

# Introduction to Robotics: Homework I

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## Introduction

The homework involves determining the transformation matrices associated with a robotic manipulation task. Specifically, you are required to identify the transformation matrices for all objects in the environment, the relative transformation matrix between the manipulator's end-effector and the object being manipulated, and the transformation matrix for the end-effector that enables the manipulated object to be precisely inserted into a designated hole.

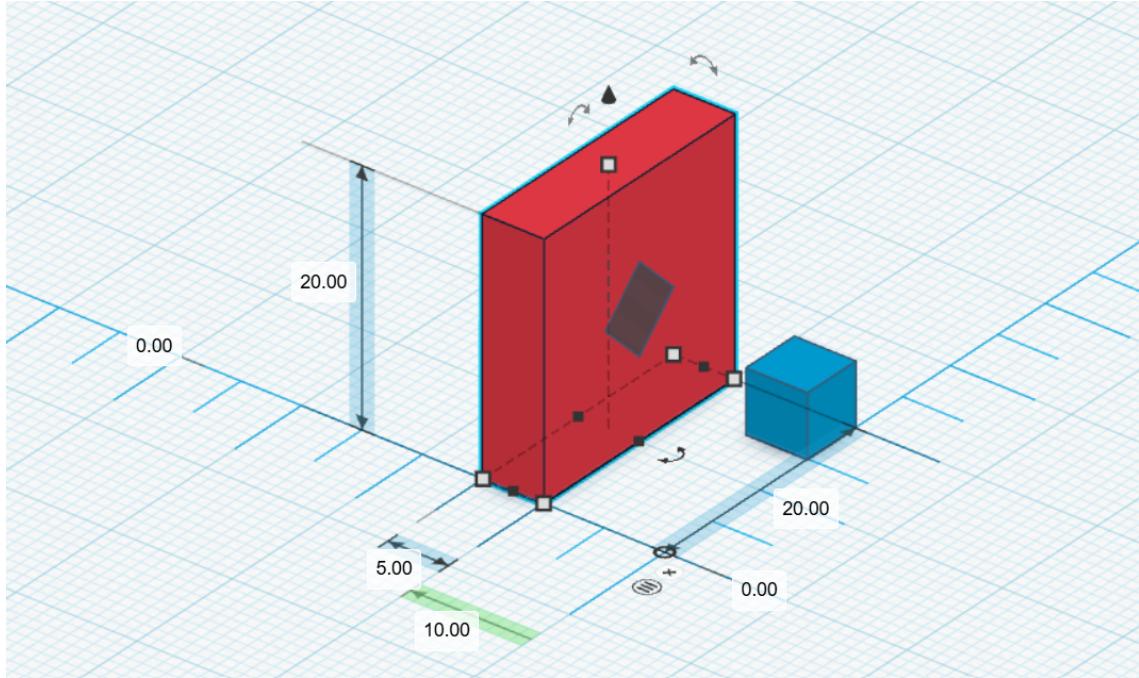


Figure 1: Visualization of the manipulation scenario. **Measurements are in cm.**

## 1 Description

The setup includes an Elephant myArm 300 Pi manipulator equipped with a gripper (Fig. 2), a box featuring a cubic hole at its center (represented as the red rectangular parallelepiped in Fig. 1), and a cube (shown as the blue cube in Fig. 1) that the manipulator must handle and insert into the hole. The Elephant myArm 300 Pi is a 7-DOF robotic arm that surpasses conventional 6-axis manipulators, offering human-like flexibility and precision. Powered by a Raspberry Pi, it supports ROS, Python, and advanced control, making it ideal for research, teaching, and application development in robotics. The manipulator's reach is shown in Fig. 3.

## 2 Task

Given Fig. 1, Fig. 2, Fig. 3, Fig. 4, Fig. 5, Fig. 6, Fig. 8, Fig. 7, Fig. 9, Fig. 10:

1. Choose the location and orientation of the world frame;
2. Assign a fixed body frame to each object in the scenario;
3. Calculate the transformation matrix for each object relative to the world frame;
4. Select an appropriate transformation matrix for the base frame of the manipulator with respect to the world frame, ensuring it can perform the manipulation task;
5. Determine the relative transformation matrix between the manipulator's end-effector and the cube, allowing the manipulator to grasp the cube (aka, what should be the orientation and position of the cube with respect to the end-effector such that it can be grasped);
6. Calculate the cube's world-frame transformation matrix both when it is positioned right next to the hole (so that moving it perpendicularly toward the box's surface would place it directly into the hole) and after it has been precisely positioned inside the box by the manipulator.
7. Visualize the results using the programming language of your choice.

