

Construct-O-Bot

1. Introduction



Environmental conditions such as extreme rainfall, earthquakes, landslides and floods often cause natural disasters which lead to tremendous loss of life and property, causing great disruption in people's lives and the economy. In 2018, across the world there were 315 natural disaster events recorded with 11,804 deaths, over 68 millions of people were affected, and 131.7 billion dollars in economic losses.

After a disaster strikes, governments and private organizations engage in reconstruction efforts of infrastructure, such as roads, bridges, power and railway lines, houses etc. This is a labor and capital-intensive task. Moreover, doing this at a disaster site, with its multiple associated risks and challenging terrain, poses an additional challenge.

Motivated by this scenario, in order to help needy victims in affected areas, this edition of e-Yantra robotics Competition (eYRC 2019-20) presents the theme "**Construct-O-Bot**".

In this theme, the arena is an abstraction of a disaster site where the robot picks Construction Material from the Warehouse and traverses paths in order to place it at a site to be reconstructed. In order to manoeuvre over these paths, the Construct-O-Bot has to use intelligent line-following and path-planning algorithms to reach safely and quickly using shortest paths.

After reaching the site, the Construct-O-Bot carefully has to place the material at the required positions which may include placing the material at different heights from the ground. It has to deposit all required material at multiple construction sites, navigating through various terrains.

The team that finishes the given task in the least amount of time whilst incurring the least penalties will be declared "**THE WINNER**".

All the best!!!

2.Theme Description:

- a). The arena for this theme is an abstraction of a disaster occurred in different terrains. This is represented as a combination of zig-zag and different terrain paths. Arena with START point and the dimensions of the House, Warehouse and Wall is shown in Figure 1 below.

