W14: [C] CIM 3.1.2C RoboCell [ER-4u] Stacking Objects and Using Roll Angles

Introduction

A **robot** pick-and-place operation moves objects from one point to another. When a robot must stack objects on top of each other, more complex robot position descriptions are necessary beyond the X, Y, Z coordinates. A more fully described robot position includes two angles, pitch, and roll, in addition to the three coordinates, X, Y, Z position of the end effector. Calculating and applying a roll angle is necessary for the sides of square objects to line up with each other when stacked, or to prevent the gripper from accidentally rotating a part when picking it up.

In this activity you will program a robot to effectively stack objects by incorporating roll angles in the robot position.

Equipment

Computer with intelitek® RoboCell software

- **YouTube Video Resource:**
- https://www.youtube.com/watch?v=p3_Wc-bvWEs&list=PLJuwb3xnlvclFigEg127kl_0baNgBkWjG&ab_channel=Chris%26JimCIM

Prerequisite Information- Roll Angles
Degrees of Freedom One way to characterize a robot's maneuverability is the number of **degrees of freedom (DOF)** of the robot. A degree of freedom is defined as the motion variable for a robot axis, each of which requires a joint. The maximum number of DOFs that a robot can have is six, which are described as: • Linear motion along the X axis • Linear motion along the Y axis • Linear motion along the Z axis • Rotation around the X axis, or Yaw • Rotation around the Y axis, or Pitch • Rotation around the Z axis, or Roll • The intelitek® RoboCell software is based on the intelitek® SCORBOT-ER 4u robot. The robot has five degrees of freedom and cannot rotate the **gripper** around the X axis (yaw).

Prerequisite Information- Roll Angles

Why Calculate Roll Angles?
Aligning objects is much easier when the objects are cylindrical, because we do not need to account for any specific rotation of the object as it is picked up from one Y location and placed on another. The sides of the cylinders should line up without a problem using only the X, Y, and Z values.

If cubes are used, then the sides will not line up unless **roll angles** are considered in the positional data. This is because the robot arm pivots around the base. As the arm pivots, the gripper remains in its initial orientation of 90 degrees relative to the arm. The gripper does not rotate to compensate as the arm pivots. To correct this problem, you must calculate the correct roll angle.

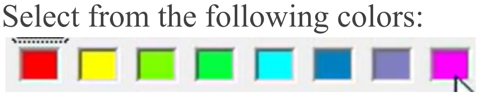
There are various methods to determine the correct roll angle using basic trigonometry. For this activity, use the inverse tangent (**$\tan^{-1}$**) function for right triangles.

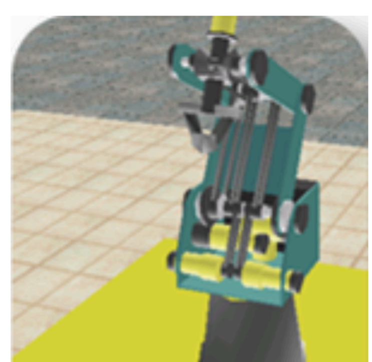
Why must you use trigonometry to position the blocks correctly?

Since the robot does not automatically adjust its "wrist" to keep the block aligned in the same orientation it was picked up, we have to calculate a "counter" angle to adjust for the robot's orientation shift to place the cube directly ontop of the other one.

A. Review Roll Angles Information.

Procedure

1. Create the graphics in CellSetup using the specifications below.
   a. Add a robot without a slide base.
   b. Add a table: 1000 x 1000. Select: 
   c. Add three cubes: 40 x 40 x 40.
   Select from the following colors:
   
   d. Enter initial starting positions:



i. Cube 1 (X 300 Y 0)
ii. Cube 2 (X 300 Y –100)
iii. Cube 3 (X 300 Y –200)

e. Save this file as “LastName_312c”.

2. Program the robot arm to perform the operation below.
   a. The objects begin at the initial starting position.
   b. Stack three cubes on top of each other.
      i. Cube 2 will be picked up and placed on top of cube 3.
      ii. Cube 1 will then be picked up and placed on top of Cube 2.

	1	2	3	11	12	13	23	33
X	300	300	300	300	300	300	300	300
Y	0	-100	-200	0	-100	-200	-200	-200
Z	17.5	17.5	17.5	157.5	157.5	157.5	97.5	157.5
Pitch	-90	-90	-90	-90	-90	-90	-90	-90
Roll	**0**	**-18.43**	**-33.69**	**0**	**-18.43**	**-33.69**	**-33.69**	**-33.69**

3. The cubes can be aligned when stacked by calculating and applying the correct roll angle for positions (2, 12) and (13, 23, and 33).

