Nutty Squirrel

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1. Introduction

Forests cover 31 percent of earth's land and is home for all the plants and animals. These plants and animals are integral to forest ecosystems and provide countless benefits to humans.

If we talk about a single animal say, a Squirrel and its lifestyle, Squirrels know when winter is arriving and start searching for food. They gather all the nuts they can during the fall and save them for future. They dig holes and bury the nuts close to their nests so that other Squirrels or animals can't steal them. When they are hungry, they use their strong sense of smell to identify the nuts they have buried. A study from University of California at Berkeley 2017 claims that tree Squirrels use a mnemonic technique called "spatial chunking" to sort and bury their nuts by size, type, and perhaps nutritional value and taste.

How about depicting the behaviour of Squirrel through the robotic platform?
Inspired by this idea, e-Yantra Robotics Competition (eYRC-2018) introduces "Nutty Squirrel", a theme that depicts the behaviour of a Squirrel storing Nuts in different places.

In this theme, a robot and a lift mechanism is designed that depicts Squirrel that sorts, carries and places Nuts at different places on land and in trees. The challenges in this theme include Path Planning, building a Lift Mechanism and Simulation. A configuration image is given to teams. The arena consists of thermocol Nuts of different colors that are placed randomly. The robot traverses the arena to pick up a Nut and place it in designated sections S1 or S2. The team needs to make a lift mechanism to lift the bot to certain height to place Nuts at the designated section S3. Refer to Figure 1.

The challenge is to complete this task in the shortest time possible and place the Nuts at designated sections. The robots that performs the task best in accordance with the rules will be declared as the WINNER of the competition.

2. Theme Description

- The arena for this theme is an abstraction of woods or field represented as a combination of circular and curved paths with thermocol Nuts representing Nuts fallen on the ground.
- The arena is made of circular, curved and straight path and the Start position for the robot as shown in Figure 1.
- Teams have to program a robot that can detect the color of the Nut, pick it and place it at the correct DEPOSIT ZONES. The DEPOSIT ZONES are at different levels. The number of Nuts that are to be placed in each DEPOSIT ZONE will be provided to the participating team.
- Teams will prepare a lift mechanism for the robot to move from base section to the top section and vice versa.

