRANJAN JHUNJHUNWALA COLLEGE OF ARTS, SCIENCE AND COMMERCE**, for the course of **M.Sc. (IT) Part II Semester – III.**

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Internal Examiner **External Examiner**

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Head Of Department **College Seal**

Index

RoboAnalyzer software – Introduction

RoboAnalyzer, a 3D model-
based software, can be used to teach robotics subjects to undergraduate and postgraduate courses in engineering colleges in India and elsewhere. It can be used to learn DH parameters,

kinematics and dynamics of serial robots and allows 3D animation and graph plots as output.

MINIMUM SYSTEM REQUIREMENT

- Processor: Atleast 1.5 GHz
- RAM: Atleast 512 MB
- Operating System: Windows XP, Windows Vista, Windows 7
- Dependencies: Microsoft .Net 2.0 framework

INSTALLATION

RoboAnalyzer can be installed on a computer by downloading it from our website. The latest version of the software (version 5) is available for free at http://www.roboanalyzer.com . T

he following are the steps to install RoboAnalyzer: Step 1: Visit http://www.roboanalyzer.com Step 2: Click on Downloads tab Step 3: Click on RoboAnalyzer V5 (or latest version) to download a .zip file Step 4: A popup window will appear. Select the folder where the file has to be saved and click on Save Step 5: After downloading is complete, unzip RoboAnalyzer5.zip to any folder on your computer. Open the folder RoboAnalyzer5 Step 6: Double-click on RoboAnalyzer5.exe to start RoboAnalyzer.

MODEL A ROBOT

Double click on RoboAnalyzer4.exe starts RoboAnalyzer. By default, it shows a robot model (2-R). Users can select a robot from the options given at the left bottom corner of the application as shown in Figure 1. After selecting a robot model, users can modify the Denavit-Hartenberg (DH) parameters shown in the tabular form and the robot model updates automatically. A few industrial robots are also listed, when selected shows a 3D CAD model of the robot (Figure).

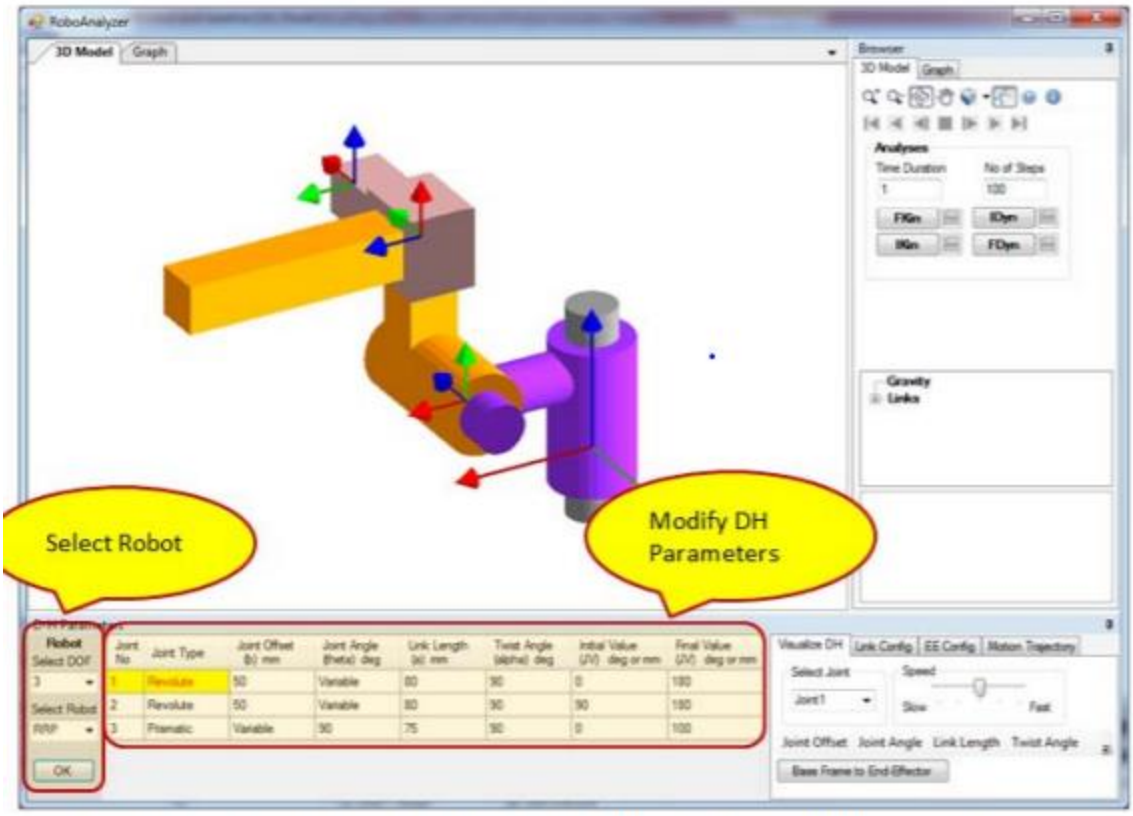


Figure 1: Select Robot Model and Redefine DH Parameters

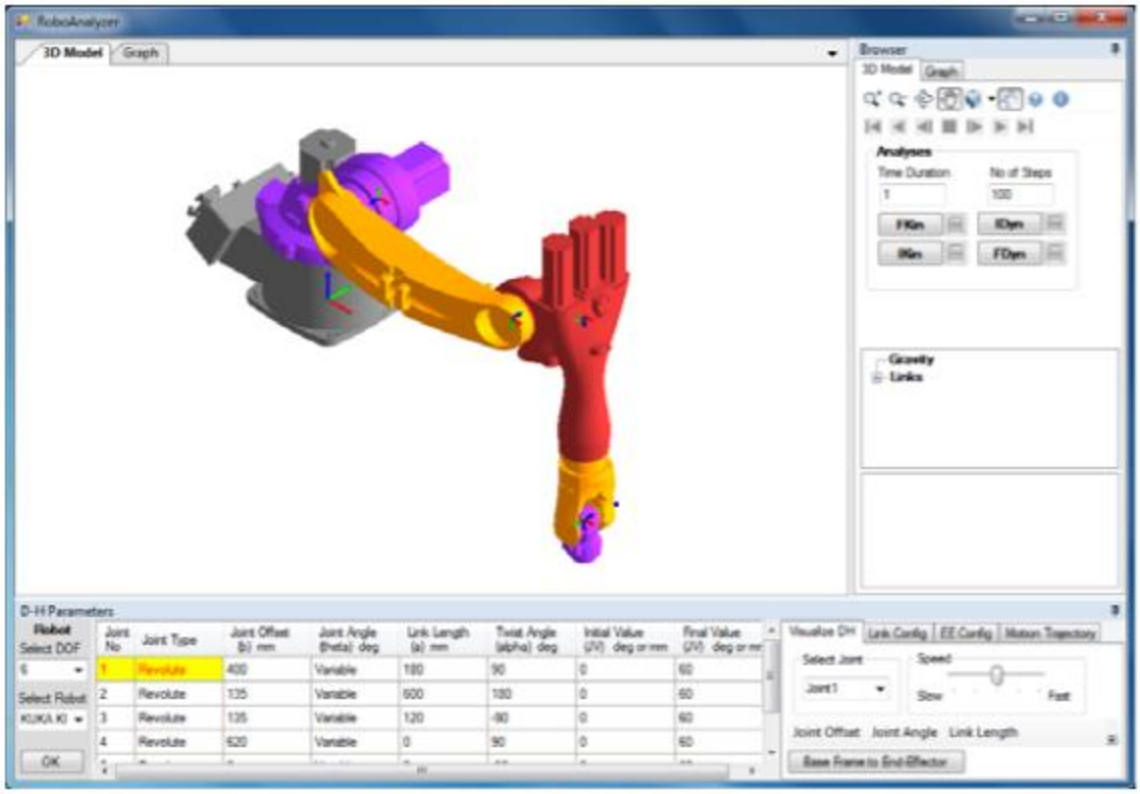


Figure2: 3D CAD Model of Industrial Robot

FEATURES OF ROBOANALYZER

RoboAnalyzer can be used to perform kinematic and dynamic analyses of serial chain robots/manipulators. The following are the main features of RoboAnalyzer:

- DH Parameter Visualization
- Forward Kinematics
- Inverse Kinematics
- Inverse Dynamics
- Forward Dynamics
- Motion Planning

DH Parameters

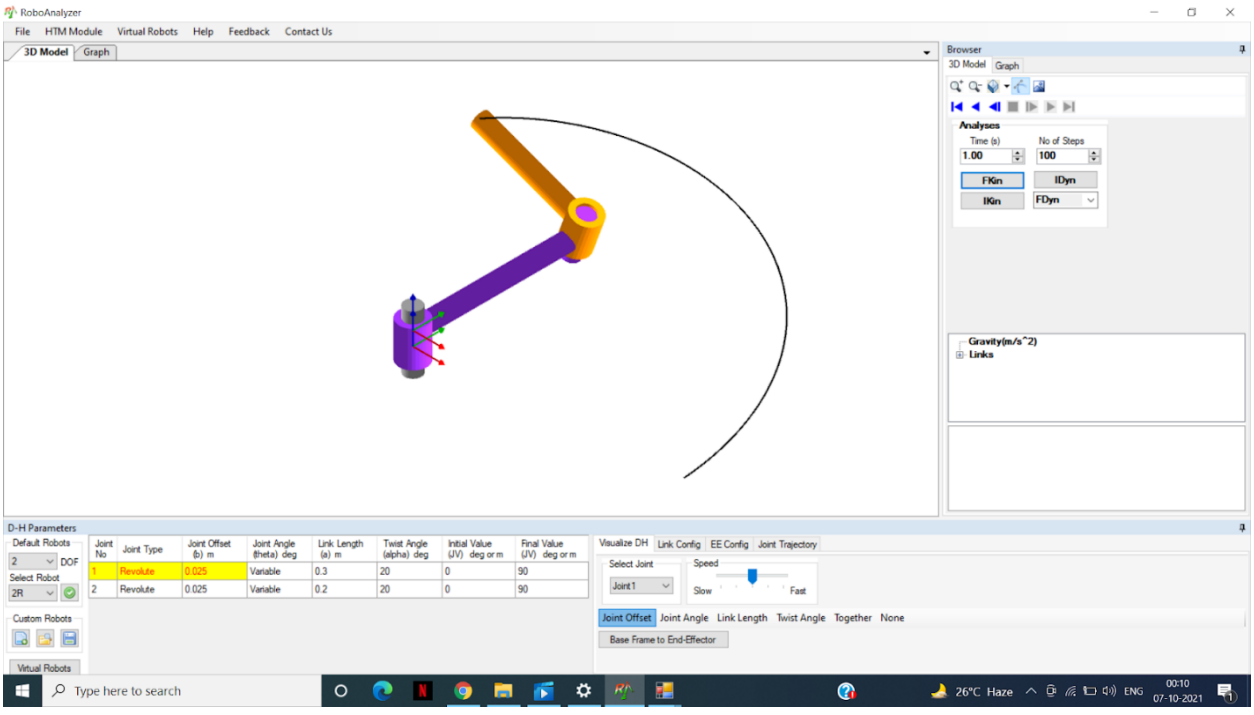
DH Parameters

Explain following DH Parameters –

- Joint offset
- Joint Angle
- Link Length
- Twist angle

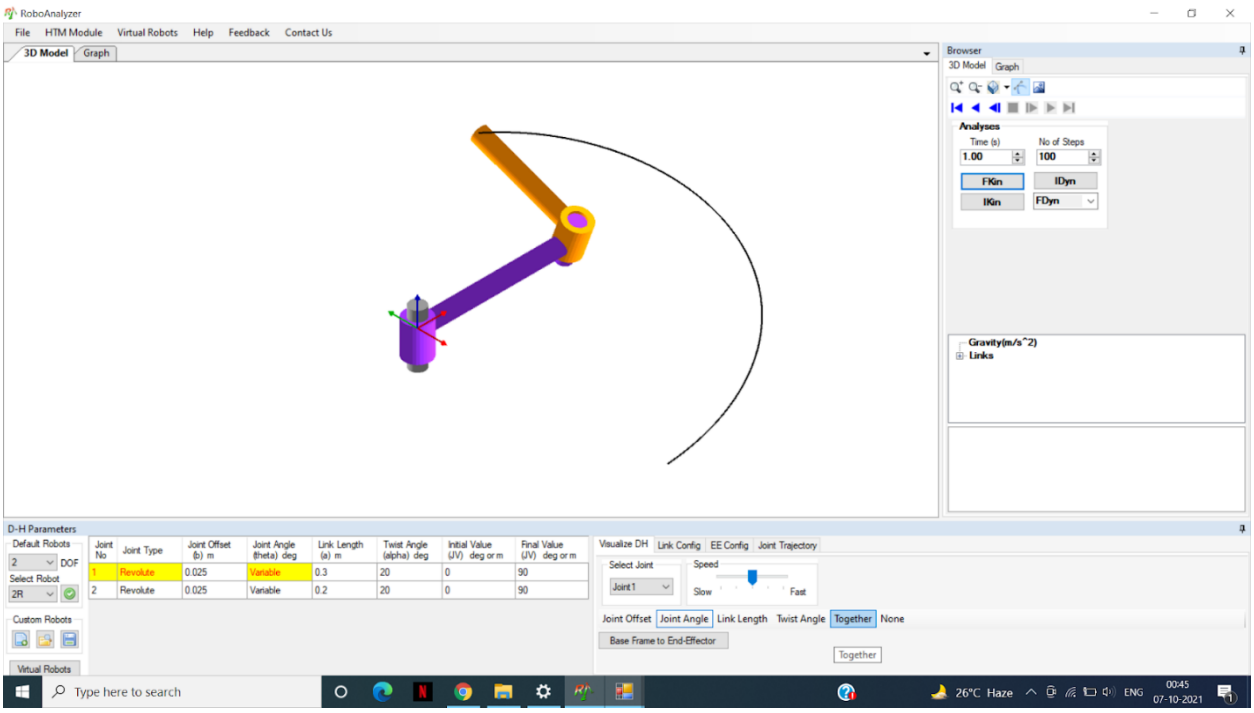
Joint offset

- When the joints in a pipe aren't properly aligned and the ends of two pipe segments, called joints, are offset from each other so much that the pipe leaks at that junction, they're called offset joints.
- Offset joints can result in decreased pressure in the pipes because of friction losses.



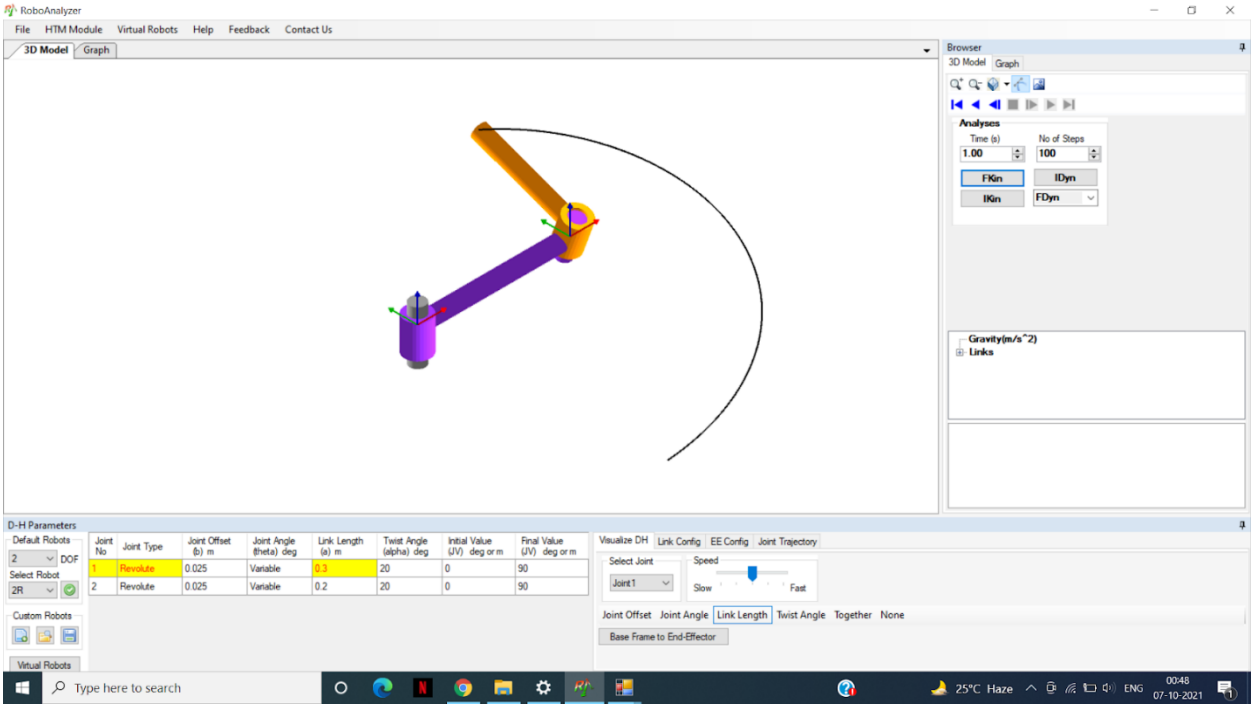
Joint Angle

The joint angle is calculated as the clockwise angle that the link length ai−1 must be rotated to be colinear with link length ai . This corresponds to the right hand rule of a rotation of link length ai−1 about the directed joint axis.

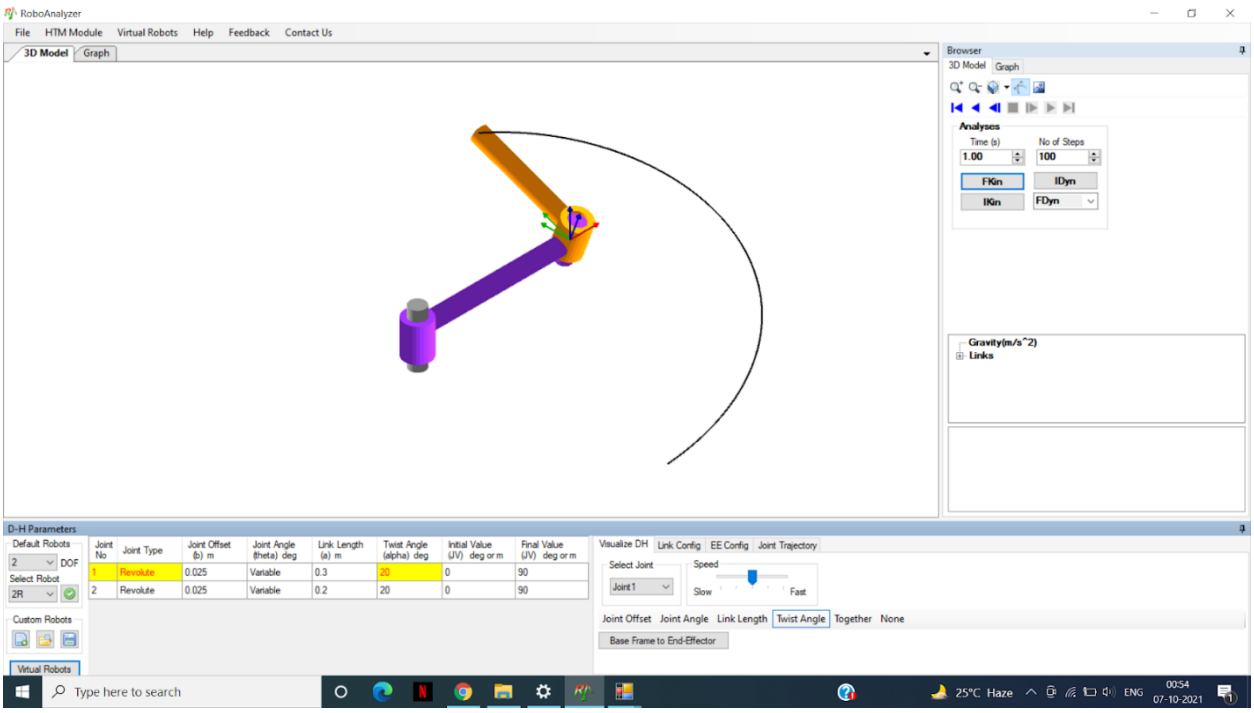


Link Length

- Suppose you're planning to design planar robot for example with revolute joints, then the links' lengths are **simply the distances between every neighboring two joints**.

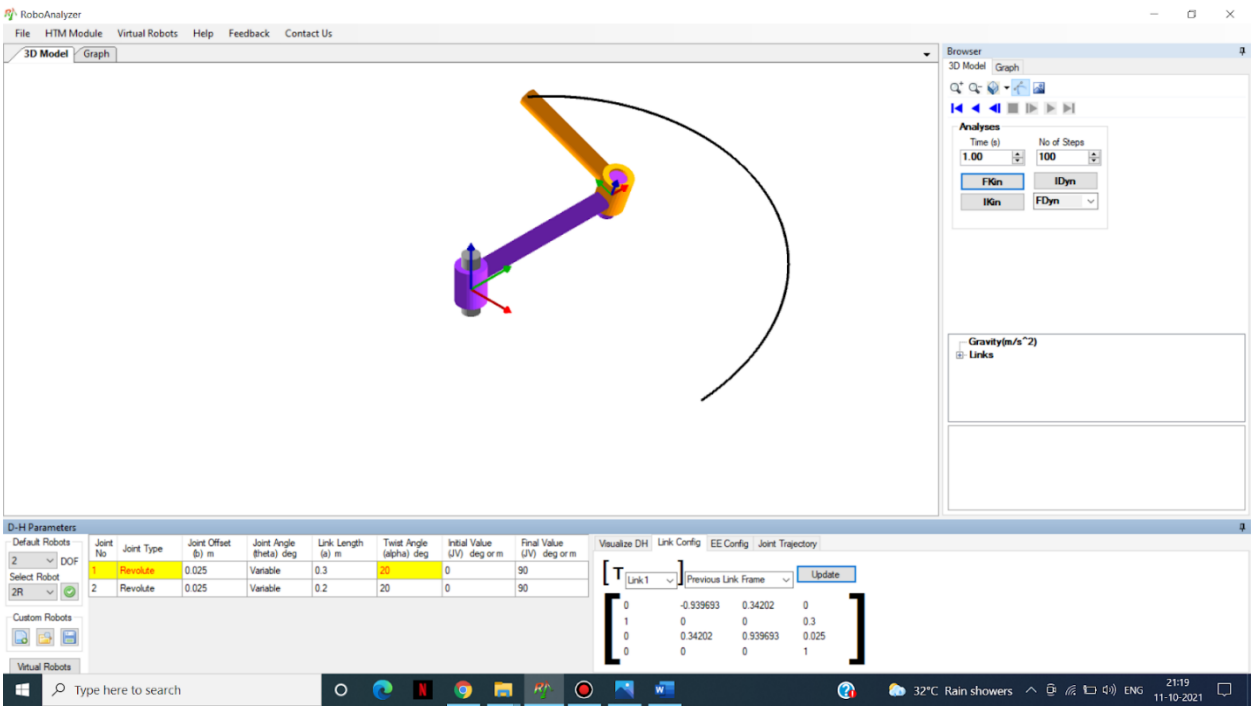


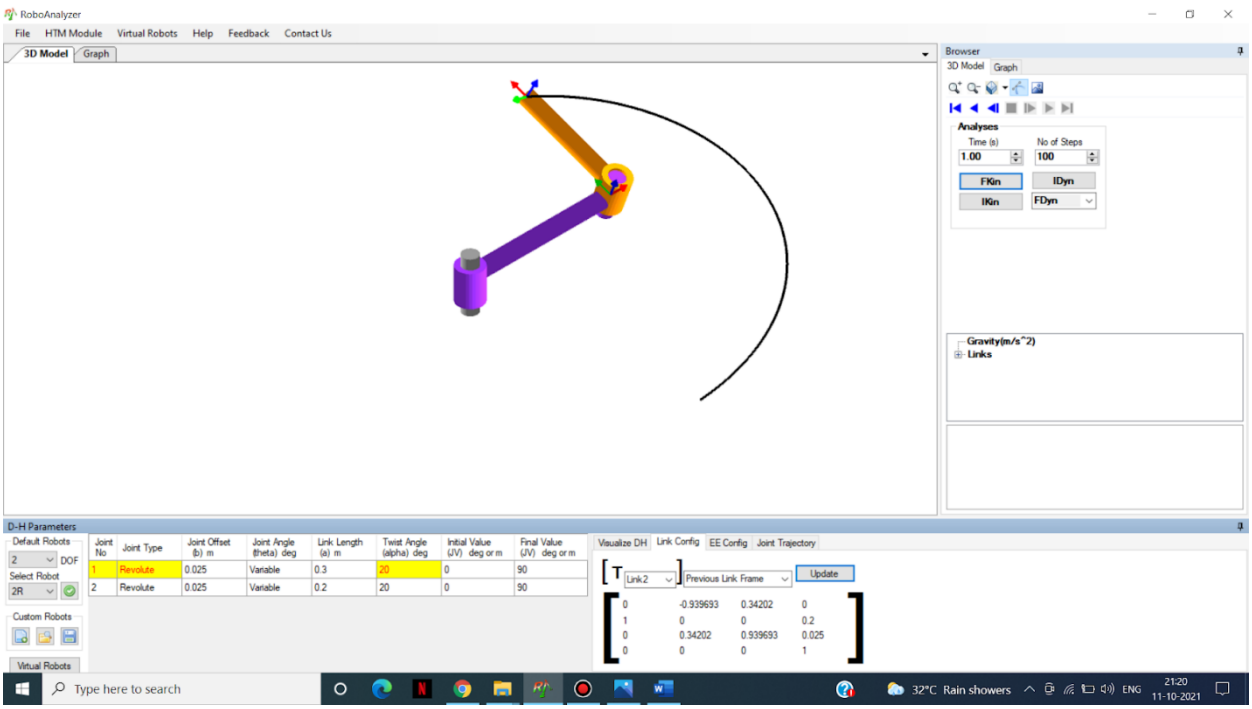
- **Twist angle**
- For a shaft under torsional loading, the angle through which fixed end of a shaft rotates with respect to the free end is called the angle of twist.