	1	2	3	11	12	13	23	33
X	300	300	300	300	300	300	300	300
Y	0	-100	-200	0	-100	-200	-200	-200
Z	17.5	17.5	17.5	157.5	157.5	57.5	97.5	157.5
Pitch	-90	-90	-90	-90	-90	-90	-90	-90
Roll	0	?	?	0	?	?	?	?

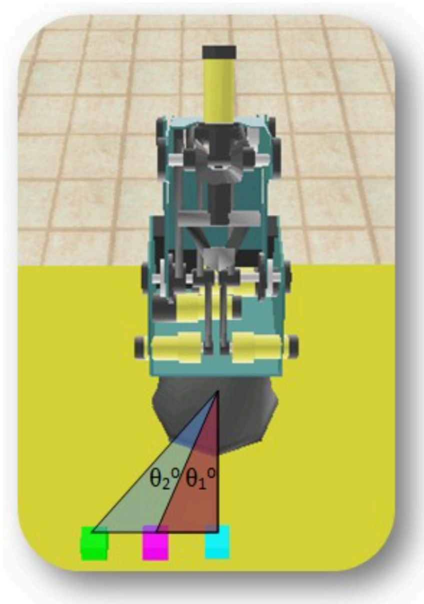


Figure 4. Robot Position Angles

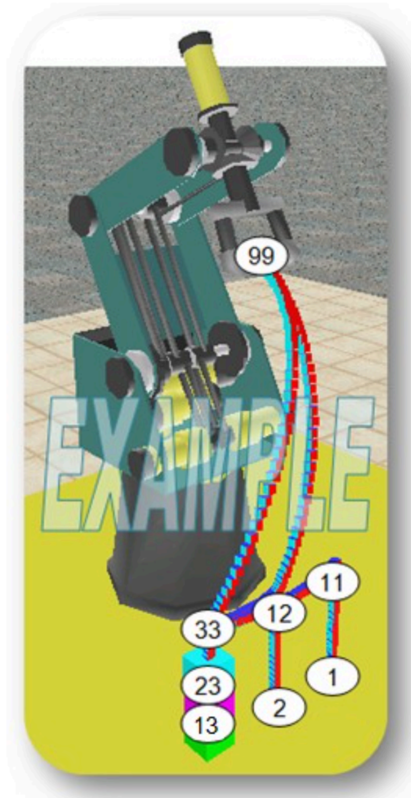
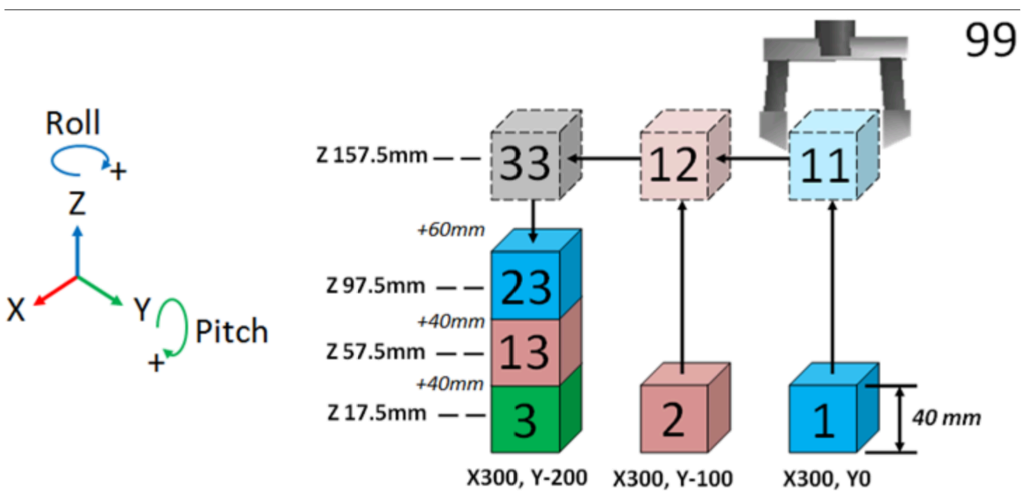
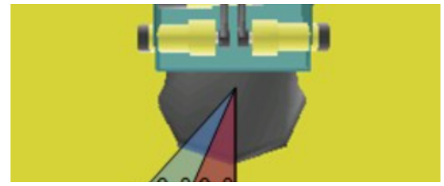