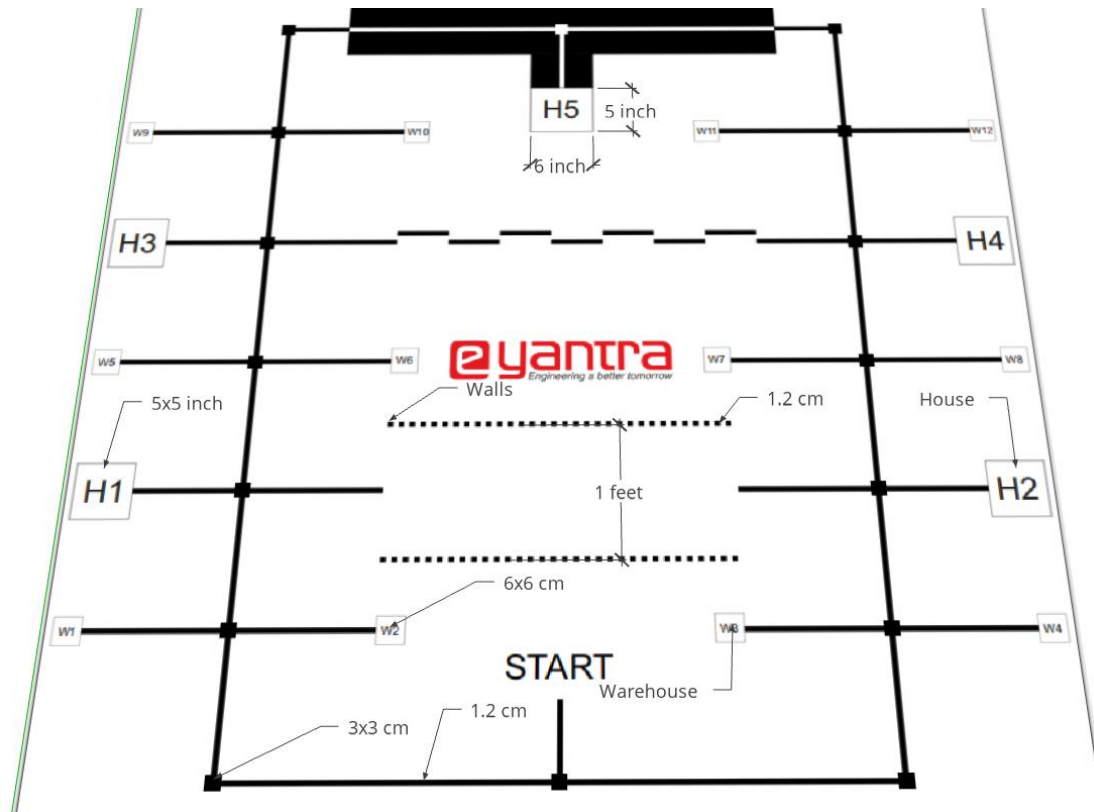


Figure 1: Arena with dimension

- **Construction Material (CM):** are coloured thermocol blocks representing the materials required for construction.
- **Warehouse (W):** are zones where Construction Materials (CM) are kept. There are total twelve (12) Warehouses in the arena represented as W1, W2, ...W12 as shown in Figure 1.

The following Construction Materials are present in the different Warehouses as shown in Figure 2.

- Brick (B)** - represented as Brown color block in the arena and available only in W1 and W2.
- Gravel (G)**- represented as Red color block in the arena and available only in W3 and W4.

III. Cement (C)- represented as Green color block in the arena and available only in W5 and W6.

IV. Sand (S)- represented as Black color block in the arena and available only in W7 and W8.

V. Electrical fittings (E)- represented as Blue color block in the arena and available only in W9 and W10.

VI. Paint (P) - represented as Pink color block in the arena and available only in W11 and W12

● **House (H):** There are five Houses in the arena namely H1, H2, H3, H4 and H5 as shown in Figure 1. A House is of two types: *low-rise House* and *high-rise House*.

I. Each House can accommodate at-most two CMs.

II. H5 is Special House termed White House.

b). Team has to prepare arena as per **Configuration Table and Configuration image** given in Table 1 and Figure 2 respectively.

Table 1: Configuration Table

House		Construction Materials Required	
H1	high-rise	Gravel	Paint
H2	low-rise	Electrical fittings	Cement
H3	low-rise	Gravel	Sand
H4	high-rise	Brick	
H5	low-rise	Brick	Sand