## 3 Deliverables

- Detailed report;
- Code for visualization and containing the transformation matrices.

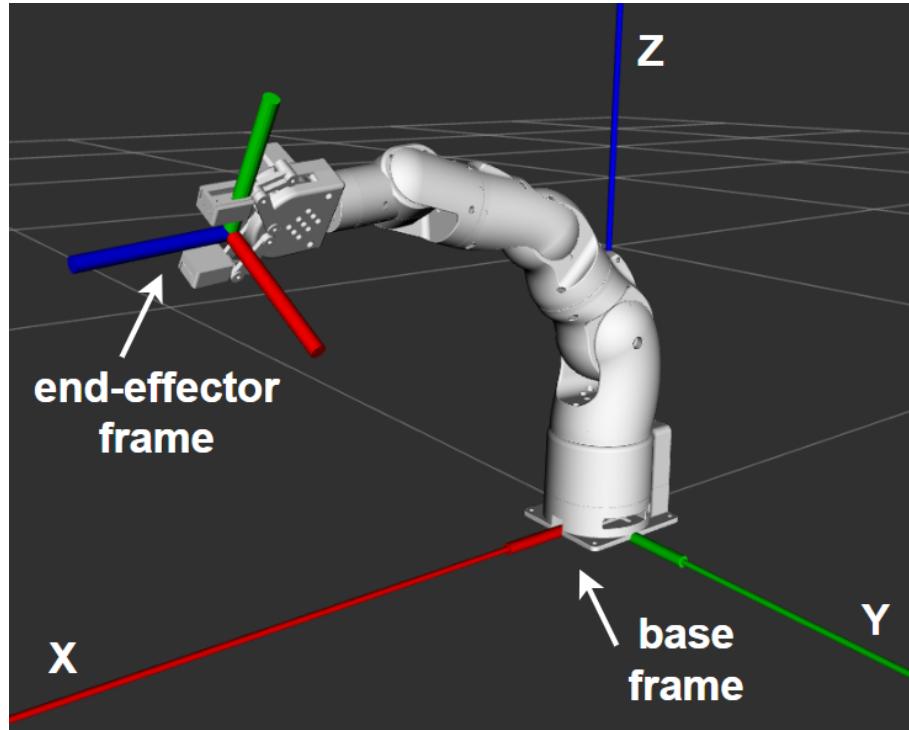


Figure 2: Visualization of the Elephant myArm manipulator.