Create a simple robot with two links and two joints, both revolute. set the link to 0.3 m and 0.2 m respectively. Start with initial joint offset value of 0.025 and twist angle of 20 degrees.

Perform the forward kinematic analysis. Get the transformation matrix for link configuration.

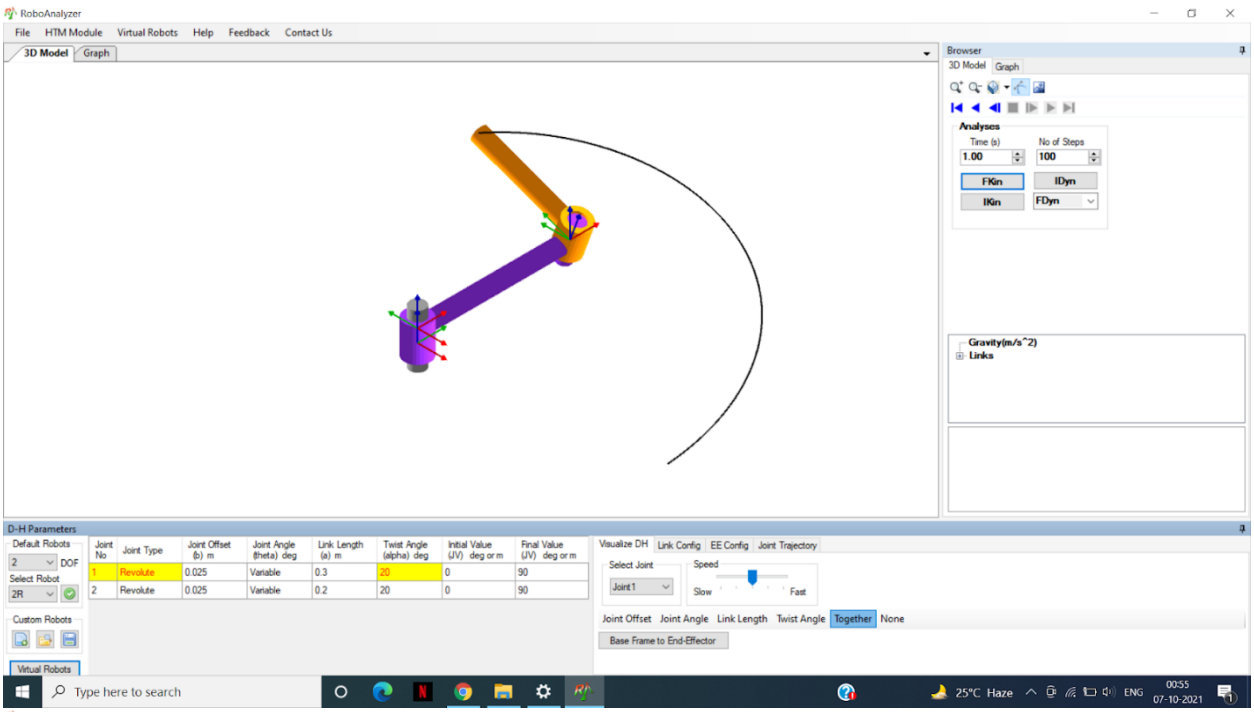




Trace the path traversed by the manipulator.

Visualize DH parameters and attach snap shots of the output.

https://drive.google.com/file/d/1zVQ46d55IQYuWv_YCGZkkOV3RF1gI8rK/view?usp=sharing


RoboAnalyzer
File HTM Module Virtual Robots Help Feedback Contact Us
3D Model Graph
Browser
3D Model Graph
Analyses
Time (s) 1.00
No of Steps 100
FKin IDyn
IKin FDyn
Gravity(m/s^2)
Links
D-H Parameters
Default Robots
2 DOF
Select Robot
2R
Custom Robots
Virtual Robots
Joint No | Joint Type | Joint Offset (b) m | Joint Angle (theta) deg | Link Length (a) m | Twist Angle (alpha) deg | Initial Value (JV) deg or m | Final Value (JV) deg or m
1 Revolute 0.025 Variable 0.3 20 0 90
2 Revolute 0.025 Variable 0.2 20 0 90
Visualize DH Link Config EE Config Joint Trajectory
Select Joint Joint1
Speed Slow Fast
Joint Offset Joint Angle Link Length Twist Angle Together None
Base Frame to End-Effector
Type here to search
25°C Haze
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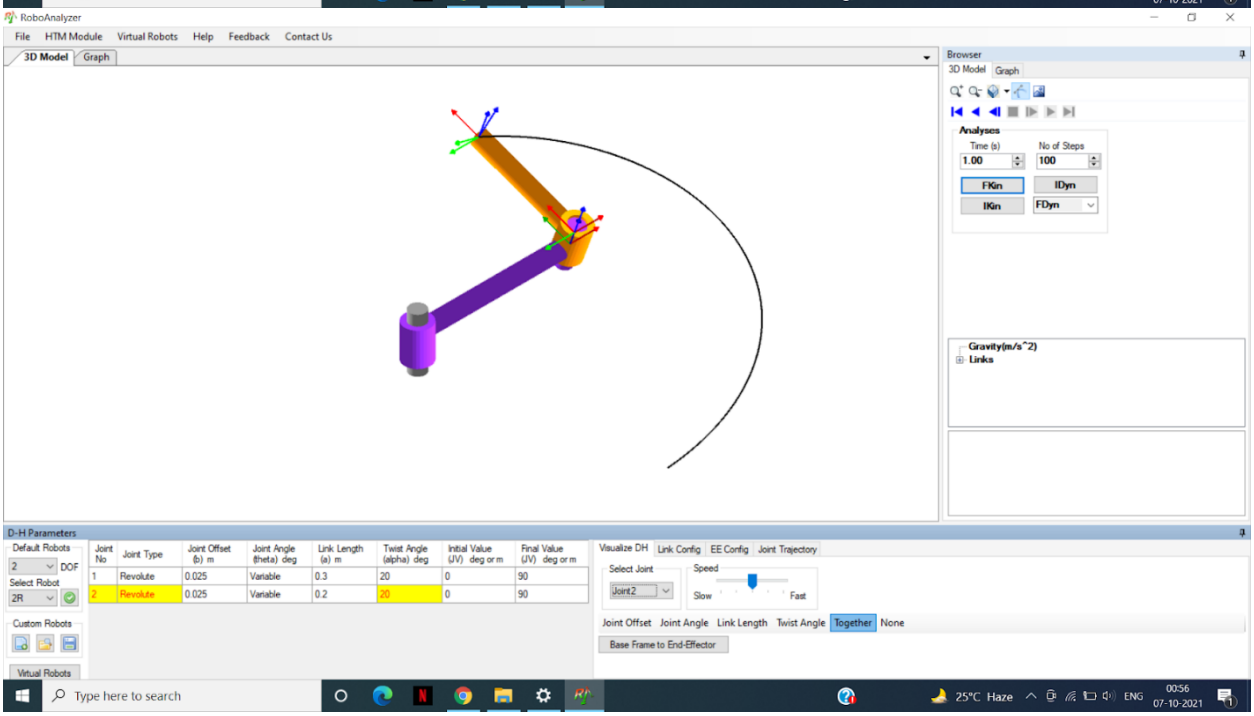
RoboAnalyzer
File HTM Module Virtual Robots Help Feedback Contact Us
3D Model Graph
Browser
3D Model Graph
Analyses
Time (s) 1.00
No of Steps 100
FKin IDyn
IKin FDyn
Gravity(m/s^2)
Links
D-H Parameters
Default Robots
2 DOF
Select Robot
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Custom Robots
Virtual Robots
Joint No | Joint Type | Joint Offset (b) m | Joint Angle (theta) deg | Link Length (a) m | Twist Angle (alpha) deg | Initial Value (JV) deg or m | Final Value (JV) deg or m
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2 Revolute 0.025 Variable 0.2 20 0 90
Visualize DH Link Config EE Config Joint Trajectory
Select Joint Joint2
Speed Slow Fast
Joint Offset Joint Angle Link Length Twist Angle Together None
Base Frame to End-Effector
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07-10-2021

RoboDk Software – Introduction

What is RoboDK ?

➔ RoboDK is an offline programming and simulation software for industrial robots. RoboDK is software for Simulation and Offline Programming. Offline Programming means that robot programs can be created, simulated and generated offline for a specific robot arm and robot controller. RoboDK can help you with manufacturing operations involving industrial robots. The simulation software can be used for many manufacturing projects including milling, welding, pick and place, packaging and labelling, palletizing, painting, robot calibration and more.

How to install RoboDk ?

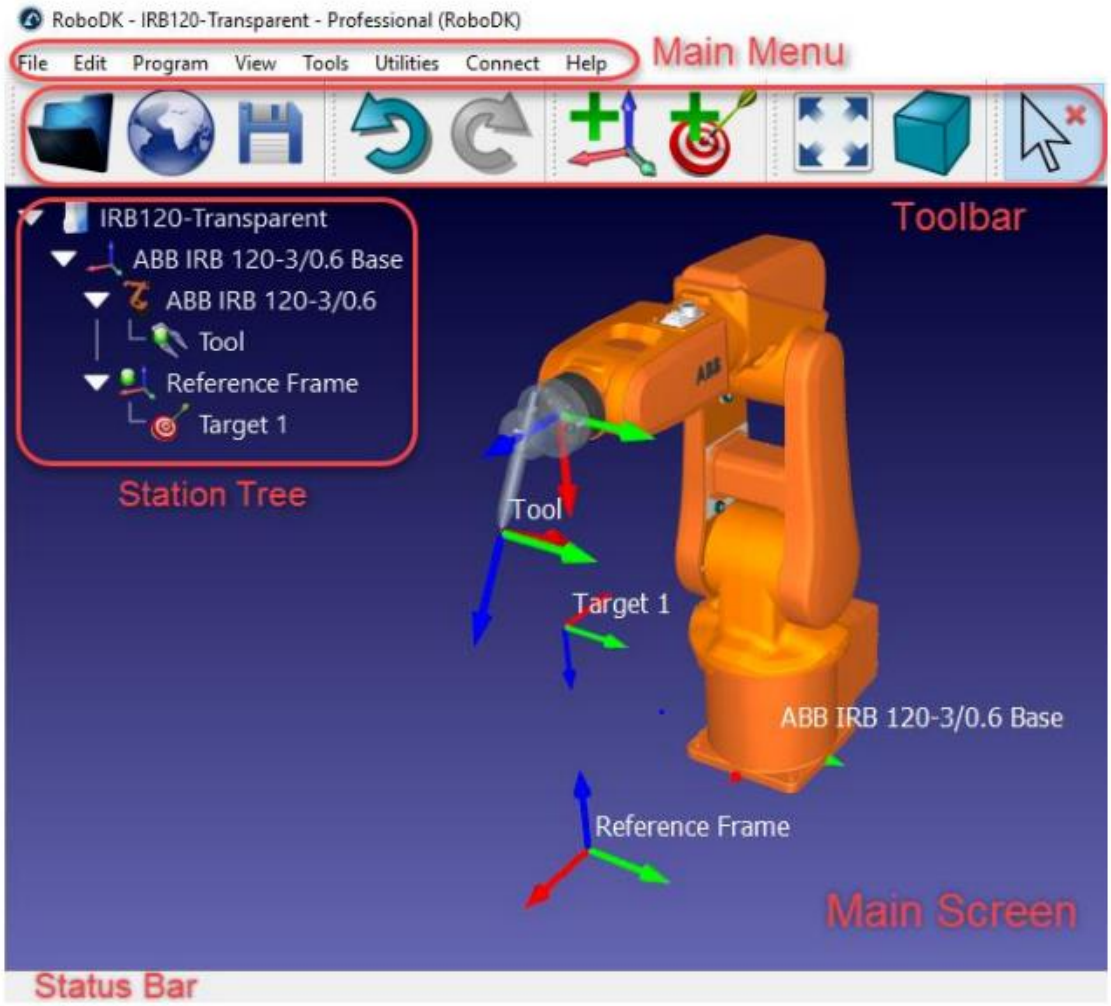
➔ 1) Visit the website https://robodk.com/download

➔ 2) Fill the Get the Download Form. And download the software.

➔ 3) Install the software.

➔ You will get to see the RoboDK shortcut on your desktop when RoboDK is installed from the website. Double click the shortcut to start RoboDK.

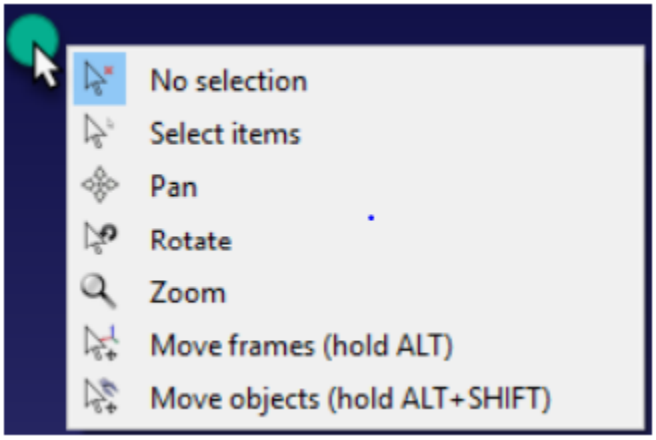
Basic Guide RoboDK is software for Simulation and Offline Programming. Offline Programming means that robot programs can be created, simulated and generated offline for a specific robot arm and robot controller. RoboDK can help you with manufacturing operations involving industrial robots. Tip: When you press F1 from RoboDK, the Help topic related to the selected item will be displayed. This document is a basic guide to the RoboDK documentation. The RoboDK documentation is based on the Windows version of RoboDK. Mac, Linux and Android versions are also available. You should see the RoboDK shortcut on your desktop when RoboDK is installed from our website. Double click the shortcut to start RoboDK. The RoboDK window contains a Main Menu, a Toolbar, a Status Bar and the Main Screen. The Station Tree in the Main Screen contains all the items available in the station, such as robots, reference frames, tools, programs, etc. More information available in the Interface Section. Select File→ Open to load one of the RoboDK station examples provided by default (RDK files). Alternatively, drag & drop a file to the RoboDK main screen to load it. A library of industrial robots is available online or directly from the RoboDK application.



3D Navigation It is recommended to use a 3-button mouse to navigate in 3D. Alternatively, you can use a combination of Ctrl, Alt and Shift keys with a simple mouse left click perform Pan, Rotate or Zoom motions.

Select	Pan	Rotate	Zoom
			
			
Left click	Hold mid button	Hold right click	Move mouse wheel
Hold Ctrl to select more than one object	Hold Ctrl + Alt and select	Hold Ctrl + Shift and select	Hold Shift and select

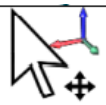
Tip: The default behavior for 3D mouse navigation can be changed in Tools→Options→General tab→Mouse 3D navigation. Right click on the main screen to see the same 3D navigation commands.



Tip: Right click on the toolbar area and check View and Selection toolbar to display these commands in the toolbar:

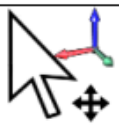
Toolbar Menu The RoboDK Toolbar contains graphical icons that allow quick access to frequently used actions in the menu. Tip: Select Tools→Toolbar Layout→Set Default Toolbar to set up the default toolbar. The following commands are available in the toolbar by default.

	**Open** Load a new file (RoboDK RDK Station) or a supported file type (robot, tool, STEP, IGES, STL, …)
	**Open online library** Show the online library (robots, tools and sample objects)
	**Save Station** Save the RoboDK station (RDK file)
	**Undo** Undo the last command (Ctrl+Z)
	**Redo** Redo the last command (Ctrl+Y)
	**Add a reference frame** Reference frames allow placing objects with respect to each other
	**Add a new target** Robot targets record robot positions with respect to a reference frame or in joint coordinates
	**Fit All** Update the 3D view to display all items
	**Isometric View** Display the default 3D isometric view

	**Move reference Frames** Move a reference frame by dragging it on the screen (hold Alt)
	**Move TCP (robot tool)** Move a robot TCP by dragging it on the screen (hold Alt+Shift)
	**Check collisions** Activate or deactivate collision checking. More information available regarding collision checking in the Collisions section
	**Fast simulation** Accelerate the simulation speed (hold the space bar)
	**Pause simulation** The simulation can be resumed by pressing the space bar
	**Add Program** Add a new robot program for simulation and program generation
	**Add Python Program** Add a new Python macro
	**Move Joint Instruction** Add a new joint movement instruction

	**Move Linear Instruction** Add a new linear movement instruction
	**Export Simulation** Export a program or simulation as a 3D PDF or 3D HTML file.

Shortcuts

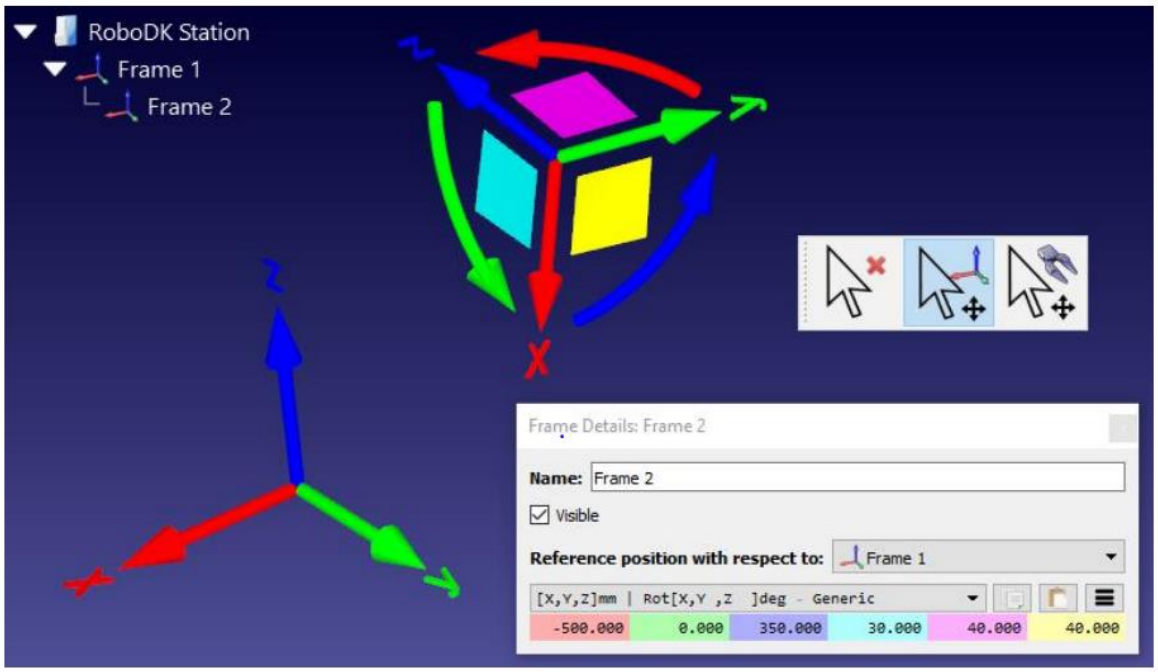
Alt		Move a reference frame
Alt+Shift		Move a TCP (tool)
F1		Show this help guide
F2		Rename item
F6		Generate selected program(s)
F7		Show/hide selected item(s)
Alt+0 Ctrl+1		Fit to selected item(s) Load last file or RoboDK station
/		Show/hide text on screen
+		Make Reference frames bigger
–		Make Reference frames smaller
*		Show/hide robot workspace

Tip: Press the + key or – key multiple times to make the reference frames bigger or smaller respectively. Setting an appropriate size of the reference frames helps grabbing them properly when they are moved using the Alt key.

Reference Frames

A Reference Frame defines the location of an item with respect to another item with a given position and orientation. An item can be an object, a robot or another reference frame. All Offline Programming applications require defining a reference frame to locate the object with respect to a robot to update the simulation accordingly. Drag & drop any reference frame or object within the Station Tree to define a specific relationship, such as the nested reference frame shown in the following image. It is common to define the location of one or more reference frames with respect to the robot by touching 3 points. This allows placing objects in the virtual space. The procedure can be accomplished using the robot teach pendant or RoboDK (more information available in the Calibrate Reference Frame section). Tip: Hold the Alt key to move reference frames with respect to each other. Alternatively, select the

corresponding button in the toolbar: . With RoboDK it is possible to manually enter the translation and rotation values, including different rotation orders of the Euler angles.