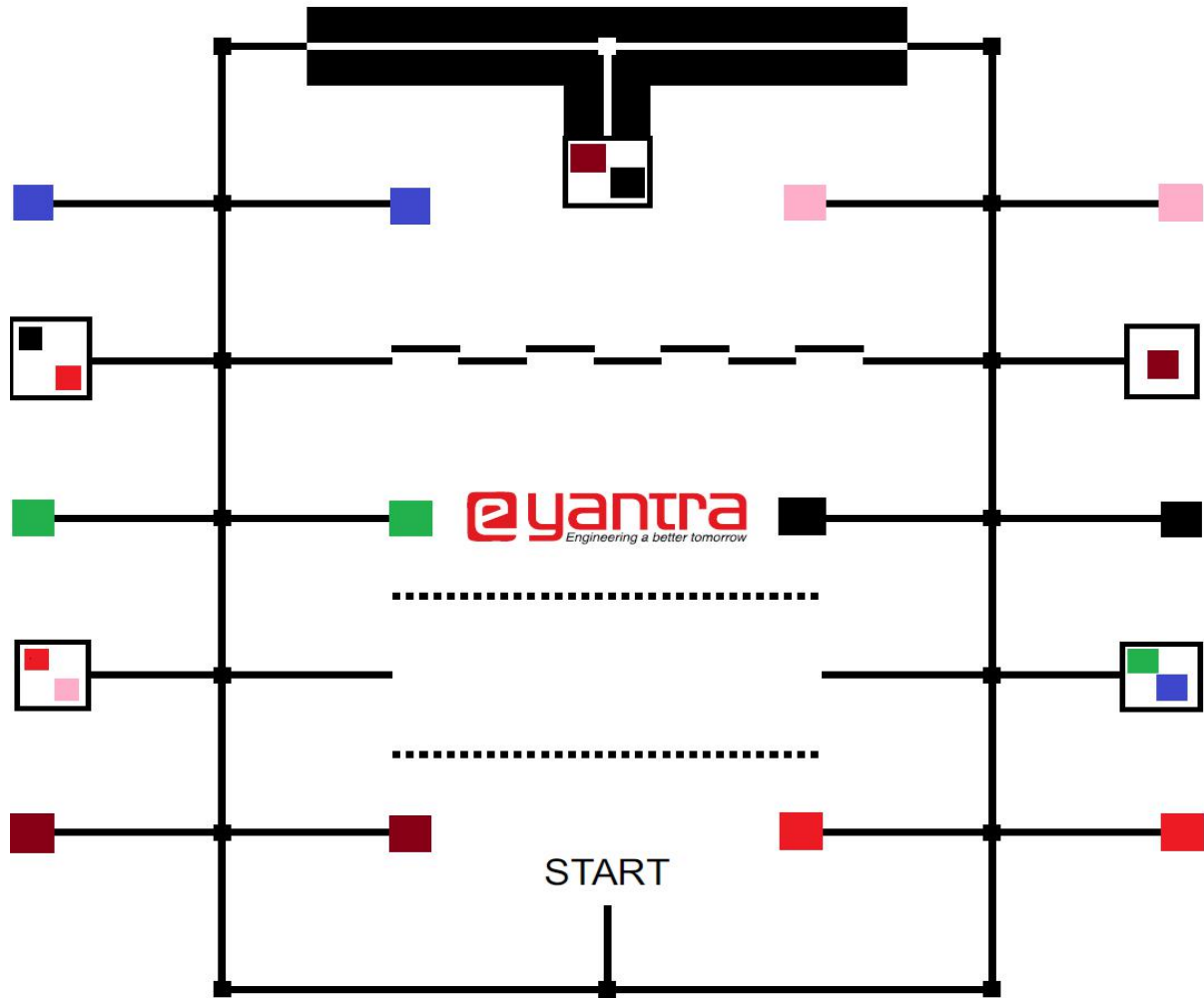


Figure 2: Configuration Image

- The robot is kept on the START point facing away from e-Yantra logo.
- Teams must have a function where configuration as input will be added. Refer Appendix 1 for example code.
- The robot is then switched ON and has to do the following:
 - i. Traverse the arena to pick the CMs from their respective Warehouses.
 - ii. Place the CMs in the designated House as mentioned in the Configuration Image and Table.
- FINISH line/node is **NOT** marked in the arena; after placing all the required CMs in the Houses, robot stops and sounds a buzzer for 5 seconds as an indication to show that the task is finished.

3. Arena

The arena for this theme is an abstraction of a disaster-struck terrain.

Preparing the arena:

The team has to prepare the arena which consists of the following steps:

1. Printing the arena on Flex Sheet.
2. Preparing the CMs.
3. Preparing the Houses.
4. Preparing the Wall.
5. Arena Configuration.

3.1 Printing the arena on Flex Sheet:

PDF file containing the arena design is given to the teams in Task 2 folder. Each team prints the arena design on flex sheet according to the instructions given in Task 2.

Teams are not authorized to make any changes in the arena design. Any team making unauthorized modifications will be disqualified from the competition.

Details of Arena design (Refer to Figure 2):

Dimension of working arena is 7 x 7 feet.

The arena consists of black lines of thickness 1.2 cm. Square nodes of dimension 3 x 3 cms are provided at the intersection of two or more black lines.

The dimension of each House is 5 x 5 inches except H5 have dimension of 6 x 5 inches.

3.2 Preparing the Construction Materials (CMs):

- Team prepares 18 Thermocol blocks; 3 copies of each coloured Construction Material.
- Dimension of each block is 6 x 6 x 6 cms as shown in Figure 3A (if the Thermocol sheets of required dimensions are not available then the teams may cut or join the available sheets on their own to build the blocks of the mentioned proportions).
- Team then pastes the coloured paper according to the colour of each Construction Material on six sides of the block (Refer to Figure 3B).