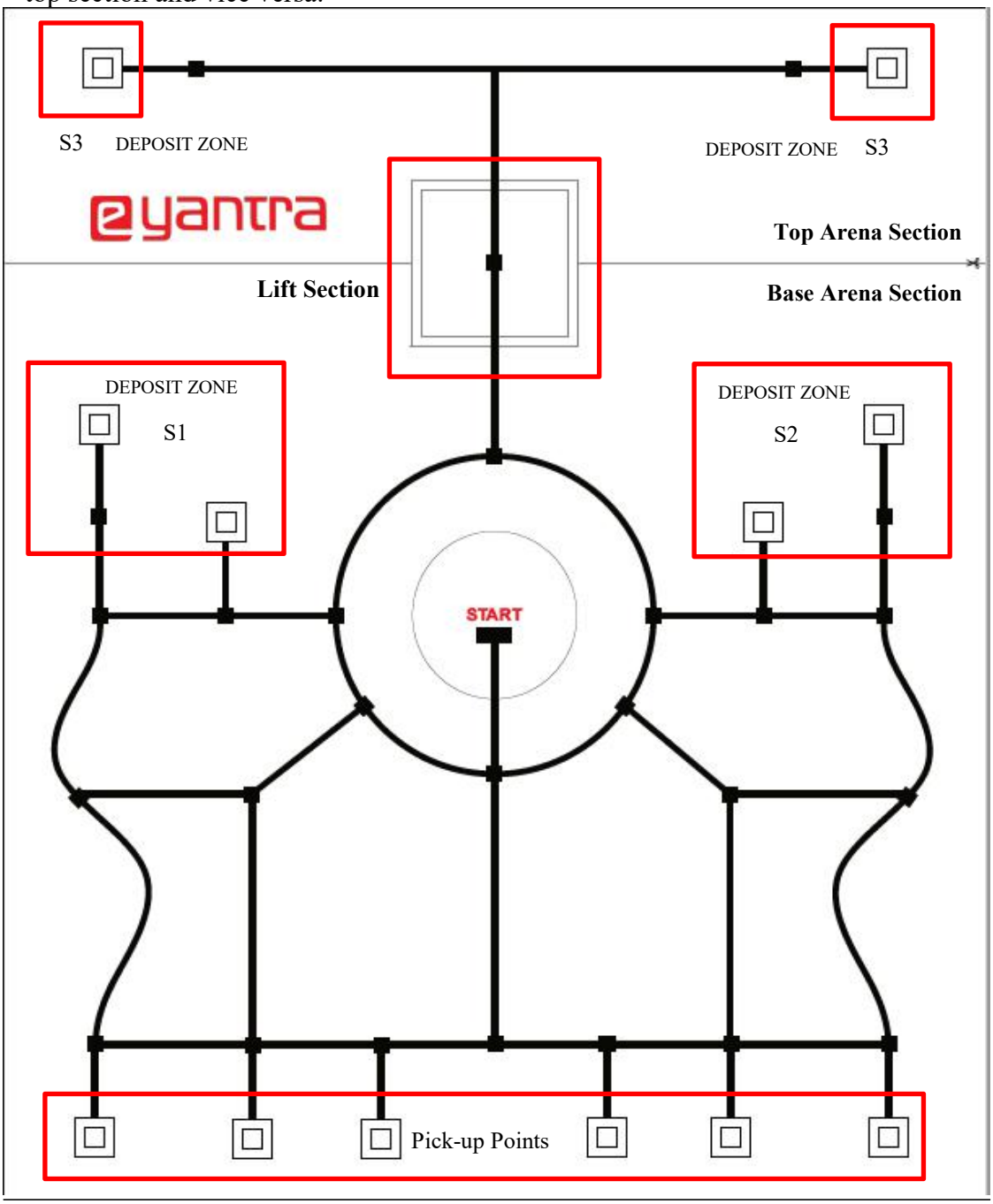

Figure 1: Arena

3. Arena

The arena for this theme is an abstraction of an area in the woods or a field where such activities take place. The DEPOSIT ZONES are indicated as S1, S2 and S3 (Refer to Table 1). The robot will follow the black line on the arena. There will be 6 pick-up points marked on Figure 1. These pick-up points are fixed and will not be altered. These pick-up points may or may not contain a Nut.

The complete arena is depicted in Figure 1.

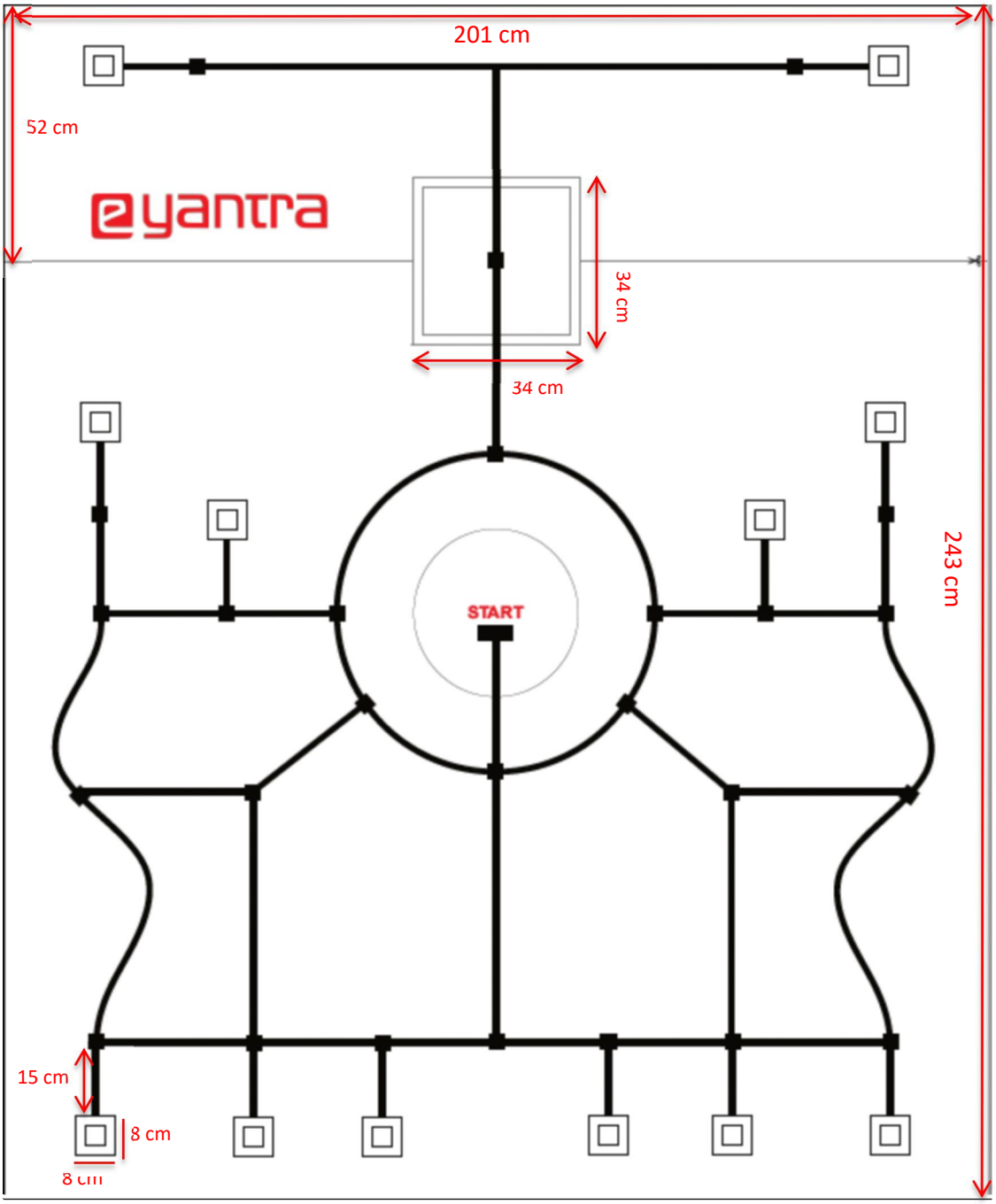

Figure 2: Arena with Dimension

Arena preparation:

Each team prepares an arena. Preparing an arena consists of the following steps.

- Printing the design provided on a flex sheet.
- Preparing and placing the Nuts on the flex sheet.
- Preparing Obstacles.
- Preparing and placing a lift structure on the flex.
- Building a robot for the theme.