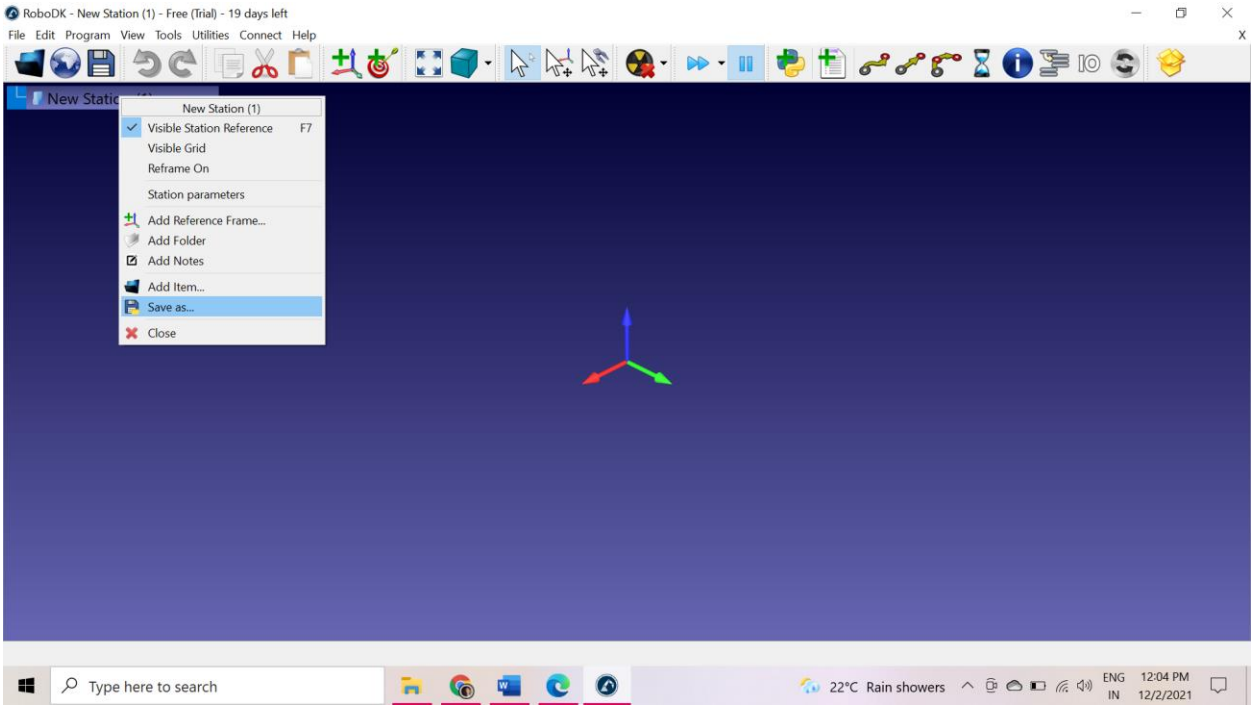


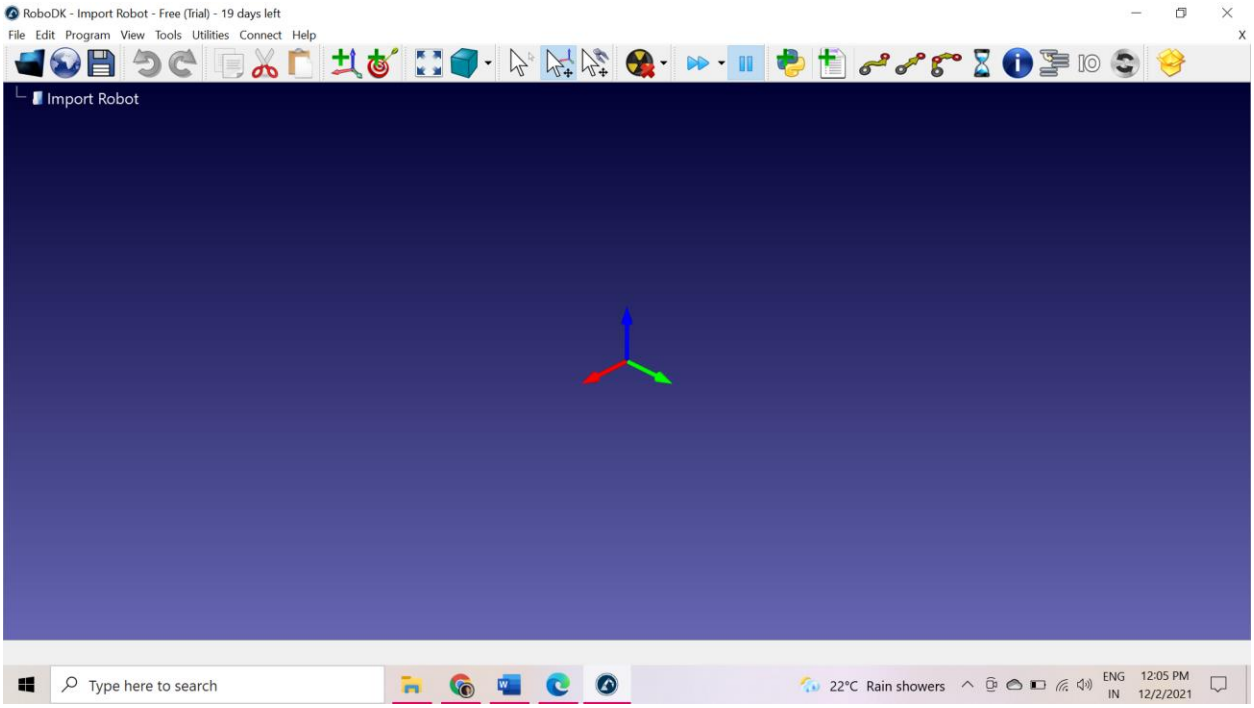
Importing Robot – Import UR10e Robot.

How to import Robot in RoboDK ?

➔ Open RoboDK.

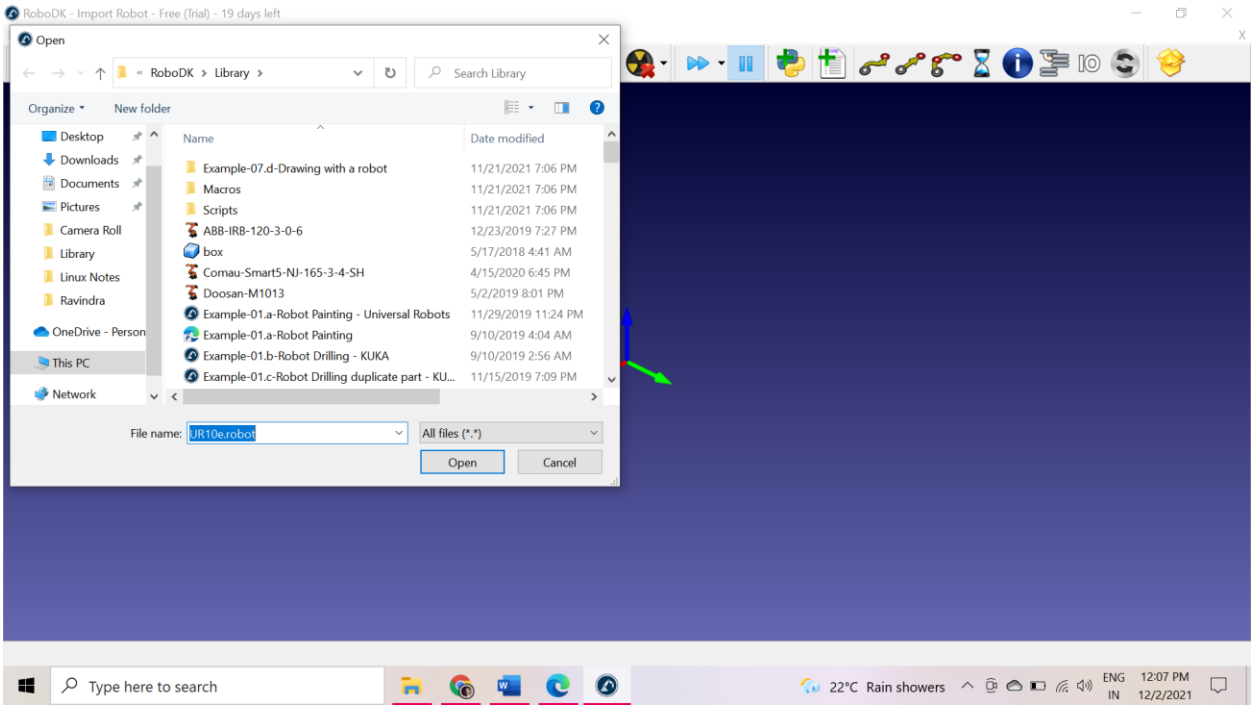
➔ In that right click on New Station and save it as Import Robot.



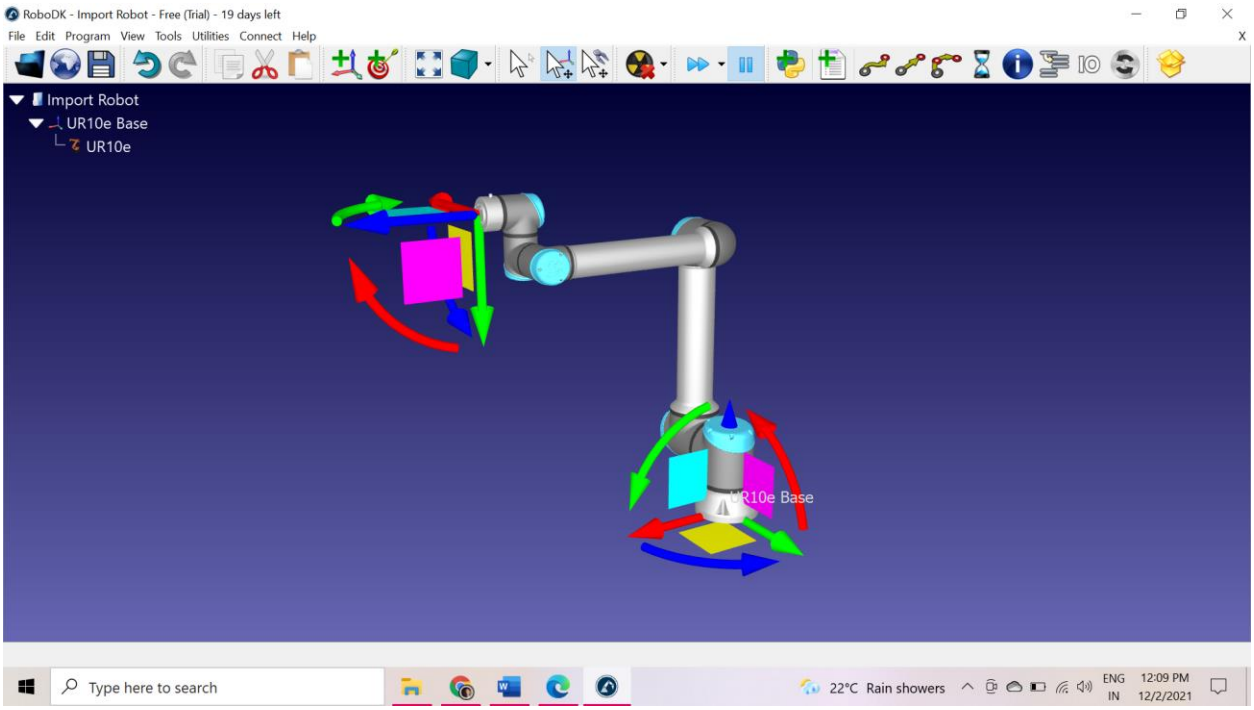


➔ You can Import the Robot by 2 ways.

➔ Click on File – Open, and select the robot which you want to import. And click on open.

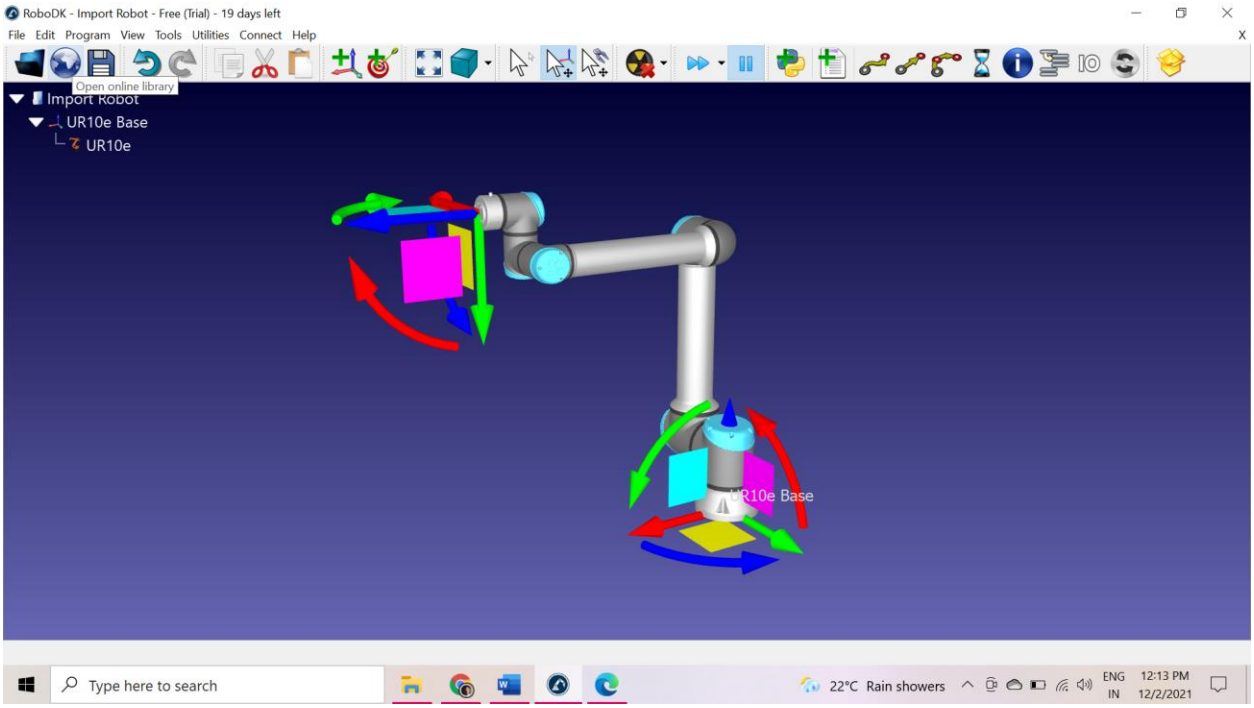


➔ The robot will get imported on the base frame of reference.



➔ If the robot which you want to import is not there in RoboDKs default library, then you can download it from RoboDK Online Library.

➔ Click on Open Online Library. And there you can filter the robot based on various categories. Then select the robot and click on Download.


RoboDK - Import Robot - Free (Trial) - 19 days left
File Edit Program View Tools Utilities Connect Help
Open online library
Import Robot
UR10e Base
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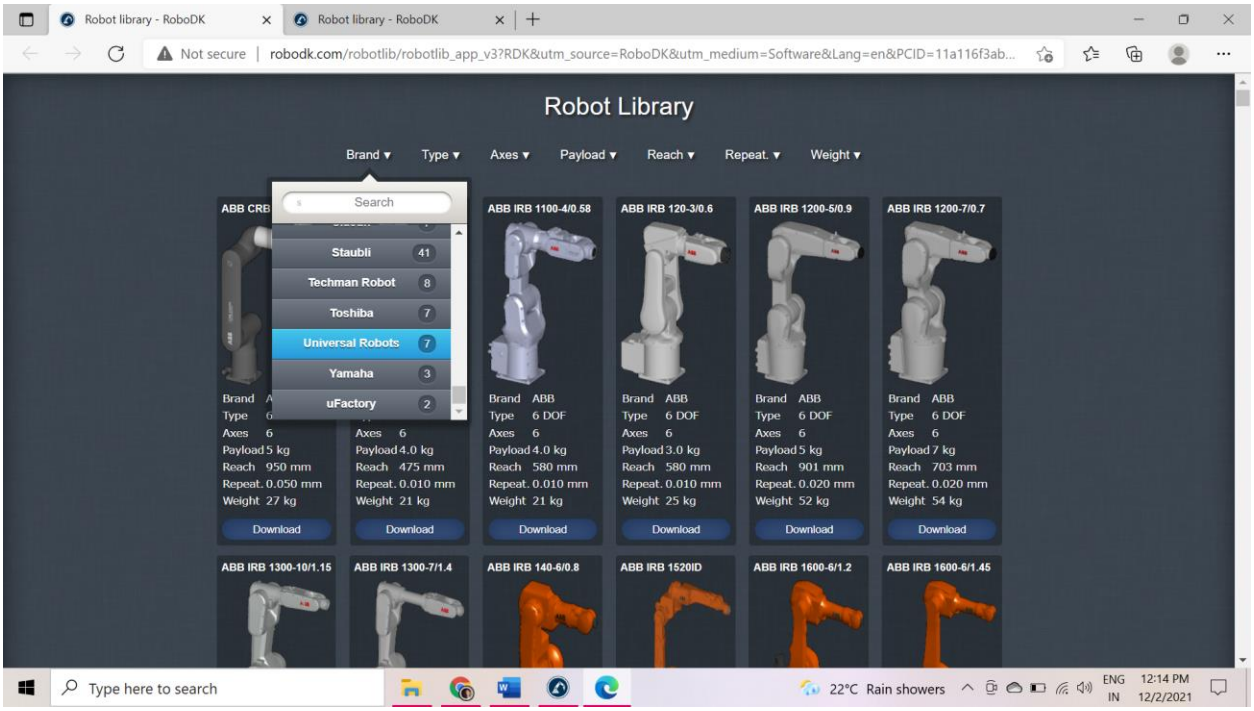
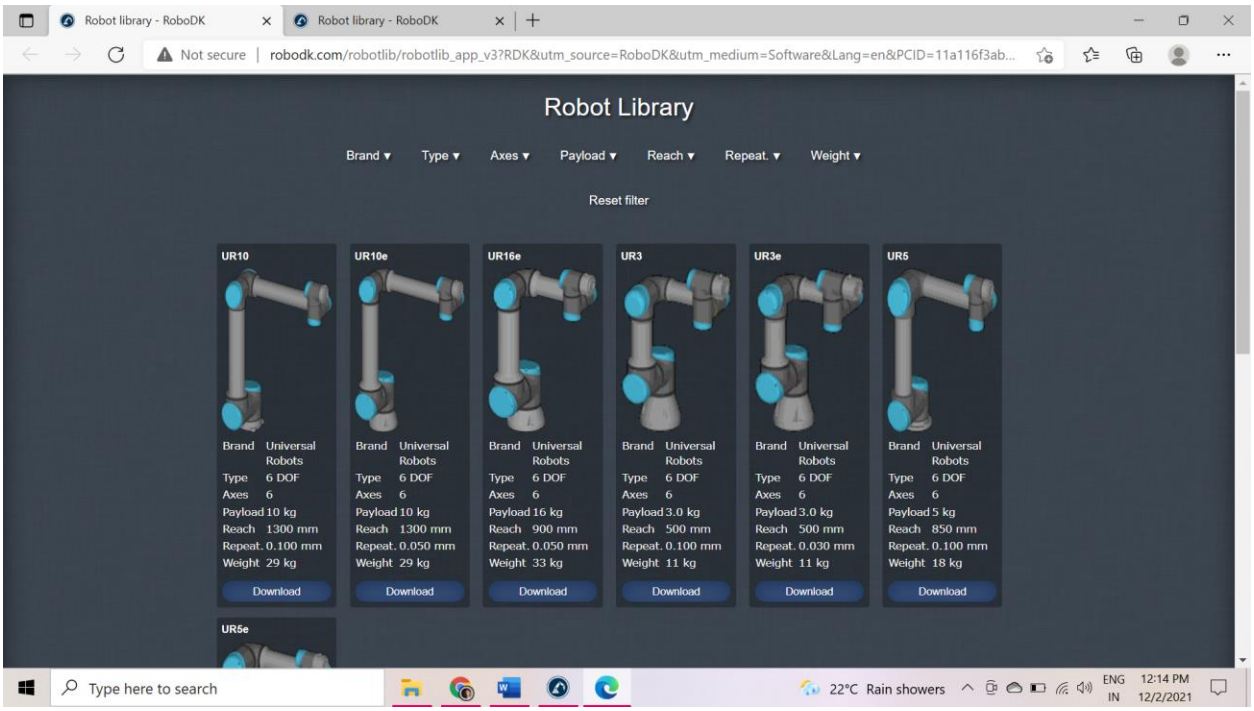
UR10e Base
Type here to search
22°C Rain showers
ENG IN
12:13 PM
12/2/2021

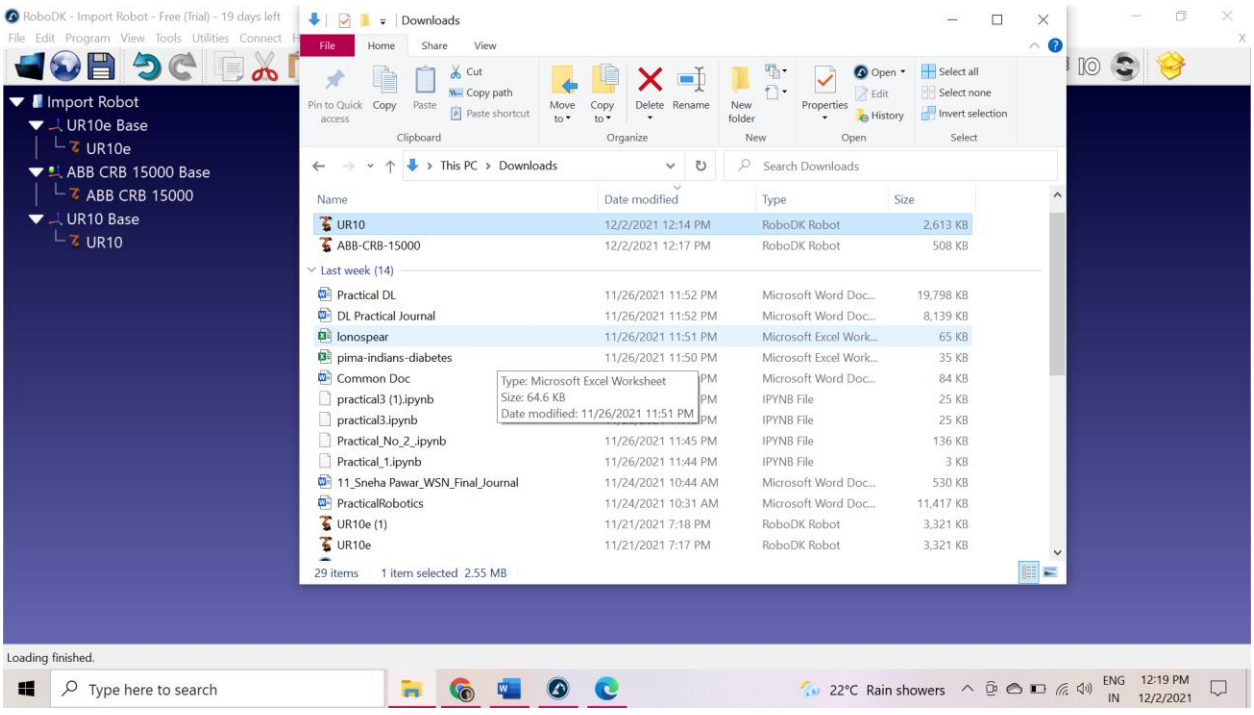

Robot library - RoboDK
Robot library - RoboDK
Not secure | robodk.com/robotlib/robotlib_app_v3?RDK&utm_source=RoboDK&utm_medium=Software&Lang=en&PCID=11a116f3ab...
Robot Library
Brand ▾ Type ▾ Axes ▾ Payload ▾ Reach ▾ Repeat. ▾ Weight ▾
Search
Staubli 41
Techman Robot 8
Toshiba 7
Universal Robots 7
Yamaha 3
uFactory 2
ABB IRB 1100-4/0.58
ABB IRB 120-3/0.6
ABB IRB 1200-5/0.9
ABB IRB 1200-7/0.7
Brand ABB
Type 6 DOF
Axes 6
Payload 4.0 kg
Reach 580 mm
Repeat. 0.010 mm
Weight 21 kg
Download
Brand ABB
Type 6 DOF
Axes 6
Payload 3.0 kg
Reach 580 mm
Repeat. 0.010 mm
Weight 25 kg
Download
Brand ABB
Type 6 DOF
Axes 6
Payload 5 kg
Reach 901 mm
Repeat. 0.020 mm
Weight 52 kg
Download
Brand ABB
Type 6 DOF
Axes 6
Payload 7 kg
Reach 703 mm
Repeat. 0.020 mm
Weight 54 kg
Download
ABB IRB 1300-10/1.15
ABB IRB 1300-7/1.4
ABB IRB 140-6/0.8
ABB IRB 1520ID
ABB IRB 1600-6/1.2
ABB IRB 1600-6/1.45
Type here to search
22°C Rain showers
ENG IN
12:14 PM
12/2/2021



➔ The robot will get downloaded. But the downloaded robot will not directly get added into the RoboDK default library.

➔ If you double click on the downloaded robot then that robot will be available in the Station in RoboKD.

➔ Or else you can drag and drop the Robot in RoboDK to add it in station.



