

RoboCup Rescue 2022

Draft Rulebook

Part 4: Dexterity

Version 2022-04-14.

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Dexterity:

6 tests for manipulation and inspection. Tests DEX1, DEX2, DEX3, DEX4, and DEX5 are considered for a robot to win Best in Class Dexterity. Door opening (DEX6) is excluded for this year due to the difficulty in comparing door opening difficulty across multiple sites.

Some tasks have multiple settings, teams accumulate points for each combination of settings that they successfully complete, with either unlimited time (in remote pre-recorded trials) or within the limit of their allocated time slots (for live remote or in-person competition). The stationary tasks (DEX1-DEX5) must be performed on a diagonal rail rather than flat flooring to force robots that must reposition the base to be aware of their terrain. ***In DEX1-DEX5, the robot must make contact with the ground in the triangle formed by the rail, the side wall, and the manipulation apparatus.***

See construction guide for further details.

(DEX 1) Directed Inspection

Motivation:

Evaluate the ability of the robot to perform Directed Inspection at varying distances and orientations from the robot.



Procedure:

1. Set the task apparatus (Linear or Omni) to the desired location and orientation.
 - For the Pre-recorded trials, teams shall demonstrate the Linear apparatus along the ground in front of the robot, in 30 cm (12 in) increments starting from directly in front of the robot.
 - For the Live Telecon trials and In-Person Preliminaries, teams shall demonstrate the Omni at 30 cm (12 in) incremental distances in front of the robot, at a height, chosen by the team, that is at least 30 cm (12 in) above the ground. The height must be a whole multiple of 30 cm (12 in).

See the “Task Positions” section for more details.

2. Prepare the linear task apparatus. Pipes shall be placed at each task location.
3. Ready the robot on the start square.
4. The trial starts once the start signal is given or the timer is started.
5. Drive the robot onto the terrain board and position to perform the manipulation tasks.
 - The robot may move at any point but may not overhang the front or sides of the terrain board (except with the manipulator).
6. Perform the selected task in all five locations on the linear task apparatus.
 - The robot shall inspect each of the five inspection pipes and read as many Landolt-C as possible.
 - The robot should avoid hard collisions with the apparatus.

- Each read Landolt-C is one point, for a total of up to 25 points.
- 7. For in-person and remote live telecon trials only: Perform the readiness test during the prescribed time.
- 8. When the robot has completed the dexterity task in all 5 locations with the linear rail or omni in the current location, the robot shall disengage from the apparatus and return to the start position. The team shall manually move the linear rail or omni to the next distance (30 cm (12 in) further from the robot, then repeat from step 5.
 - The clock continues running.
 - For safety, the team shall not begin moving the rail or omni until the robot manipulator is back over the terrain.
- 9. Completion of trial:
 - For the pre-recorded remote trials, the team has unlimited time to complete as much of the test as they can achieve with their robot and totals up all of the points. Note that the dexterity task must be completed in all 5 locations on a rail or omni before the rail or omni may be moved to the next distance. Record the time that the final dexterity task was completed and the total number of points. The video does not stop between each rail or omni movement.
 - For the in-person and remote live telecon trials, the team has a fixed amount of time to perform the trial. The team stops when the time is complete and the number of points achieved is recorded.

Test-specific Faults:

- None beyond the standard faults.

(DEX 2) Touch/Insert

Motivation:

Evaluate the ability of the robot to precisely touch points and insert objects into holes at varying distances and orientations from the robot. .



Procedure:

1. Set the task apparatus (Linear or Omni) to the desired location and orientation.
 - For the Pre-recorded trials, teams shall demonstrate the Linear apparatus along the ground in front of the robot, in 30 cm (12 in) increments starting from directly in front of the robot.
 - For the Live Telecon trials and In-Person Preliminaries, teams shall demonstrate the Omni at 30 cm (12 in) incremental distances in front of the robot, at a height, chosen by the team, that is at least 30 cm (12 in) above the ground. The height must be a whole multiple of 30 cm (12 in).
- See the “Task Positions” section for more details.
2. Prepare the linear task apparatus. Each task location shall be a hole of the prescribed diameter and depth.
 3. Ready the robot on the start square. The robot shall start with the Touch/Insert tool in the gripper.
 4. The trial starts once the start signal is given or the timer is started.
 5. Drive the robot onto the terrain board and position to perform the manipulation tasks.
 - The robot may move at any point but may not overhang the front or sides of the terrain board (except with the manipulator).
 6. Perform the selected task in all five locations on the linear task apparatus.
 - The robot shall touch and insert the Touch/Insert tool into each of the five task holes.
 - Each hole that is touched is 1 point.
 - Each hole where the tool is inserted to a depth of at least 25 mm (1 in) is worth an additional 4 points, for a total of up to 25 points.

- The robot may release or drop the tool in the environment and re-acquire it, or drop and pick up a new tool from its on-board tool magazine. At no point is physical human intervention allowed unless the robot is in the start square.
- 7. For in-person and remote live telecon trials only: Perform the readiness test during the prescribed time.
- 8. When the robot has completed the dexterity task in all 5 locations with the linear rail or omni in the current location, the robot shall disengage from the apparatus and return to the start position. The team shall manually move the linear rail or omni to the next distance (30 cm (12 in) further from the robot, then repeat from step 5.
 - The clock continues running.
 - For safety, the team shall not begin moving the rail or omni until the robot manipulator is back over the terrain.
- 9. Completion of trial:
 - For the pre-recorded remote trials, the team has unlimited time to complete as much of the test as they can achieve with their robot and totals up all of the points. Note that the dexterity task must be completed in all 5 locations on a rail or omni before the rail or omni may be moved to the next distance. Record the time that the final dexterity task was completed and the total number of points. The video does not stop between each rail or omni movement.
 - For the in-person and remote live telecon trials, the team has a fixed amount of time to perform the trial. The team stops when the time is complete and the number of points achieved is recorded.