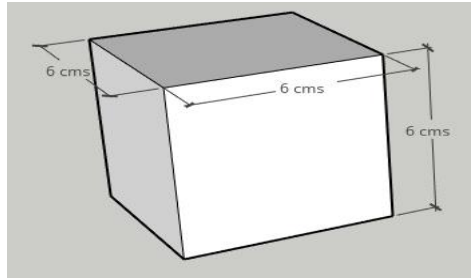


Figure 3A: CM (Plain)

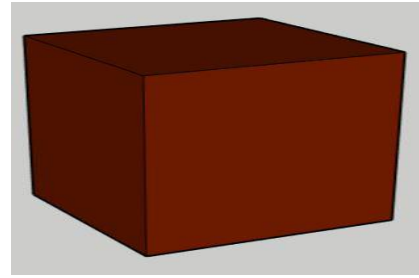


Figure 3B: Brown CM (Sample)

3.3 Preparing the Houses (low-rise and high-rise):

- Team prepares 6 houses - 3 low-rise and 3 high-rise
- Dimension of low-rise House is 15 x 15 x 6 cms as shown in Figure 4A (if the Thermocol sheets of required dimensions are not available then the teams may cut or join the available sheets on their own to build the low-rise House of the mentioned proportions).
- Dimension of high-rise House is 15 x 15 x 18 cms as shown in Figure 4B (if the Thermocol sheets of required dimensions are not available then the teams may cut or join the available sheets on their own to build the high-rise House of the mentioned proportions).

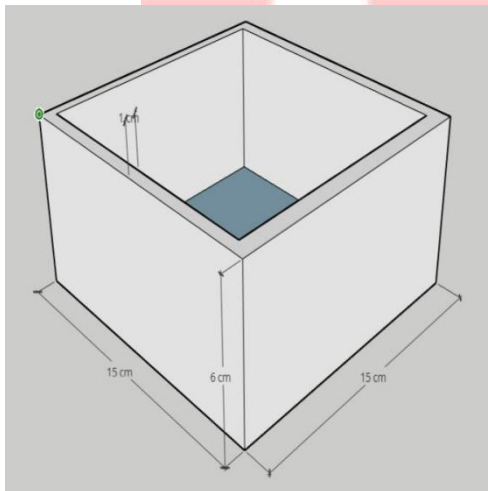


Figure 4A: low-rise House

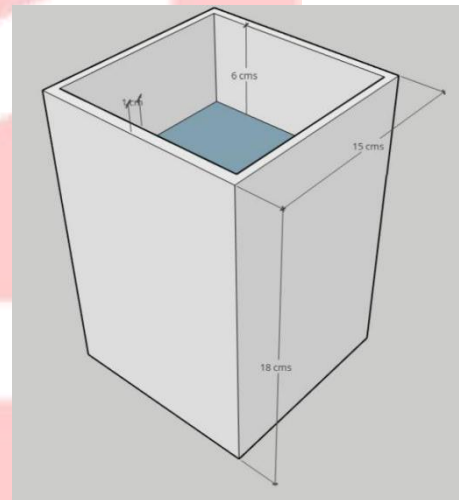


Figure 4B: high-rise House

3.4 Preparing the Wall:

- Team prepares 2 Thermocol walls; .
- Length of each wall is 30 inch (76.2 cm) and width is 20 cm.
- The thickness of the wall is 2 cm. Refer Figure 5.
- Team has to stick the walls on the dotted lines of the arena with double-sided tape of width 2 cm.

