CARGO SORTING ROBOT

1. INTRODUCTION

Increase in air traffic has led to an increase in cargo as well as the concern for airport authorities to send cargo to its appropriate destination. Let's consider a typical scenario in an airport: flights coming at different terminals unload cargo at these terminals. Based on its final destination, cargo unloaded at a given terminal has to be taken to an appropriate terminal to be loaded onto a flight to its destination.

This process of cargo sorting involves: (i) identifying the destination of cargo and (ii) depositing the cargo at an appropriate terminal based on its destination. By automating this process, we can ensure that cargo is delivered to its destination on time, avoiding human errors.

In keeping with the importance of the subject, in e-Yantra Robotics Competition 2014 (eYRC-2014), one of the themes chosen is Cargo Sorting Robot. In this theme, we focus on automating the task of sorting cargoes arriving at a simplified abstraction of an airport having **four terminals**. Each terminal has two **deposition zones** where arriving cargo is placed. We use colored blocks to represent four **types** of cargoes. There are two **sorting zones** used as placeholders during the sorting process.

In this competition, you are free to design the mechanism for detecting cargo and placing it in the appropriate terminal. The challenge is to sort the cargo such that each cargo block is placed at its appropriate destination terminal, in the shortest possible time. The robot that performs the task best in accordance with the rules set out for this task will be declared the WINNER of the competition.

2. THEME DESCRIPTION:

Make an autonomous robot that performs the following tasks:

1. The robot starts from **START** position of the arena representing an airport (Refer to Figure 1).

- There are four terminals**, Terminal 1 … Terminal 4** (referred to as **T1, T2, T3, and T4** in the rest of this rulebook) in the airport where cargo is placed on arrival to the airport. Each terminal has two deposition zones **Left (L)** and **Right (R**). We use **T1-L** to represent the left deposition zone in T1 and **T1-R** to represent the right deposition zone in T1. Similar notation is used for the other terminals.
- Thermocol blocks of four colors Red (**R**), Blue (**B**), Green (**G**) or Black (**Bk**) are used to represent different **types** of cargoes.
- Each deposition zone can contain: (i) **No package** – when the deposit zone is empty or (ii) **Valid package** – when a package of one of the colors – Red (R), Blue (B), Green (G), or Black (Bk) – is at the deposition zone.
- There are four **indicator spots** labelled **I1, I2, I3, and I4** as shown in Figure 1. Each indicator spot has an associated terminal: I1 for T1, I2 for T2, etc. At the time of the competition, blocks of colors R, B, G, or Bk will be placed on these indicator spots, which are used to assign a color to the respective terminal. For example, if a red block is placed at I1 (Refer to Figure 2), then both deposition zones of T1, **T1-L** and **T1-R**, are designated to contain red packages; only packages of that color should be present in that terminal.
- There are two **sorting zones** marked by "sort" on the arena that can be used for sorting the packages – by acting as temporary "hold" areas.

2. The robot traverses the path around the terminals and does the following:

   i) Checks each indicator spot and registers the **designated color** for each terminal.

   ii) Traverses the arena and checks each deposition zone. If a block is found in a deposition zone, it does the following:

   - Checks if the block is of the **designated color** for that terminal.
   - If so, sounds a buzzer of 500 ms.
   - If not, picks up the block and carries out the sequence of operations to place it at its designated terminal.

iii) Repeats step (ii) till all the blocks are **sorted** such that the blocks are placed at the terminals having the respective designated colors.

iv) When all packages are sorted, the task ends.

v) Sound of a continuous buzzer of 5 seconds indicates END of task.

