# Robot Arm Rigid Body Grasping Tests

*version 1.2/23-Sep-2025/CJ,ES*

## Purpose

This test is to assess a harvesting system that involves grasping tasks done by a robotic ar,s using a simplified test set-up inspired by the NIST Assembly Task Board (NIST 2018).

The test evaluates arm position accuracy and repeatability through having a robot arm picking single objects at various orientations which are common in fruit harvesting situations. It involves grasping and picking objects at specific orientations, and the success rate is based upon repeated trials of the test set-up. The test is related to ISO 9283 (ISO 1998), which includes tests in positioning repeatability.

## Test Facility

The test site is indoors in a greenhouse or polytunnel setting (i.e. a semi-controlled environment, which could include artificial light and assumes no wind).

The test set-up is for the robotic system to grasp and remove target objects attached to cube (see Figure 1). The cube is elevated from the ground. The targets are arranged at orthogonal positions and aim to test reach and ability to grasp from different angles. There is a receptacle for the targets to be placed after picking on the ground in front of the test cube. The dimensions of the test cube are shown in Figure 2 and are dependent on the height and scale of the robot arm system.

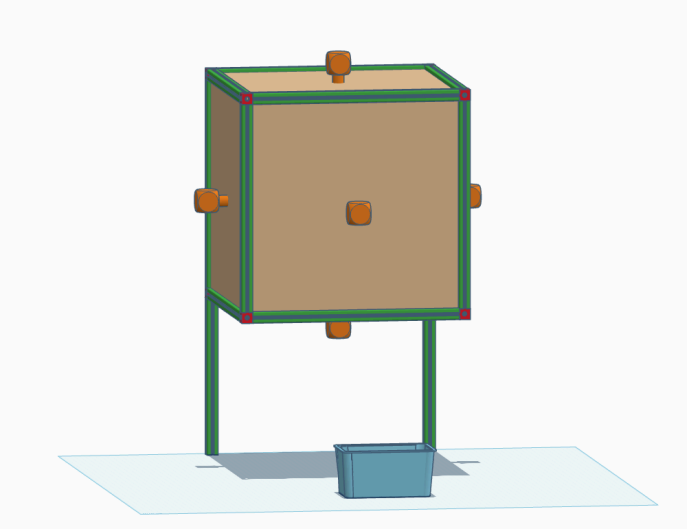

Figure 1 - Test Set-up is a rigid cube with targets (orange) centered on orthogonal planes – Front, Top, Bottom and Sides (not on the Back). There is a punnet placed on the ground in front of the cube.

The cube is a distance **d** from the ground. The cube is sized by width **c_w**, height **c_h** and depth **c_d**. It is assumed that **c_w = c_h = c_d**. The target (orange object) are located in the center of five of the cube's facings: Front (as shown in Figure 2), Top, Bottom, Left Side, and Right Side. The Back side of the cube does not have a target.

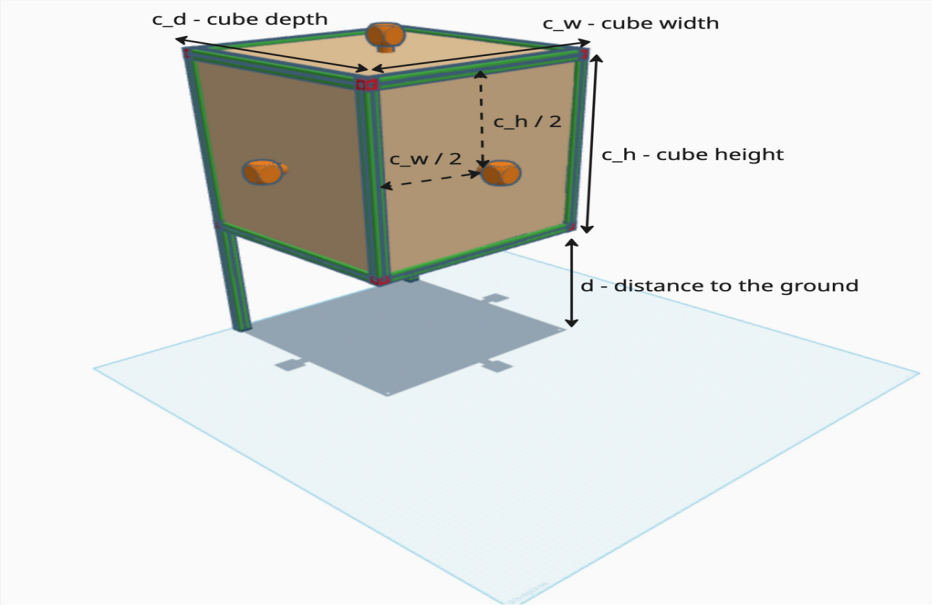


Figure 2 – Dimensions of test cube set-up facing the Front side of the cube.