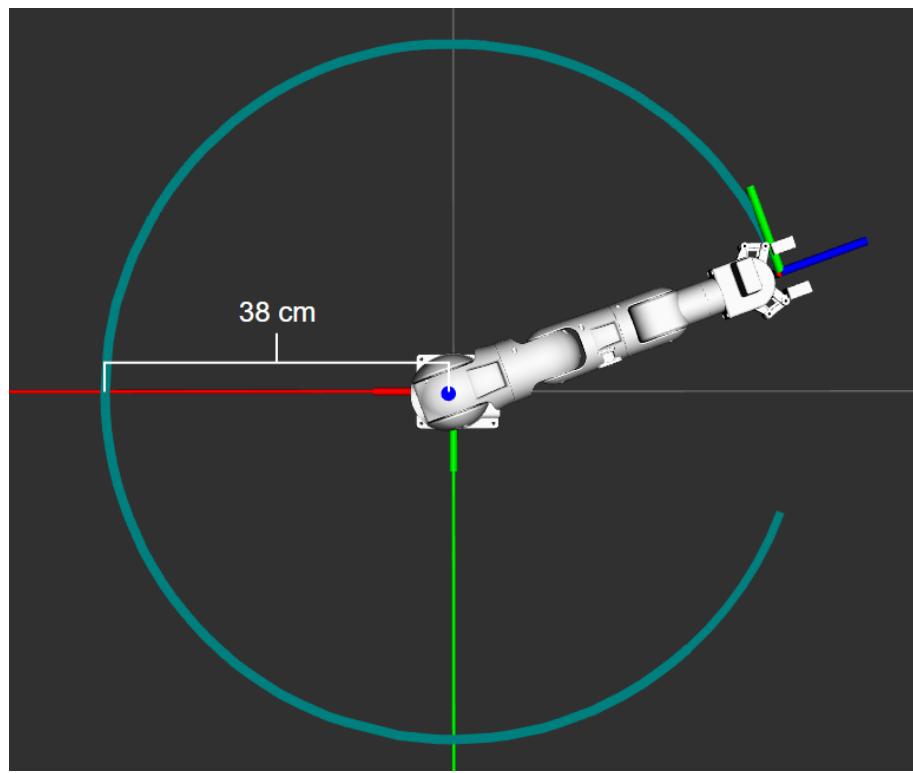


Figure 3: Elephant myArm manipulator's reach (top view).

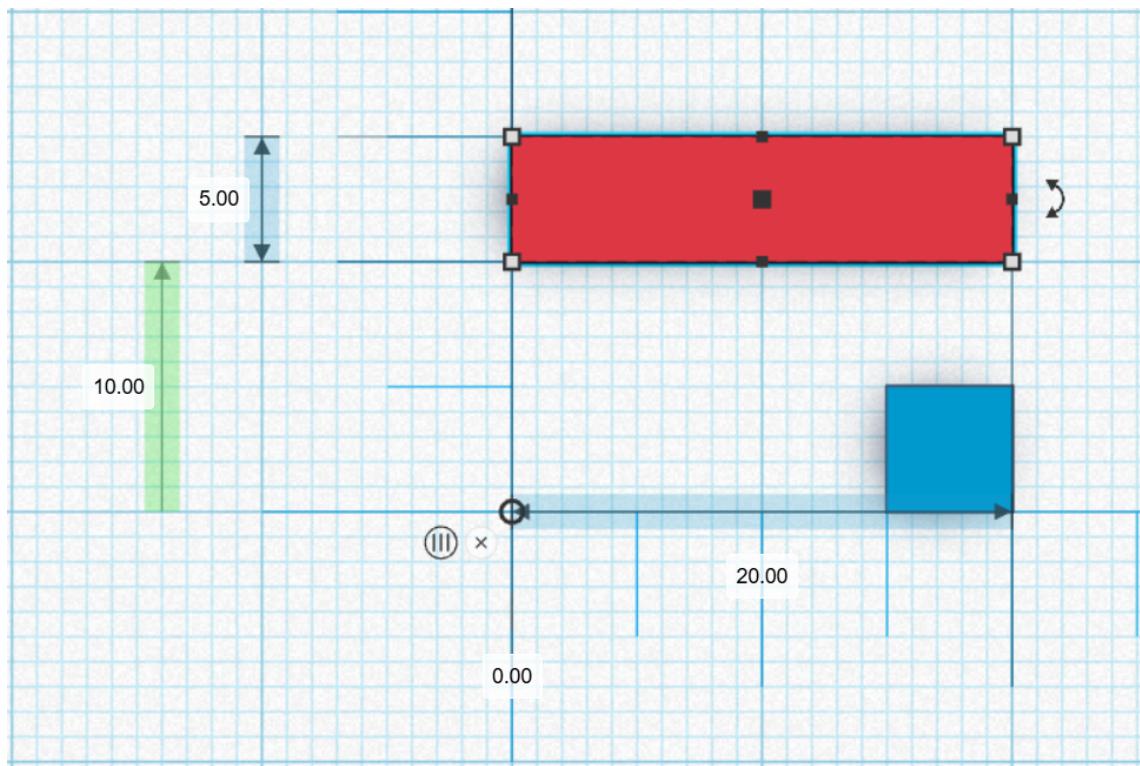


Figure 4: Scenario measurements. Measurements are in cm.