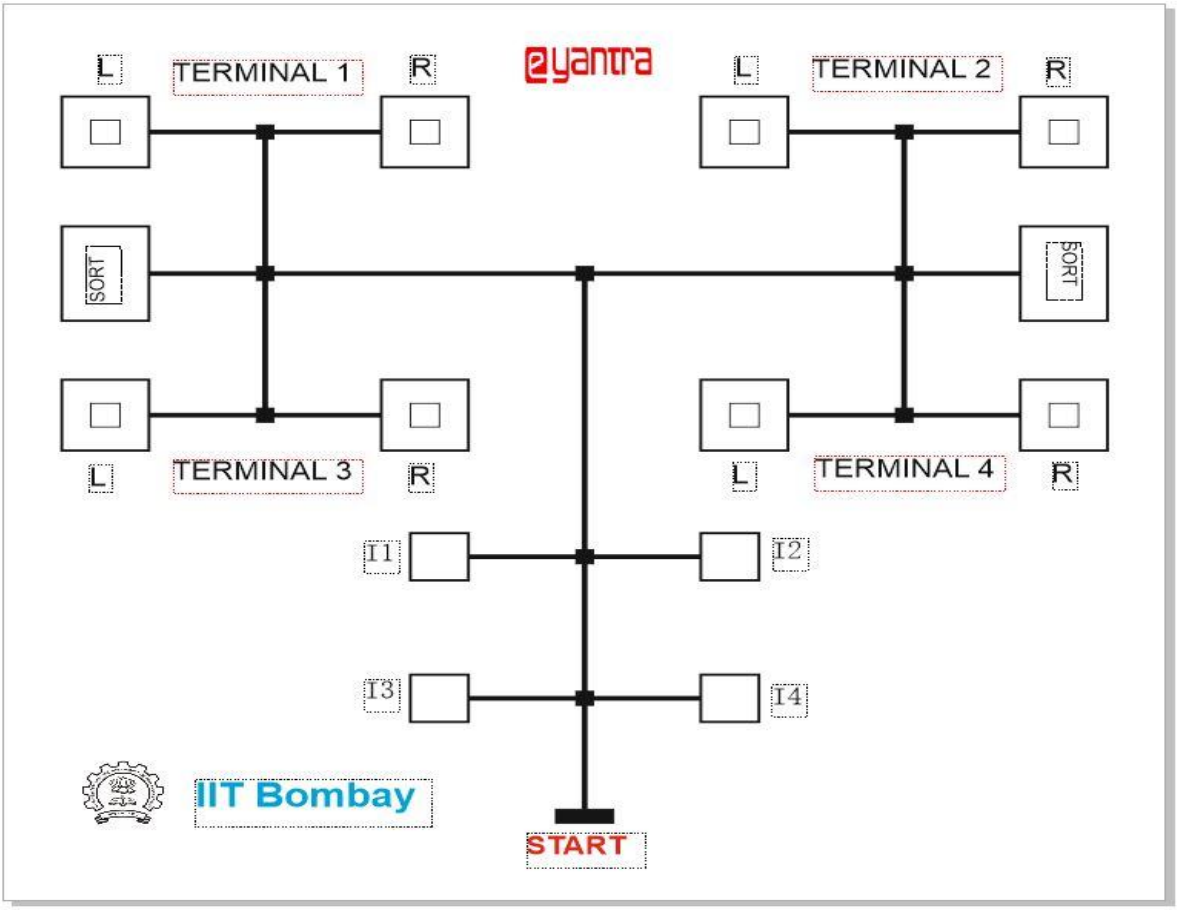

Figure 1: Arena

3. ARENA

The arena for this theme is a simplified abstraction of an airport. There are 4 terminals marked on the arena (referred to as T1… T4) with each terminal having two deposition zones: Left (L) and Right (R). Each terminal has a designated color which is assigned by placing an **indicator block** on the indicator spots, I1… I4. With reference to Figure 2, note that the designated colors for T1… T4 are as follows: T1 – Red; T2 – Blue; T3 – Black; T4 – Green. Packages of different types represented by blocks of colors Red, Blue, Green or Black are placed on arrival at the deposition zones. In the example shown in Figure 2, while T1 and T4 contain the blocks of their designated colors, T2-R contains a black block and T3-R contains a blue block which have to be sorted; in this case, the black block has to be placed in T3 and the blue block in T2. The black line on the arena is used for the robot to navigate its path to complete the task.