Figure 3 shows the dimensions of the grasp targets. Each target is sized the same. The target is a dice-like object with the same width, height and depth of size s. The target is attached to the cube via a stem protruding a distance c. The target is magnetically attached to the stem, and detaches under grasping actions. The target detaches with a comparable force to a soft fruit, such as strawberry detaches. Dimeas et al. (2013) have measured that a direct pulling detachment force of ~14N, or a bend of pull detachment force of ~3N is adequate to detach a ripe strawberry.

The punnet is fixed on the ground next to the cube (Figure 4). Its dimensions are shown in Figure 5.

Dimensions for the test set-up are assumed to be as follows:

| *Dimension* | *Variable* | *Value* |
|---|---|---|
| Test Cube Width | c_w | 300 mm |
| Test Cube Height | c_h | 300 mm |
| Test Cube Depth | c_d | 300 mm |
| Distance from Ground | d | 20 cm |
| Target distance from cube | c | 1 cm |
| Target size | s | 3 cm |
| Distance of punnet from cube | p | 200 mm |

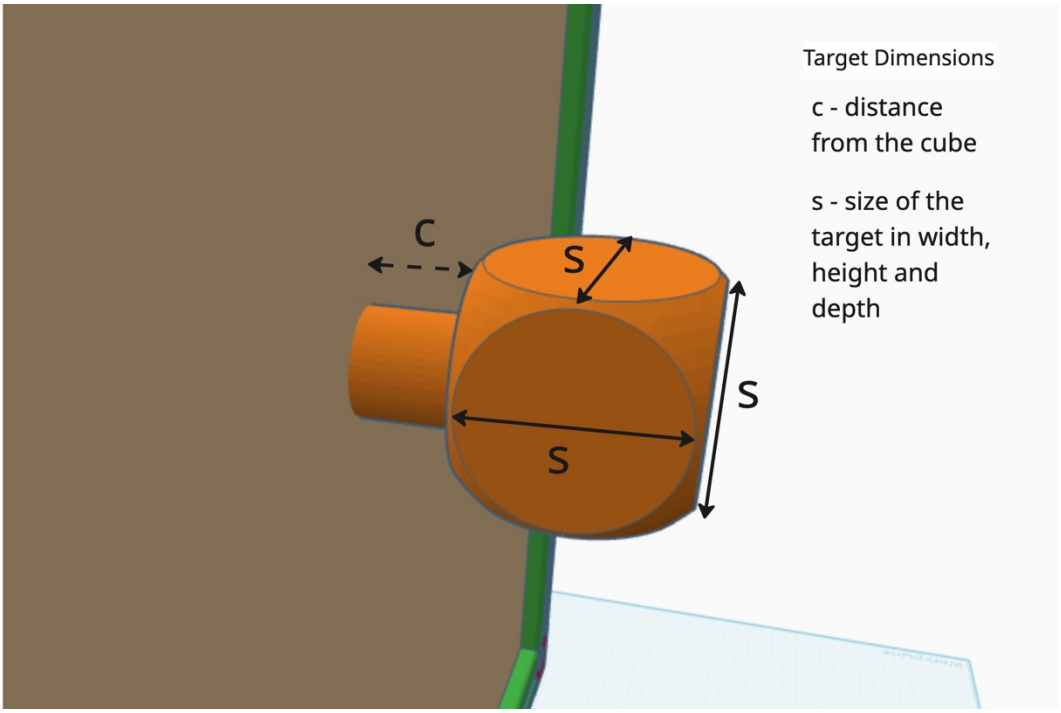


Figure 3 – Dimensions of the grasp targets – which is composed of a stem and a dice-like object to pick.