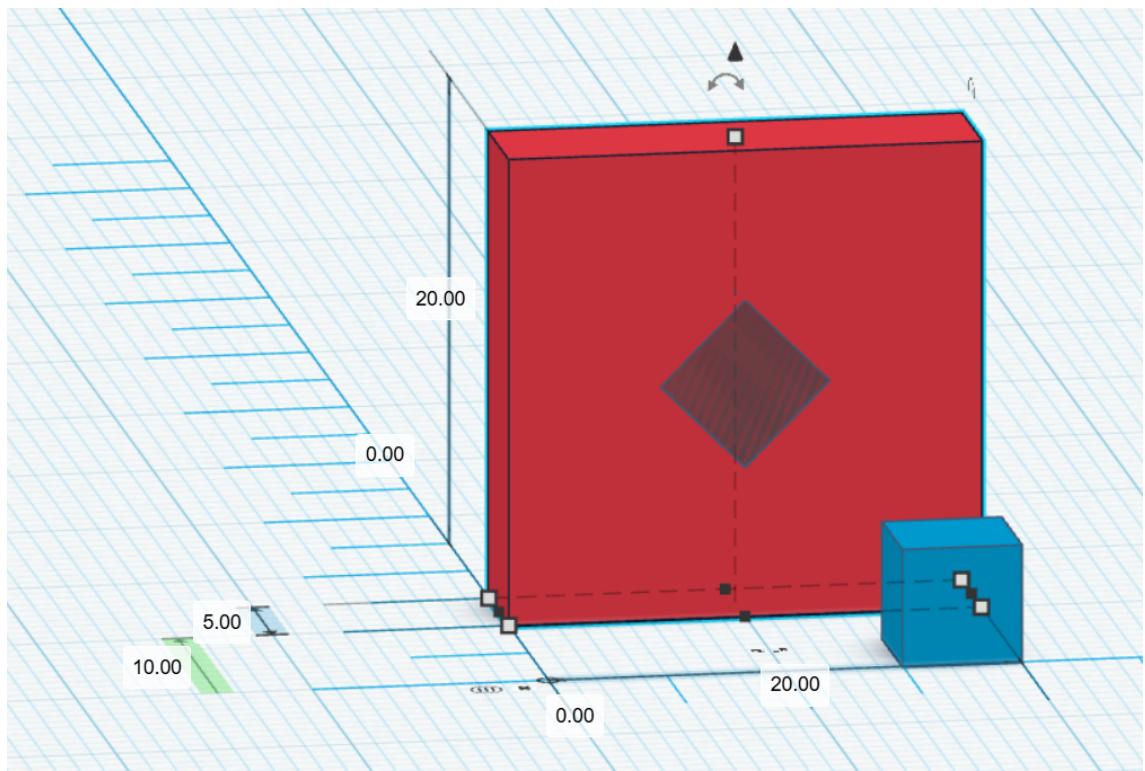


Figure 5: Scenario measurements. **Measurements are in cm.**

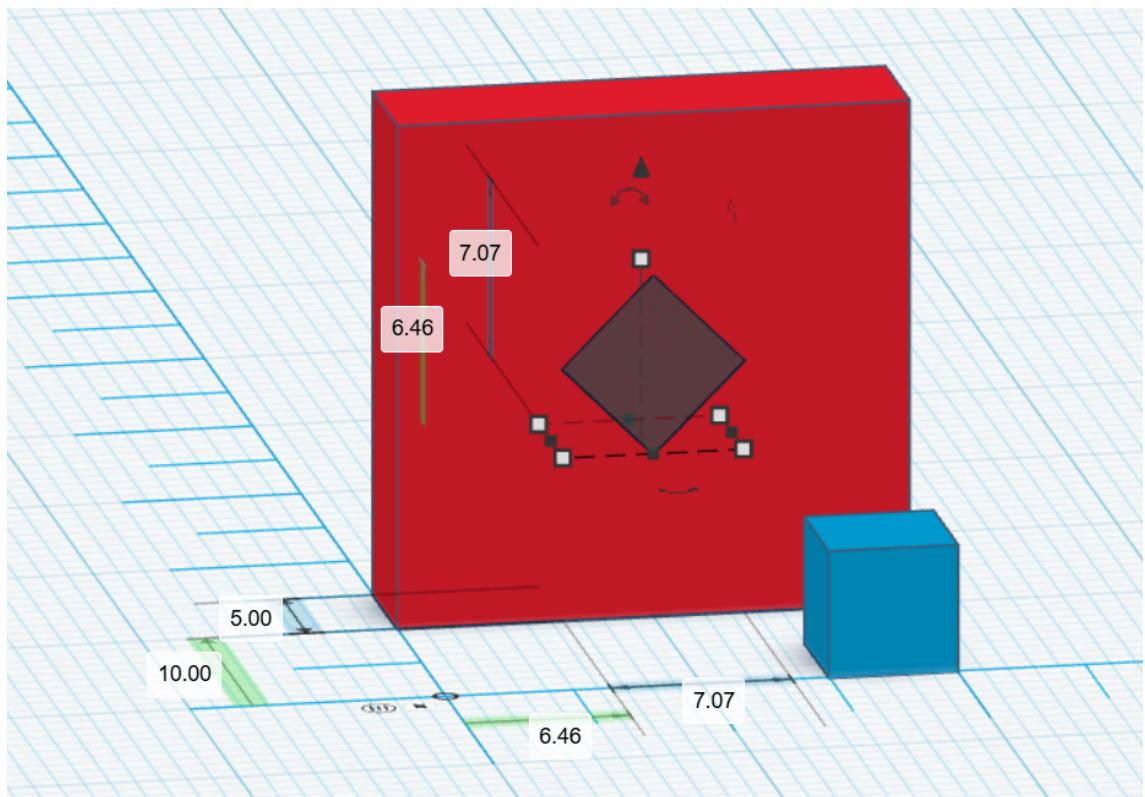


