OPEN 2025 Category Rules

Version 1.0 – 2025 January

Coffee Collector Robot

1. Introduction

Robots are increasingly closer to ordinary people and perform tasks where they assist members of society, whether at home, in industry, medicine, construction, or work.

This time, the Latin American Robotics Competition proposes the construction of a coffee-collecting robot. Latin America is one of the world's major coffee producers, and currently, hundreds of people harvest coffee beans in the field.

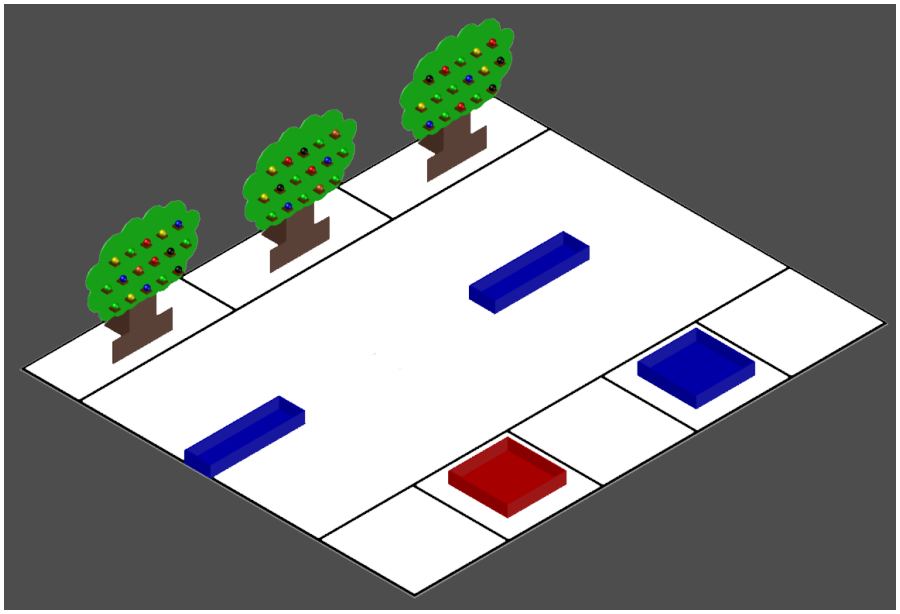

Figure 1. Pictorial view of the scenario representing the plantation and the processing facility.

The competition challenges young Latin Americans to construct a robot that collects ripe and overripe coffee beans from a plantation, leaving green beans on the trees. The collected beans must be classified and transported to a storage area located at the "processing facility," avoiding the obstacles in the scenario.

2. The Objective of the Competition

Develop a robot using educational kits to collect ripe and overripe coffee beans while leaving green ones on the tree. Once collected, the robot must move to the processing facility and deposit the ripe beans in the red box and the overripe beans in the blue box. The goal is to collect the maximum number of ripe and overripe beans within 8 minutes.

The scenario represents part of a plantation composed of three trees where the ripe coffee beans (red, orange, and yellow), green beans (green), and overripe beans (blue and black) are located. Golf balls represent the coffee beans. Additionally, part of the coffee processing facility is represented, consisting of two hoppers depicted as two boxes, one red and one blue, where the coffee beans collected by the robot must be stored for subsequent pulping and drying.

In the central area of the scenario, two rectangular blue boxes symbolize the pools used for water storage during the coffee-washing process. The robot must avoid these pools while navigating between the plantation and the coffee processing facility. These pools will be placed randomly.

The robot must be capable of differentiating the color of each coffee bean, picking only the ripe and overripe beans and subsequently depositing them into the hoppers in the coffee processing facility, classifying them as ripe or overripe beans.

3. Scenario Specifications

The scenario is constructed from a white canvas measuring 3,600 mm x 3,000 mm. A 19 mm black line printed on the canvas marks the outer perimeter and divisions of the scenario.