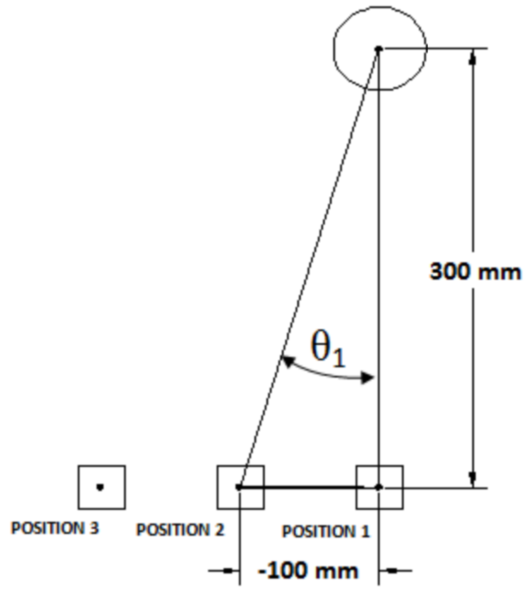
Figure 5. Robot Positions



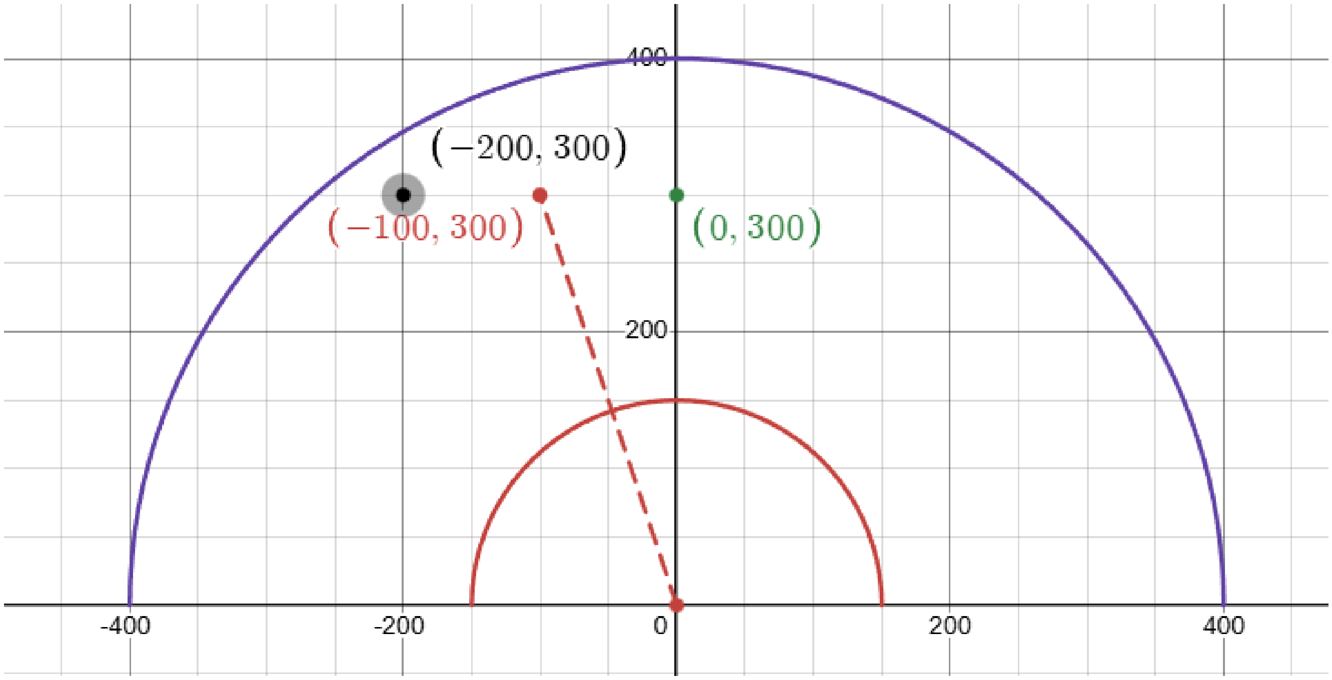
4. The amount of rotation needed can be found by determining the size of the angle whose tangent is calculated based on the dimensions of the triangle formed between the following positions:
The robot’s base, position 1, and position 2.