The complete arena with the above mentioned details for this theme is depicted in Figure 2.

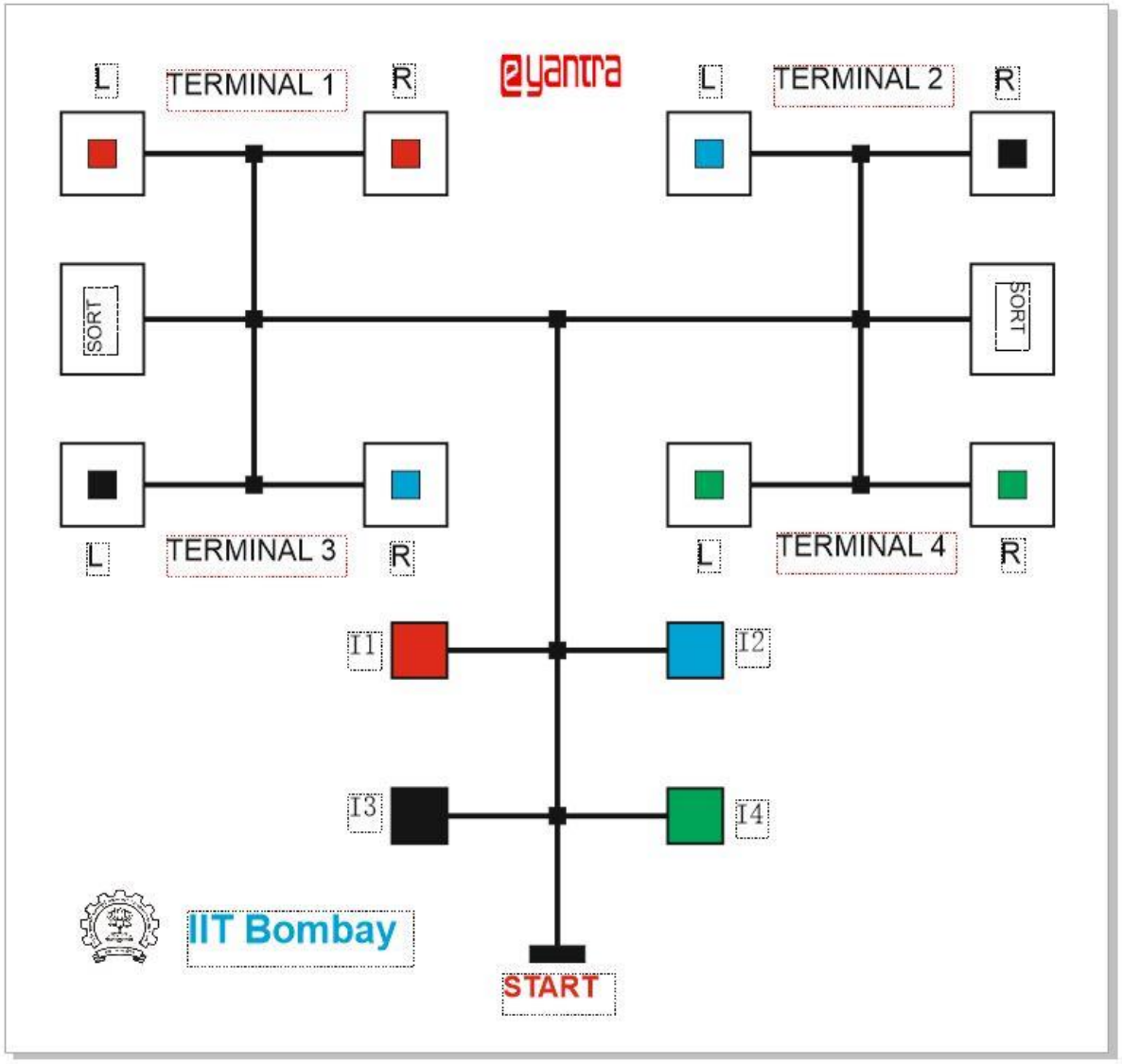

Figure 2: Example of a Complete Arena

Arena preparation:

Each team prepares the arena. Preparing the arena consists of three major steps.