Figure 6: Scenario measurements. **Measurements are in cm.**

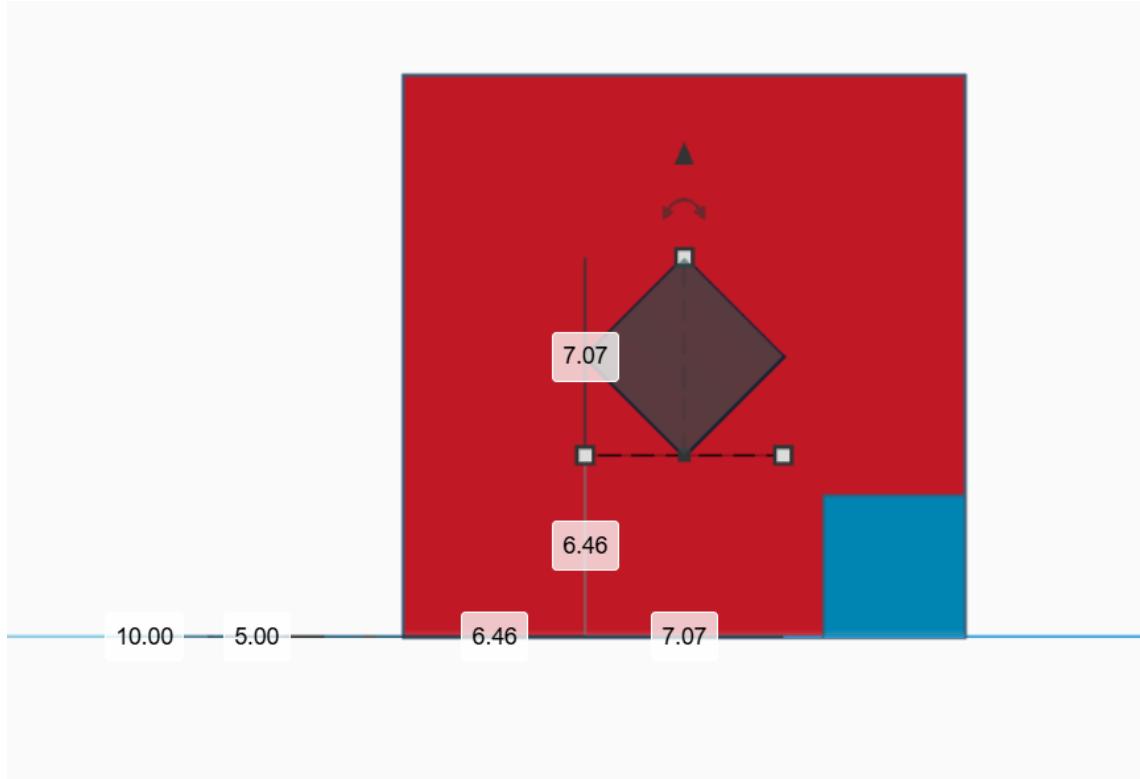


Figure 7: Scenario measurements. **Measurements are in cm.**