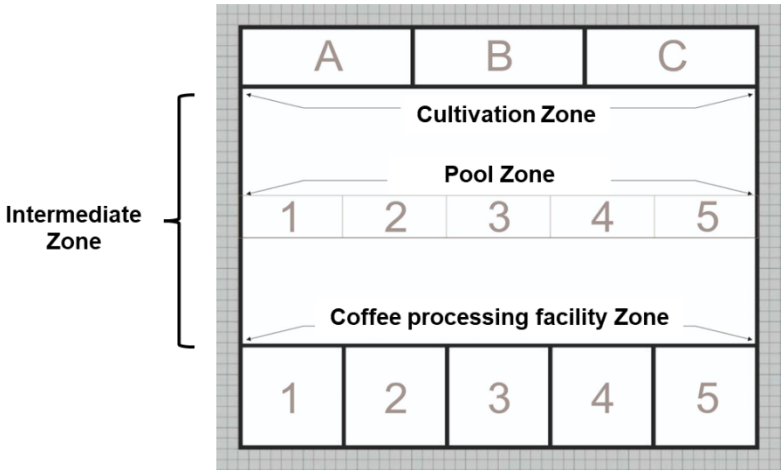

Figure 2. Scenario Zones (Top View).

The scenario will be placed on a flat surface; however, due to the ground where it is positioned, there may be variations of ±5 mm.

The following zones are identified within the scenario:

- **Cultivation Zone**: The cultivation area is outlined by a black line measuring 19 mm. It is

divided into three sectors, each containing a coffee tree. Each sector measures 1174,5 mm x 412 mm internally.

- **Coffee processing facility Zone**: Located at the opposite end of the cultivation zone, it is identified by a black line measuring 19 mm. This zone is divided into five sectors, two of which will hold the bean storage hoppers and one of which will serve as the starting area for the harvesting robot. Each sector measures 712 mm x 697 mm internally.
- **Intermediate Zone**: This area lies between the cultivation and Coffee processing facility zones. The central part of this zone contains the pool area. The robot must navigate this area, avoiding two randomly positioned pools. Each pool measures 720 mm x 200 mm x 90 mm.

Detailed measurements of the scenario can be found in Appendix A.
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4. Scenario Elements

Trees: In the cultivation zone, three trees (one in each sector) are made of wood and uniformly painted green. The tree is centered within the 1,174.5 mm and positioned 100 mm from the nearest line to the central area. It is anchored to the floor from the rear side. At the top of each tree are three rows of holders where golf balls representing coffee beans are placed. The bottom and top rows hold five coffee beans each, while the middle row has six beans, totaling 16 beans per tree distributed among green, red, orange, and blue beans. See Appendix B for detailed tree plans.

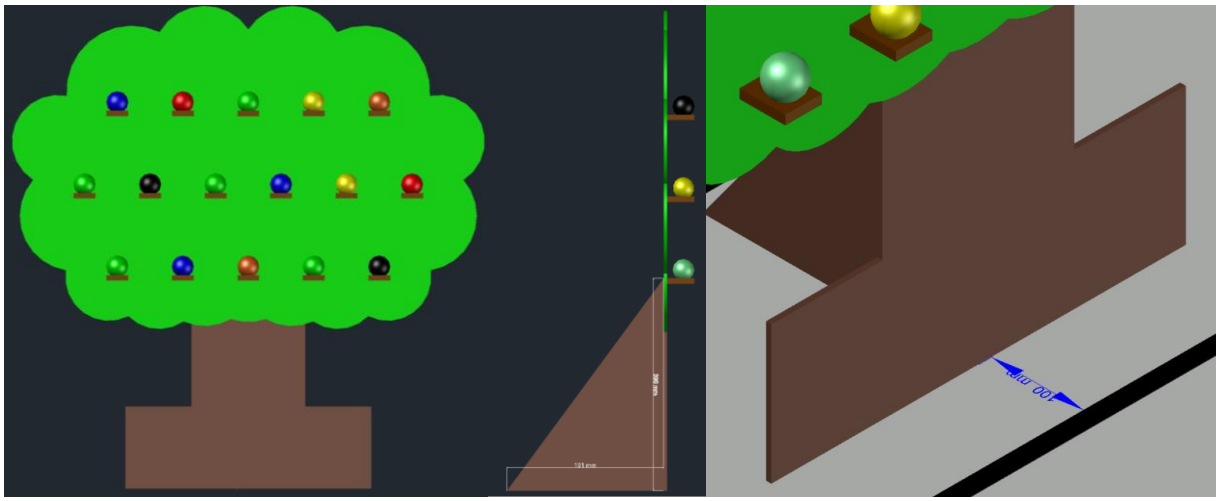
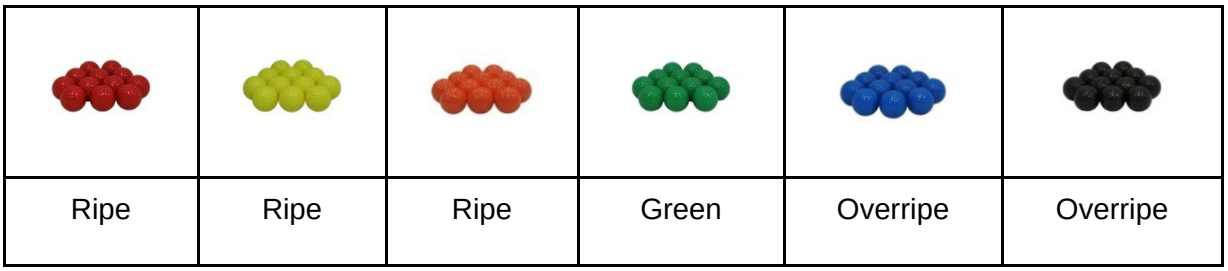