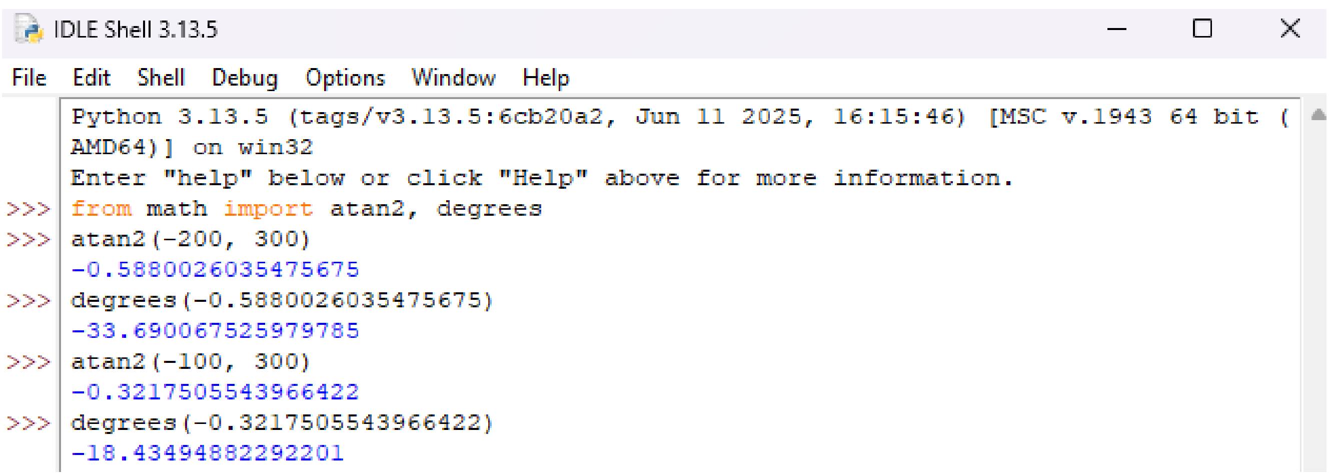


In the space provided, calculate the correct roll angle for positions 2 and 12. Show your work even though you are using a calculator. Note that: Tan υ = Opp/Adj and $\upsilon = \tan^{-1}$ (Opp/Adj)



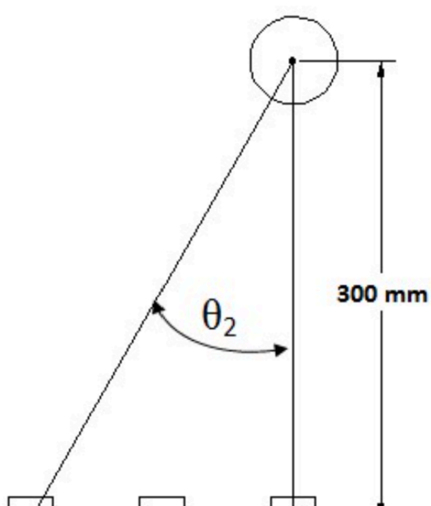
Calculate the angle of Rotation for the image provided. Must show all work.