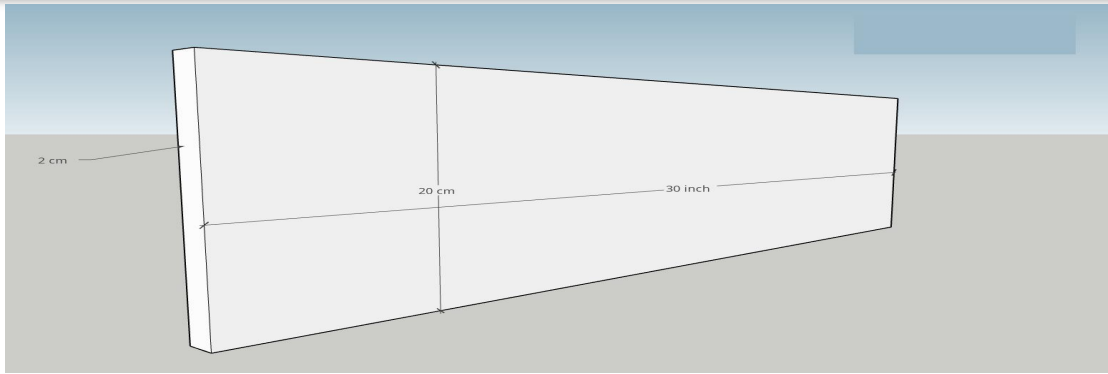


Figure 5: Wall dimensions

3.5 Arena Configuration:

When you are ready with all the above steps, you have to set up the Arena according to a given Configuration. Each Configuration involves a Configuration Image as shown in Figure 2 and a Configuration Table as shown in Table 1 that describes the type of House viz. low-rise House or a high-rise House, the type and quantity of CM required by different Houses.

After the team is done, the arena should resemble the Figure 6.

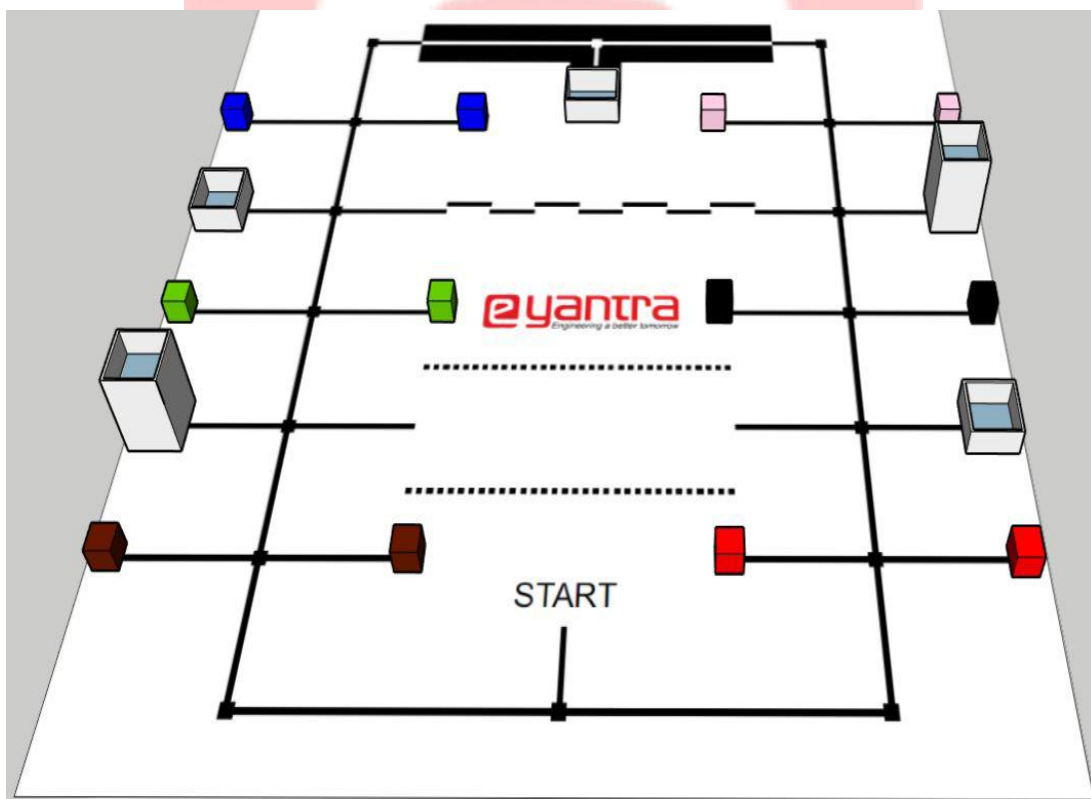


Figure 6: Final Arena

Note: You must keep the wall on the dotted line. We have intentionally removed the wall in Figure 6 to show the complete 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 not good enough to properly evaluate

the team, e-Yantra has the right to disqualify the team. The final decision is at the discretion of the reviewer.