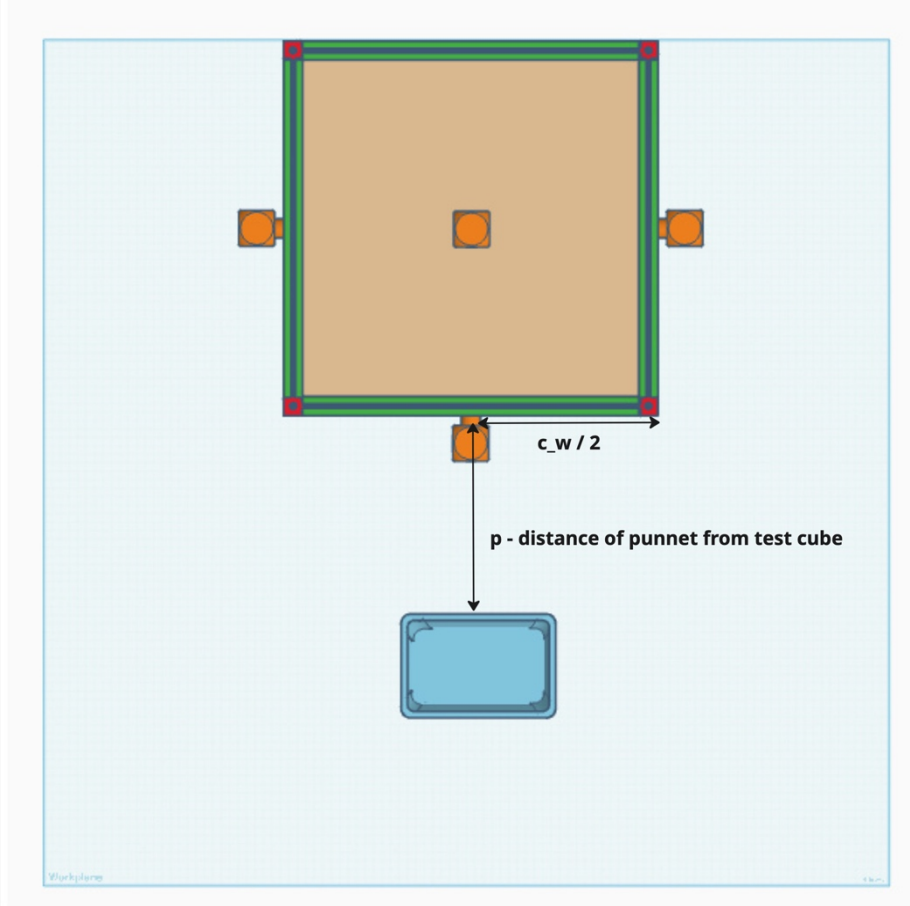


Figure 4. Punnet configuration relative to the test cube. Punnet is placed on the ground.

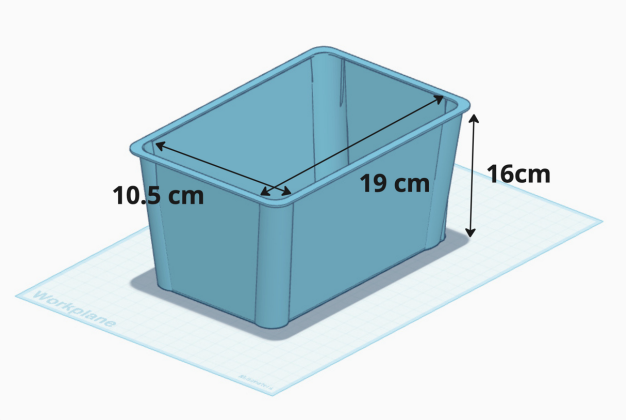


Figure 5. Dimensions of the punnet. Width and length are inner dimensions of the opening.

Sample image files of the test cube and the objects are available in the test git respository: https://github.com/LAR/ARRnet_grasping_tests

## Test Procedure

This test is a sequence of grasping tasks that center around the Test Setup. Sucess in each task allows the entry to attempt the next task. There are 4 tasks: Baseline, Equal Spacing, Random Spacing, Random Clustering. The Baseline Grasping Task set-up is shown in Figure 1, with 5 targets in the center of each cube face. The rest of the tasks have 5 targets per cube face, in increasing complexity of target configuration.