1. Printing the design on a flex sheet.
2. Preparing the blocks and indicator blocks.
3. Placing the blocks and indicator blocks on the arena.

Details of these steps are given below:

3.1. Printing the design on a flex sheet:

- The arena design is as shown in Figure 3.
- A Corel Draw (.cdr) file containing the flex design will be provided to the teams along with .pdf for reference. Each team shall print the arena layout design according to the instructions provided in the .cdr file.

Details of arena design:

- Dimension of arena is 154 cm x 180 cm.
- Dimension of the flex sheet is 190 cm x 200 cm. A margin of a few cms is provided on all sides to allow for sticking the flex sheet on the ground (Refer to Figure 3).
- START line is marked on the flex sheet. This is the point from where the robot starts its task.
- FINISH line is NOT marked on the sheet as when the robot sorts the last cargo by placing it at the appropriate deposition zone, it sounds a continuous buzzer indicating completion of task.
- The size of each deposition zone is 15 cm x 15 cm.
- The arena consists of a grid made of black lines of 1 cm thickness. Square nodes of dimension 3 cm x 3 cm are provided at the intersection of two or more black lines.
- Teams are not allowed to make any changes in the arena design. Any team making any modification whatsoever will be disqualified from the competition.

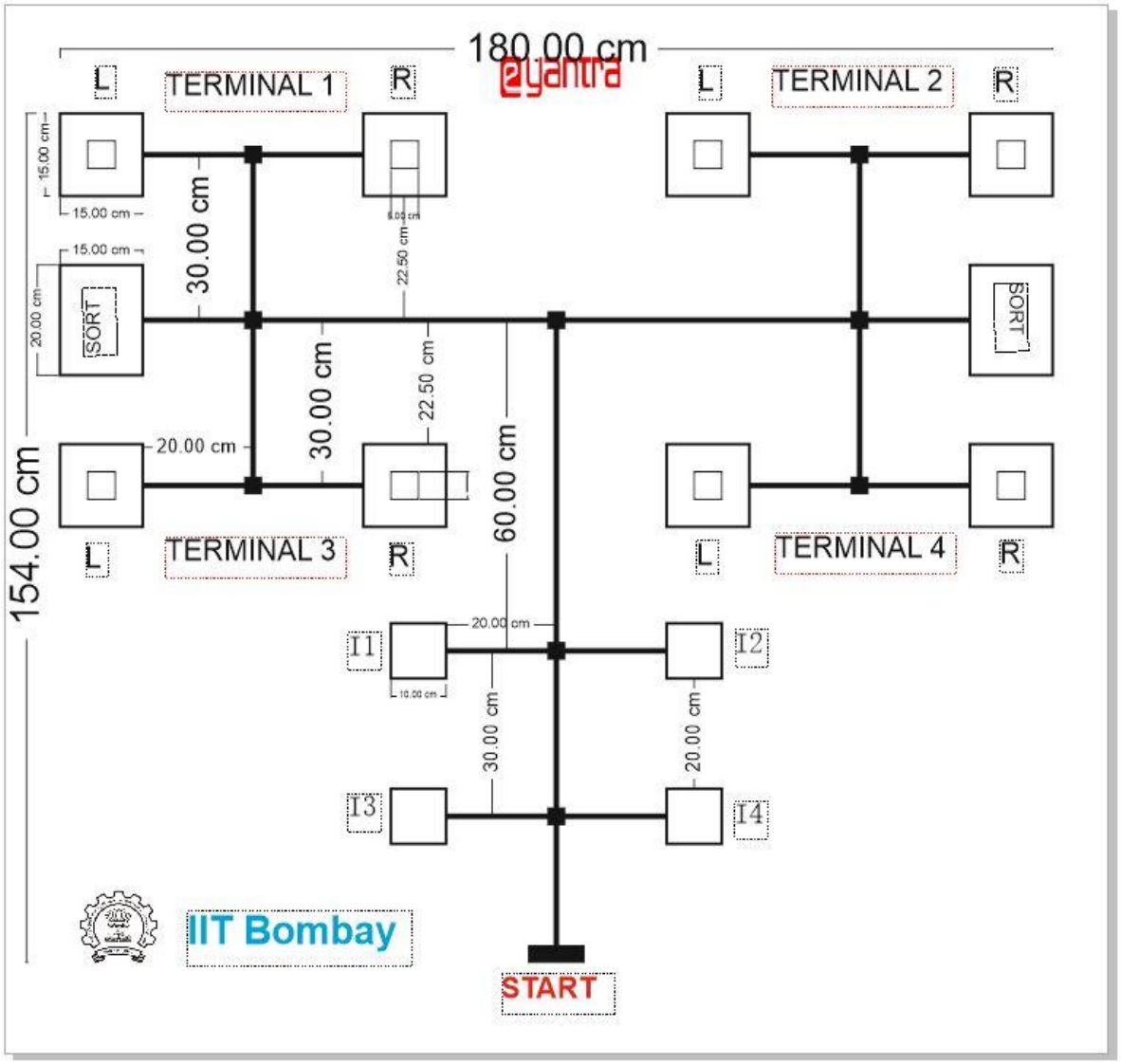

Figure 3: Arena Design

3.2. Preparing the blocks and indicator blocks

There are two types of blocks that teams prepare: (i) **blocks** of 4 colors (R, B, G, and Bk) to represent different types of cargo and (ii) **indicator blocks** of 4 colors (R, B, G, and Bk) used to designate the color associated with each terminal.