Test-specific Faults:

- None beyond the standard faults.

(DEX 3) Extract/Place

Motivation:

Evaluate the ability of the robot to extract objects and place them into a container at varying distances and orientations from the robot.



Procedure:

1. Set the task apparatus (Linear or Omni) to the desired location and orientation.
 - For the Pre-recorded trials, teams shall demonstrate the Linear apparatus along the ground in front of the robot, in 30 cm (12 in) increments starting from directly in front of the robot.
 - For the Live Telecon trials and In-Person Preliminaries, teams shall demonstrate the Omni at 30 cm (12 in) incremental distances in front of the robot, at a height, chosen by the team, that is at least 30 cm (12 in) above the ground. The height must be a whole multiple of 30 cm (12 in).

See the “Task Positions” section for more details.

2. Prepare the linear task apparatus. Each task location shall be populated with the selected extract and place object.
3. Ready the robot on the start square. The robot shall start with the container in the gripper.
4. The trial starts once the start signal is given or the timer is started.
5. Drive the robot onto the terrain board and position to perform the manipulation tasks.
 - The robot may move at any point but may not overhang the front or sides of the terrain board (except with the manipulator).
 - The robot shall place the container on, or immediately adjacent to, the apparatus. The robot is free to move the container around during the test.
6. Perform the selected task in all five locations on the linear task apparatus.
 - The robot shall pick up each extract and place object and place it into the container.
 - If the robot drops the extract and place object into the environment outside the container or task apparatus holes, or if it falls out of a hole due to the robot bumping the apparatus, it may not re-acquire it. ¹

¹ This rule differs from Touch/Insert due to the likelihood that a sample or other object, extracted from the environment, is more likely to be something that is not appropriate to drop.

- Each object is worth 1 point if picked up in the robot's gripper
 - Each point is worth an additional 4 points if placed into the container for a total of up to 25.
7. For in-person and remote live telecon trials only: Perform the readiness test during the prescribed time.
8. When the robot has completed the dexterity task in all 5 locations with the linear rail or omni in the current location, the robot shall disengage from the apparatus and return to the start position. The team shall manually move the linear rail or omni to the next distance (30 cm (12 in) further from the robot, then repeat from step 5.
- The clock continues running.
 - For safety, the team shall not begin moving the rail or omni until the robot manipulator is back over the terrain.
9. Completion of trial:
- For the pre-recorded remote trials, the team has unlimited time to complete as much of the test as they can achieve with their robot and totals up all of the points. Note that the dexterity task must be completed in all 5 locations on a rail or omni before the rail or omni may be moved to the next distance. Record the time that the final dexterity task was completed and the total number of points. The video does not stop between each rail or omni movement.
 - For the in-person and remote live telecon trials, the team has a fixed amount of time to perform the trial. The team stops when the time is complete and the number of points achieved is recorded.

Test-specific Faults:

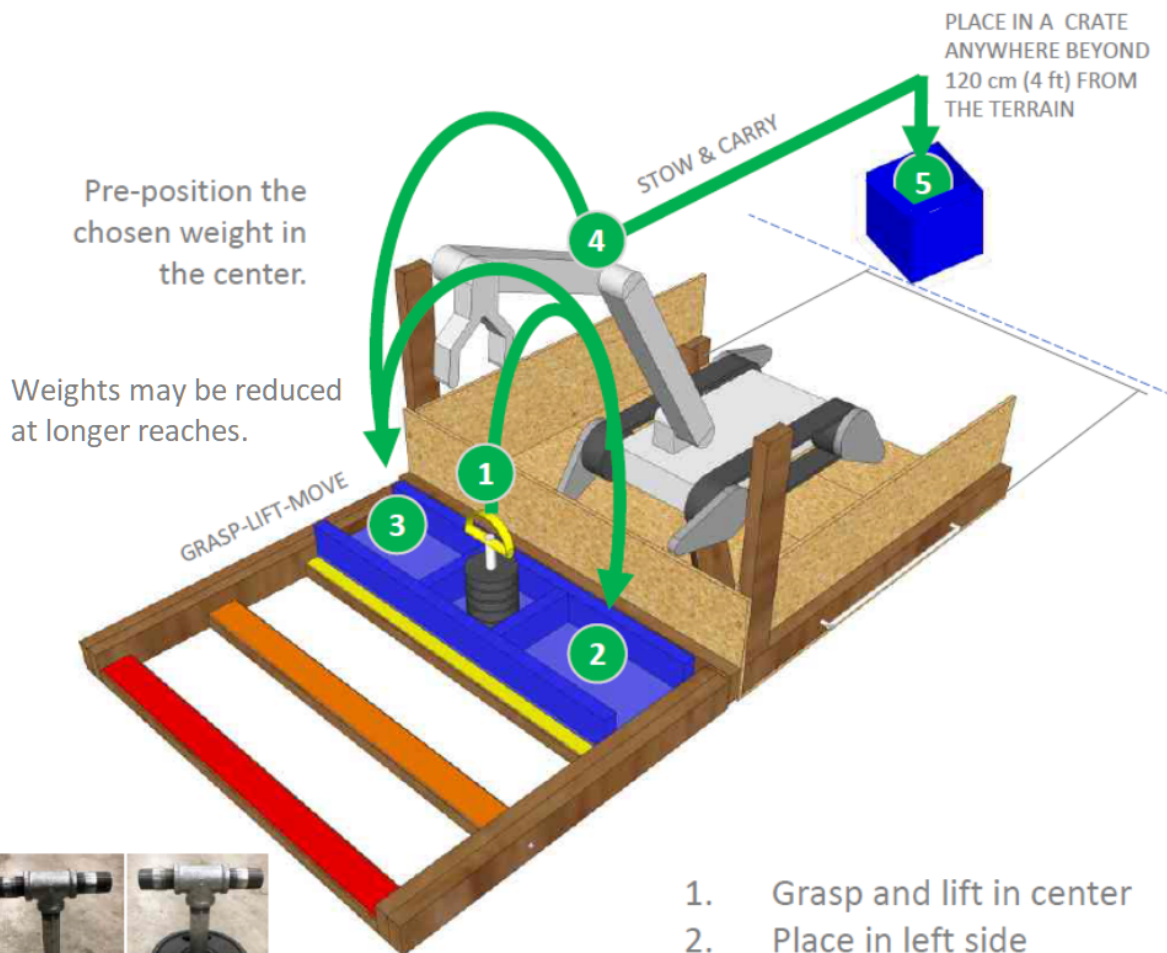
- None beyond the standard faults.