Details of these steps are given below:

1. **Printing the design provided on a flex sheet:**
   - The layout of the arena is shown in Figure 2.
   - A PDF file containing the flex design is provided to teams in Flex Printing folder. Each team prints the arena layout design according to instructions provided in the Flex Printing Instructions.pdf file.
   - Team cuts the flex sheet along dotted lines. The scissor mark is shown in the flex where ever required.

   Details of the design:

   - The dimension of the complete arena is 201 cm x 243 cm.
   - START line is marked on the flex sheet. This is the point from which the robot starts its task.
   - FINISH line is NOT marked on the flex sheet as the robot places the last Nut and sounds a continuous buzzer indicating that the task is complete.
   - The arena consists of a circular path, straight and curved lines made of black lines of 1.2 cm thickness. Square nodes of dimension 3 cm x 3 cm are provided at the intersection of two or more black lines and curves.

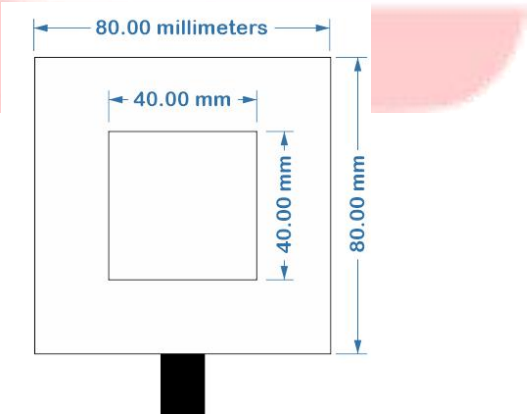

Figure 3: Pick-up and Deposit Block Dimension

   - There are three DEPOSIT ZONES S1, S2 and S3 shown in Table 1. The numbering is the same throughout the competition. Refer to Figure 1.
   - The size of the deposit block is shown in Figure 3

- Outer square: 8cm x 8cm
- Inner square: 4cm x 4cm.

➢ The size of the lift section is shown in Figure 4

- Outer square: 34cm x 34cm
- Inner square: 30cm x 30cm

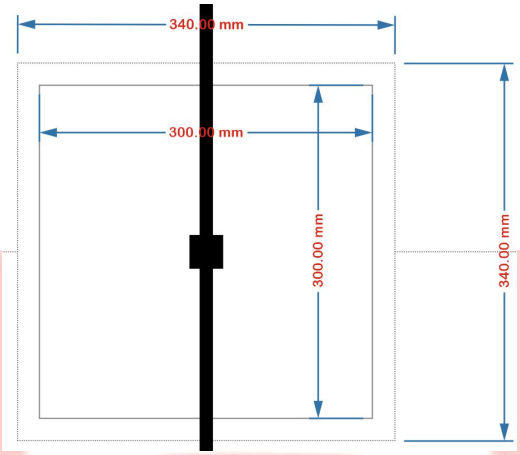

Figure 4: Lift Section Dimension

➢ The distance between the node and pick-up or DEPOSIT ZONE is: 15cm. Refer to Figure 5.

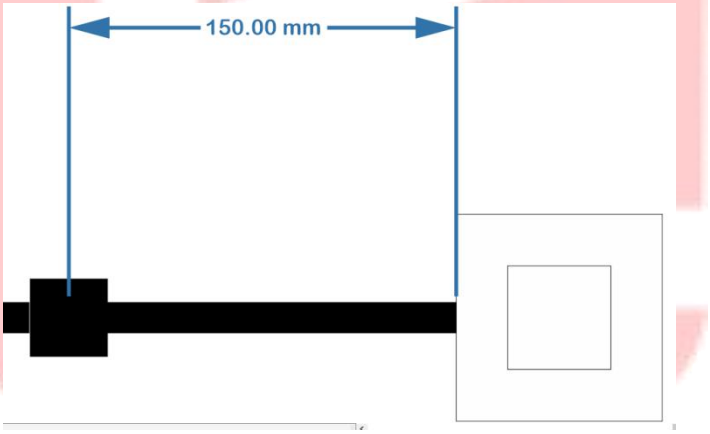

Figure 5: Distance between node and pick-up and DEPOSIT ZONE.

➢ Team cuts the flex along the dotted line to prepare two levels for the arena as shown in Figure 9a and 9b.

➢ Teams are not allowed to make any changes in the arena design. Any team making any modification whatsoever will be disqualified from the competition.

2. Preparing and placing the Nuts on the flex sheet:

i. Materials required for preparing the Nuts:

- Thermocol sheet for making Nuts. (Team may purchase a new sheet or use unused/recycled thermocol pieces available to them).
- Red, Green and Blue color paper;

  A RGB.pdf file is provided in Flex Printing folder. You have to print the RGB.pdf file in 75GSM paper. The color shade should be similar to the colors given in the file and even minor variation in the shade of recommended colors is not allowed as that might cause errors in detection of color. The same color shades will be used for finals.

ii. Preparing Nuts:

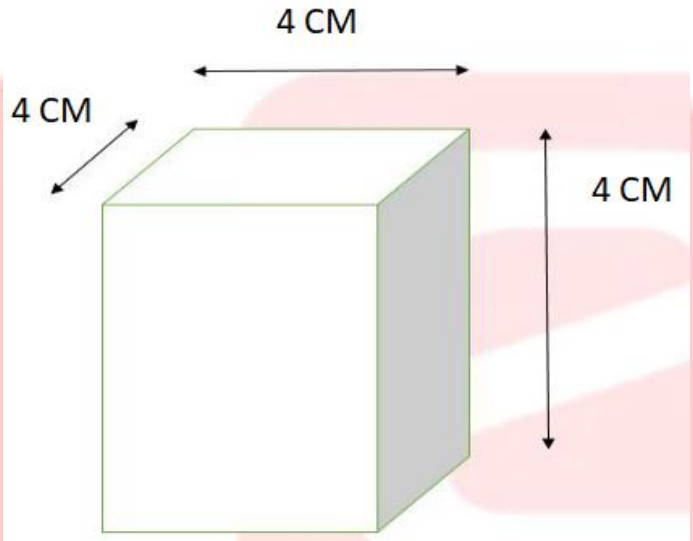

Figure 6: Dimensions of the Nuts

- Teams need to prepare Nuts with the thermocol sheets.
- Dimension of the Nuts are 4cm x 4cm x 4cm as shown in the Figure 6.
- Teams need to prepare Twelve(12) such Nuts from thermocol sheets of red, blue and green Four (4) in color each.
- Teams should print RGB.pdf for the red, green, and blue color sheets. Note that the color is same as provided in the file. (Refer Figure 7 for shades of colors).

Figure 7: Red, Blue, Green and White Color Paper.

- Wrap all the Nuts with red, blue and green colored paper so that all sides are of same color. (Refer to Figure 8).

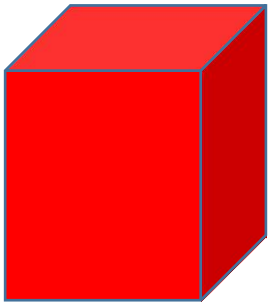

Figure 8: Wrapping the Nuts with Coloured Paper

iii. Placing the Nuts in the arena:

- Nuts are to be placed in the pick up places provided.
- Any color Nuts can be placed at any pick up point (Refer Figure 9a, 9b and 9c). Figure 9b is a labeled layout of the arena.

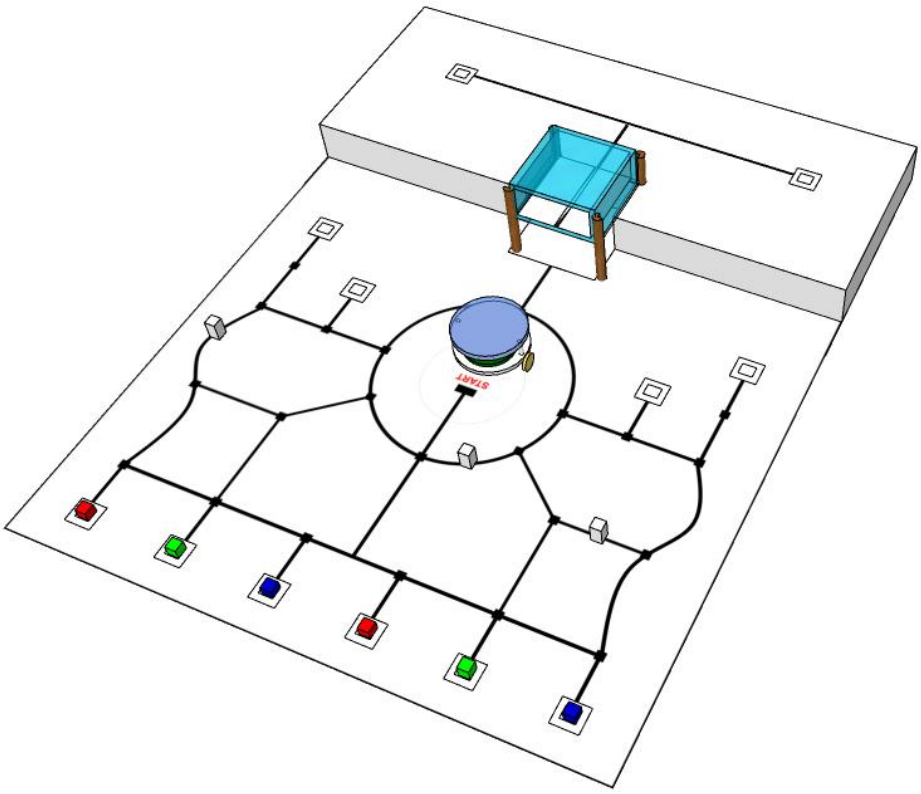

Figure 9a: Side view of placement of colored Nuts on the arena

- Final arena will look like Figure 9a and 9c.