### 0. Safety Stop

Demonstrate that the robot can respond correctly to activation of an Safety Stop command.

### 1. Baseline Grasping Task Test

This task's aim is to evaluate the baseline ability of the robotic system to remove the 5 targets within a budgeted amount of time per trial. This is repeated for **5 consecutive trials**.

The robot system is set up in front of the Front face of the test cube with the objects in place (as shown in Figure 1). The robot grippers should be in a "home" position.

The test is for robot arms to remove each of the 5 targets. Each target must be brought to the punnet and deposited. Successfully depositing the target into the punnet is considered the success state for that target for this trial.

Dropping a target prior to bringing the target to the punnet is counted as a missed target for this trial. Even if the target is re-picked up, it is considered a miss.

Targets can be regrasp while they are attached to the cube.

Each trial has a **2 minute** time limit, any targets not picked or brought to the punnet by the time limit are considered missed.

### 2. Equal Grasping Task Test

Equal spacing configuration is shown in Figure 6.

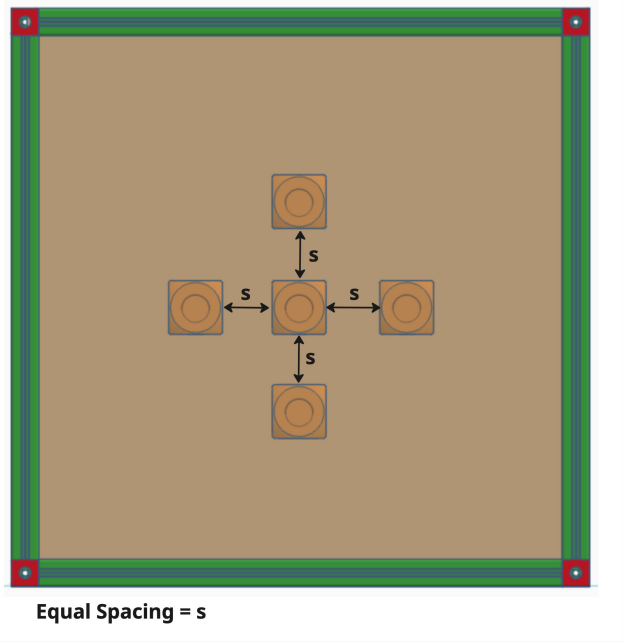


Figure 6. Equal spacing target configuration.

This target configuration tests the ability to handle picking amongst multiple targets on the same face. The configuration is as shown in Figure 5, with 4 targets placed orthogonally around the centered target. The targets are spaced by one target length (s) apart from each other.

The time limit for this task is **10 minutes.**

### 3. Random Spacing Grasping Task Test

Random spacing configuration is shown in Figure 7.

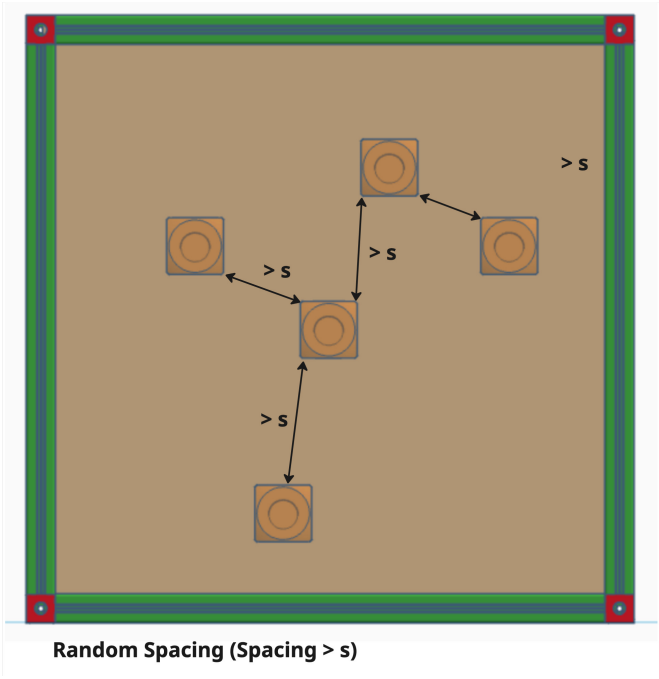


Figure 7. Random spacing configuration.