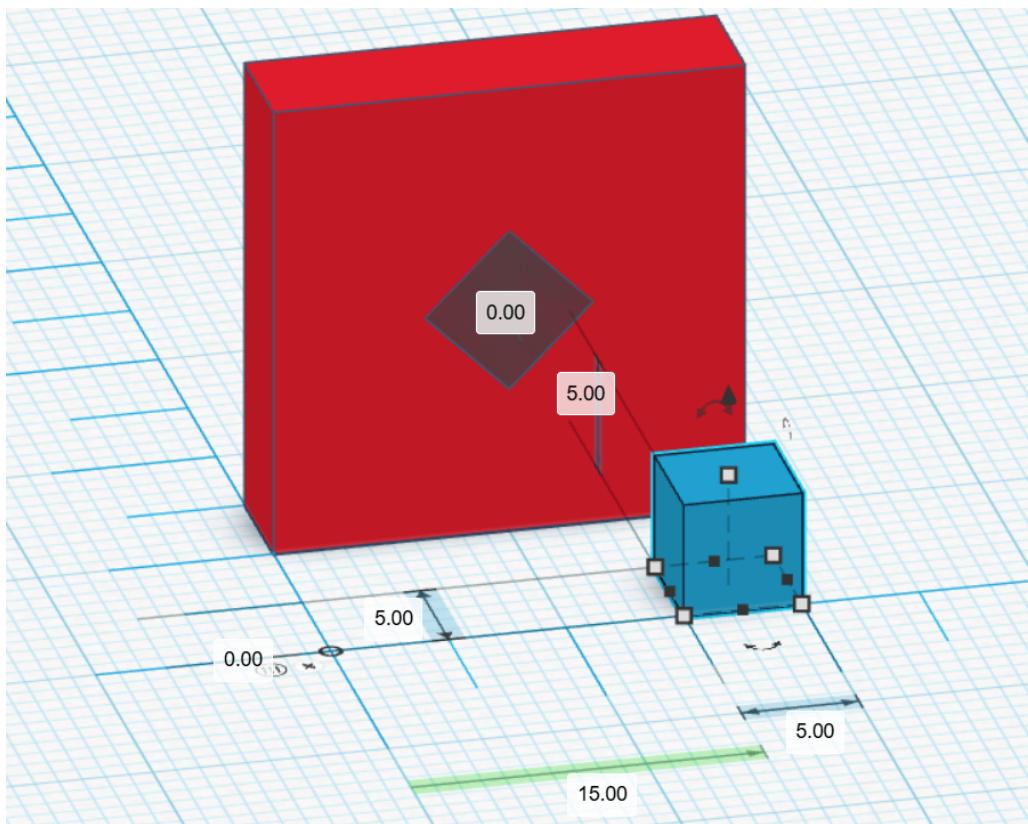


Figure 8: Scenario measurements. **Measurements are in cm.**

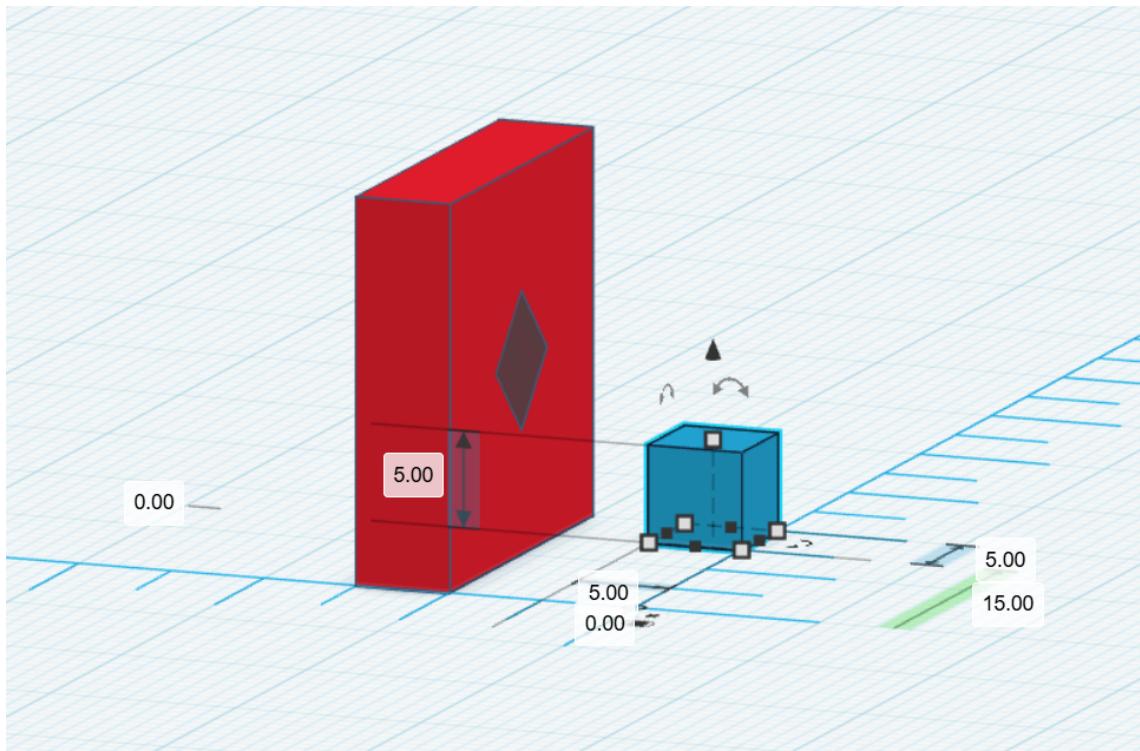