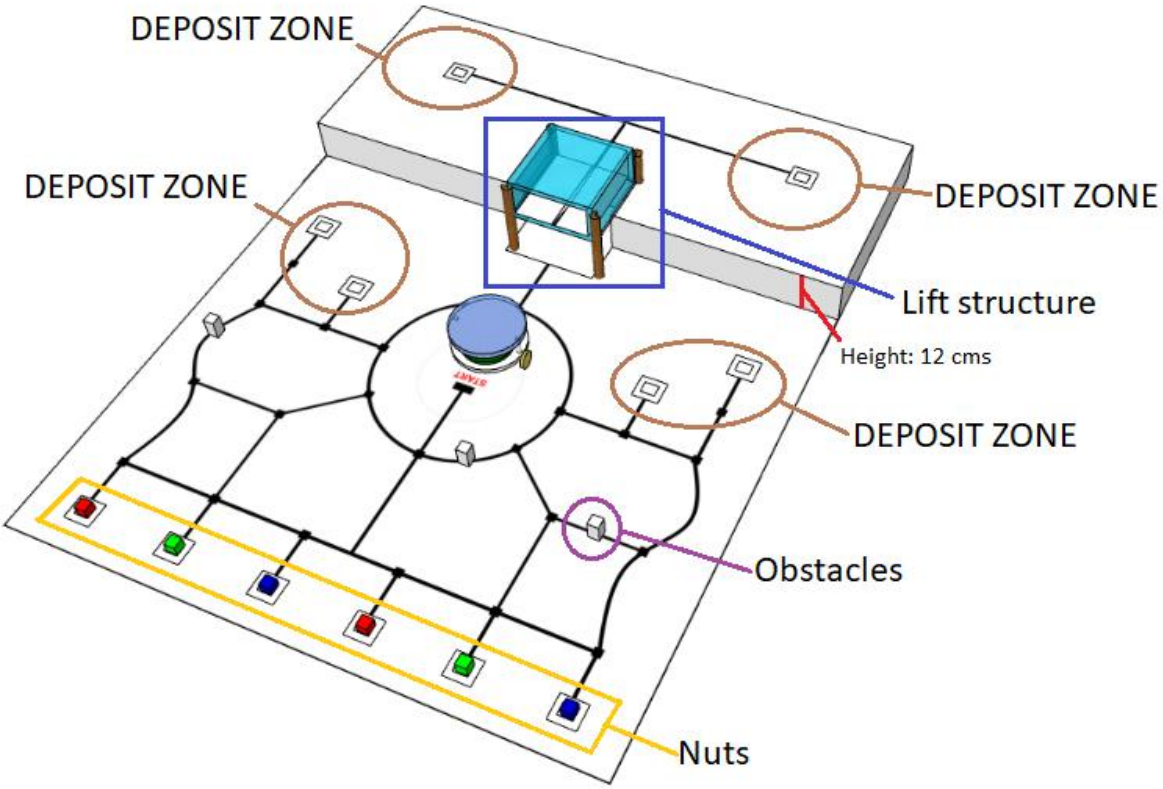

Figure 9b: Labeled Arena

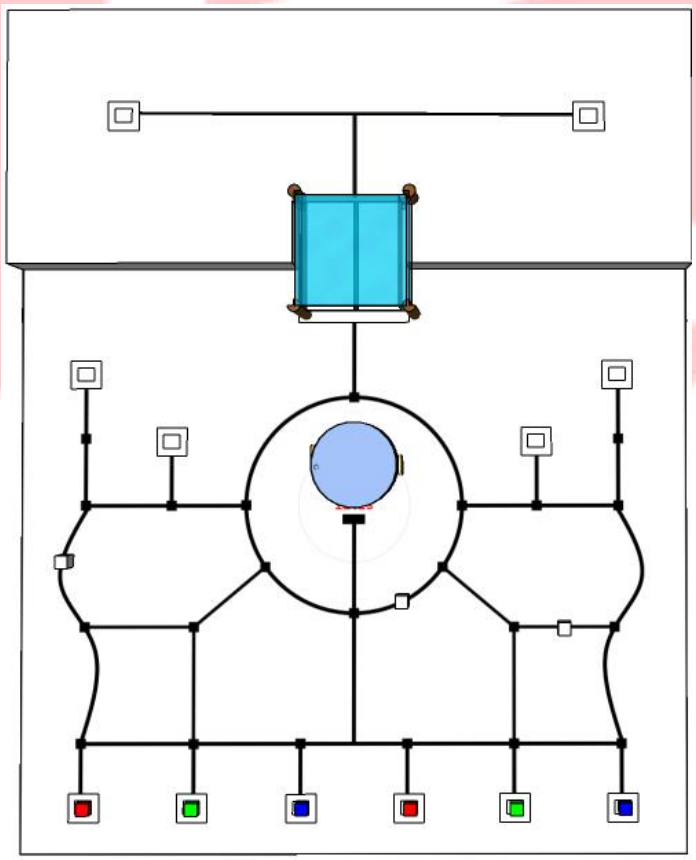

Figure 9c: Top View of the placement of colored Nuts on the arena

3. **Preparing the Obstacles:**

i. Materials required for preparing the Nuts:

- Thermocol sheet for making obstacles. (Team may purchase a new sheet or use the unused / recycled thermocol pieces).
- White color paper should be used to cover the obstacles if the thermocol sheets are not properly white in color.