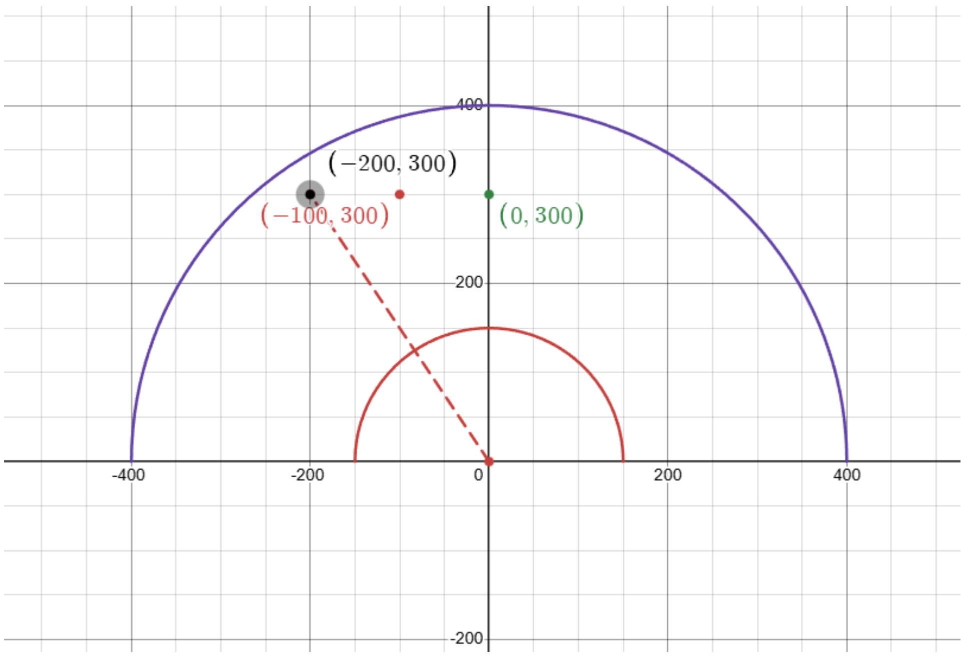


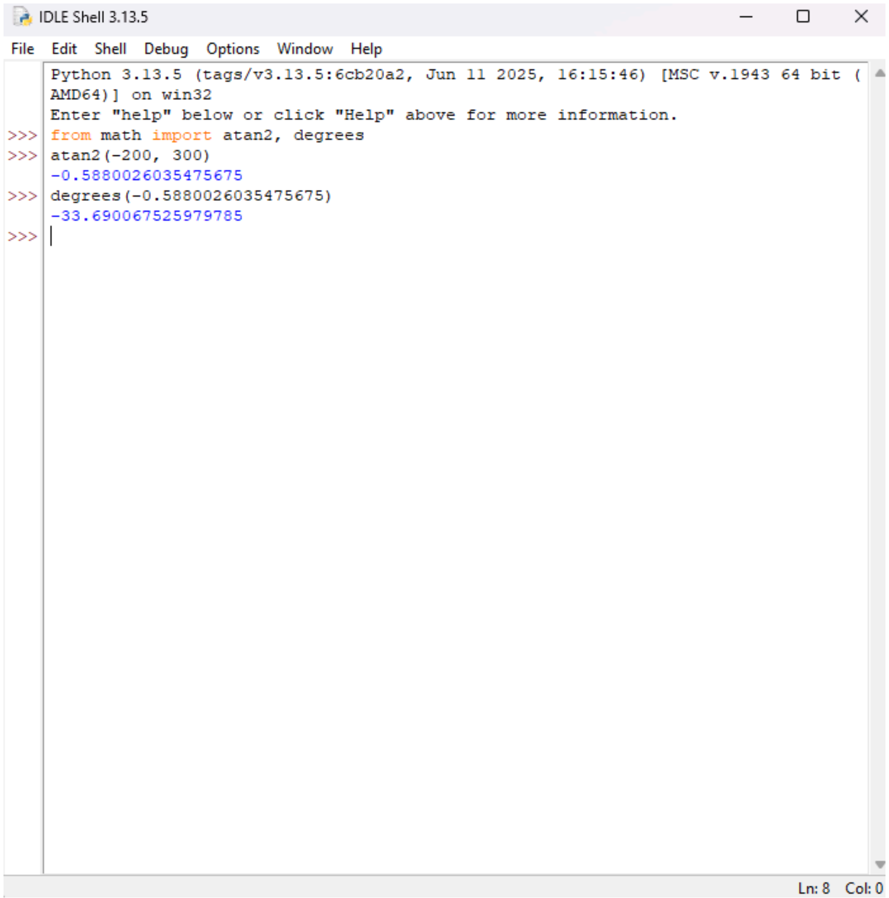
```
IDLE Shell 3.13.5
File  Edit  Shell  Debug  Options  Window  Help
Python 3.13.5 (tags/v3.13.5:6cb20a2, Jun 11 2025, 16:15:46) [MSC v.1943 64 bit (
AMD64)] on win32
Enter "help" below or click "Help" above for more information.
>>> from math import atan2, degrees
>>> atan2(-200, 300)
-0.5880026035475675
>>> degrees(-0.5880026035475675)
-33.690067525979785
>>> atan2(-100, 300)
-0.3217505543966422
>>> degrees(-0.3217505543966422)
-18.43494882292201
```

5. The amount of rotation needed for 13, 23, and 33 can be found by determining the size of the angle whose tangent is calculated based on the dimensions of the triangle formed between the following positions:
The robot's base, position 1, and position 3.