Note: The arena shown in Figure 6 is simply an example so that the teams can understand the given configuration.

WARNING: Please be careful while handling the flex sheet – avoid folding it like a bed-sheet since the resultant folds will cause problems while the robot moves. 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. Best is to store the sheet rolled up.

4. Hardware Specifications:

4.1 Use of robot:

- **Only one** robot is allowed per team.
- The dimension of the robot should not exceed 20 x 20 cms excluding the mechanical assembly for pick place.
- The robot should be **completely autonomous**. The team is not allowed to use any wireless remote or any other communication protocol unless specifically allowed.

4.2 Use of additional components NOT provided in the kit:

- No other microcontroller-based board shall be attached to the robot.
- Teams may connect external actuators along with their driver circuits on the robot only on condition that the actuators must be controlled by the robot.
- Team is allowed to attach any **self-designed** mechanical assembly (arm/s, gripper, rack and pinion, etc..) 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 team is not allowed to use any other sensors apart from those provided in the kit.

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.**

4.3 Power Supply:

- The battery can be charged through auxiliary power adaptor which have been sent to you along with the kit.
- The team **cannot** use any other power source for powering the robot.

5. Software Specifications:

- e-Yantra has provided all teams with ATMEL STUDIO 6, a free software for programming AVR microcontroller. Participating teams are free to use any other open source Integrated Development Environment (IDE) for programming AVR microcontroller.
- Use of any non-open source libraries is not allowed and will result in disqualification.
- As per e-Yantra policy, all your code and documents are open-source and may be published on the e-Yantra website.

6. Theme Rules:

- The maximum time allotted to complete the task is 10 minutes. A maximum of two runs will be given to a team (the better score from two runs will be considered as the team's score). A maximum of two repositions (explained below) will be allowed in each run.
- Configuration Image and Table will be given before start of a run. Only 2 minutes will be given to input the configuration in your program.
- The robot should be kept at Start point with the castor wheel positioned on the black line and robot facing away from e-Yantra logo on the arena.
- The team should switch ON the robot when told to do so by e-Yantra reviewer. This is the start of a run. The timer will start at the same time.
- The position of Construction Materials (CM) in their respective Warehouses (W) will always remain fixed as given Configuration Image and Table.
- A House can either be a low-rise House or high-rise House.
- A House can either require 0 CM, 1CM or 2 CMs.
- Required CM can be from same or different Warehouses;
 - I. 0 CM or
 - II. 1 CM - can be from any one of the warehouse or
 - III. 2 CMs - both CMs can be from same Warehouse or from different Warehouses.

For example - a House H1 may require

0 CM or 1 CM of Brick or 2 CMs of one Brick and one Sand or 2 CMs of Sand etc.

- Once the robot is switched on, human intervention is NOT allowed.
- A run ends and the timer is stopped when:
 - The robot stops and sounds the continuous buzzer for more than 5 seconds or
 - If the maximum time limit for completing the task is reached or
 - If the team needs repositioning but has used both repositioning options of that run (repositioning is explained below).
- 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.

- Teams are not allowed to keep anything inside the arena other than the robot. The time measured by the reviewer will be final and will be used for scoring the teams.
- Time measured by any team by any other means is not acceptable for scoring.
- Once the robot starts moving on the arena, teams are not allowed to touch the robot.
- The robot is not allowed to make any marks while traversing the arena. Any robot found damaging the arena will be immediately stopped; repositioning will be allowed as per the rules. The final decision is at the discretion of the e-Yantra team.
- If robot places required CM to H5(White House) prior to any other Houses will be awarded White House Bonus (WHB) as explained in the Scoring Formula in the further section. CM is considered placed only if it is inside the House.
- This rule must be kept in mind while designing the mechanism so that there is no hindrance in the path of the robot.
- The task is considered complete, if the requirement of the House is satisfied.