Figure 3. Front, Side, and Position View of the Tree.

Coffee Beans: The beans are on the supports at the top of the trees. They are 3D-printed spheres in PLA material with a diameter of 42 mm and a weight of 12± 4 grams. The spheres are different colors, each symbolizing a degree of coffee bean development.

Color	Maturity Stage
Red, orange, yellow	Ripe
Green	Green
Blue, black	Overripe

Table 1. Relationship Between Color and Coffee Bean Maturity Level.



Ripe	Ripe	Ripe	Green	Overripe	Overripe

Figure 4. Coffee Bean Colors.

The beans are 3D-printed spheres with 15% gyroid type filling. The color can be directly from the PLA or painted with spray paint.

Coffee Bean Holders: Each coffee bean is placed in a holder with a 25 mm diameter hole where the bean sits. The thickness can range from 6 to 10 mm, but the height of the bean remains the same. The holder is brown and embedded at the top of the tree, forming three rows of beans.

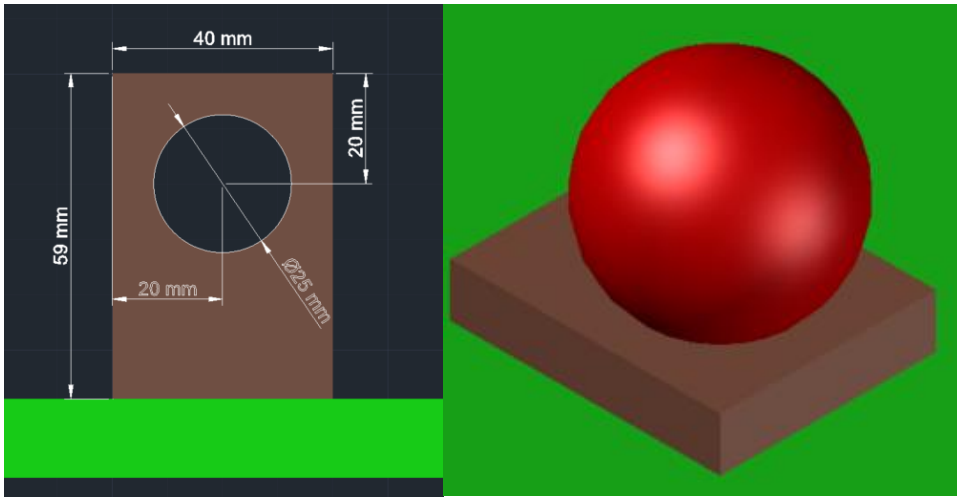


Figure 5. Coffee Bean Holders.

Storage Containers: In the Coffee processing facility zone, the robot must deposit the collected coffee beans in two containers, red and blue, as shown in Figure 2. Each container measures 450mm in length and width and 90 mm in height on the outside. It is positioned in the center of the designated zone.