In this configuration, each face has 5 targets randomly spaced amongst each other. The spacing will always be > s between the targets and the edge of the face.

The time limit for this task is **10 minutes.**

### 4. Random Clustering Grasping Task Test

Random clustering configuration is shown in Figure 8.

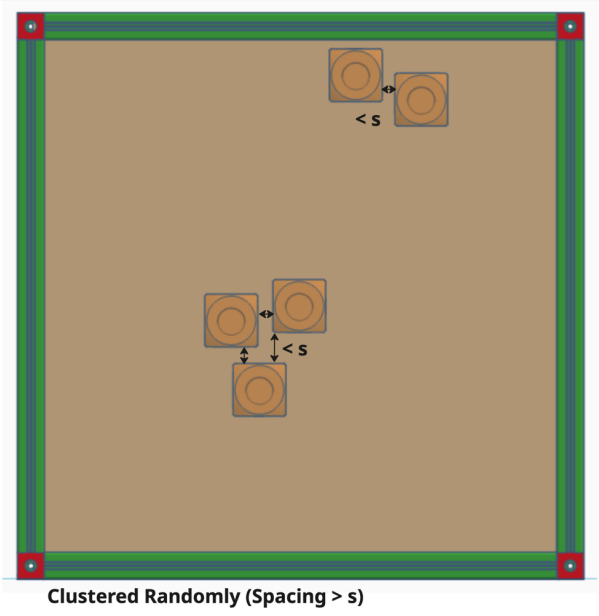


Figure 8. Random clustering configuration of the targets.

In this task configuration, each face has 5 targets randomly spaced amongst each other. The spacing will be < s for some of the targets. Targets may be placed close to the edge of the face.

The time limit for this task is **10 minutes.**

## Evaluation Criteria and Error Conditions

These are the evaluation criteria for the test.

**Pick Success**. The success rate (%) of picking all of the targets over the repeated 5 trials.

**Throughput.** The second criteria is the time to complete the trial, which is compared to a human completing the trial. The human benchmark will be established prior to the test.

## Conditions

The following data is gathered about the robotic system:

- Robotic hardware and software configuration and versions
- Position of the base of the robot system with reference to the Front facing target (a fixed reference point of the test setup).

Each trial is run separately with the ability to reset the robot system as needed.

The following information is recorded for each trial run:

- The robot system is video recorded with full view of each of the targets and the "home" position where the targets are deposited.
- The trial is timed with a limit of 2 minutes for the baseline and 10 minutes for the multiple targets per face tasks.
- Each target removal point is timestamped.
- The deposit of the target after being picked is timestamped.
- The success rate of picking the 5 targets along with the final time to complete the 5 picking tasks.

## Test Result

The following shall be recorded and included in the test report (template to be provided):

- **Pick Success Results.** A total success rate of for picking all of the targets across the number of trials for a specific task. The acceptable rate is > 95% overall.
- **Throughput Results.** The completion time is averaged across the number of trials for a given task. This is compared as a ratio towards the average human completion time for the trials. The acceptance rate for throughput is TBD and will be based on empirical data.

Environment conditions (e.g. light levels) should also be recorded in the test report.

## References

1. "Assembly Performance Metrics and Test Methods." *NIST*, 2018. https://www.nist.gov/el/intelligent-systems-division-73500/robotic-grasping-and-manipulation-assembly/assembly.

2. ISO. “ISO 9283:1998.” Accessed August 8, 2025. https://www.iso.org/standard/22244.html.
3. Dimeas, Fotios, Dhionis Sako, Vassilis Moulianitis, and Nikos Aspragathos. “Towards Designing a Robot Gripper for Efficient Strawberry Harvesting.” Paper presented at RAAD, Portoroz, Slovenia. September 11, 2013.

## Version change notes

- v1.0/12-Aug-2025/CJ Original version
- v1.1/16-Sep-2025/ES Added mention of template for test report.
- V1.2/23-Sep-2025/CJ Updated cube, target, and set-up dimensions to reflect demonstration. Added images link.