(DEX 4) Strength Tasks in the Work Volume:

Motivation:

The “Lift-Stow-Carry” tasks measure the maximum weight the robot can hold with its gripper within the terrain. The tasks - **Lift-Stow-Carry** - are performed in different stages:

- Lift the weight from the center
- Place the weight one space to the left
- Place the weight two spaces to the right
- Lift the weight into the terrain area
- Stow and carry the weight and place into the crate



- Pipe T with optional rope handle
- Weight-lifting plates with 25mm (1 in) center holes – Use any weights that fit easily into center containment such as 1 or 2 kg (2.5 or 5 lb) plates.

1. Grasp and lift in center
2. Place in left side
3. Place in right side
4. Stow and carry out
5. Place in the crate

Procedure:

1. Set the task apparatus to the desired location and orientation.
 - For the Pre-recorded trials, teams shall demonstrate the tasks along the ground in front of the robot, in 30 cm (12 in) increments starting from directly in front of the robot.
 - For the Live Telecon trials and In-Person Preliminaries, teams shall demonstrate the tasks at 30 cm (12 in) incremental distances in front of the robot, at a height, chosen by the team, that is at least 30 cm (12 in) above the ground. The height must be a whole multiple of 30 cm (12 in).

See the “Task Positions” section for more details.

2. Prepare the task apparatus.
 - The chosen weight shall be pre-positioned in the center location. Teams should practice in advance and choose a weight for the intended reach distance and elevation that allows for COMPLETION OF ALL FIVE TASKS at the given distance. Teams may use different weights for different distances. Note the stow and carry tasks may be equally challenging because the terrain can change robot orientations quickly.
 - For trials by video, each chosen weight must be measured with a spring scale and captured at the start of the trial video.
 - The crate or container shall be placed anywhere 120 cm (4 ft) behind the terrain.
3. Ready the robot on the start square.
4. The trial starts once the start signal is given or the timer is started.
5. Drive the robot onto the terrain board and position to perform the strength tasks.
 - The robot may move at any point but may not overhang the front or sides of the terrain board (except with the manipulator).
6. Perform the five strength tasks:
 - Lift the weight from the center.
 - Place the weight to the left side, clear of the partition.
 - Lift and place the weight to the right side, clear of the partition.
 - Lift the weight out of the manipulation apparatus.
 - Carry the weight out of the apparatus and place it into the crate.
7. For in-person and remote live telecon trials only: Perform the readiness test during the prescribed time.
8. When the robot manipulator and weight are over the terrain (and no part is over the manipulation apparatus) the team shall manually move the strength tasks tray to the next distance (30 cm (12 in) further from the robot and place the next weight in the center location, in preparation for continuing the test from step 5.
 - The clock continues running.
 - For safety, the team shall not begin moving apparatus until the robot manipulator and weight are over the terrain.
 - Once the robot is on the terrain, the team may remove the previous weight from the crate.
9. Completion of trial:

- For the pre-recorded remote trials, the team has unlimited time to complete as much of the test as they can achieve with their robot, with the maximum weight at each distance with which they can complete the test.
 - For each distance, the maximum number of kilograms at which all five strength tasks are completed is noted.
 - These maximums are added up across all distances resulting in the final score.
 - Record the time that the final weight was placed in the crate and the total number of points.
 - The video does not stop between each apparatus movement.
- For the in-person and remote live telecon trials, the team has a fixed amount of time to perform the trial. The team stops when the time is complete and the score achieved is recorded. If a team is partway through a set of tasks when the time runs out, the final weight is multiplied by the number of tasks that have been completed up to that point and divided by 5.