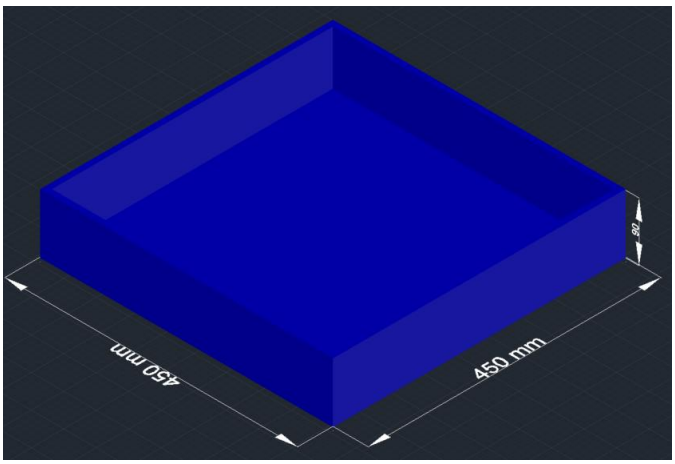


Figure 6. Container for Coffee Bean Storage.

Pools: In the central zone, a pool area is divided into five sections, 1 through 5. A maximum of 2 pools are used per round, and a draw determines their position. There may be 0, 1, or 2 pools during a round. The pools are blue containers with external dimensions of 720 mm long, 200 mm wide, and 90 mm in height. They are not fixed to the scenario.

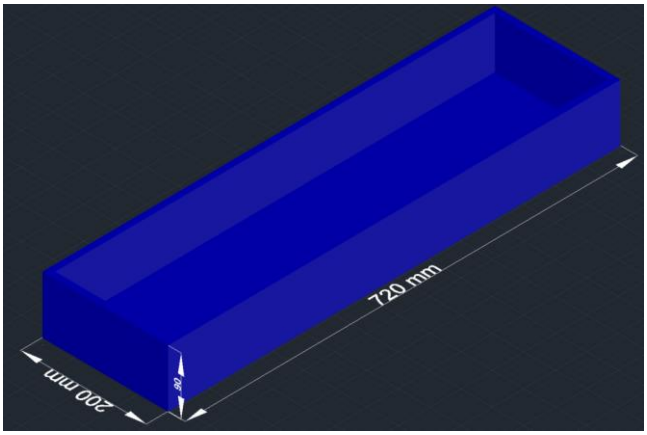


Figure 7. Pool Dimensions.

5. Lighting Conditions

The local committee will provide uniform indoor lighting throughout the day. However, participating teams must be prepared to calibrate their robots according to the lighting conditions at the competition venue. The local committee will try to minimize the effects of shadows and natural lighting, but these factors cannot be entirely eliminated.

Therefore, it is highly recommended that the participating robots be designed to be immune to variations in lighting that may occur at the venue. Once the competition has started, teams will compete under the existing lighting conditions without complaints or appeals.

6. The robot

The robot must be a fully autonomous mobile device, meaning it must navigate the scenario and complete its objectives without human intervention. During official rounds, the robot is not allowed

to communicate with external devices, and it must complete the task using only the devices it carries internally.

It has no manufacturing restrictions regarding materials, mechanical or electronic components and can have unlimited prefabricated or handmade parts, sensors, actuators, and controllers.

Other restrictions for the robot include:

- At the start of the round, the robot must fit into a 450 mm cube (including cables). Once the start button is pressed, the robot can autonomously expand and exceed its initial dimensions.
- The robot cannot communicate with external devices.
- The robot must not damage the scenario.
- The robot must have a single start button in all competition rounds. This ensures that the information it uses comes from its own sensors, not the team members' observations.
- Only one robot is allowed inside the scenario and cannot split into two or more during the rounds.

Violating any of the above restrictions will result in disqualification.

7. Competition Rules

Once the competition begins, all participating teams must place their robots in the space assigned by the organizers, visible to everyone. Robots can only be removed from this space when competing and after completing a round. This ensures all teams have the same time to adjust their robots.

When all robots are in their assigned spaces, the team captains will gather, and the positions of the containers and the robot's starting point will be determined for each round by a draw. The containers and the robot's starting position are in the Coffee processing facility zone. To facilitate the draw, the Coffee processing facility is divided into five numbered zones, two of which will hold the containers, and one will hold the robot. A second draw will determine the placement of the coffee beans on each tree.