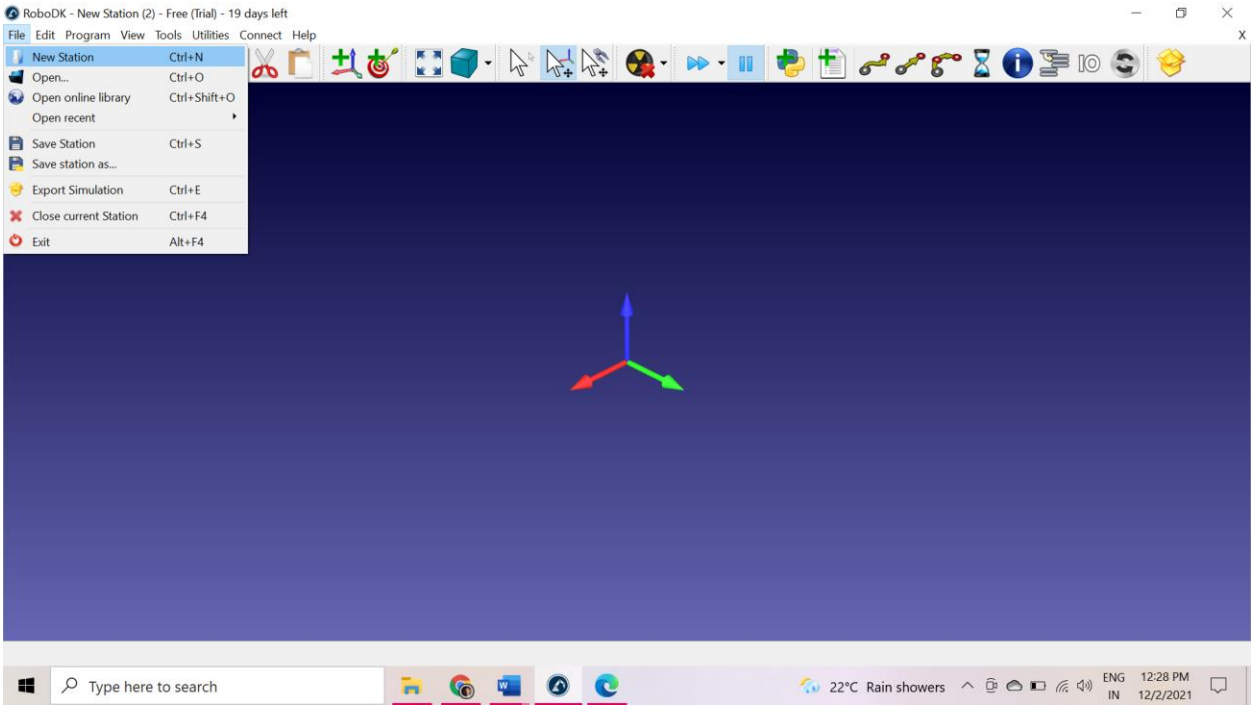
Adding Frame of Reference.

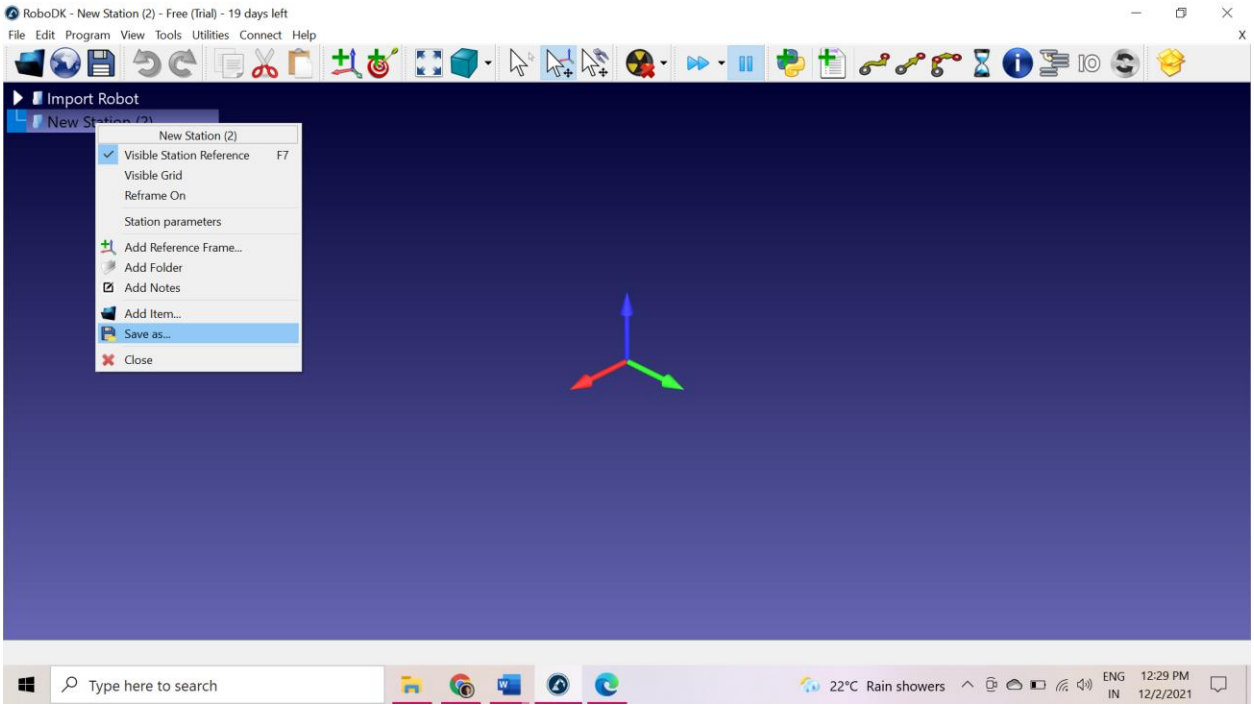
What is Frame of Reference: -

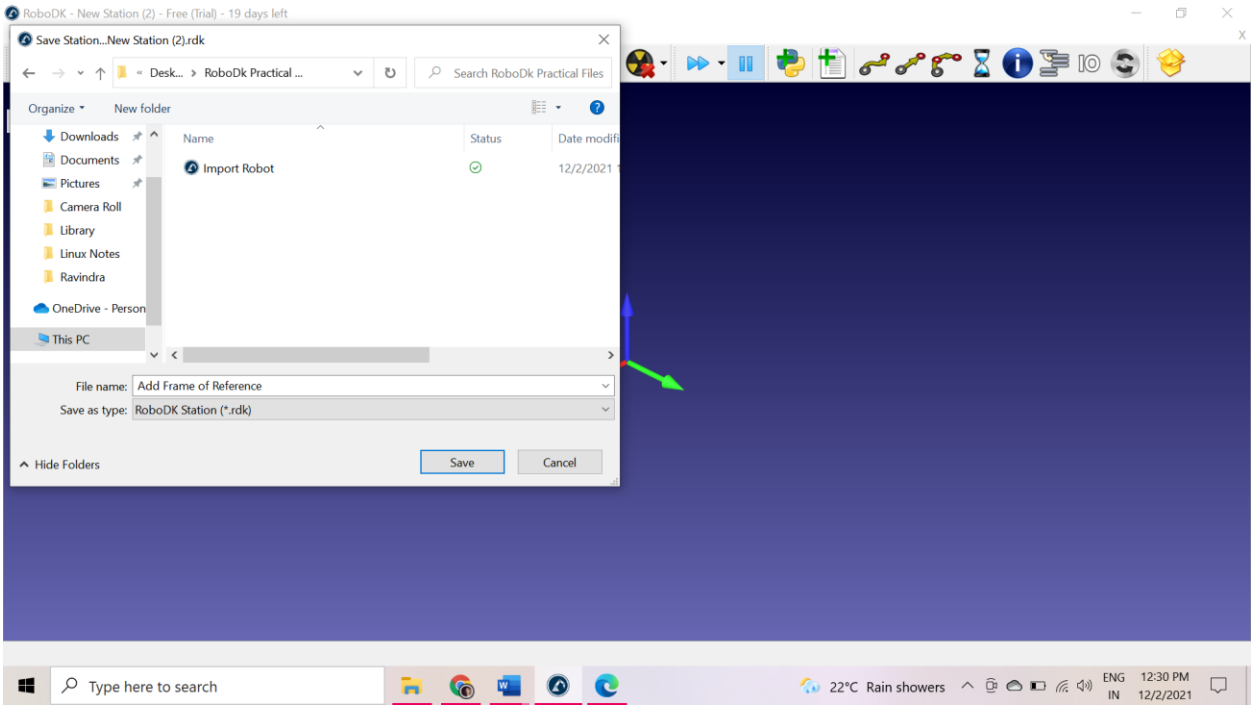
An arbitrary set of axes with reference to which the position or motion of something is described or physical laws are formulated.

How to add Frame of Reference in RoboDK ?

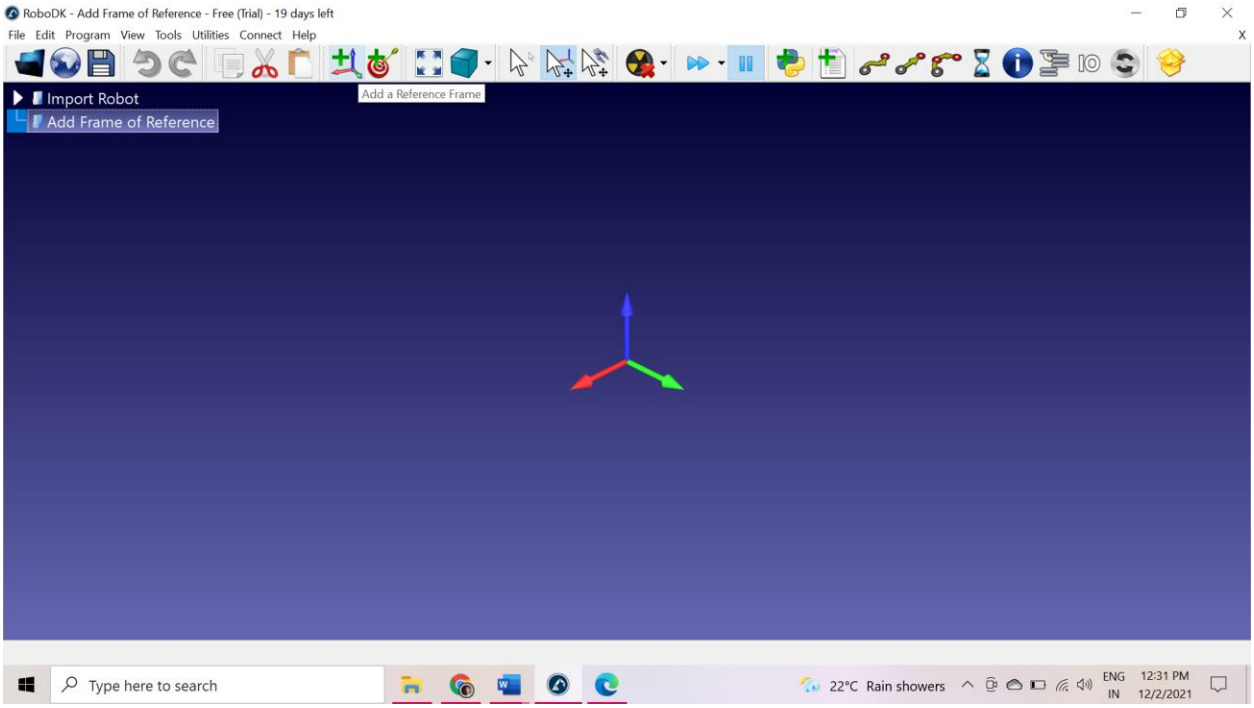
➔ Open RoboDK.
➔ In that File – New Station, to add a new Station.
➔ After that right click on New Station – Save it as Add Frame of Reference.

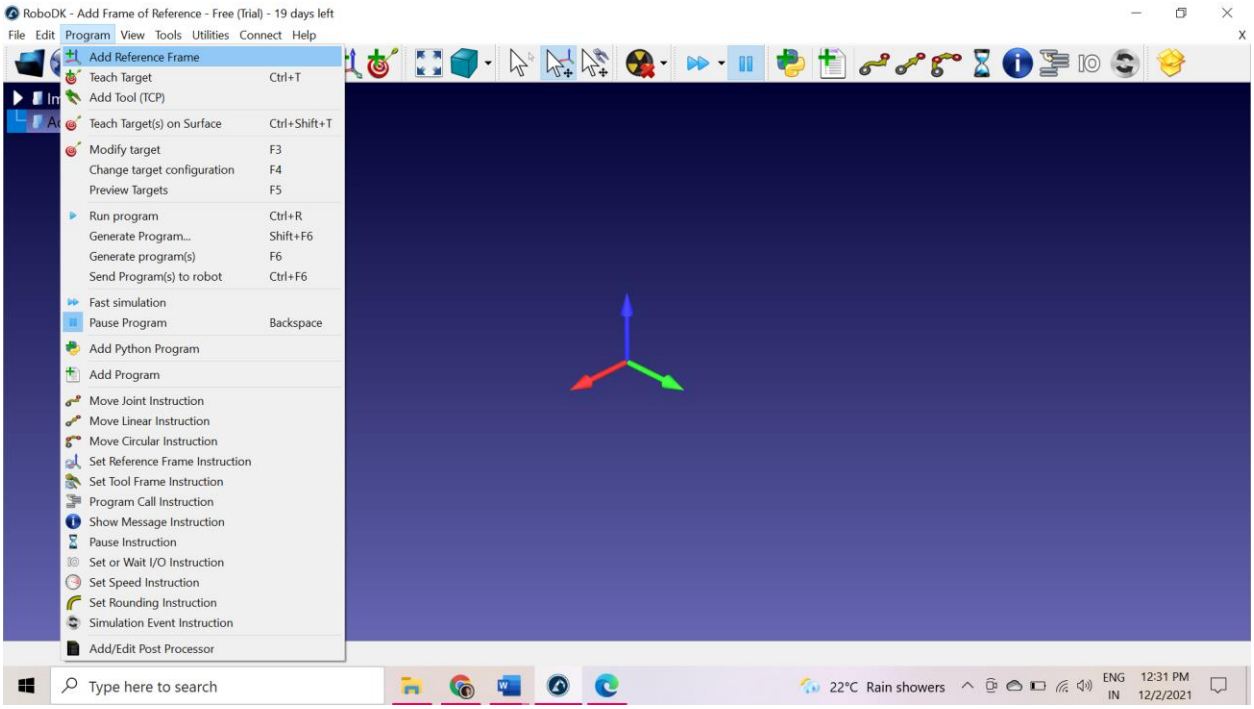




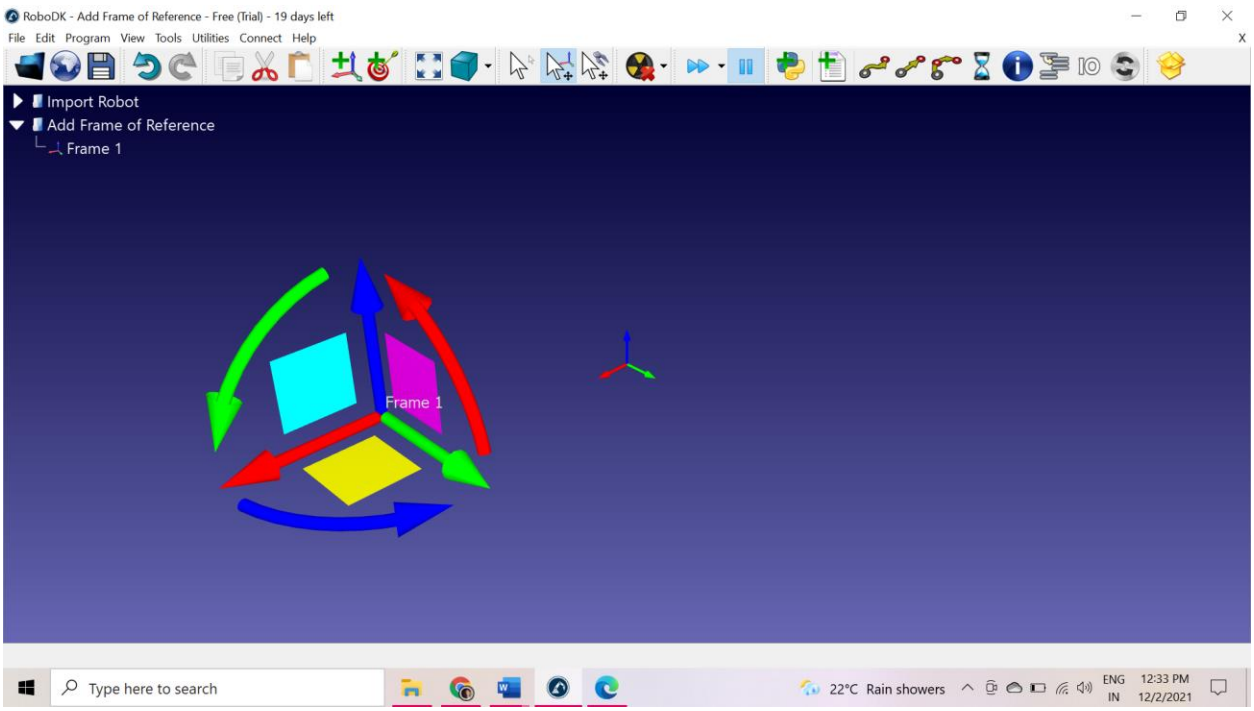


➔ To add a reference frame Click on Add a Reference Frame or in Program select Add a Reference Frame.





➔ A new Frame of Reference will get added.


RoboDK - Add Frame of Reference - Free (Trial) - 19 days left
File Edit Program View Tools Utilities Connect Help
Import Robot
Add Frame of Reference
Frame 1
Frame 1
Type here to search
22°C Rain showers
ENG
IN
12:33 PM
12/2/2021

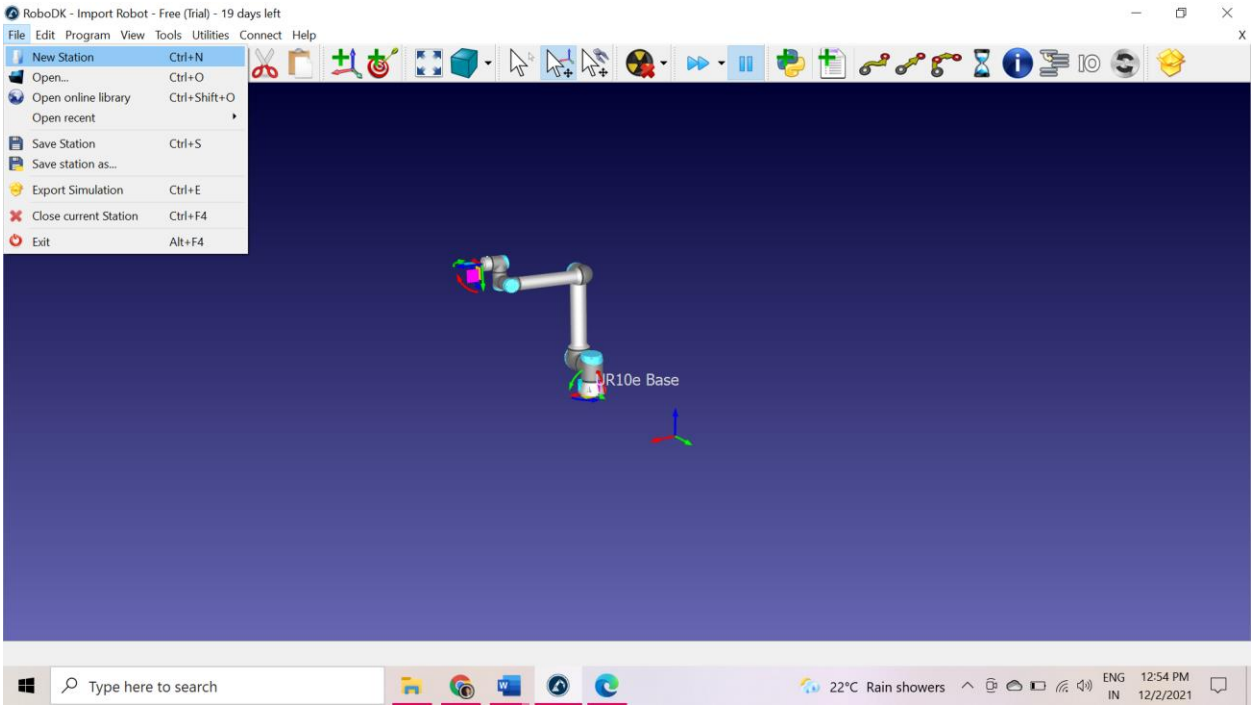
Importing a Tool – Import a Paint Gun Tool.

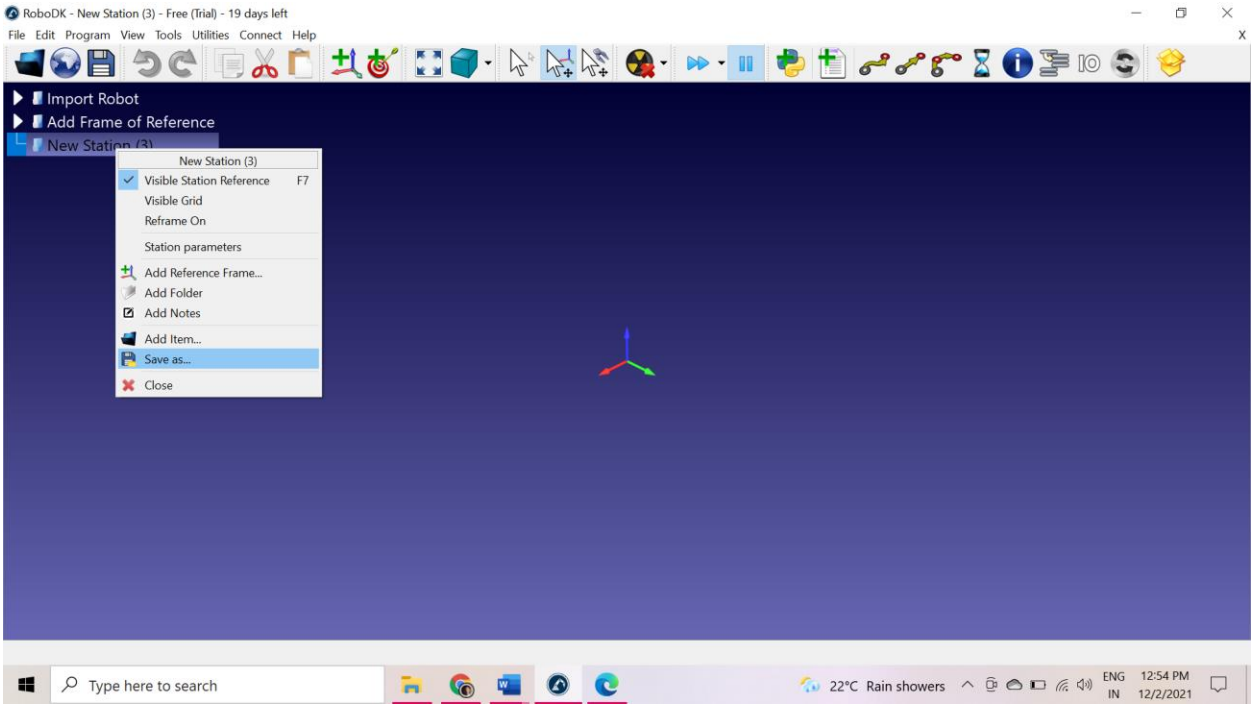
How to Import a Paint Gun Tool ?

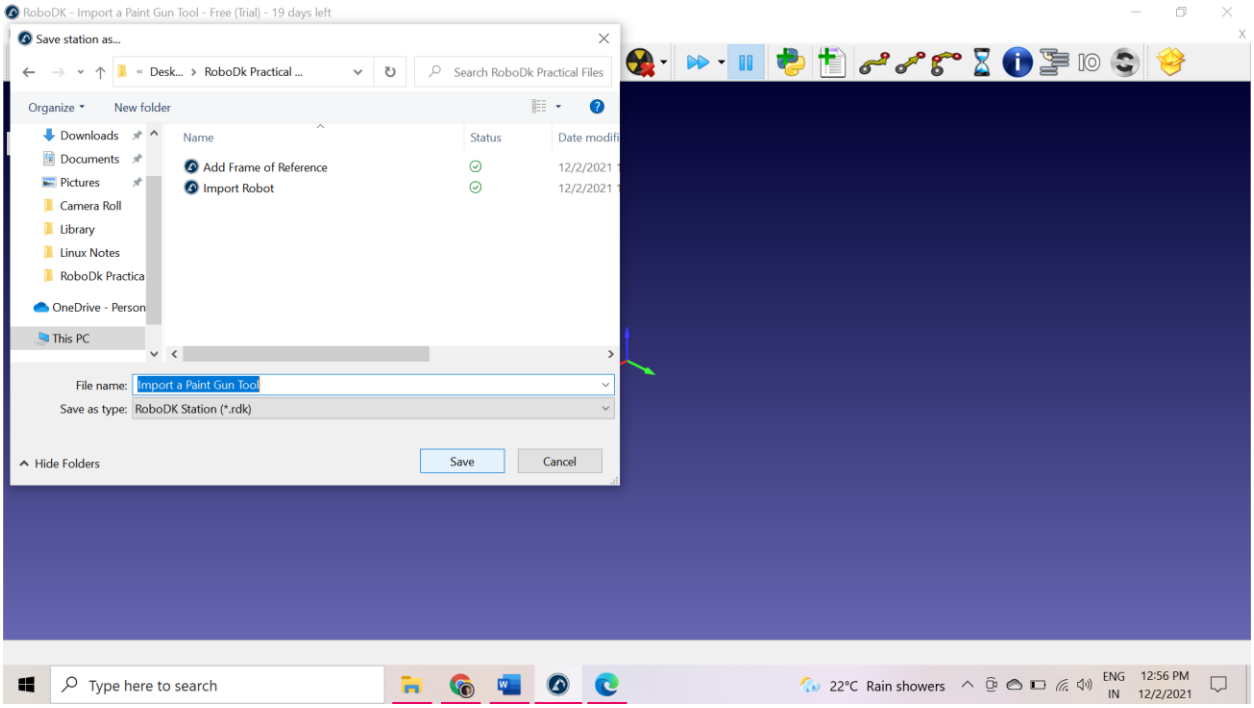
➔ Open RoboDK.