Calculate the angle of Rotation for the image provided. Must show all work. Show your work as you calculate the correct roll angle for positions 3, 13, 23, and 33.





6. Open the RoboCell software.

   a. Under the Options menu, select **PRO**.
   b. Import the 3D graphics file.
   c. Add the four Remark statements to your program:
      i. Remark: Activity 3.1.2c StackRoll
      ii. Remark: Your Name
      iii. Remark: Period X
      iv. Remark: Date: MM/DD/YY
   d. Use the Teach method to establish the required positions.
   e. Write the program as described in the narrative.

Run the program to verify that it functions as expected. Make necessary corrections. Submit your program file.

Insert Code to program RoboCell. Make sure to Remark the following

i. Remark: Activity 3.1.2c StackRoll
ii. Remark: Your Name
iii. Remark: Period X

iv. Remark: Date: MM/DD/YY

Remark: Remark: Activity 3.1.2c StackRoll
Remark: Jeide, Matthew
Remark: Period 2
Remark: 11/17/25
Open Gripper
Go to Position 99 Fast
Go to Position 2 Fast
Close Gripper
Go to Position 12 Fast
Go to Position 13 Fast
Go to Position 23 Fast
Open Gripper
Go to Position 13 Fast
Go to Position 11 Fast
Go to Position 1 Fast
Close Gripper
Go to Position 11 Fast
Go to Position 13 Fast
Go to Position 33 Fast
Open Gripper
Go to Position 13 Fast
Go to Position 99 Fast

#	Coor.	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 7	Axis 8	Type
		X (mm)	Y (mm)	Z (mm)	Pitch (deg)	Roll (deg)	mm/deg	mm/deg	
1	Joint	0.00	-6.47	79.53	16.94	0.00			
	XYZ	300.00	0.00	17.50	-90.00	0.00			Abs. (XYZ)
2	Joint	-18.43	-5.06	73.81	21.25	-18.43			
	XYZ	300.00	-100.00	17.50	-90.00	-18.43			Abs. (XYZ)
3	Joint	-33.69	2.84	53.10	34.03	-30.04			Abs. (Joint)
	XYZ	300.06	-200.02	9.99	-89.96	-30.04			
11	Joint	0.00	-40.08	98.75	31.32	0.00			
	XYZ	300.00	0.00	157.50	-90.00	0.00			Abs. (XYZ)
12	Joint	-18.43	-37.77	93.16	34.62	-18.43			
	XYZ	300.00	-100.00	157.50	-90.00	-18.43			Abs. (XYZ)
13	Joint	-33.69	-30.44	76.26	44.18	-33.69			
	XYZ	300.00	-200.00	157.50	-90.00	-33.69			Abs. (XYZ)
23	Joint	-33.69	-9.07	64.21	34.86	-33.69			
	XYZ	300.00	-200.00	57.50	-90.00	-33.69			Abs. (XYZ)
33	Joint	-33.69	-18.14	70.64	37.50	-33.69			
	XYZ	300.00	-200.00	97.50	-90.00	-33.69			Abs. (XYZ)
99	Joint	0.00	-120.28	95.02	88.81	0.00			Abs. (Joint)
	XYZ	169.03	0.00	504.33	-63.55	0.00			

7. E-Portfolio video with updated code.

E-Porfolio Published link with video file. Use the Snipping Tool to record. Then upload the file to your Google Drive to upload on your Portfolio.
https://m-jeide.github.io/eng-portfolio/CIM/Robocell

Conclusion Answer in complete sentences each of the questions below.

1. Describe how the six degrees of freedom are important for the effectiveness of a robot.

The six degrees of freedom are essential for robot effectiveness because they allow the robot to position and orient its end-effector anywhere in three-dimensional space. The three translational degrees of freedom enable movement along the x, y, and z axes to reach different locations, while the three rotational degrees of freedom allow the robot to orient objects at any angle.

2. Describe how pitch, roll, and yaw are important position descriptions for a robot end effector.

Pitch, roll, and yaw are critical for describing the end-effector's orientation because they define the three rotational angles that control how the gripper approaches and manipulates objects. Pitch controls the up-and-down tilting motion, roll controls rotation around the arm's length, and yaw controls side-to-side rotation.