Placement of Coffee Beans: Each tree has three rows (low, middle, high) containing three categories of beans (green, ripe, and overripe). The grains will be placed randomly in each row, with each grain type having a probability level depending on the row in which it is located, as shown in Table 2.

Table 2.Distribution of coffee beans according to the row within the tree..

Row	Green Beans	Ripe Beans	Overripe Beans
High	1	3	1
Middle	2	2	2
Low	2 or 3	1	1 or 2

A software program that respects the assigned probability values will facilitate the draws for the coffee beans, the robot's starting point, and the container positions.

A separate draw will determine the position of the pools in the central zone, divided into five sections numbered 1 to 5. A die is rolled for this draw, and the resulting number corresponds to the pool's position. If the number 6 is rolled, the pool will not be used in that round. This process is repeated for the second pool. The second pool will not be used if the second roll results in the same number as the first. Therefore, a round may have 0, 1, or 2 pools.

Finally, the order in which the robots compete will be determined by a draw. At the start of the round, the team captain may choose the robot's orientation.

No team member is allowed to modify their robot during the draw or throughout the round. Changes and reprogramming are only allowed after all teams have completed the round. In order, the judges will announce the team name and the robot's initial position.

The robot starts the test in the designated area of the coffee processing facility and must move to the harvesting zone to collect the coffee beans. The time will not stop until the team concludes its participation or the end of the 8 minutes. When the robot starts its attempt, it cannot be touched; otherwise, it will be considered a restart. The team can request a restart during the round execution. Each robot will have a maximum of two restarts per round. When a restart occurs, all the coffee beans are placed in their initial positions from the attempt, but without stopping the time. If the judges approve, the team participants and volunteers will rearrange the scenario and beans. If the robot presents an evident mechanical problem and the judges authorize it, the participating team can intervene with the robot, and it will be considered a restart; the test restarts, and the time measurement will not stop. An evident mechanical problem is considered, for example, the detachment of a piece, motor failures, sensor problems, a battery without energy, or any difficulty not associated with poor design or due to poor programming that prevents its normal operation and can be repaired inside the scenario quickly. The team captain can end the test at any time.

The robot cannot leave the scenario. If any wheel, tire, or track touches the black lines marking the scenario's perimeter or the pool borders, it will be considered outside, resulting in a restart.

The robot must not move the pools in the central zone. Pools are not fixed, and moving one more than 10 mm from its initial position will result in a restart.

Coffee beans must be extracted one at a time but can be stored inside the robot for transport. Only ripe and overripe beans can be collected; green beans must remain on the tree. Beans cannot be abandoned or placed outside the designated containers. Beans left in the robot at the end of the round are considered stored. Extracting or knocking down two or more beans simultaneously will force a restart.

The round can end in four ways:

- The maximum time of 8 minutes is reached.
- The team decides to end their participation.
- The robot reaches its third restart.
- The robot places all ripe and overripe beans in the corresponding containers.

The primary criterion for determining the winner is the highest score. In the event of a tie, the second

criterion is the shortest time. If teams are still tied, an additional round will be held to break the tie.

During the development of the final rounds, in the event of a tie in the score, an additional test will be conducted immediately to determine 1st, 2nd, and 3rd place.

Any consideration or exception will be at the discretion of the judges and organizers.

8. Scoring and Evaluation Method

The scoring will be based on how each collected coffee bean is handled, and the total score for each team will be calculated at the end of the round.

Scoring:

- +3 points for each correctly removed ripe bean inside the robot.
- +1 point for each correctly removed overripe bean inside the robot.
- +4 extra points for each ripe bean deposited in the red container. (+7 total points for each ripe bean in the correct container).
- +4 extra points for each overripe bean deposited in the blue container. (+5 total points for each overripe bean in the correct container).

- Penalties:
- -7 points for each bean abandoned or forgotten in a location other than the designated storage containers (except inside the robot). Points for correct removal will not be counted.
- -7 points for each green bean found outside its original position on the tree (including abandoned beans, beans in containers, or inside the robot at the end of the round).
- -7 points for each ripe bean placed in the wrong container. Points for correct removal will not be counted.
- -5 points for each overripe bean placed in the wrong container. Points for correct removal will not be counted.
- Moving any pool from its initial position forces a restart. The team captain can decide whether to restart the robot at 0 points or end the round with the points accumulated up to that point.
- Extracting or knocking down two or more beans from the tree simultaneously forces a restart. The team captain can decide whether to restart the robot at 0 points or end the round with the points accumulated up to that point.
- Each round allows a maximum of two restarts. Restarts are not penalized, but the score is reset to 0, and the timer does not stop.