➔ In that File – New Station, to add a new Station.

➔ After that right click on New Station – Save it as Import a Paint Gun Tool.

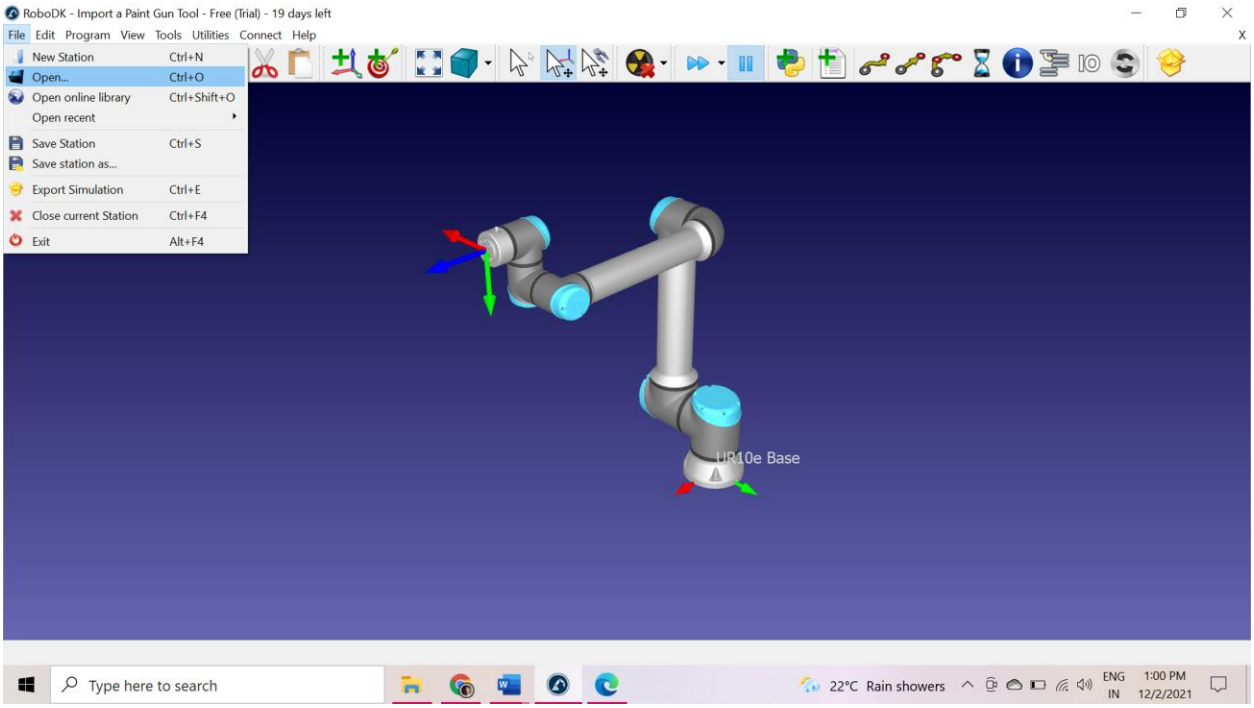


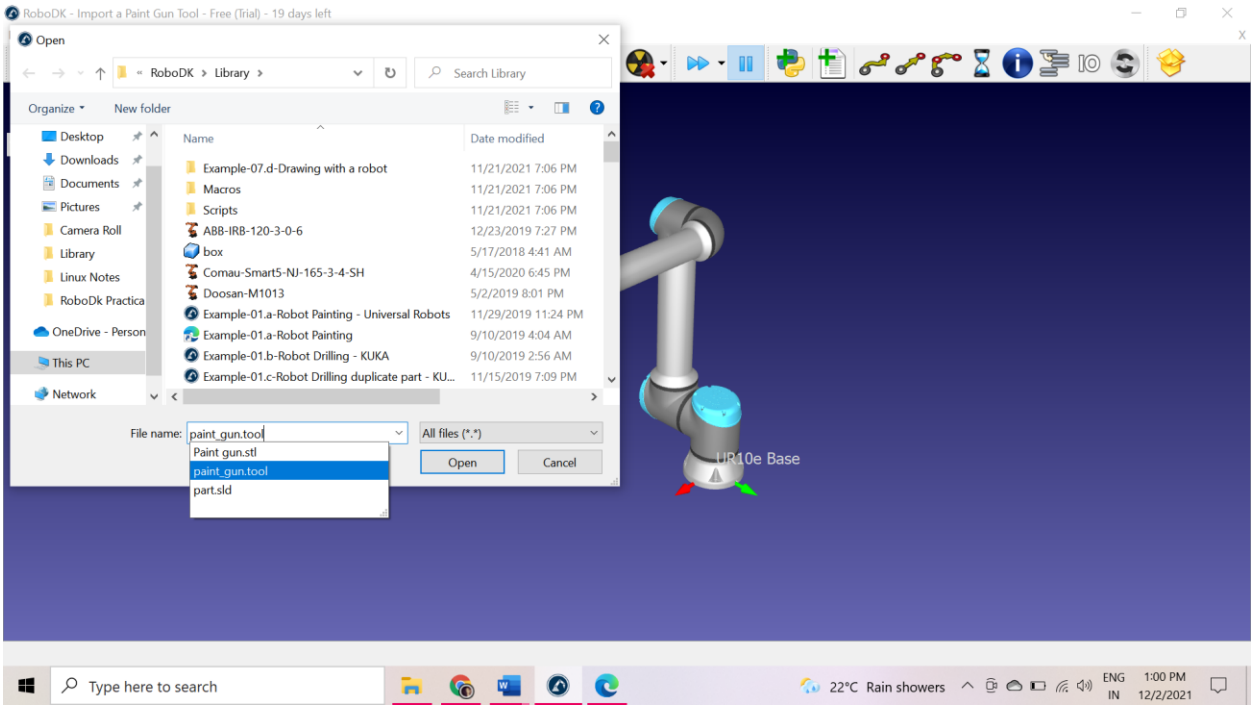




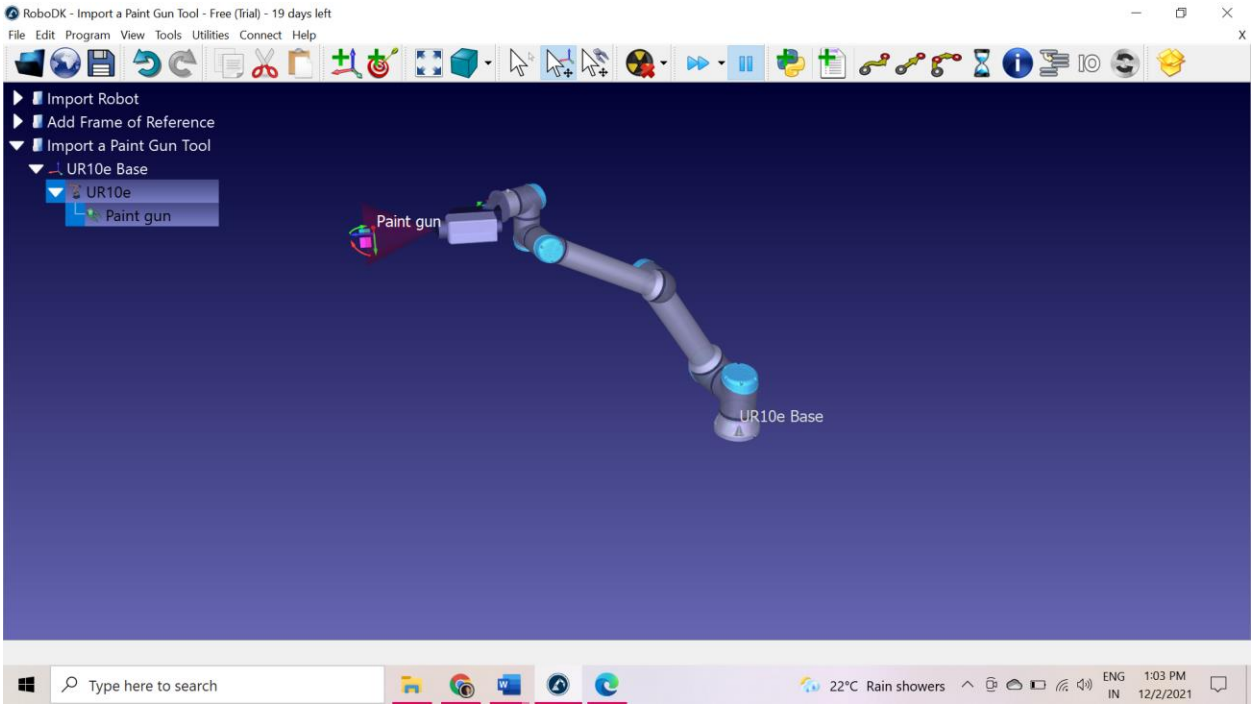
➔ Add a UR10e robot.

➔ Then click on File – Open – Select Paint_gun.tool to add Paint Gun tool.





➔ Paint Gun tool will get added at the end effectors reference frame.


RoboDK - Import a Paint Gun Tool - Free (Trial) - 19 days left
File Edit Program View Tools Utilities Connect Help
Import Robot
Add Frame of Reference
Import a Paint Gun Tool
UR10e Base
UR10e
Paint gun
Paint gun
UR10e Base
Type here to search
22°C Rain showers
ENG
IN
1:03 PM
12/2/2021

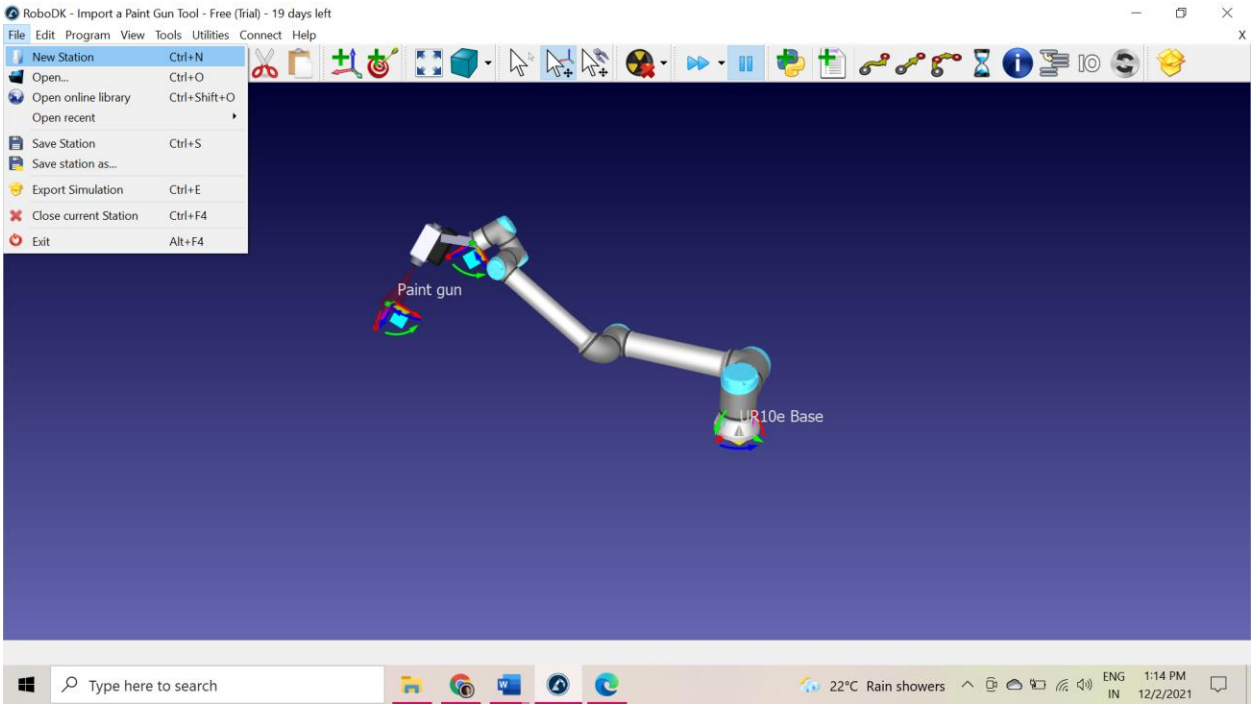
Adding Inspection object

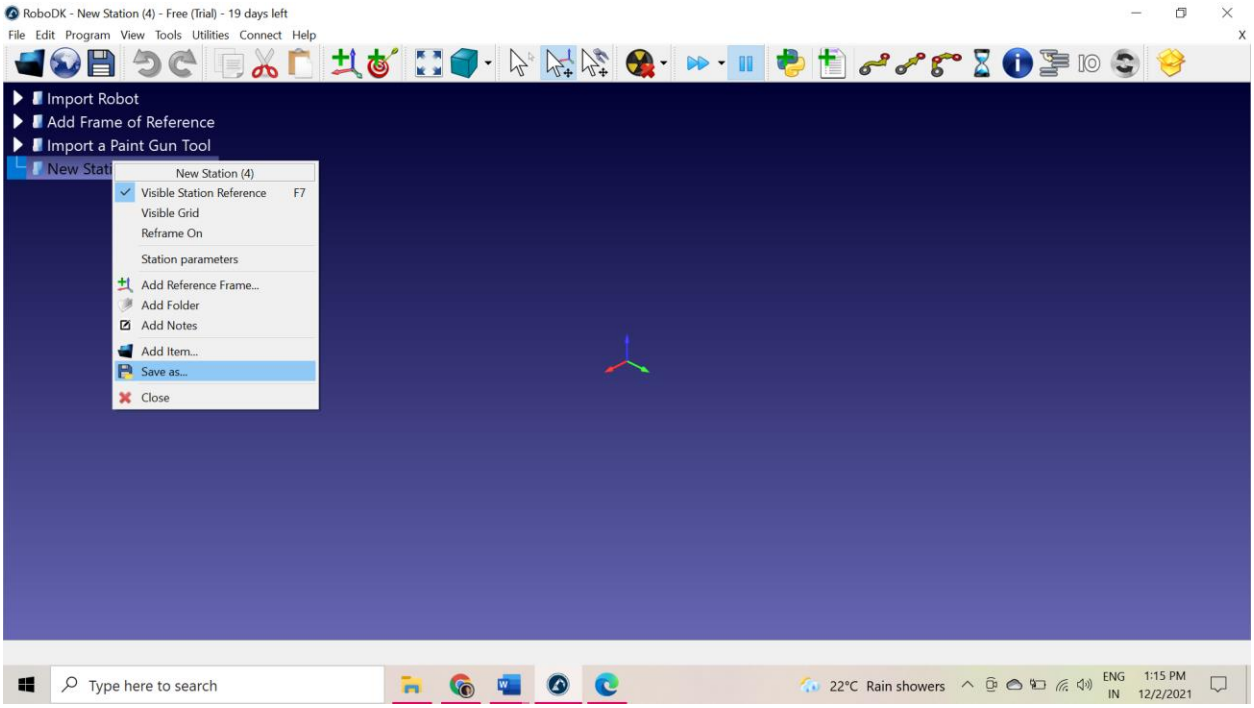
How to add Inspection Object?

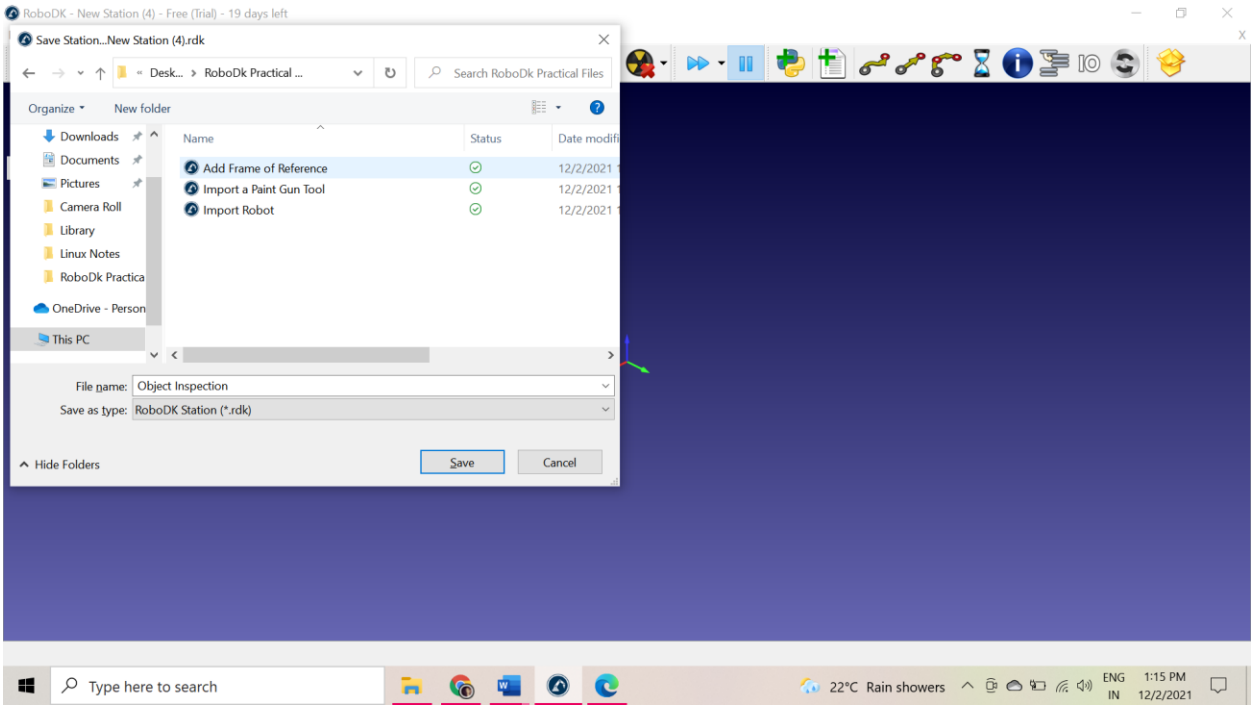
➔ Open RoboDK.

➔ In that File – New Station, to add a new Station.

➔ After that right click on New Station – Save it as Object Inspection.



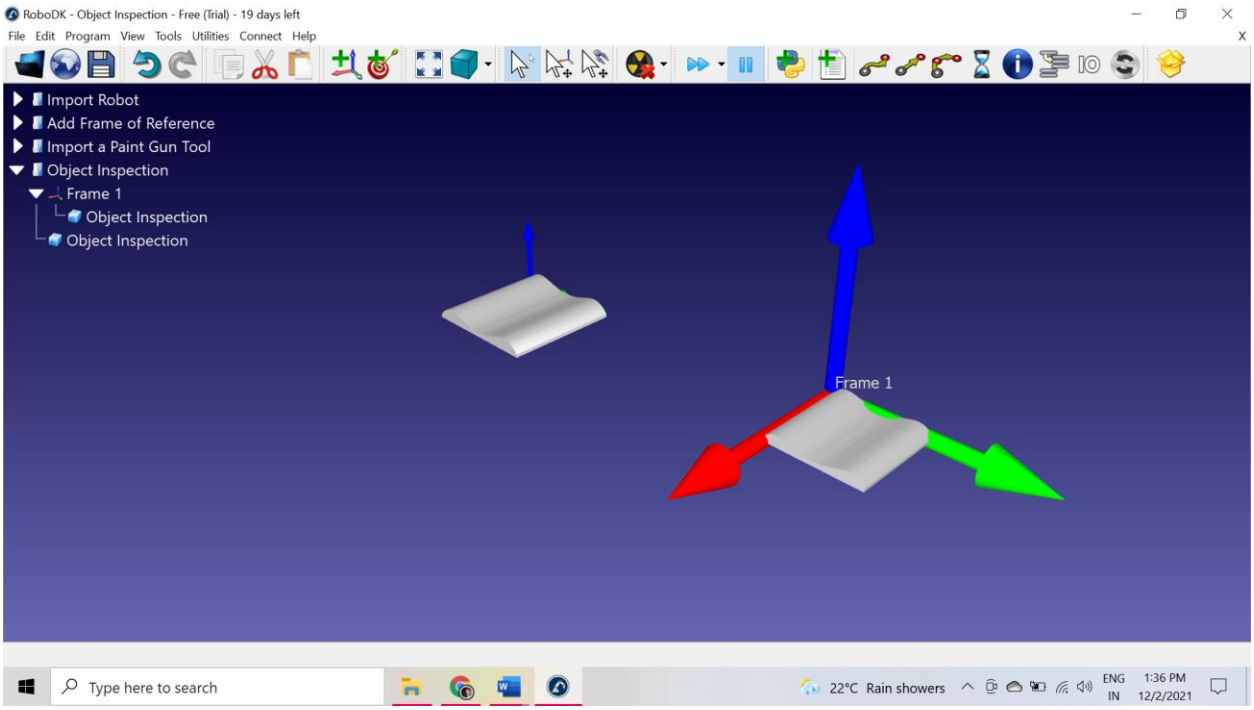




➔ Click on File – Open – Select Object Inspection.stl or Object Inspection.stp from RoboDk default Library.

➔ Object will get added to the base frame of reference.

➔ If you have added a new frame then you can also drag and drop object to new frame of reference.