Figure 9: Scenario measurements. **Measurements are in cm.**

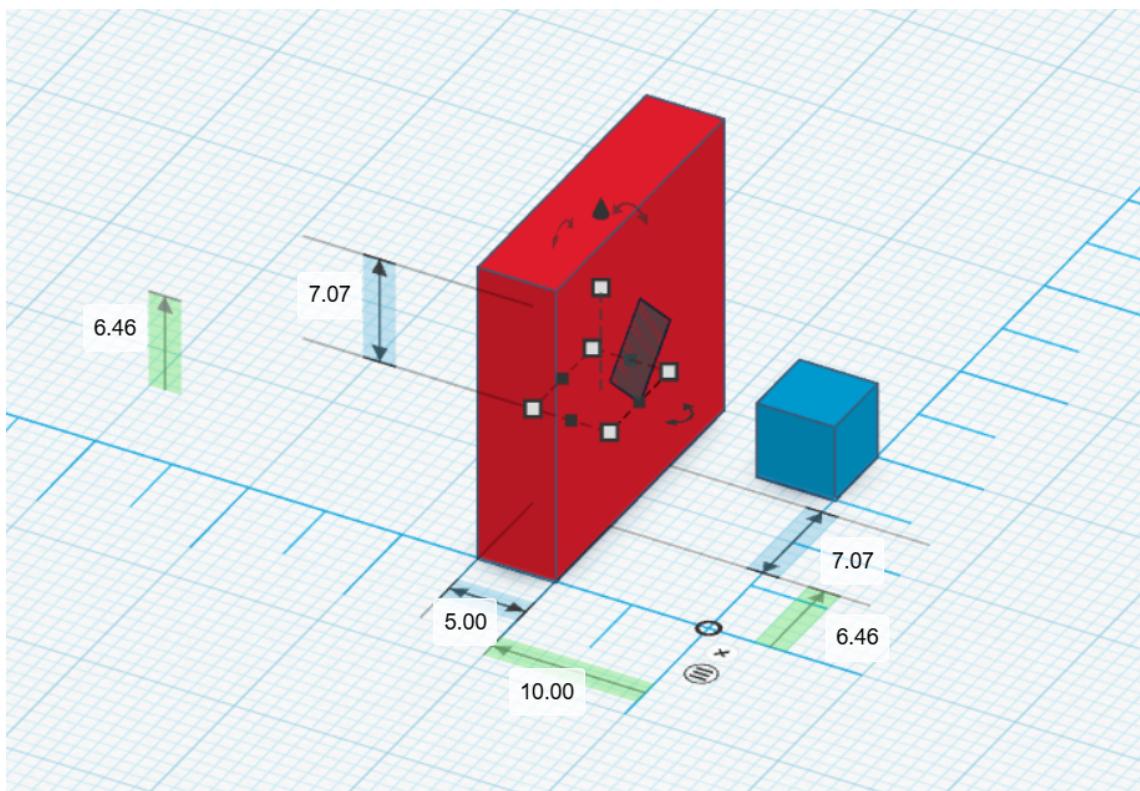


Figure 10: Scenario measurements. **Measurements are in cm.**