Example: At the end of the round, the team achieved the following:

5 ripe beans in the correct container, four overripe beans in the correct container, one green bean in the incorrect container, two ripe beans in the incorrect container, one overripe bean in the incorrect container, one bean abandoned on the field, three ripe beans inside the robot, three overripe beans inside the robot, zero green beans inside the robot, one restart

Table 3. Example scoring for an official round

Quantity	Concept	Points	Total Points
5	Ripe beans in the correct container	+7	35
4	Overripe beans in the correct container	+5	20
3	Ripe beans inside the robot at the end	+3	9
3	Overripe beans inside the robot at the end	+1	3
0	Green beans inside the robot or abandoned	-7	0
2	Ripe beans in the wrong container	-7	-14
1	Overripe bean in the wrong container	-5	-5
1	Abandoned ripe/overripe bean	-7	-7
1	Green bean in any container	-7	-7
1	Restart	0	0
		Final Score	34
		Total Time	4:15 min

9. Execution of Tests and Rounds

Before the rounds begin, participants will be notified and given sufficient time to calibrate their robots based on the number of teams. If the judges consider it necessary to perform calibration due to lighting conditions, each team will be granted an additional minute before their round.

There are two types of rounds: qualifying and final.

Qualifying Rounds:

- All teams registered in the category participate.
- Each team has four rounds. This number may vary at the judges' discretion.
- The maximum time per team to complete the test is 8 minutes.
- Each team may restart their robot twice per round. After each restart, the score resets to 0, and the timer does not stop.
- The sum of the two best rounds will determine which teams advance to the final rounds. The

top five teams qualify.
- In case of a tie, the team with the highest score in the shortest time will advance.
- Each team has a maximum of 1 minute to present themselves on the field; after this time, the competition timer will start.

Final Rounds:

The top five teams from the qualifying rounds compete in the finals. The final consists of three rounds.

- The maximum time per team to complete the test is 8 minutes.
- Each team may restart its robot twice per round. Each restart incurs a penalty, and the timer does not stop.
- The best score from the three rounds determines the final ranking.
- In a tie, a fourth round will be held immediately to break the tie.
- Each team has 1 minute to present on the field; the competition timer will start afterward.

To ensure fair participation, the scoring table is organized as follows:

- First, teams are ranked by the points obtained in the official round, from highest to lowest. This includes teams with 0 points due to the balance of positive points and penalties.
- Next, teams that attempted the test started their robot but did not perform successfully and ended the round with 0 points will be ranked. (If there are teams with negative points, those who attempted are ranked after them).
- Finally, teams that did not participate in the official round and received no score will be ranked last.

Only teams that earned positive points in at least one qualifying round can advance to the final rounds.

10. Requirements to Participate in the Competition

To participate in the LARC 2025 Robotics Competition in the OPEN category, a team must consist of a maximum of 4 students enrolled in any educational institution in any country. A student may not belong to more than one team.

As a participation requirement, teams must submit an IEEE-formatted document describing the development and functionality of their robot (TDP). This TDP will be used for the winners of the first and second places to present their work briefly to their peers. Failure to submit this document will prevent the team from participating, as it is crucial for developing and advancing participants' knowledge.

11. The Jury

The jury will consist of one person from the organizing team familiar with the rules and one related to robotics or a similar field. The names of these two individuals will be announced on the days of the competition.

12. Extraordinary Situations During the Competition

In the event of an extraordinary situation regarding the rules or scoring, the jury and the competition organizers will analyze the circumstances of the case and make a decision as impartially as possible.

Appendix A: Scenario Dimensions

The black lines are made of 19 mm wide black electrical tape.