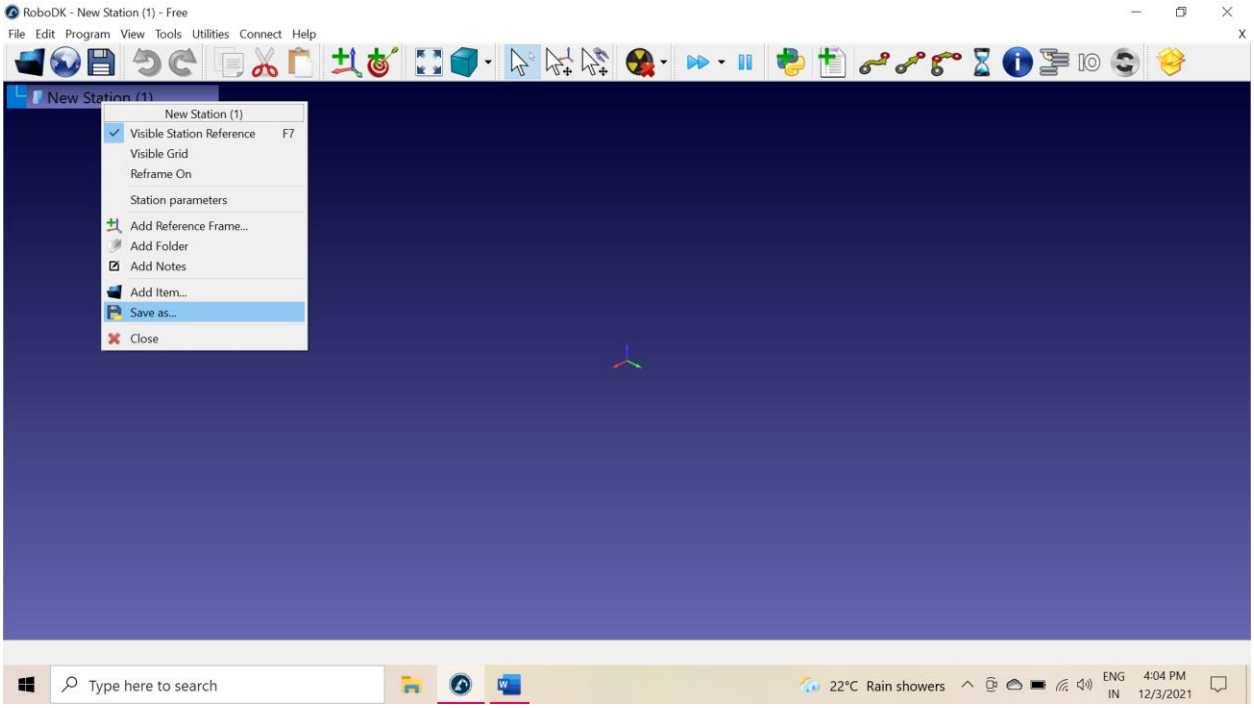


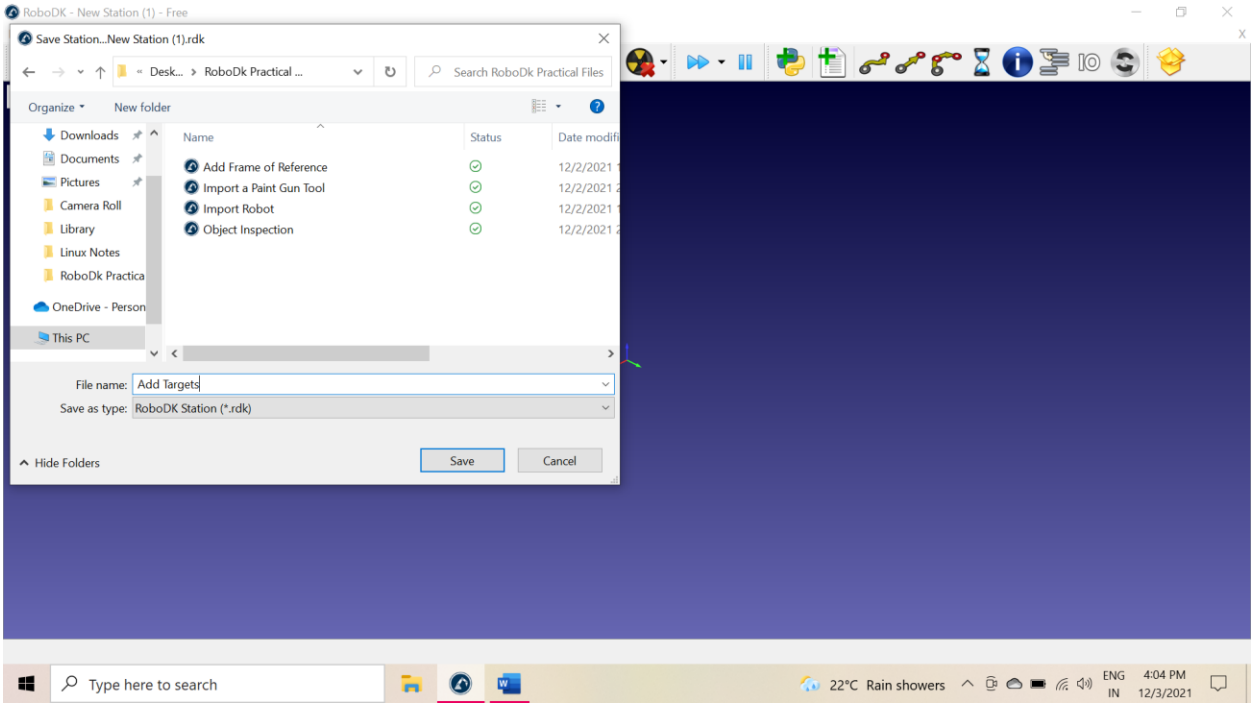
Adding Targets - Home, Approach and Retract.

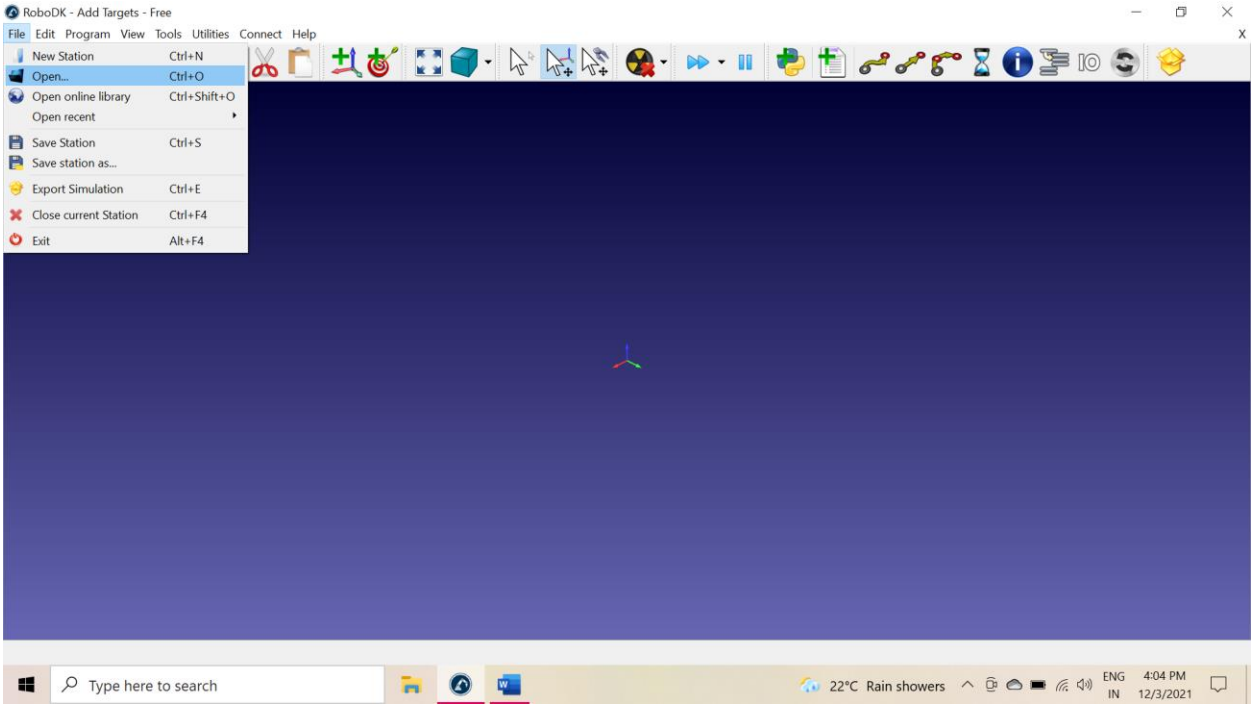
How to add Targets?

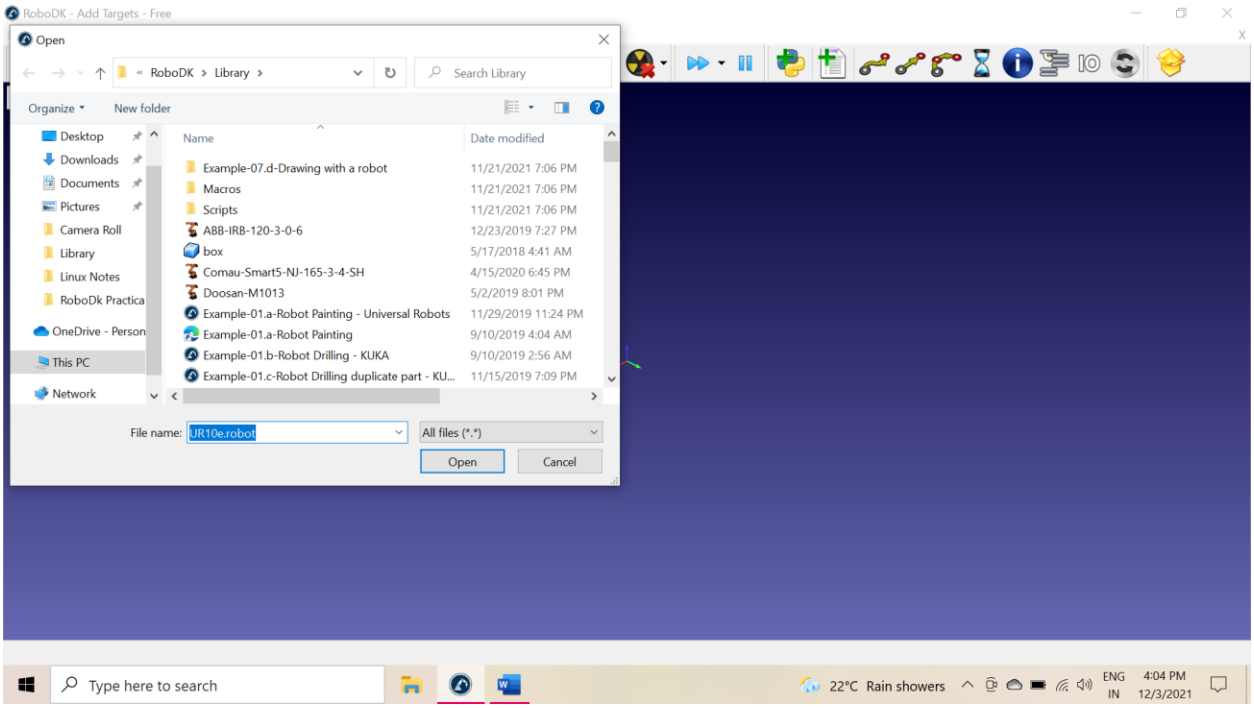
➔ **First add UR10e robot on the station.**

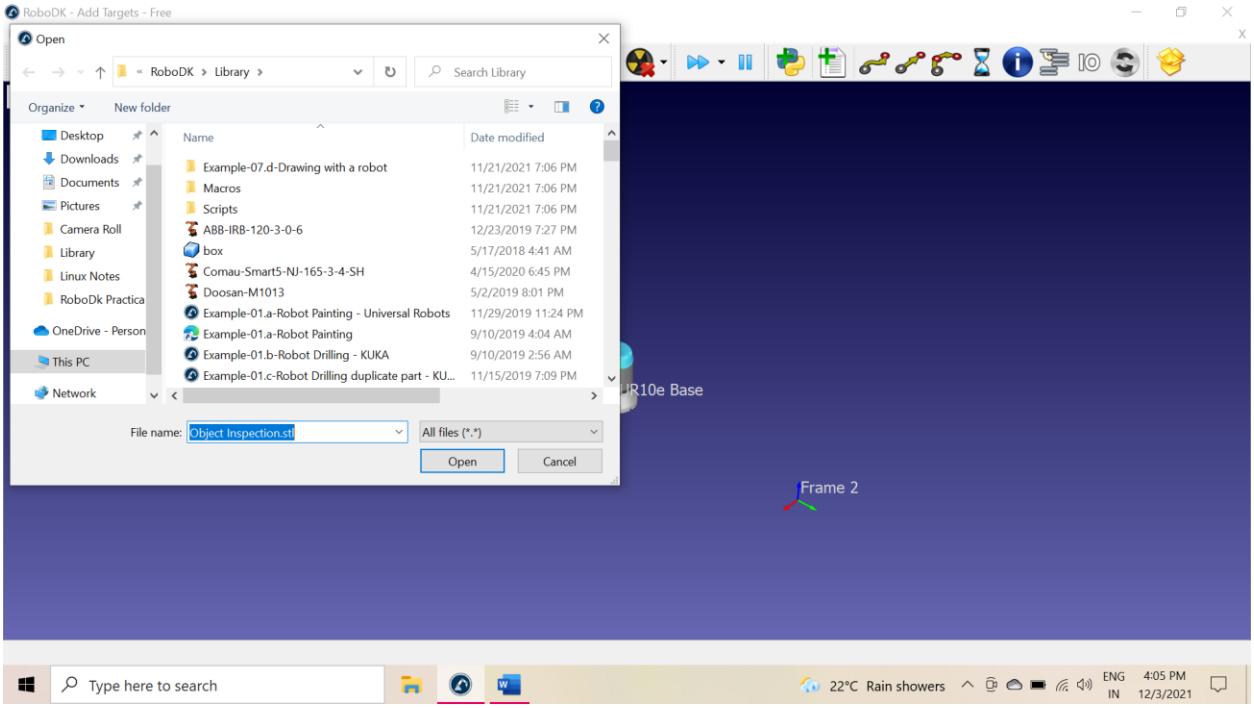
➔ **One object on the station.**




RoboDK - New Station (1) - Free
Save Station...New Station (1).rdk
Desk... › RoboDk Practical ...
Search RoboDk Practical Files
Organize
New folder
Downloads
Documents
Pictures
Camera Roll
Library
Linux Notes
RoboDk Practica
OneDrive - Person
This PC
Name
Status
Add Frame of Reference
Import a Paint Gun Tool
Import Robot
Object Inspection
File name: Add Targets
Save as type: RoboDK Station (*.rdk)
Hide Folders
Save
Cancel
Type here to search
22°C Rain showers
ENG
IN
4:04 PM
12/3/2021

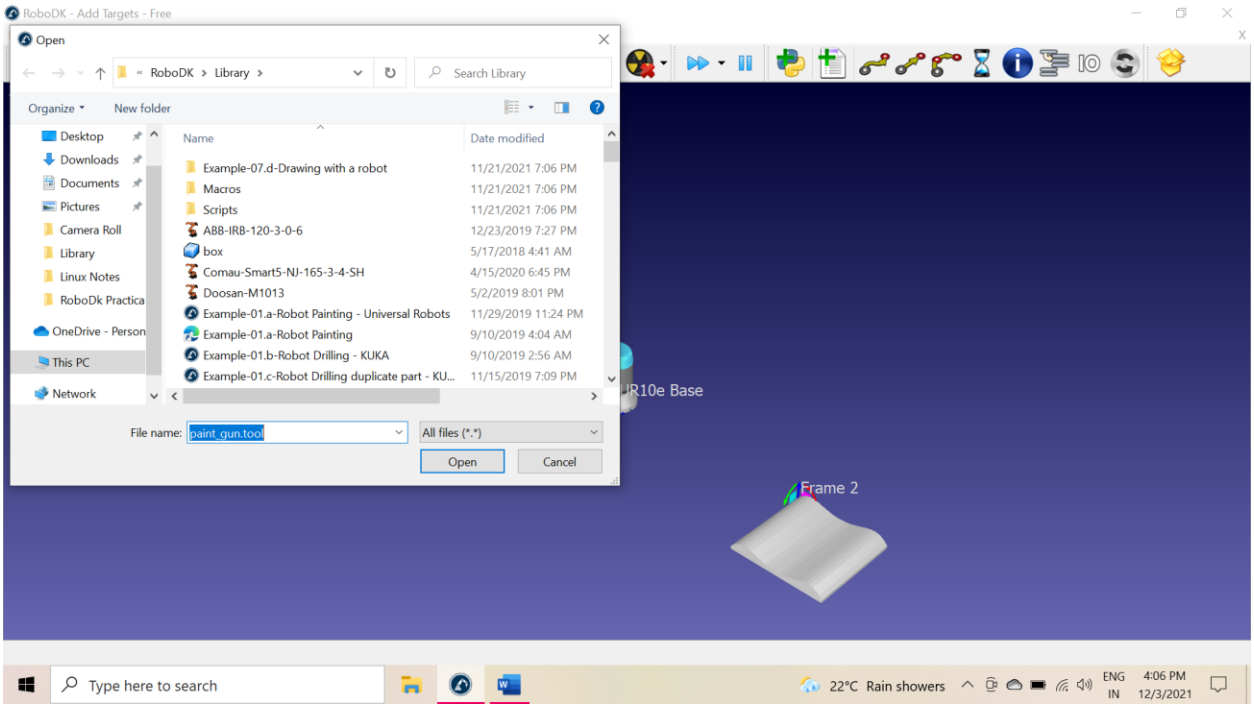

RoboDK - Add Targets - Free
File Edit Program View Tools Utilities Connect Help
New Station Ctrl+N
Open... Ctrl+O
Open online library Ctrl+Shift+O
Open recent
Save Station Ctrl+S
Save station as...
Export Simulation Ctrl+E
Close current Station Ctrl+F4
Exit Alt+F4
Type here to search
22°C Rain showers
ENG
IN
4:04 PM
12/3/2021

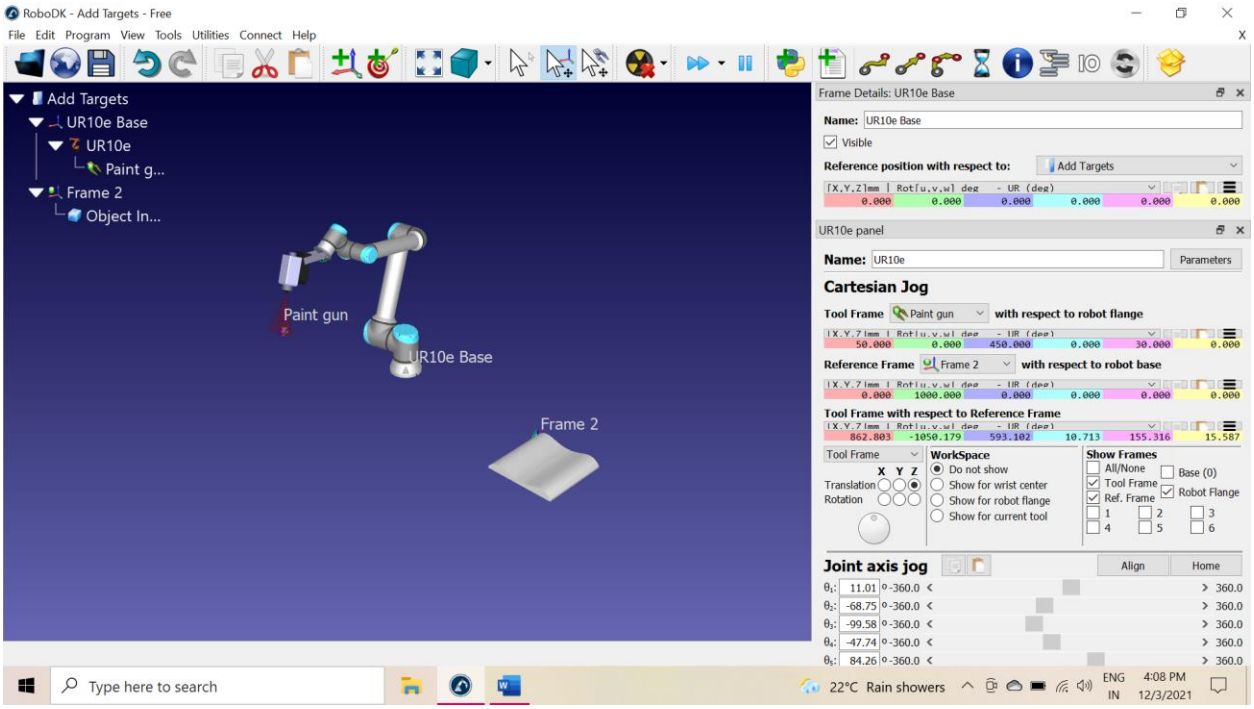




➔ **Drag and drop the object in the Newly added frame 2.**

➔ **Now add Paint_Gun.tool.**



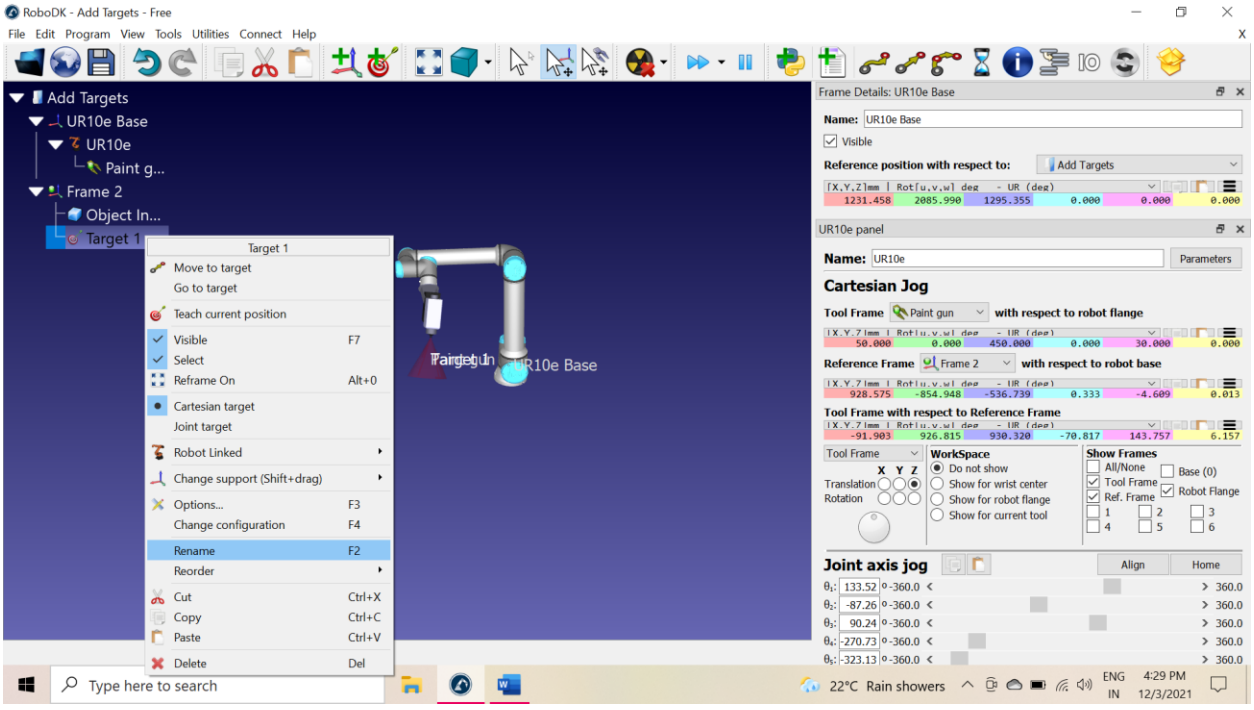


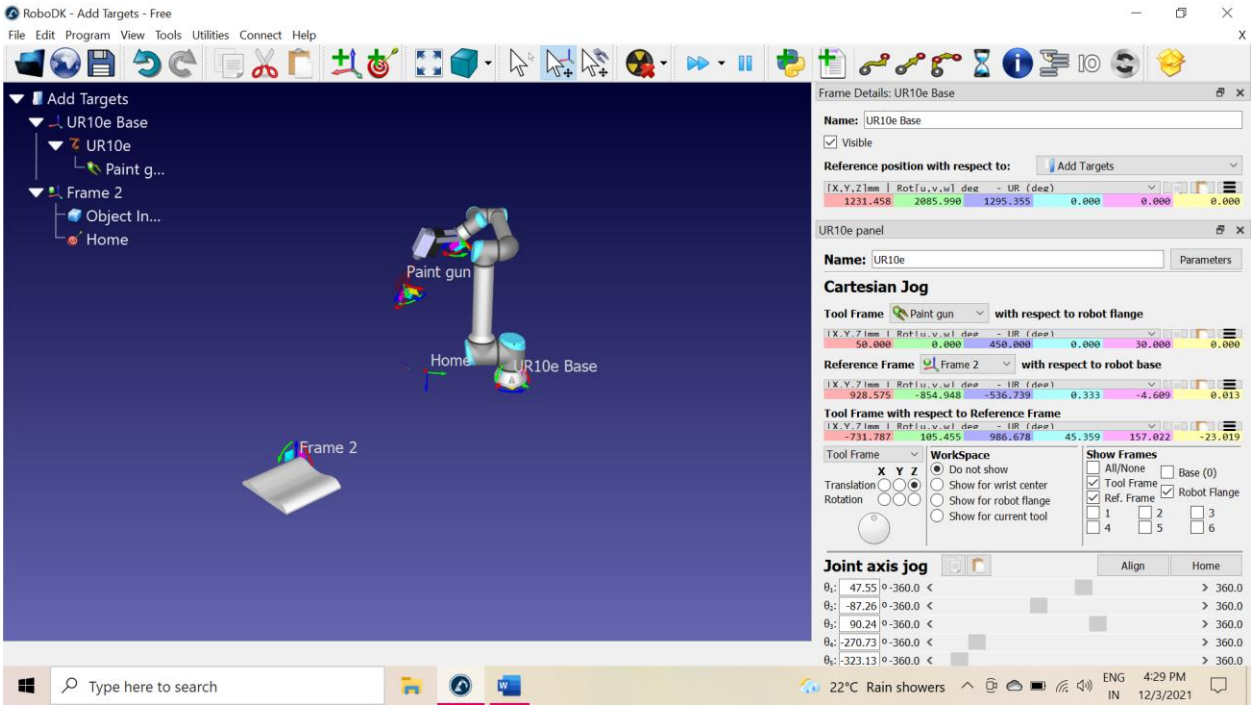
➔ **Targets – Targets are positions to reach, with the tool of the robot.**