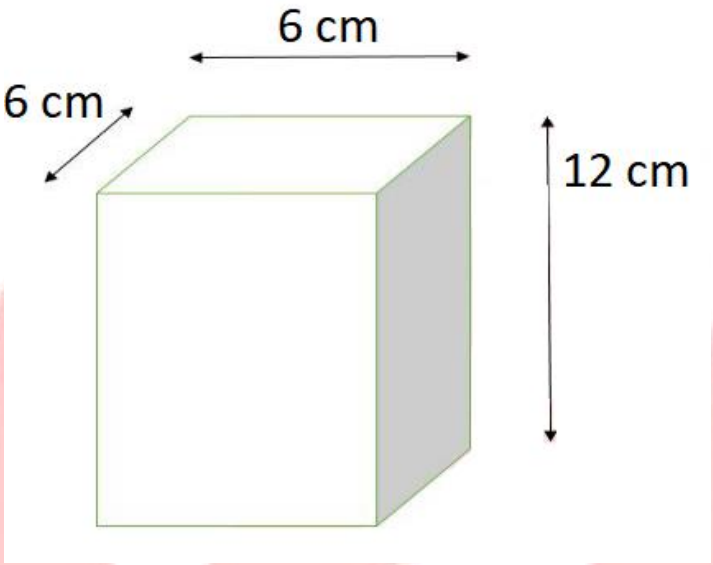

Figure 10: Dimensions of the Obstacle

- Teams need to prepare obstacles with thermocol.
- Dimension of the obstacles are 6cm x 6cm x 12cm as shown in the Figure 10.
- Teams need to prepare Three (3) such obstacles from thermocol.
- Wrap all the three obstacles with white colored chart paper if needed.

ii. Placing the Obstacles in the arena:

- Obstacles are to be placed in the 3 places as shown in Figure 9a.
- The Obstacles can be placed at any random place on the path between the two nodes. Obstacles will not be placed on the node.

4. Preparing and placing Lift Structure:

In Arena preparation section, cut the flex on the dotted line. You will have three sheets -

- **Base arena section**
- **Lift section** - with one node as shown in Figure 4. Keep this lift section on lift base for robot's locomotion.
- **Top arena section**

To prepare the top arena, team will use -

- Thermocol sheets of size 52cm x 201cm x 12cm
- Sunboard of size 52cm x 201cm x 0.3 cm to make the top surface smooth for robot's locomotion. Sunboard will be kept on top of thermocol sheet.
- Team can fix the thermocol and sunboard sheet in any way.

The lift mechanism has to be prepared by the teams. The electronic components are provided to the team, using which the team will make lift structure of following specification:

i. Material required for the Lift structure:
   - Team can use any material to make the lift structure. This structure will depend on the design you choose for to and fro motion of the robot. If you use thin material you will need to reinforce it with ribs for rigidity.

ii. Preparing the Lift structure:
   - The base size of lift should be: 34cm x 34cm.
   - Team is free to design the lift mechanism for the given dimension.
   - For good design, you may laser cut the material.
   - Team should work on making a sturdy structure, so that it can lift the weight of the robot.
   - Team can use any material - pulley, gears, etc for preparing the lift mechanism.

iii. Placing the Lift Structure:

Place the lift structure, thermocol sheets, sunboard and top arena sheet as shown in Figure 9, such a way that the robot can traverse from base arena to the lift which lifts the robot to the top arena.

Now we are ready with the arena. Please maintain the arena in good condition. If the arena is found damaged or in a condition that makes evaluation difficult, e-Yantra has the right to disqualify the team. **The final decision is at the discretion of the reviewer / judges of e-Yantra.**

Note: Please design your mechanism in a modular fashion so that you can transport it if you are selected for the Finals at IIT-Bombay. A common problem is that sometimes mechanisms get damaged or disturbed in transport.

WARNING: Please be careful while handling the flex sheet – avoid folding it at any stage as folding will result in creases which in turn will impair the movement of the robot. One way of "flattening" flex if it has been compromised is to hang it for a few hours in the sun – it tends to straighten out. Never attempt ironing it or applying heat of any kind – it may be a fire hazard.

4. Hardware Specification

Robot:

- Only one robotic kit allowed per team.
- All participating teams must build the robot. Necessary components are provided by e-Yantra.
- No other microcontroller-based board may be attached to the Arduino ATmega2560 board.
- Team is allowed to attach any **self-designed** mechanical assembly and external motors as required to complete the project.
- The participating team is not allowed to use any commercially available mechanism such as Lego kits or any other off-the-shelf mechanical components to design the structure on the robot.
- The robot should be **completely autonomous.** The team is not allowed to use any wireless remote or any other communication protocol or devices such as camera while the robot is performing the task. The team is also not allowed to use any other sensors except the ones provided in the kit.
- The footprint of the robot dimension should not cross 20 cm x 20 cm.

During the run, the robot can expand itself provided it does not damage the arena in any manner. However, it is not allowed to make any marks while traversing the arena. All robots found damaging the arena will be immediately disqualified. **The final decision is at the discretion of the e-Yantra team reviewer / judges.**

Lift Mechanism:

- Team is free to design any lift mechanism as per the lift specifications given in Arena Preparation section.
- All the participating teams must build the mechanism. Necessary electronic components are provided by e-Yantra.
- Ramp will not be acceptable to move the bot between two levels. Teams have to make the lift structure with necessary sensors and actuator/s.
- No other microcontroller-based board may be attached to the lift mechanism apart from the provided Arduino Nano.
- Team is allowed to attach any **self-designed** mechanical assembly and external motors as required to complete the project.
- The participating team is not allowed to use any commercially available mechanism such as Lego kits or any other off-the-shelf mechanical components to design the structure.
- The lift mechanism should be **completely autonomous.** The team is not allowed to use any wireless remote or any other communication protocol or devices such as camera for performing the task. The team is also not allowed to use any other sensors except the ones provided in the kit. The lift mechanism should be capable of taking the robot from base section to top section at the exact height.