Test-specific Faults:

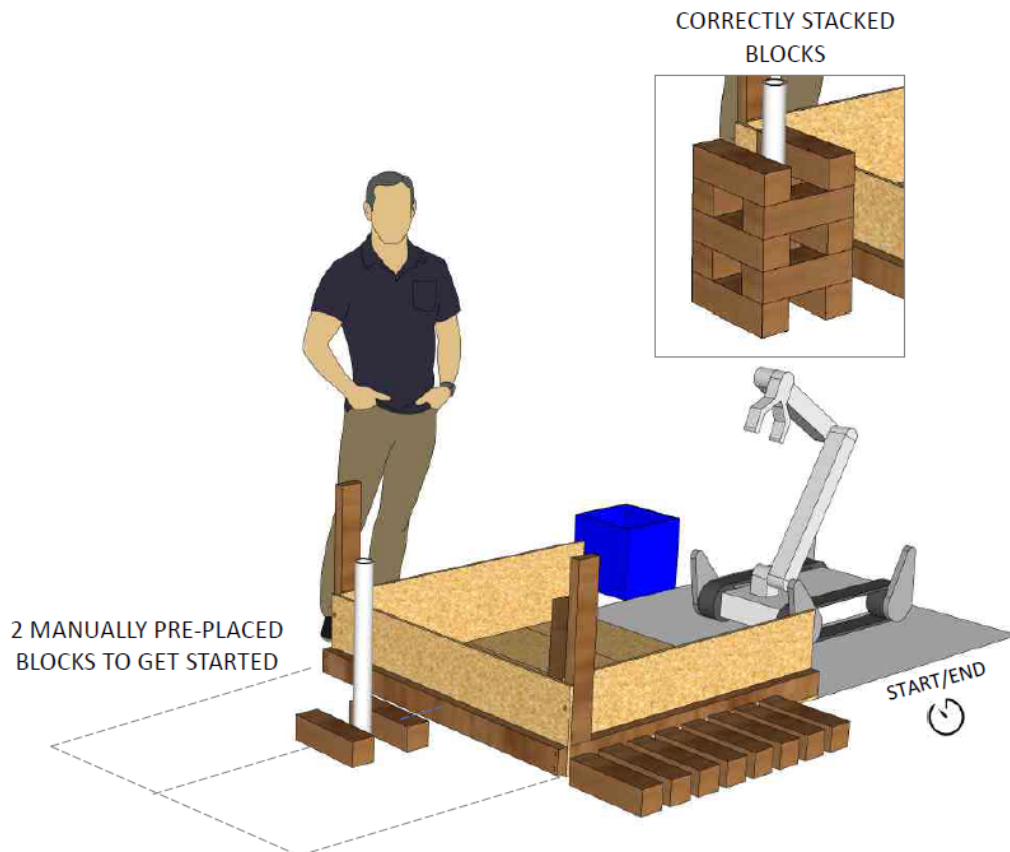
In addition to the standard faults:

- If the robot drops the weight partway through performing the tasks, the robot may **not** pick the weight up again as it represents an object from the environment (sample, etc.) that should be handled carefully.
 - The team may elect to reset for that distance without penalty. The robot must be driven back to the start square (not picked up). The team may place the weight (or a lighter weight) back at the center position of the apparatus and then that distance re-attempted.
 - If the weight is dropped in a location that blocks the robot, the team may manually move the weight as long as the robot is completely stopped.

(DEX 5) Shoring:

Motivation:

The Shoring task is intended to measure the robot's pick and place capabilities while avoiding contact with the post. This is an actual task performed by emergency responders trying to shore a compromised structure in which they are deployed.



The pipe can be at any distance along the terrain centerline and the blocks can be anywhere around the terrain (not in front)

The blocks should be of solid structural timber, such as pine. See construction guide for further details.

Procedure:

1. Prepare the task apparatus.
 - a. Pre-position a hollow pipe as the post at any distance along the centerline in front of the terrain. Use a 5 cm (2 in) diameter x 60 cm (24 in) PVC pipe standing on end, not secured to the ground or weighted in any way. For remote pre-recorded and live telecon trials, show the placement of the pipe and the initial blocks at the start of the trial video.

- b. Pre-place two initial 10 x 10 x 30 cm (4 x 4 x 12 in) blocks on two sides of the post and parallel to each other so the surrounding square base dimension is correct.
 - c. All other blocks can be pre-placed anywhere except in front of the terrain.
 2. Ready the robot on the start square.
 3. The trial starts once the start signal is given or the timer is started.
 4. Drive the robot onto the terrain board and position to perform the shoring task.
 - a. The robot may move at any point but may not overhang the front or sides of the terrain board (except with the manipulator).
 5. The robot should stack the blocks in the alternating pattern shown above, without knocking the post over. The stacked blocks should be easily visible in the video.
 6. For in-person and remote live telecon trials only: Perform the readiness test during the prescribed time.
 7. The number of blocks stacked (not including the two that were pre-placed at the start of the trial) at the end of the prescribed time (for in-person and remote live telecon trials) or once the robot can no longer stack blocks (for remote pre-recorded trials) represents the score achieved.

Test-specific Faults:

In addition to the standard faults:

- If the block stack is knocked over, the operator may choose to call a reset, or may use the robot to re-build the part of the stack that is knocked over.
- If the pipe is knocked over, the team must call a reset.

(DEX 6) Door Opening: (In-person finals only)

Motivation:

Evaluate the ability of the robot to open doors, pushing and pulling, unloaded (preliminaries and live remote best-in-class finals) and sprung (in-person finals).



Procedure:

1. Ready the robot within the A-Area (Near Side) .
2. The trial starts once the start signal is given or the timer is started.
3. Traverse forward from A-Area (Near Side), opening the door and navigating thru B-Area, opening the next door and navigating to A-Area (Far Side)
4. Both doors should be closed manually once the robot is in the A-Area (Far Side)
5. Turn around and traverse forward from A-Area (Far Side), opening the door and navigating thru B-Area, opening the next door and navigating to A-Area (Near Side)
 - a. Note: Robot must be completely in A-Area before turning around and beginning the route back to A-Area (Near Side)
6. Successful repetition is counted when the robot completely passes into the opposite A Area.
7. Record successful repetition on the scoresheet.
8. Both doors should be closed manually once the robot is in the A-Area (Near Side)
9. Repeat until the end signal or the timer has elapsed.
10. For in-person and remote live telecon trials only: Perform the readiness test during the prescribed time.