Important: A Run is considered valid only if Team picks one correct CM and place it in correct House according to the Configuration given. Otherwise, time will be considered Maximum.

Repositioning of robot:

Suppose while traversing the arena robot strays off the black line (Refer to Figure 8A), a member of e-Yantra team monitoring the task will place that robot on the previous node (node already traversed by the robot) in such a way that both the wheels of robot are parallel to the node and castor wheel is on the black line (Refer to Figure 8B). This is termed as a **Reposition**.

Note that the timer used for measuring the task completion time in the competition will be continuously running during a Reposition and the robot will not be switched off. **robot is given only two repositions** per run. If the robot has been repositioned twice and requires a third reposition, the run will **be ended**.

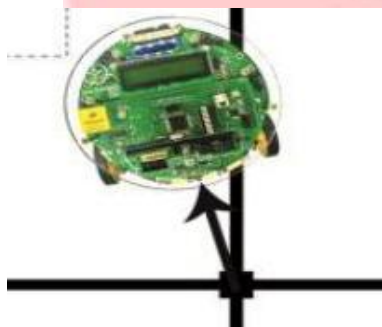


Figure 8A: robot strays off the line

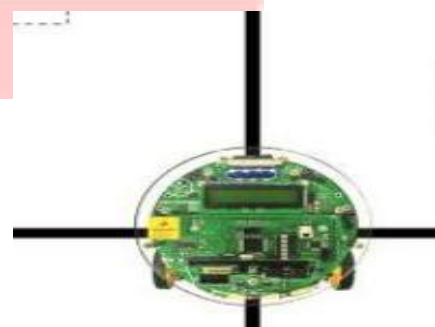


Figure 8B: robot after Reposition

NOTE:

- You will be given final Configuration image and Configuration Table just before the submission of Final Task (Task 4: Video Submission).
- After completion of all tasks, teams will be selected as finalists based on their cumulative scores across all the tasks. Complete rules and instructions for the finals at IIT Bombay will be sent to those teams that qualify for the finals.
- 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 above rules as we deem fit. Any change in rules will be highlighted on the website and notified to the participating teams.

7. Judging and Scoring System:

- The competition time for a team starts from the moment the robot is switched ON. The timer will stop as soon as the robot finishes the task.
- Best score of the two runs for a team will be considered as the final score of the team.
- The team's total score is calculated by the following formula:

$$\text{Total Score} = (600 - T) + (CP * 30) + (CD1 * 80) + (CD2 * 100) + (WHB * 100) + (B * 100) - (P * 50)$$

- **T** is total time taken to complete task (in seconds).
- **CP** is the total number of CMs picked correctly.
- **CD1** is the total number of CMs placed correctly on low-rise.
- **CD2** is the total number of CMs placed correctly on high-rise.
- **WHB**(White House Bonus) is 100 Bonus points awarded, when the robot places the required CMs in H5 i.e. H5 prior to any other Houses .
- Bonus Points (**B**) is hundred (100) Bonus points awarded, if the robot
 - I. has competed the task without any penalty **AND** .
 - II. Completes task before 10 minutes.
- Penalty (**P**) are 50 points deducted each time as follows:
 - I. The robot dashes against the arena objects, walls.
 - II. Team take robot reposition.
 - III. The CM which is not required for the House is placed in the House.

ALL THE BEST...!!!

Appendix I

```
void config()
{
    //All these variables should have global definition to use them globally in
    code
    floor_array[5] = {1,0,0,1,0} //0 low-rise house and 1 for high-rise house
    house_total_requirement[5] = {2,2,2,1,2} //How many required at
    particular house
    which_material[10] = {3,11,9,5,4,7,1,0,2,8} //requirement of each house
}
```