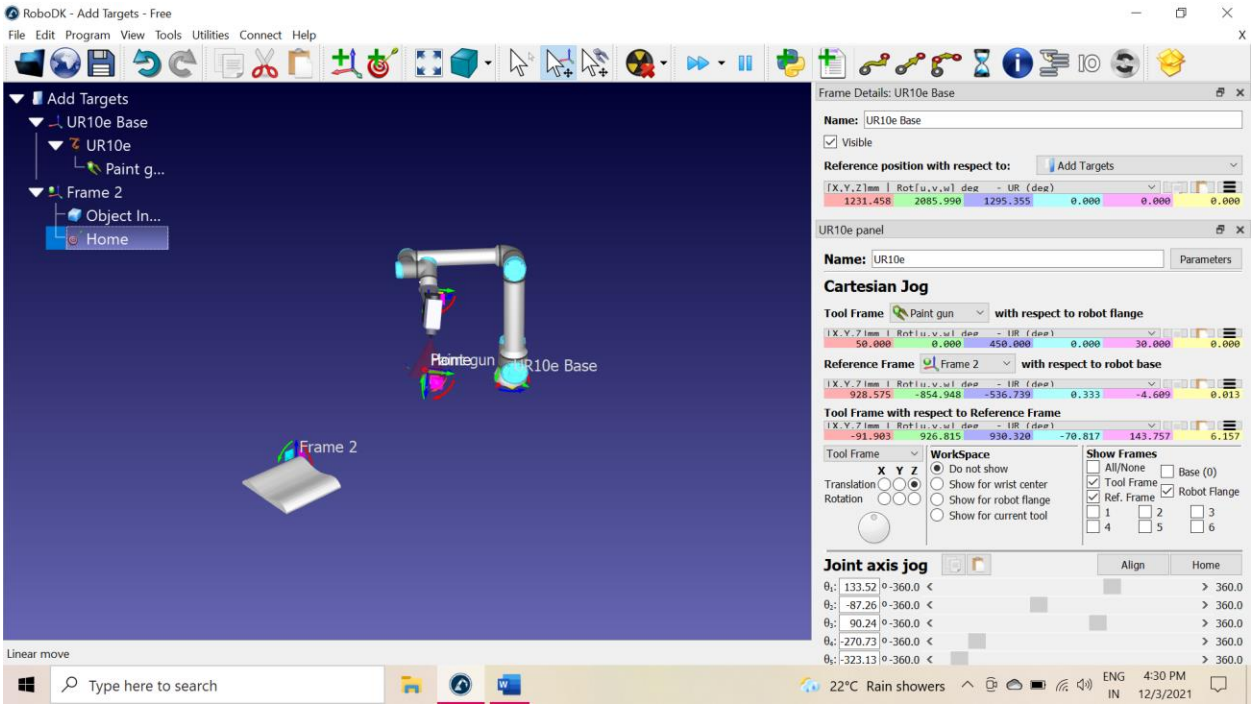
➔ **You can add targets by using the tool in the tool bar Add a new target for the selected robot. Or in Program – Teach Target Or by using shortcut key Ctrl + T.**

➔ **Target will get added. If you move the robot, and then click on the target then that robot will come to the target position.**

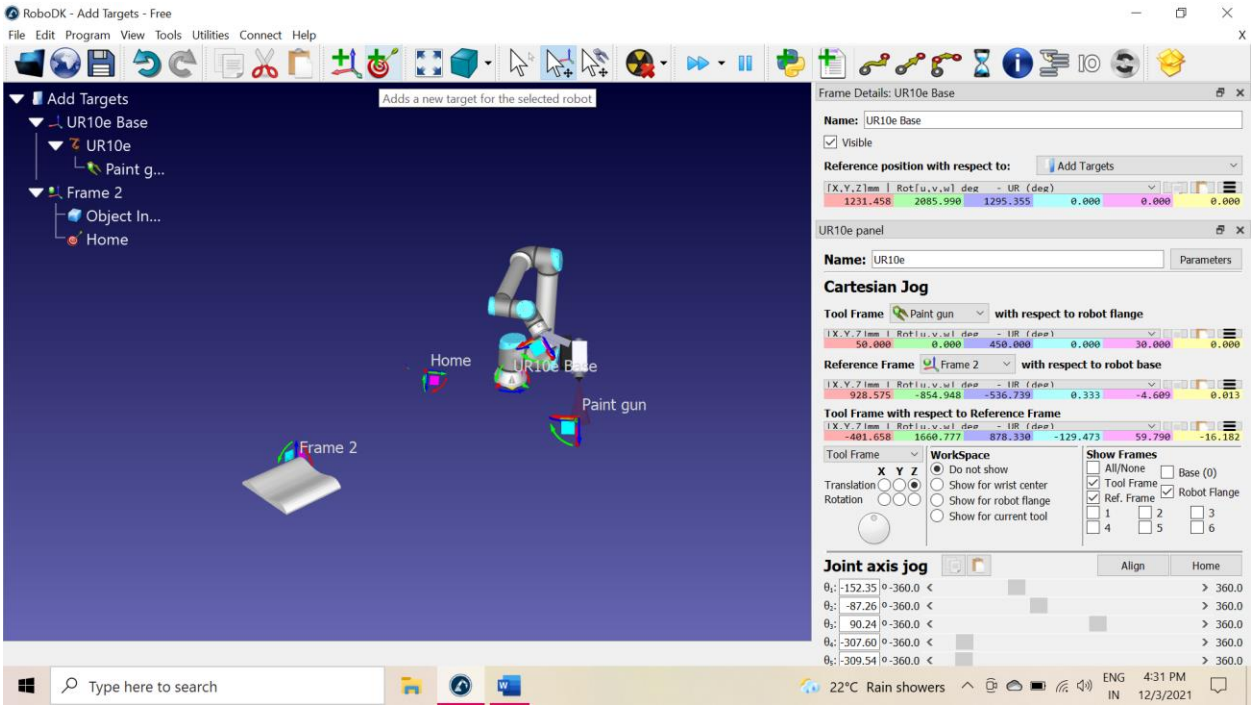
➔ **Press ctrl+T a new target will get created. Rename it to Home.**



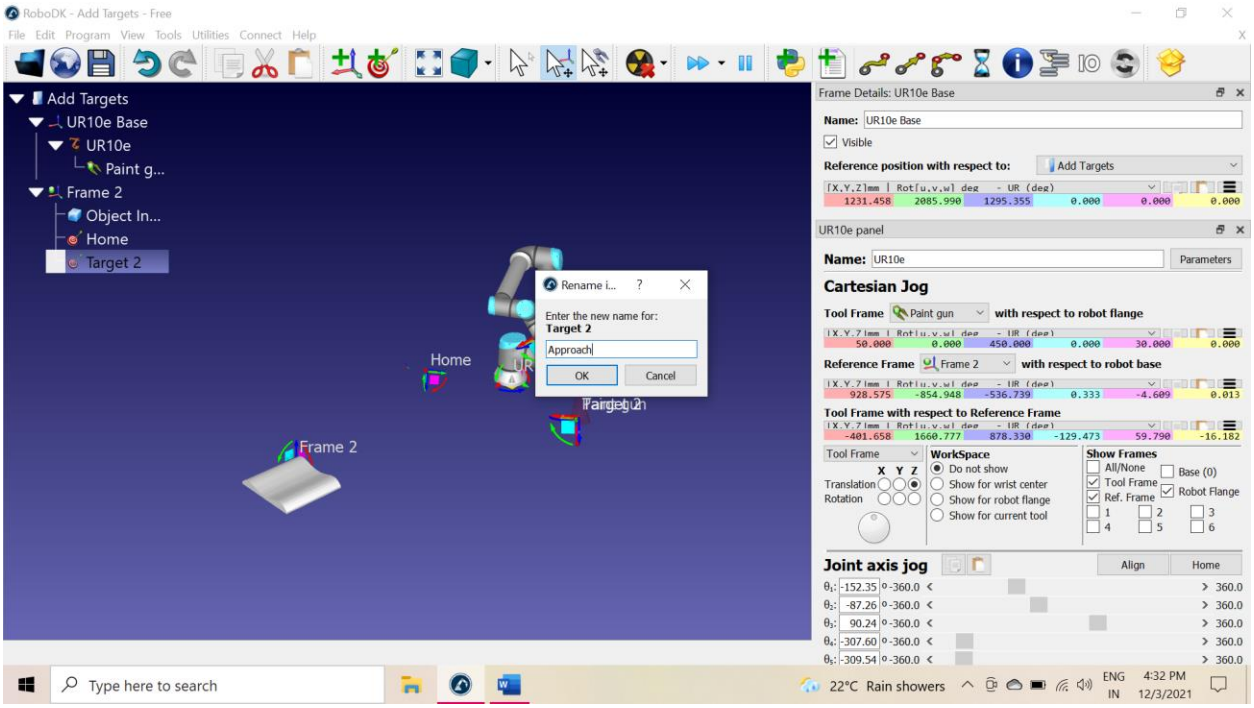




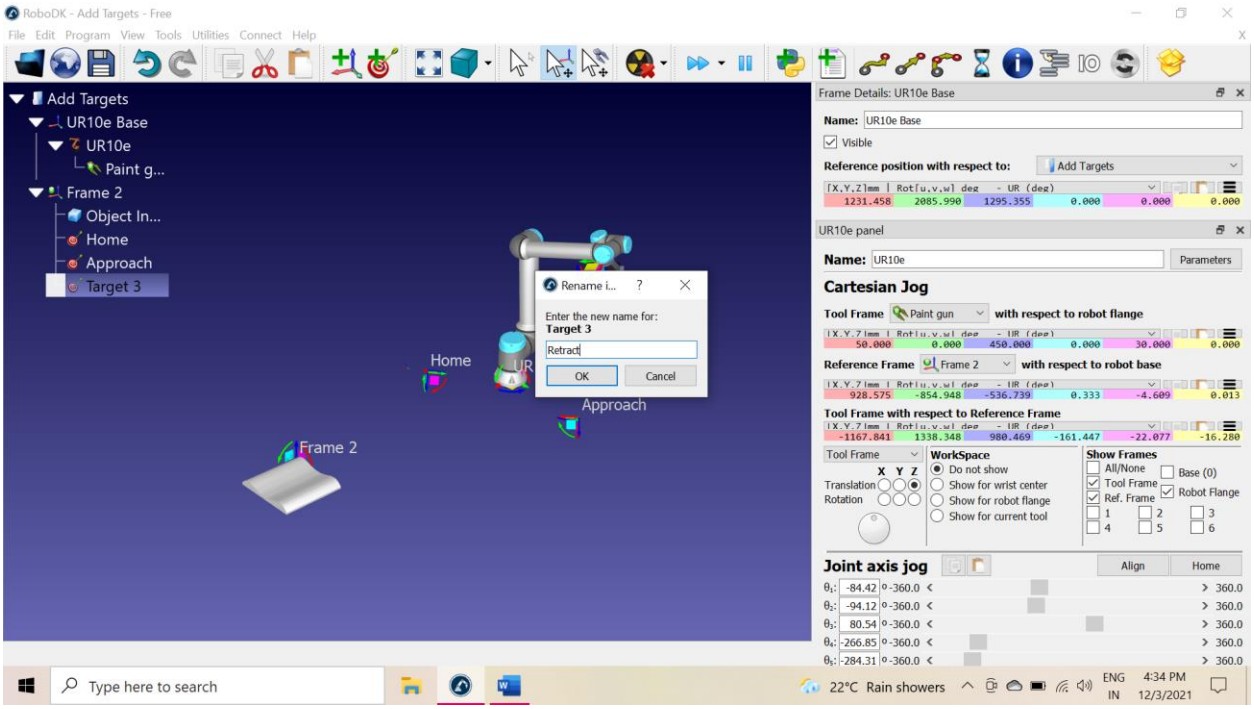
➔ **Move the robot slightly aand then again add a new target. Keep the gun pointing to downwards.**

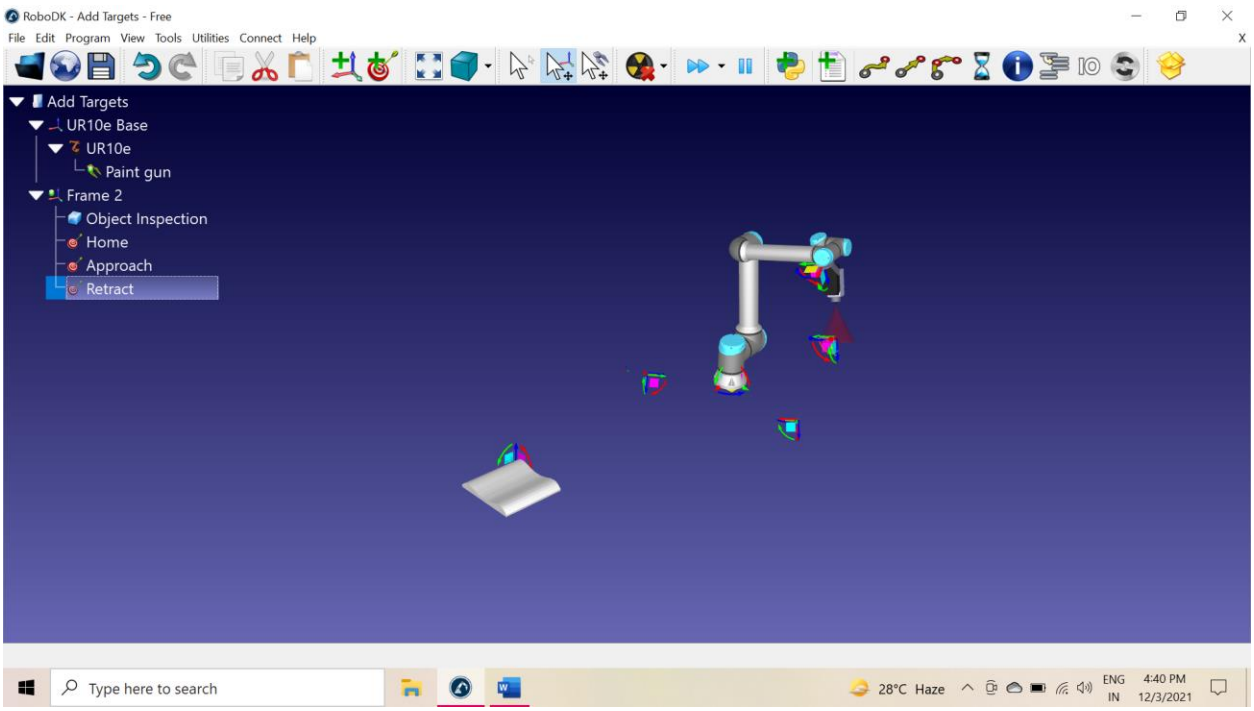


➔ **Rename that target as Approach.**



➔ **Simply move the robot sightly and then again create the Target and rename it to Retract.**





➔ **You can also manually edit the positions of targets in the right-side panel.**

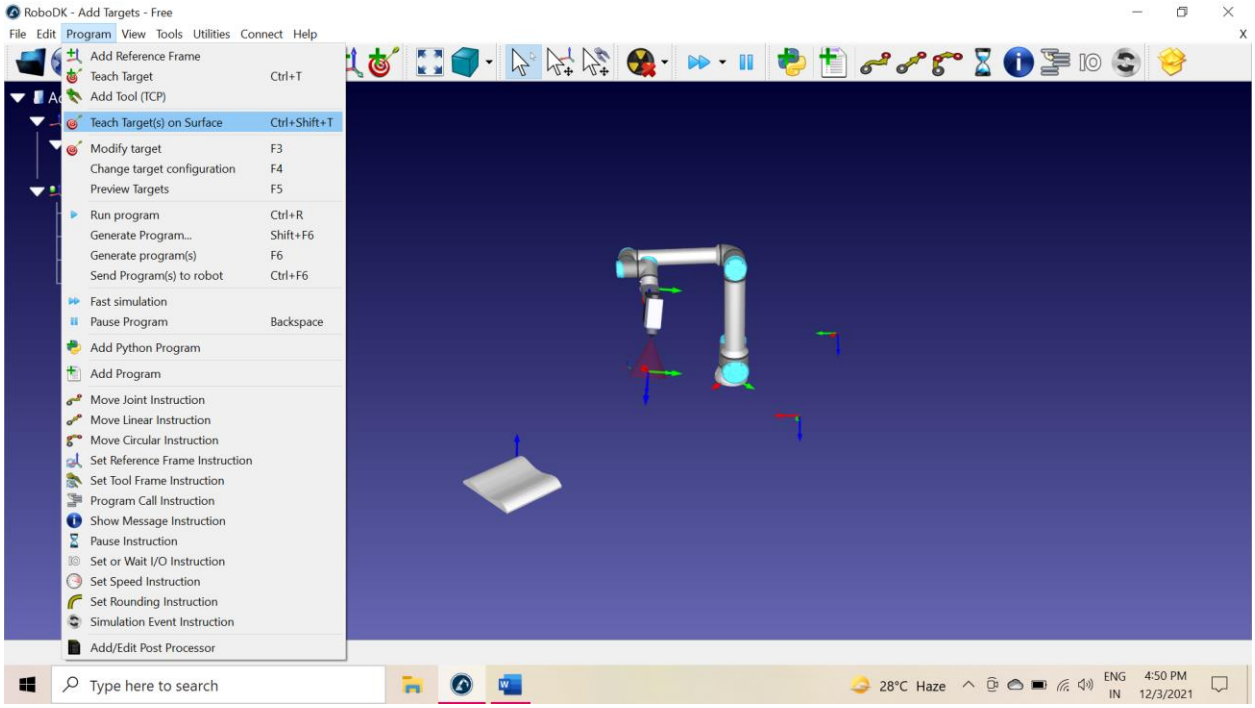
➔ **You can click on the created targets to move them from one target to another.**

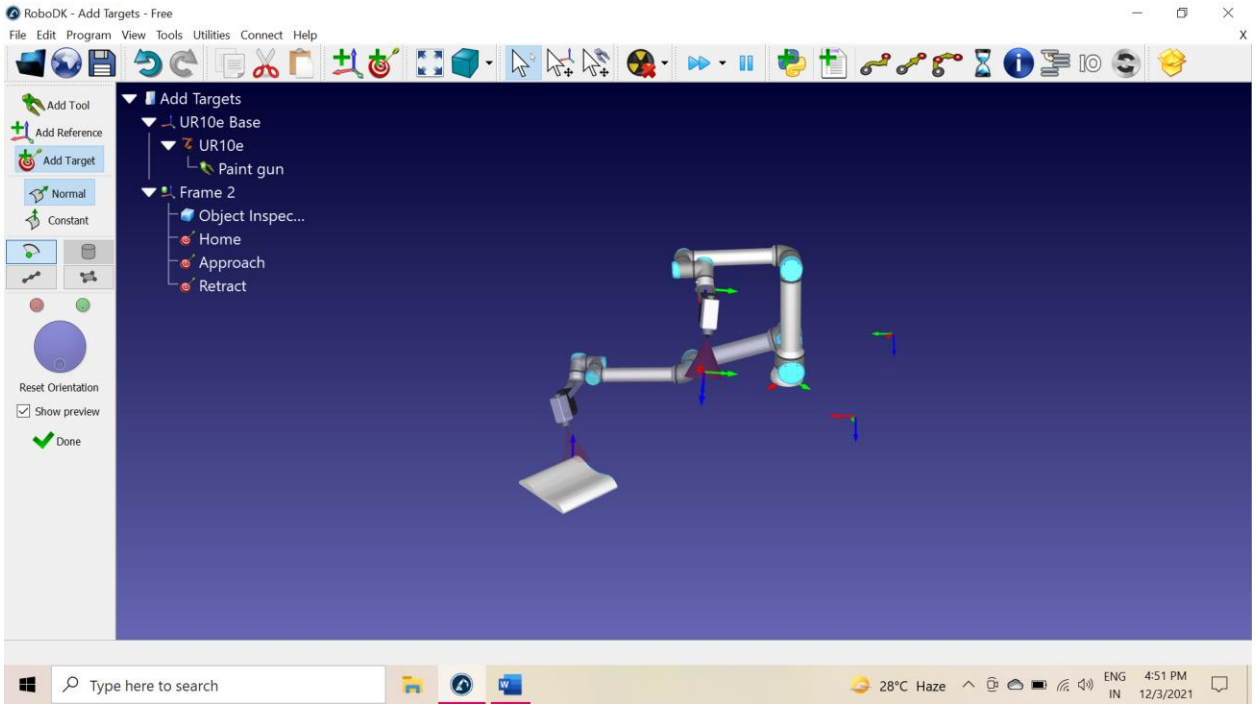
Adding paint targets using teach target method

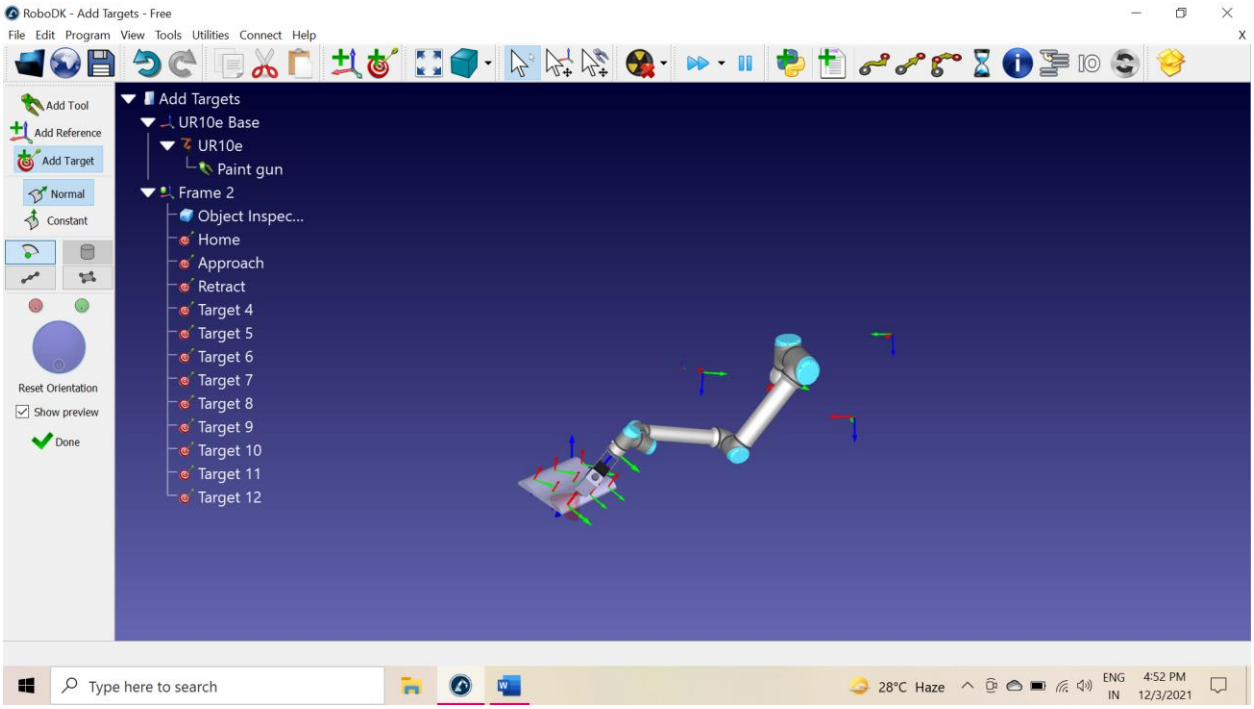
➔ **To teach the targets on the surface, you can choose the option from Program – Teach Target on Surface or Ctrl + T.**