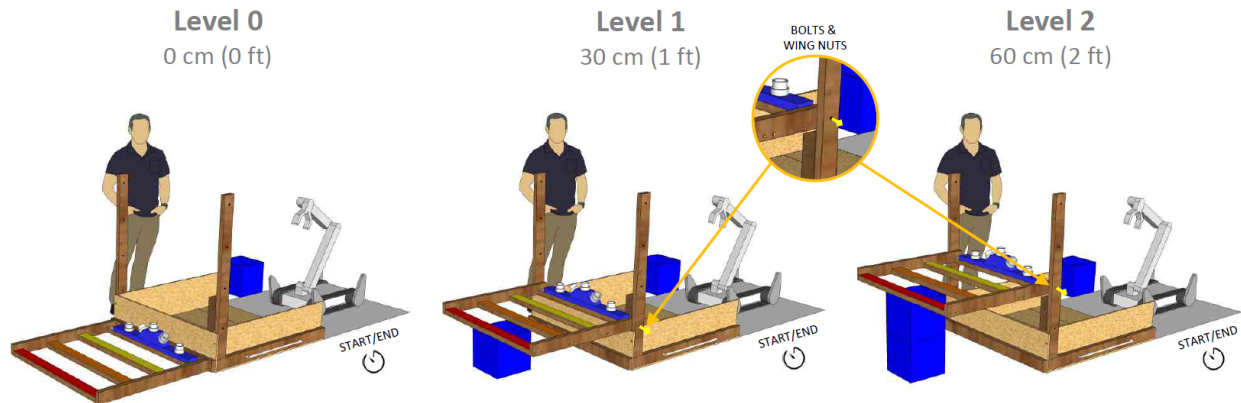
Test-specific Faults:

None beyond the standard faults.

Task Positions:

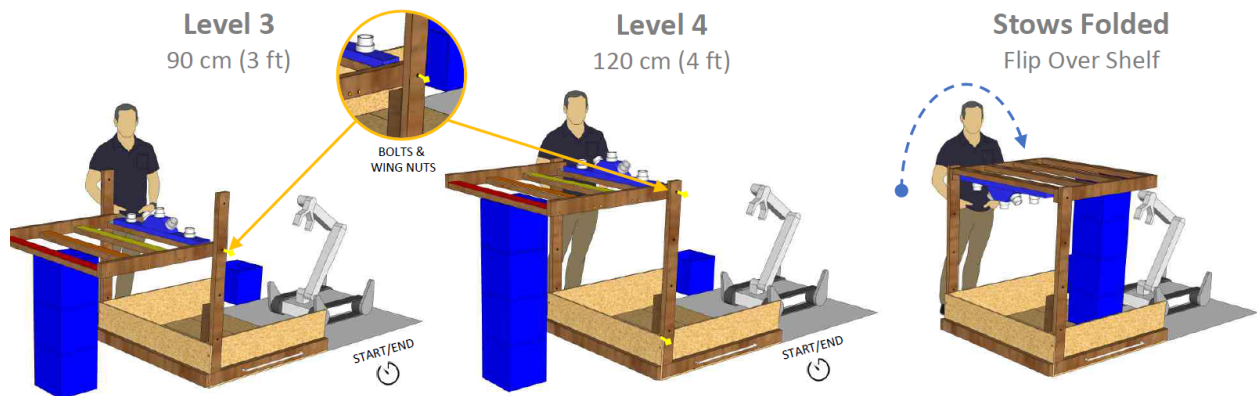
Each of these tests apart from Shoring is performed at different distances from the front of the terrain, and at different heights above the ground, in 30 cm (1 ft) increments. These are shown below.

Incremental 30 cm (1 ft) settings both horizontally and vertically



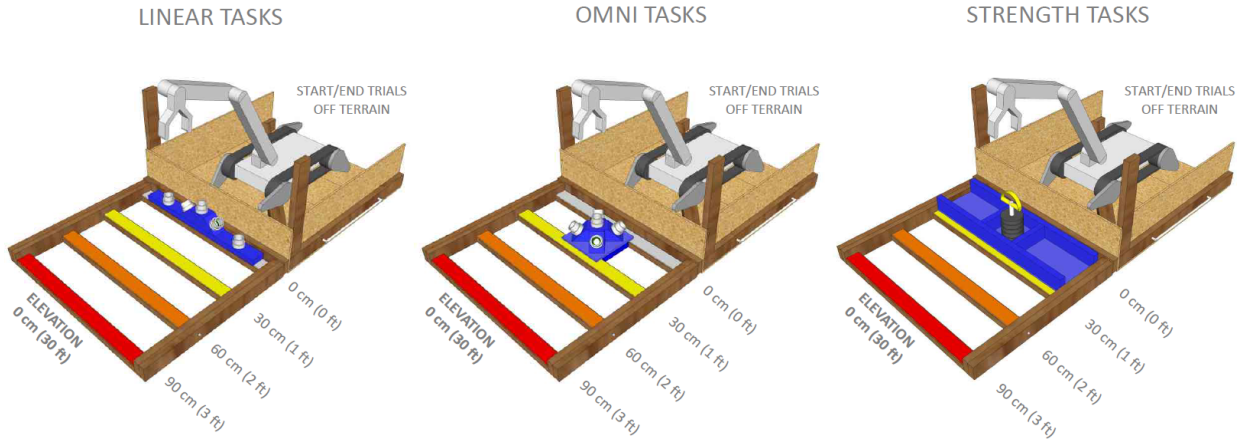
Crates, bolts, and wingnuts support incremental shelf elevations