Materials required for preparing the blocks:

- Thermocol sheet for making the blocks.
- Red, Blue, Green and Black color chart paper for covering the blocks.
- Sample chart paper of all these colors are provided in your kit. Teams may need to purchase additional chart paper for preparing the blocks. Even minor variation in the shades of chart paper can cause error in detection of these colors. Hence, we recommend that you take the sample chart paper and exactly match these when you buy additional chart paper.

- All the colors given as samples have been tested for detection by the sensors provided with the robot. Note that the sample colors provided in the kit will be used in the finals of the competition. You should calibrate your system using the provided colors since these will be present in the finals.

  NOTE: Accurate calibration of the sensors is key for successful implementation of a solution to this theme. You should make the sensing as robust as possible under different lighting conditions. Also take care in the fabrication of the blocks since the proper sizing, positioning and positional stability of the blocks might make the difference between failure and success.

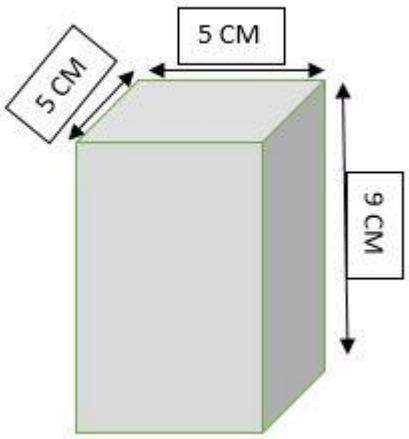

Figure 4A: Dimension of Block

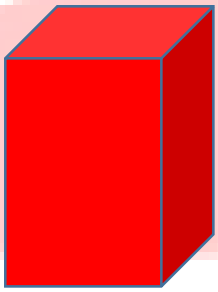

Figure 4B: A Red Colored block

- Dimension of each block is 5cm x 5cm x 9cm 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.).
- Team prepares 3 blocks each of Red, Blue, Green and Black by covering the blocks with the respective colored chart paper. A red block is shown as an example in Figure 4B.