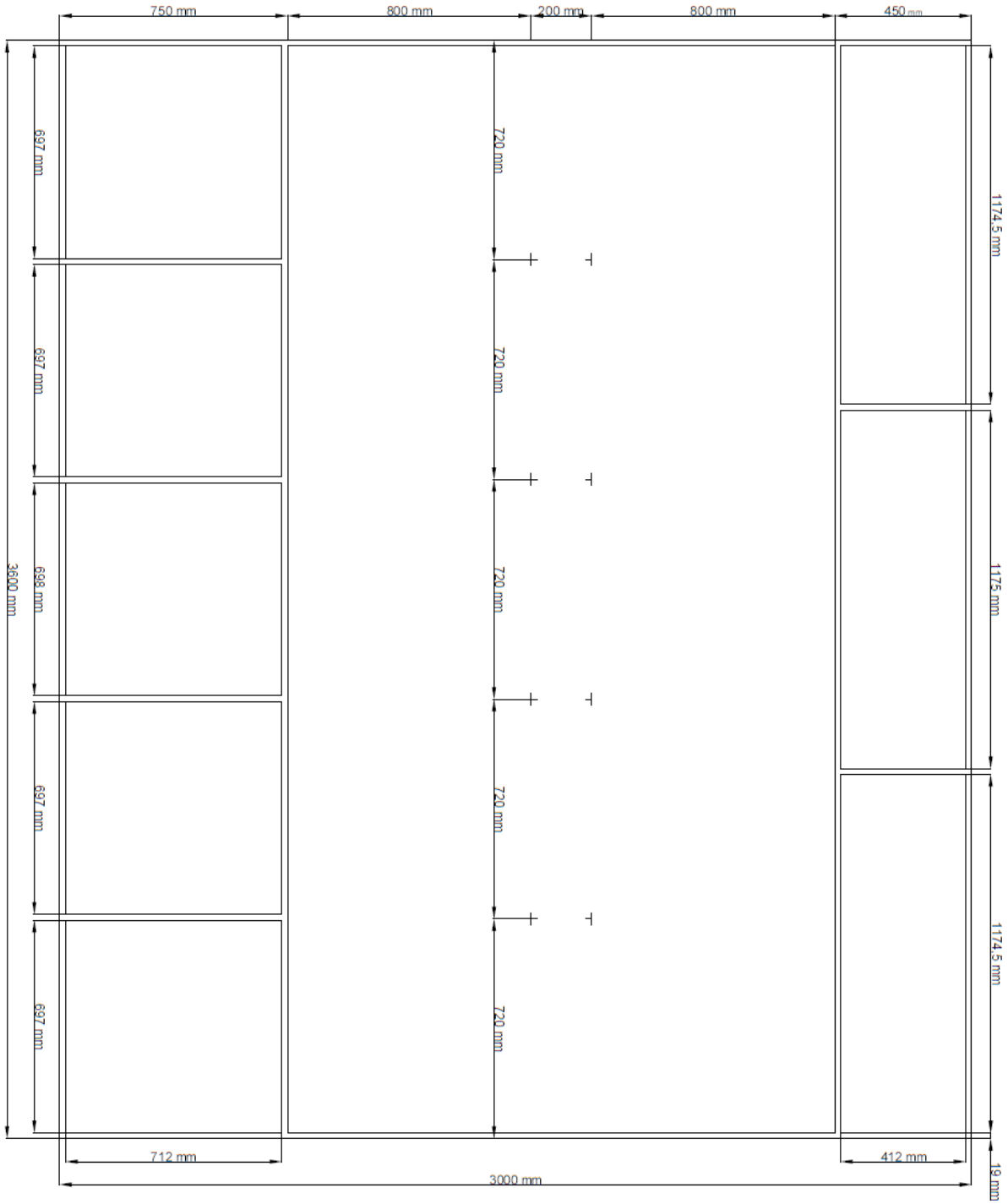


Figure 8. Scenario Dimensions

Appendix B: Tree Dimensions

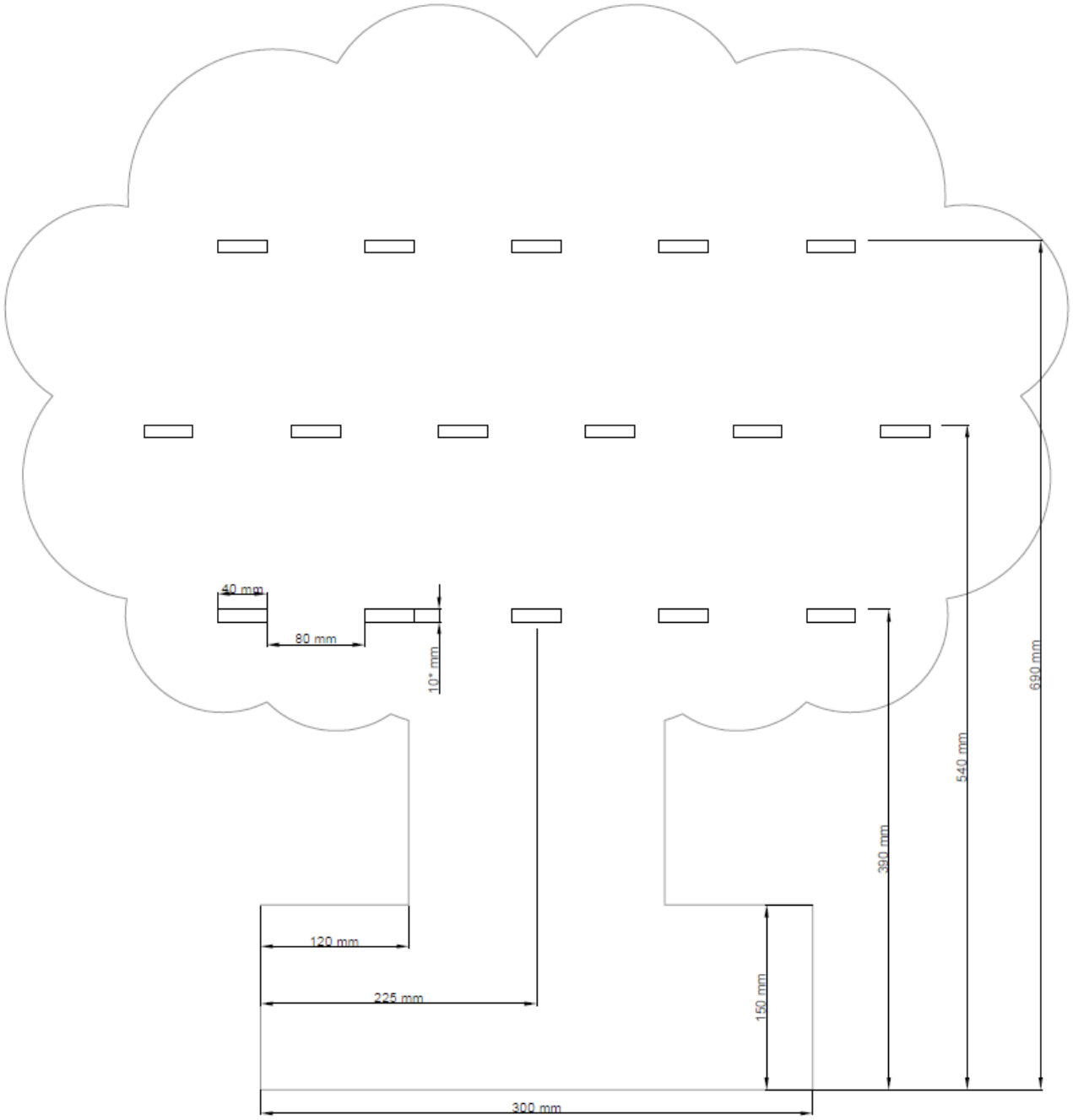


Figure 9. Tree Dimensions

*The holder's thickness can range from 6 mm to 10 mm to facilitate the tree's construction. However, the top surface of the holder must remain at the corresponding height.

Appendix C: Proposed Scoring Sheet

LARC OPEN Scoring Sheet

Round: _____

Team name: _____

Academic Institution: _____

Quantity	Concept	Points	Total Points
	Ripe beans in the correct container	+7	
	Overripe beans in the correct container	+5	
	Ripe beans inside the robot at the end	+3	
	Overripe beans inside the robot at the end	+1	
	Green beans in any container	-7	
	Ripe beans in the wrong container	-7	
	Overripe bean in the wrong container	-5	
	Ripe/overripe beans abandoned on the field	-7	
	Green beans inside the robot or abandoned	-7	
	Restarts	0	
		Total Points:	
		Total Time	

Team Captain's Name and Signature: _____

Lead Judge's Name and Signature: _____