Incremental 30 cm (1 ft) settings both horizontally and vertically

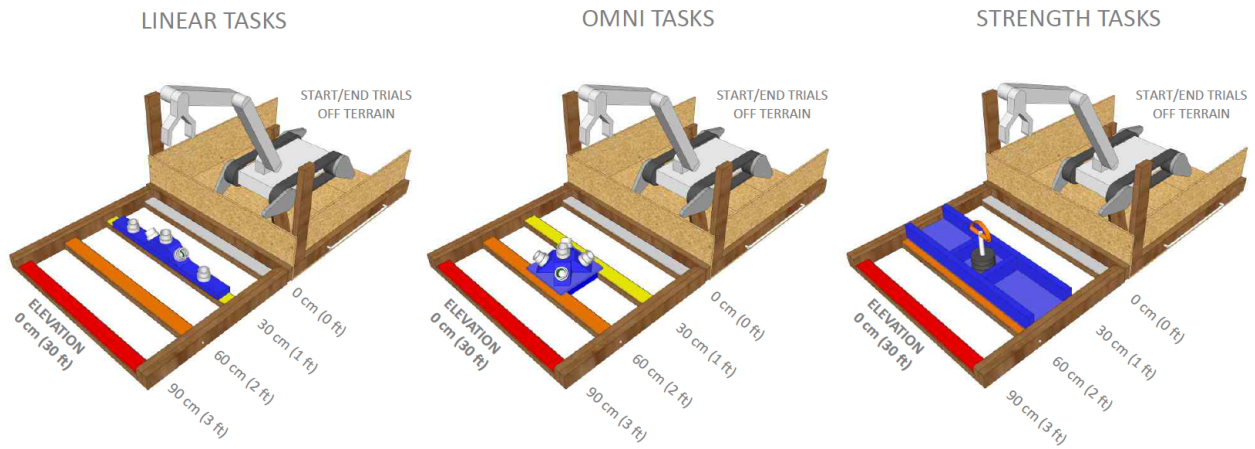


Crates, bolts, and wingnuts support incremental shelf elevations

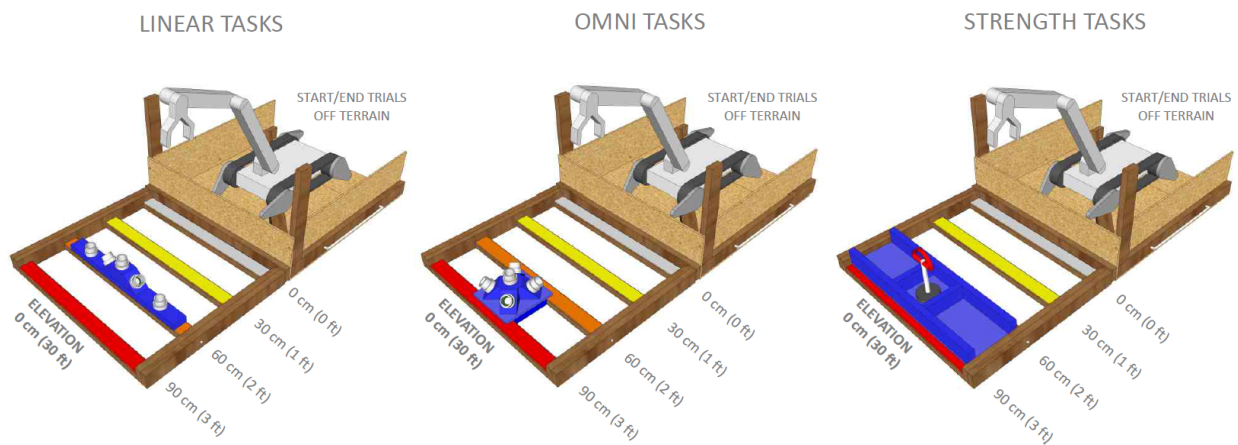
Trials are 5 tasks at each 30 cm (1 ft) increment



Trials are 5 tasks at each 30 cm (1 ft) increment



Trials are 5 tasks at each 30 cm (1 ft) increment



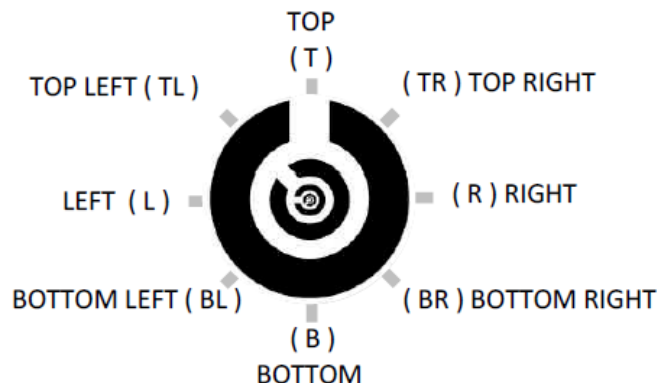
Further details are in the construction guide.