POWER SUPPLY:

- The robot may be charged through battery or auxiliary power supply which has been sent to you along with the robot.
- The team shall not use any other energy source to power the robot.
- The team can use auxiliary power during practice but the final demonstration should use the battery-powered robot only.
- The team may use auxiliary power for lift mechanism.

CONTROLS:

- The robot and lift mechanism must be completely autonomous.
- It should not receive any extraneous or manual input.

5. Software Specification

- e-Yantra has provided all teams with Atmel Studio 6 (build 1843) – a free software programming AVR microcontroller.
- Participating teams are free to use any other open source Integrated Development Environment for programming AVR microcontroller but Arduino IDE is **not allowed**.
- As per e-Yantra policy, all your code and documents are open-source and maybe published on the e-Yantra website.

6. Theme Rules

- The participating team will receive information regarding the configuration of the DEPOSIT ZONES only 10 minutes before competition.
- All the information will be given in a configuration table. A sample of the configuration table along with a suitable example is provided below:

CONFIGURATION TABLE:

DEPOSIT ZONE	COLOR	CAPACITY
S1	BLUE NUT	2
S2	RED NUT	2
S3	GREEN NUT	VACANT

Table 1: Configuration Table

Explanation of configuration table:

- First column represents DEPOSIT ZONE number is fixed throughout the competition.
- Second column represents COLOR allotted to each zone. The allotment of color for each zone can be random.
- Third column represents the maximum CAPACITY of each zone, which is fixed and will remain same throughout the competition.

DEPOSIT ZONES:

- Each zone will have only one color.
- There can be multiple zones for each color.
- The participants will have to place minimum of 4 Nuts and maximum of 6 Nuts in DEPOSIT ZONES.
- There may be empty space (i.e. no block), blue block, green block and red block in the given six pick-up points. No other color will be used.
- All Nuts to be placed inside DEPOSIT ZONES. Nuts which are **on or inside** the line will be considered valid depositions. Refer to Figure 11.
- Only red, green, and blue Nuts will be given to place in the DEPOSIT ZONE.
- The robot will **glow appropriate LED** for every detection of red, blue or green block.
- The participant can place any block in any order at the DEPOSIT ZONE.
- After completion of task the robot should sound the continuous buzzer.

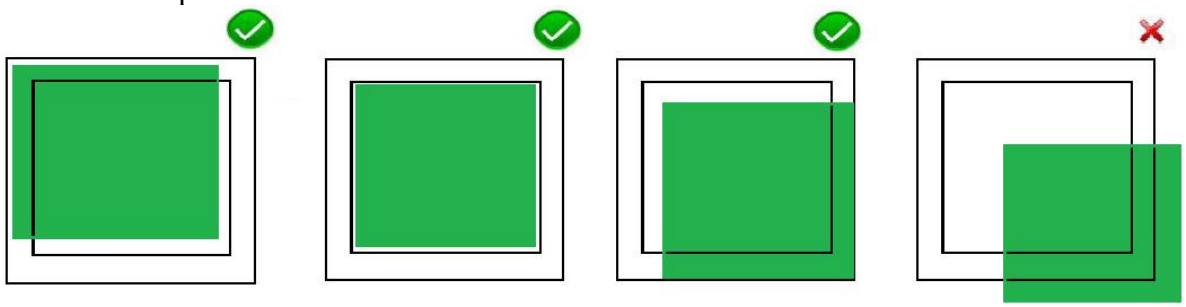

Figure 11: Nuts Deposition

For given configuration Table 1, the final arena will look like as shown in Figure 12:

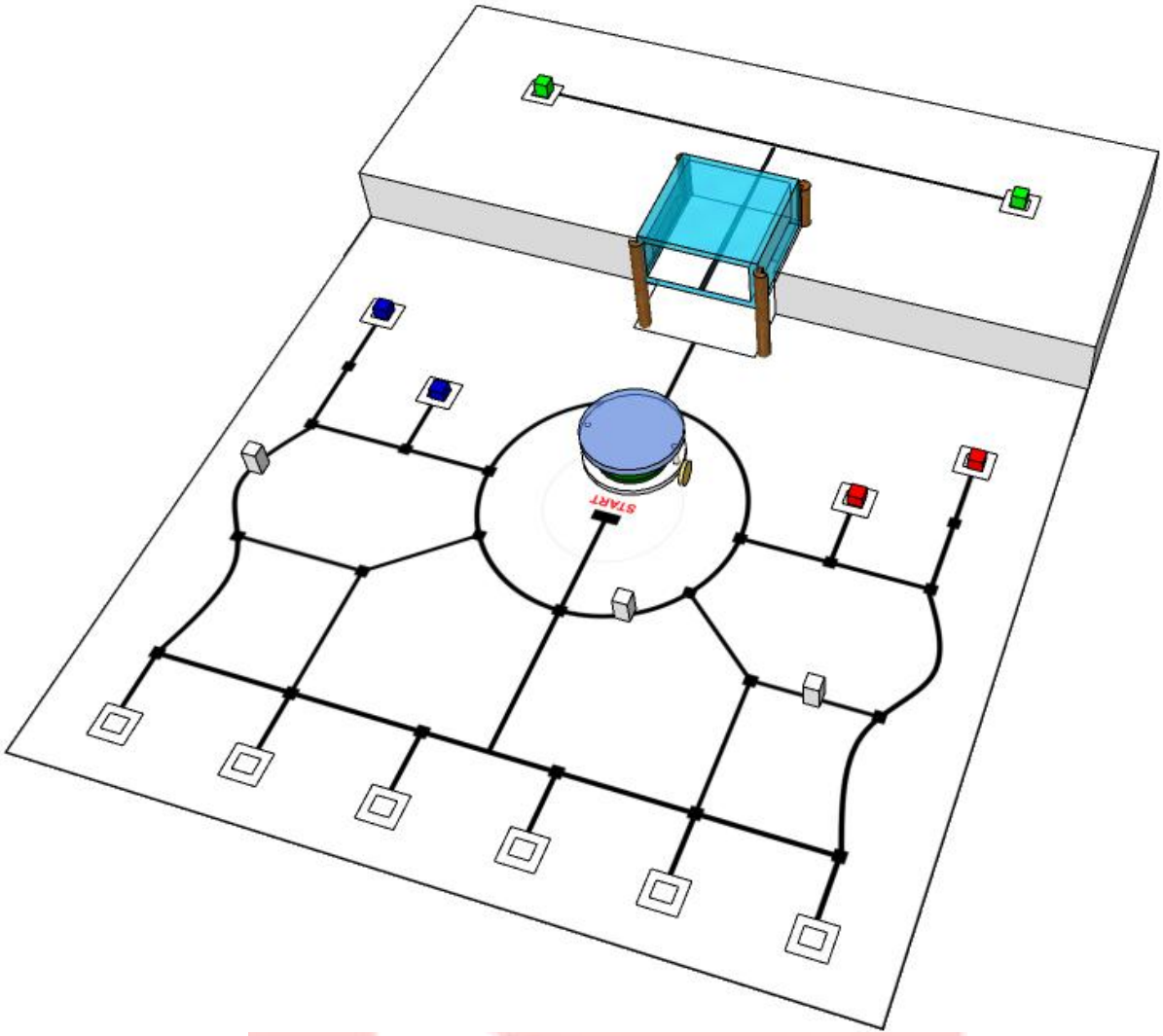

Figure 12: Final Arena as per Configuration Table

- The robot and lift mechanism must be self-contained, and not externally operated by wire or by wireless communication during the competition.
- The team has to use the same color shade as shown in Figure 7. In the finals of the competition same color shades will be used for the Nuts.
- The robot must be started with only one switch. The starting procedure of the robot should be simple and should not involve giving robot any manual force or impulse in any direction.
- Robot should be kept at the **START** line with the castor wheel of the robot positioned on the line.
- The team should switch ON the robot and turn on power supply for Lift mechanism when asked by the reviewer. This is the start of a RUN. The timer will start the same time.
- Once the robot is switched on, human intervention is NOT allowed.
- Maximum time given for completing the task is 10 minutes. A maximum of two runs will be given to a team.
- When the robot malfunctions during a run it can be re-positioned. In this case the robot is kept at the START position without resetting the timer.
- A maximum of two re-positions are allowed in each run.

- A run ends and the timer is stopped when :
  - The robot stops and sounds continuous buzzer or
  - If the maximum time limit for completing is reached or
  - If the team needs re-positioning but has used both options.
  - Buzzer sound for more than 5 seconds will be considered end of task.
  - Second run will start once again whilst resetting the score, timer and arena.
  - The score of both runs will be recorded and best of two runs will be considered as the team's score.
- The arena sequence will be same for all the teams.
- Once the robot starts moving on the arena, participants are not allowed to touch the robot.
- If the robot is found damaging the arena, it will be kept at START position.

In case of any disputes/discrepancies e-Yantra's decision is final and binding.
e-Yantra reserves the rights to change any or all of the rules as it deems fit. Any change in rules will be highlighted on the website and notified to the participating teams.

7. Judging and Scoring System

The total score will be calculated by the following formula:

Total Score = (600-T) + (CD*50) + (CDP*100) – (ID*20) – (IDP*40) + B – P

- **T** is total time taken to complete task in seconds.
- **Correct Detection (CD)** is the total number of Nuts detected correctly. Robot should glow LED on detection of each Nut. E.g. If red block is detected, the robot will glow Red LED.
- **Correct Deposition (CDP)** is the total number of Nuts placed correctly in DEPOSIT ZONE.
- **Incorrect Detection (ID)** is the incorrect detection of the Nuts. E.g. In case for red Nut if robot glows Green or Blue LED, the points will be deducted.
- **Incorrect Deposition (IDP)** is the incorrect deposition of the Nuts.
    - When the color mentioned for a particular DEPOSIT ZONE is different from the color of the Nut placed in that ZONE. For example, if red Nut was supposed to be placed in DEPOSIT ZONE S1 instead green Nut or blue Nut is placed in DEPOSIT ZONE S1, the points will be deducted.

- **Bonus Points (B)**

Hundred (100) Bonus points will be awarded, if the robot:

- Places all the Nuts correctly.
- Completes task before 10 minutes.
- Does not damage arena.
- Hundred (100) Bonus points will be awarded, if:
- Robot design is sturdy and elegantly designed.
- Lift mechanism is sturdy and smooth in lifting the robot to and fro from base to top level.

- **Penalty(P)**
    - Twenty (20) points will be deducted for damaging arena, hitting the Obstacles.
    - Twenty (20) points will be deducted if any Nuts are wrongly displaced from its position.

ALL THE BEST!