➔ **After that you can move the paint gun over the surface to add the targets.**

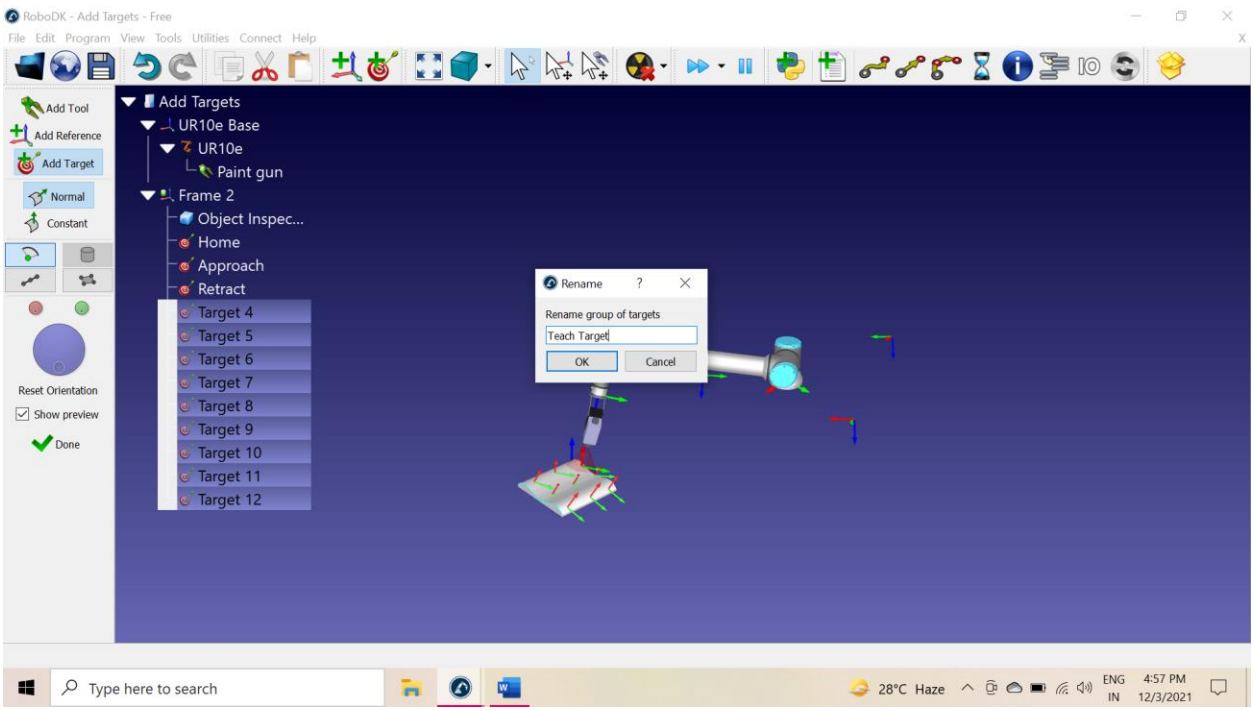
➔ **So this is how you can add the targets.**







➔ **You can click esc key to exit from the Teach target on the surface mode.**



Link of Simulation:-

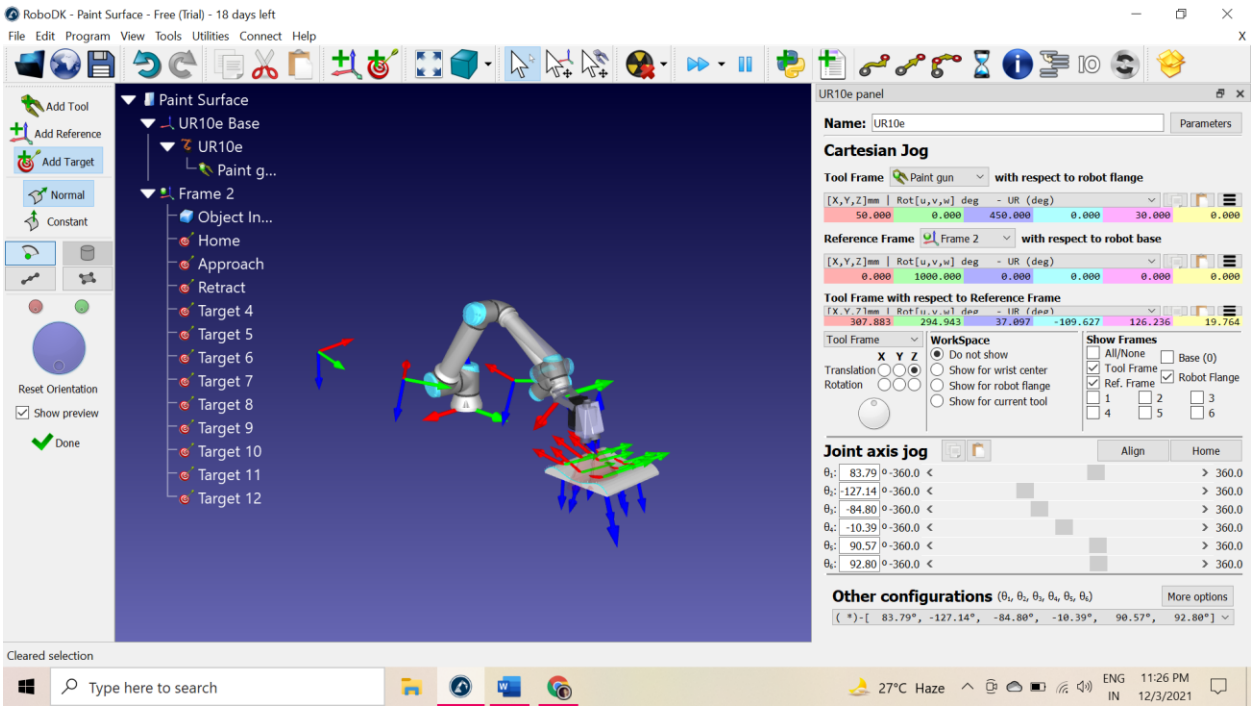
https://drive.google.com/file/d/1v_3_2I2FB_GoyaGZIJu1or28bCyMuR4B/view?usp=sharing

..\..\Downloads\Add Targets.webm

Adding robot programs
Merging programs into main programs to paint surface
Simulate the job

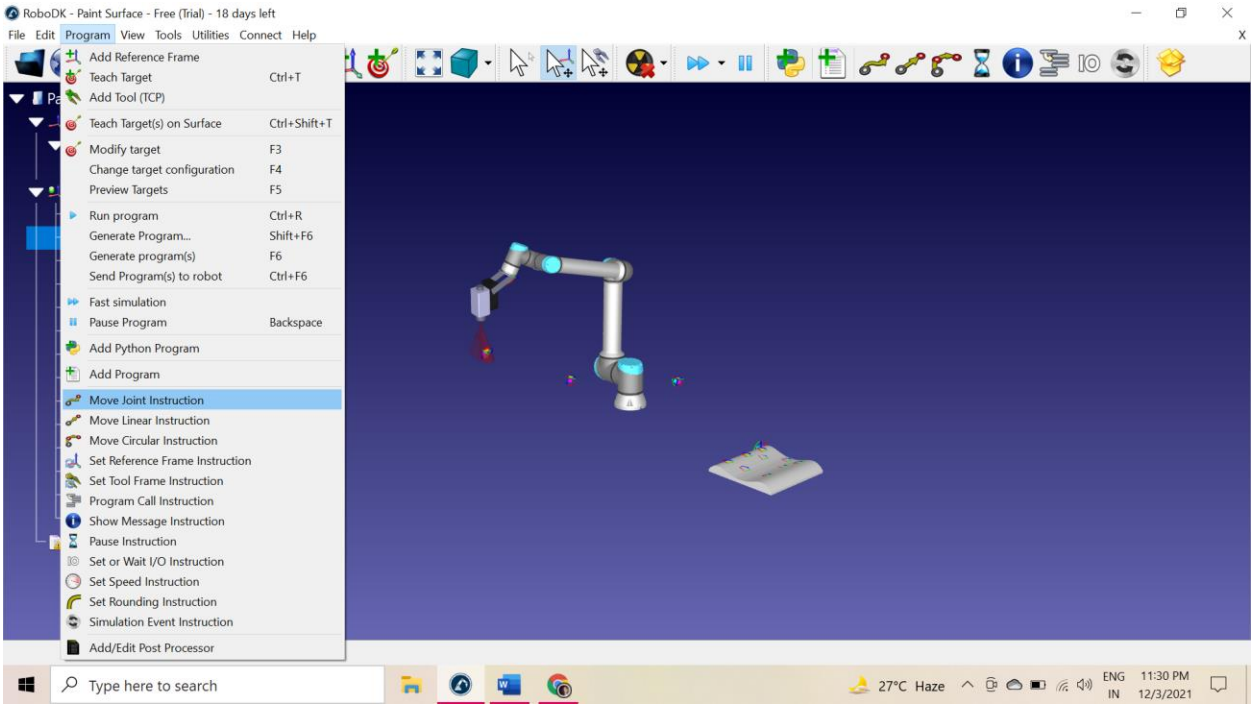
➔Add the Paint_Gun.tool, UR10e Robot, Reference Frame and Object Inspection.

➔Then add the Home, Approach, & Retract targets and Teach the Targets on surfsce.



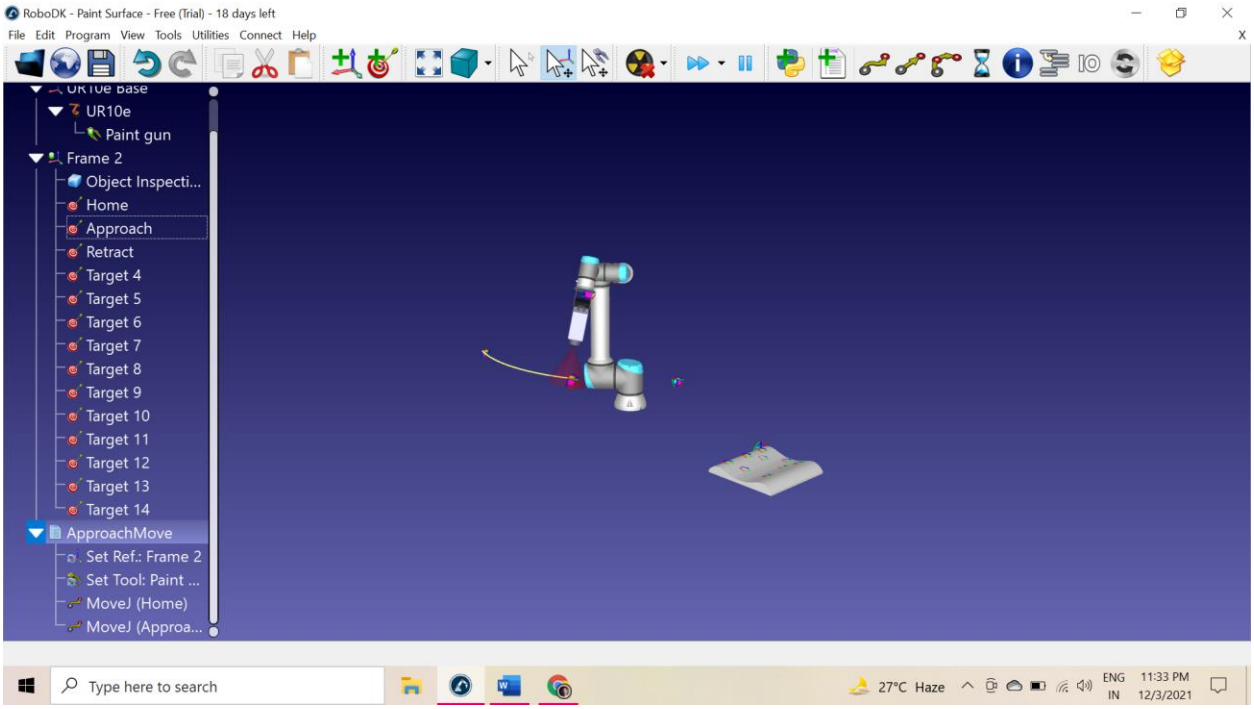
➔Click on Add a new program linked to the selected robot, to add a new program.

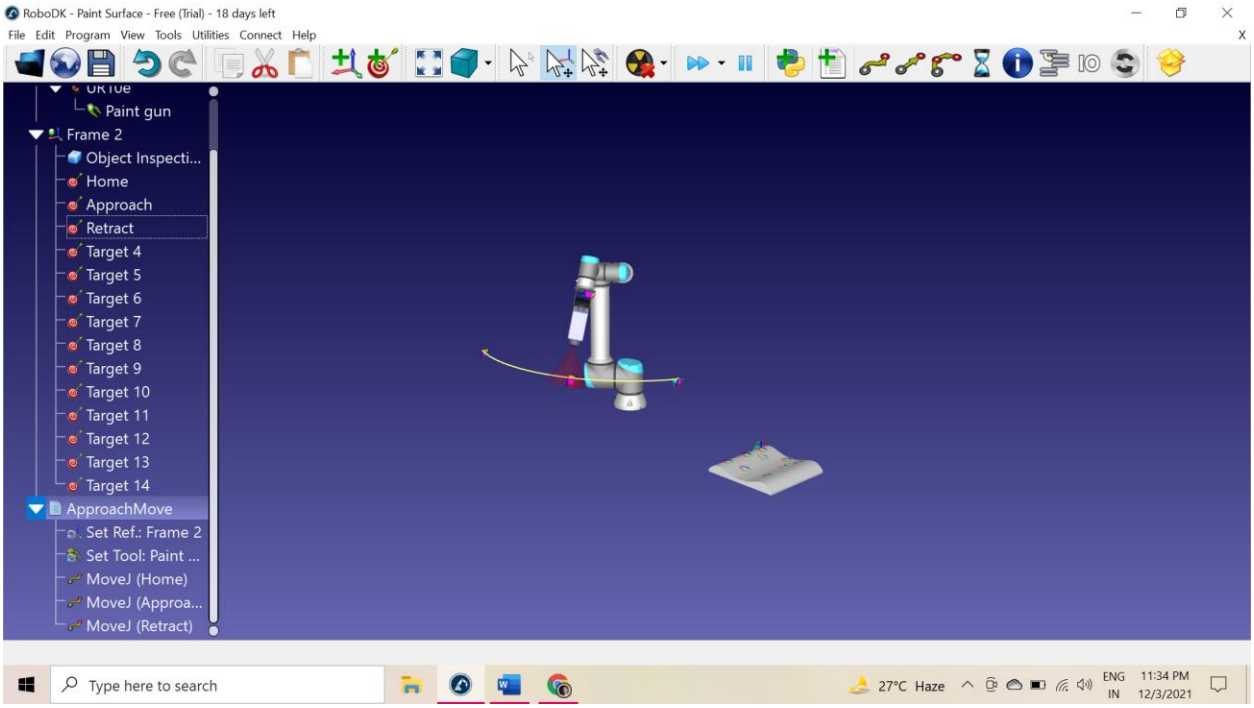
➔Click on Home Target – Program – Move joint instruction.



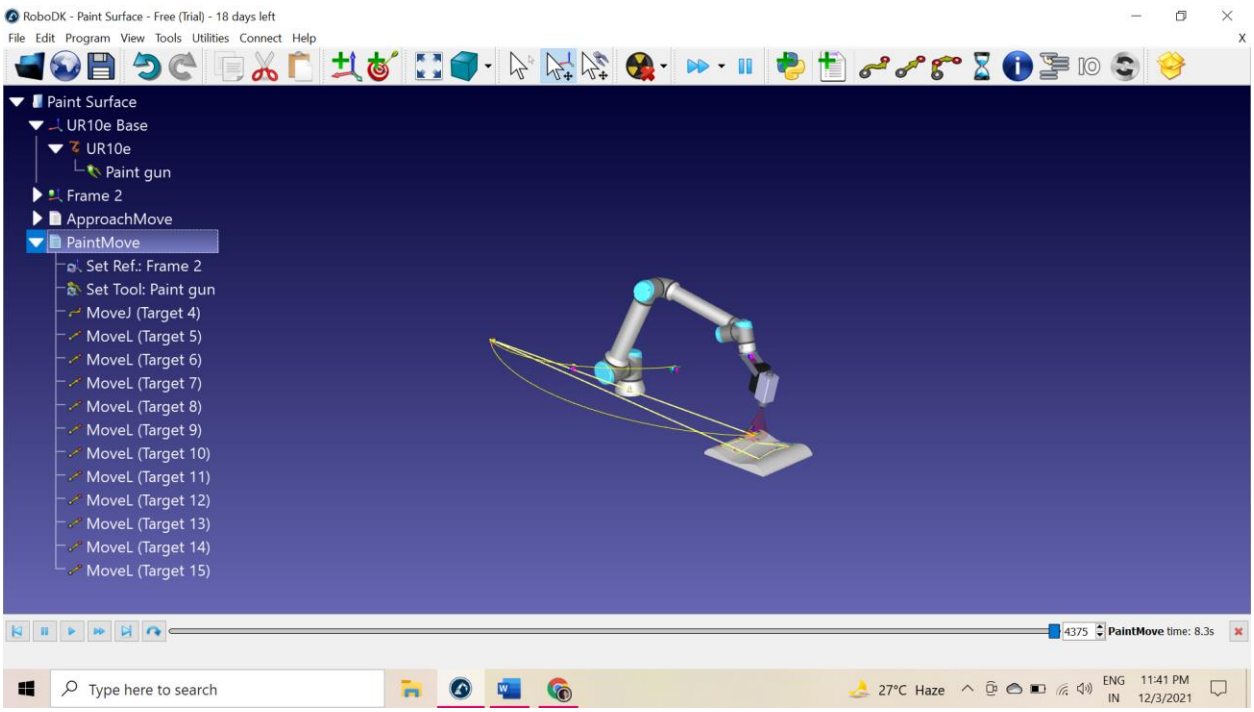
➔Then click on Approach Target and then on Move Joint icon.

➔Then on Retract and then on Move Joint icon.

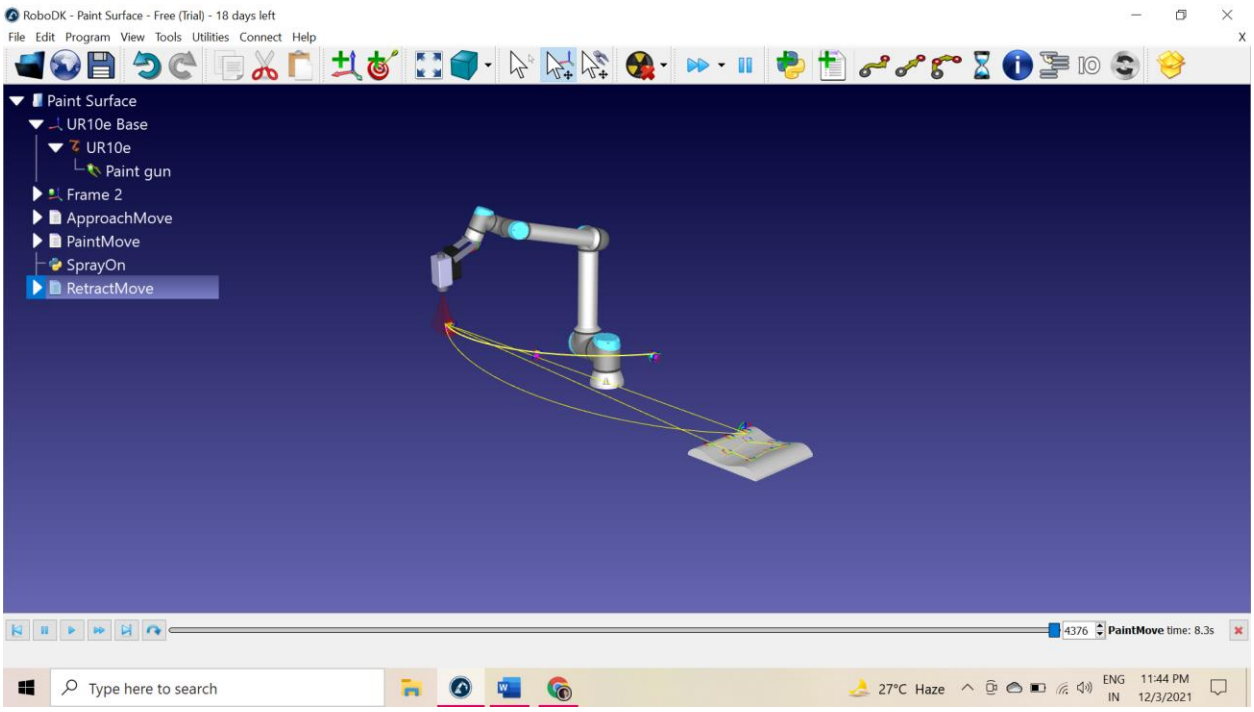




➔ Now select the targets created on surface and right click and then create program.



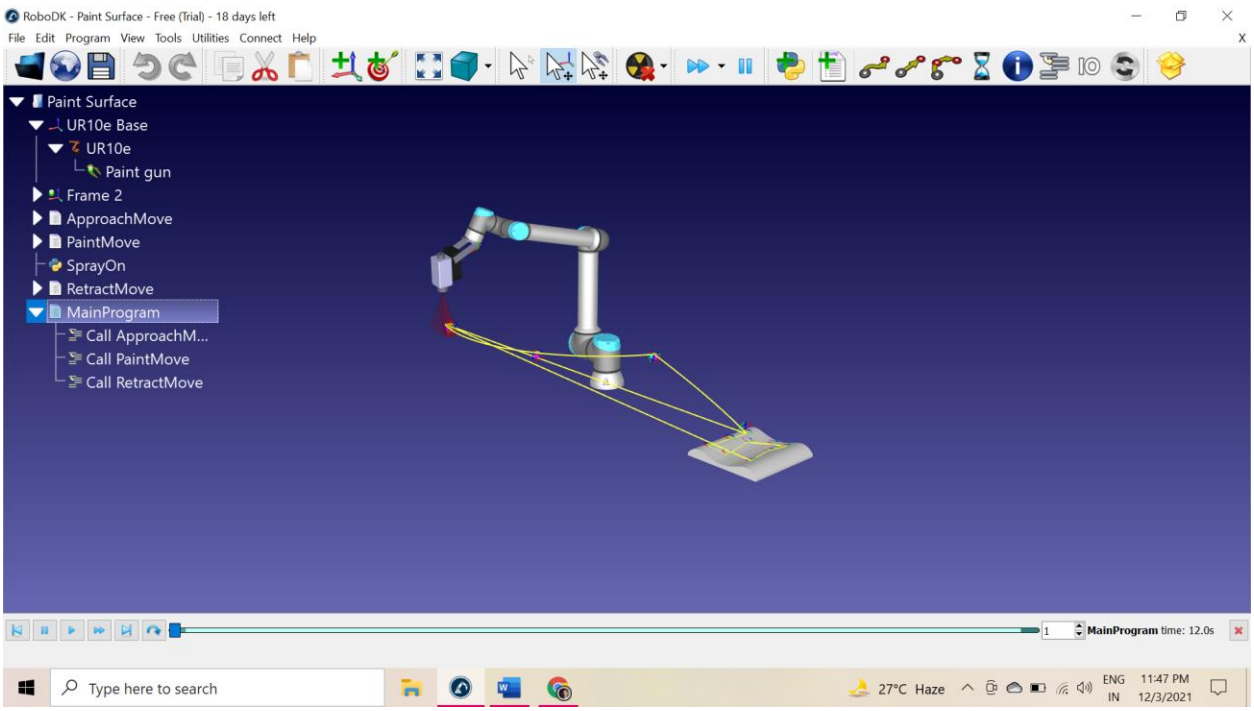
➔Then create retract move program add retract, approach and home targets in it.



➔Then add a main program.

➔Then click on add instruction icon & add evry sub program in that.

And run the simulation.



Link of Simulation:-

https://drive.google.com/file/d/1nHZTD3A33bBkpi9lCbvzzb40shG5Iv8l/view?usp=sharing