Dexterity Task Descriptions:

Directed Inspection Tasks:

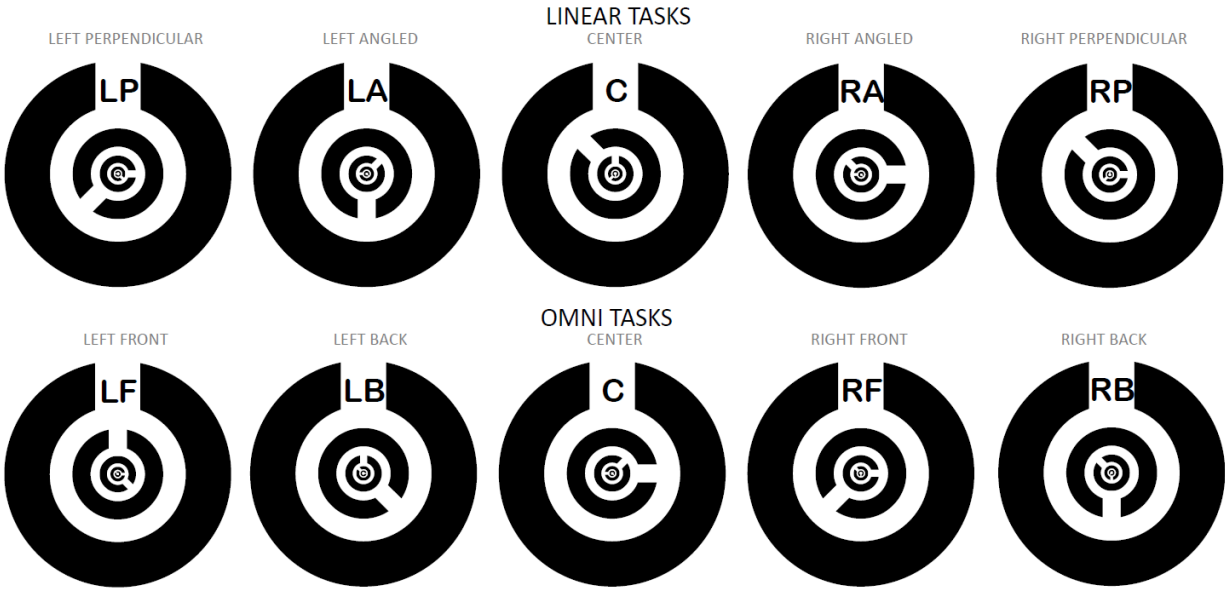
The “Directed Inspection” tasks measure the reach space of the robot without the difficulties associated with interacting with the environment. They are performed in both the Linear and Omni orientations at 30 cm (1 ft) incremental reach distances and elevations.

- Each alignment position and orientation is close to the approach point necessary for related tasks requiring contact such as Touch/Insert Tools, Rotate, and Extract.
- Align with the 5 cm (2 in) diameter pipe so the inner edge of the largest visual acuity ring is completely visible. The targets can be downloaded and printed on paper or sticker sheets.
- Each pipe has 5 increasingly small ring gaps to identify based on their orientations (random combinations of 8 orientations).
- Score up to 5 points per task = 25 points total:
 - 1 point for successful alignment with the outer ring showing the gap oriented to the Top (always).
 - 1 point for each smaller gap orientation identified correctly.



50 mm (2 in) inside diameter PVC Pipe

<https://www.amazon.com/PVC-Pipe-Sch-Inch-White/dp/B072Q9M54Z/>

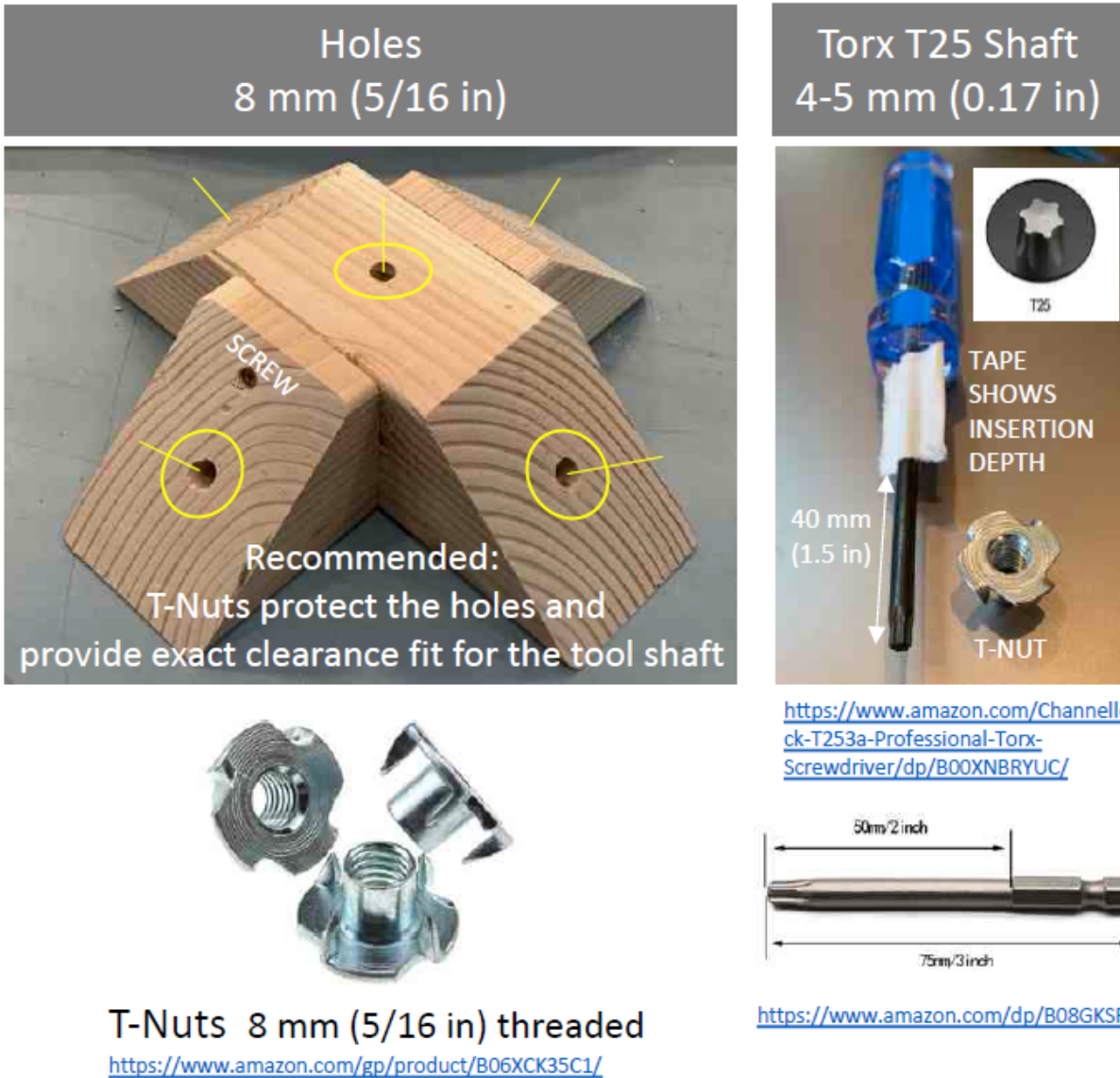


Note: The inner edge of the largest ring should be 55 mm (2.2 in).

Touch/Insert Tool Tasks:

The “Touch/Insert Tool” tasks measure the reach space of the robot for using tools of various kinds. They are performed in both Linear and Omni orientations at 30 cm (1 ft) incremental reach distances and elevations.

- The task requires the robot to position and orient the tool tip perpendicular to the hole in the apparatus, then insert the tool into the hole. A Torx T-25 tool, a window-breaker tool, or any shaft with 4-5 mm diameter can be easily inserted into the 8 mm (5/16 in) hole diameter.
- Successful insertion requires the tool tip to recess at least 25 mm (1 in). Partial points are awarded for simply touching the tool tip to the hole at some angle that doesn't allow insertion.
- Score up to 5 points per task = 25 points total:
 - 1 point for touching the tool tip to the hole at any angle.
 - 4 points for inserting the tool 25 mm (1 in) into the hole.

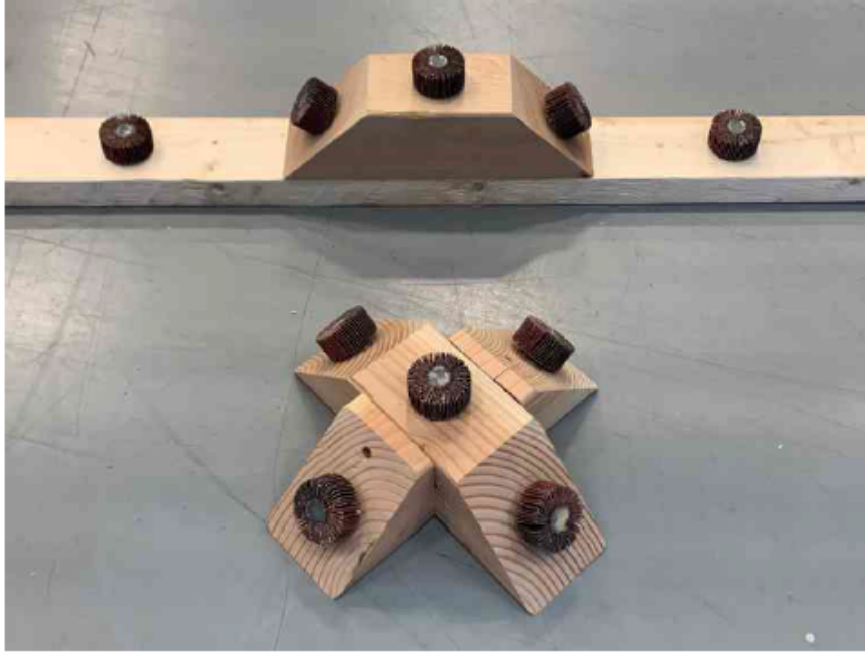


Extract and Place Tasks:

The “Extract and Place” tasks measure the reach space of the robot for precisely grasping objects. They are performed in both Linear and Omni orientations at 30 cm (1 ft) incremental reach distances and elevations.

- The task requires the robot to position and orient the gripper to grasp and extract the objects pre-placed in the apparatus. Any grasp object with a 6 mm (1/4 in) diameter shaft can be used to fit into the 8 mm (5/16 in) hole or T-Nut diameter.
- Successful extraction requires the object to be completely removed from the hole. Successful placement of the object requires it to be in the crate. Dropped objects cannot re-grasped and placed in the crate.

- At the start of the trial the crate must be pre-positioned behind the start area at least 120 cm (4 ft) from the terrain. It can be moved by the robot anywhere at any time during the trial.
- Score up to 5 points = 25 points total:
 - 1 point for extracting the object from the apparatus.
 - 4 points for placing the object in the crate.



Small Round Abrasive Flap Wheel Sanders

Grasp Object: 25 mm (1 in) diam high friction cylinder

Shaft: 6 mm ($\frac{1}{4}$ in) diameter, at least 25 mm (1 in) long

<https://www.amazon.com/dp/B077809Y13/>



Large Round Abrasive Flap Wheel Sanders

Grasp Object: 50 mm (2 in) diam high friction cylinder Shaft: 6 mm ($\frac{1}{4}$ in) diameter, at least 25 mm (1 in) long

<https://www.amazon.com/gp/product/B0621B4B7N/>



Glue your own grasp object onto a disc pad holder

ANY SOLID/CONVEX SHAPE (not magnetic, sticky, etc.)

Shaft: 6 mm ($\frac{1}{4}$ in) diameter, at least 25 mm (1 in) long

<https://www.amazon.com/dp/B07D33NG4M/>