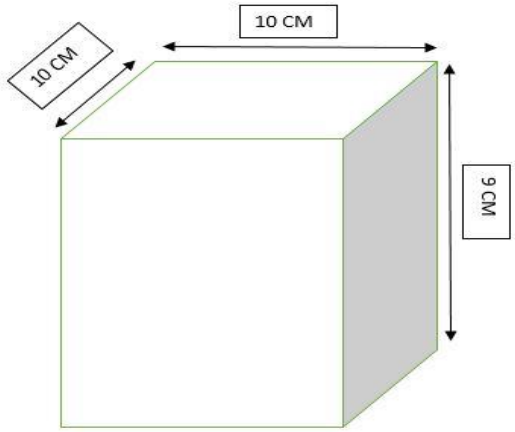

Figure 5: Dimension of Indicator Block

- Dimension of each indicator block is 10cm x 10cm x 9 cm as shown in Figure 5.
- Team prepares 1 indicator block each of Red, Blue, Green and Black by covering the blocks with the respective colored chart paper as done earlier for other blocks.

3.3. Placing the blocks and indicator blocks on the arena

- Placement of the blocks and indicator blocks will be given to the team as an image just before the deadline for video submission. Note that the image can represent any random placement of the blocks and indicator blocks.
- Four indicator blocks will be randomly placed and on the four indicator spots.
- A deposition zone may or may not contain a block.
- Teams arrange the blocks and indicator blocks on the arena as per the image provided.
- Note that blocks have to be placed at the center of each deposition zone (on the square marked in the middle of each deposition zone).
- Now you are ready with the arena. Please maintain the arena in good condition.

Note:

If the arena is found damaged or in a condition that makes evaluation difficult, e-Yantra has the right to disqualify a team. The final decision is at the discretion of the reviewer.

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 SPECIFICATONS

4.1 Use of Firebird V:

- All participating teams must use **only** the Firebird V robot sent to them in the kit. **Only one** robot given in the kit is allowed per team.
- Team shall not dismantle 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 a camera while the robot is performing the task.

4.2 Use of additional components not provided in the kit:

- No other microcontroller-based board shall be attached to the Firebird-V robot.
- Teams may connect external actuators along with their driver circuits to the Firebird V robot only on the condition that the actuators must be controlled through the Firebird V robot.
- The team is not allowed to use any other sensors apart from those provided in the kit.

4.3 Power Supply:

- The robot may be charged through battery or auxiliary power supply. These are supplied with the robot.
- The team cannot use any other power source for powering the robot.
- The team can use auxiliary power during practice but the final demonstration should only be made using only the battery powered robot.

5. SOFTWARE SPECIFICATIONS

- e-Yantra has provided all teams with ATMEL STUDIO 6 – a free software programming AVR microcontroller. Participating teams are free to use any other open source Integrated Development Environment for programming AVR microcontroller.
- As per e-Yantra policy, all your code and documents is open-source and maybe published on the e-Yantra website.

6. Theme Rules

- The maximum time allotted to complete the task is 10min. A maximum of **two runs** will be given to a team (the better score from the two runs will be considered as the team's score). A maximum of **two repositions** (explained below) will be allowed in each run.
- The team should switch **ON** the robot when told to do so by reviewer. This is the start of a **run**. The timer will start at the same time.
- The participant has to keep the robot at the START position and turn on the robot.
- The robot has to take reference of the indicator blocks to determine the designated color of each terminal. Note that the indicator blocks placed at the indicator spots should not be displaced as they are used only to determine the designated color for each terminal.
- The robot may use the sorting zones for sorting of blocks.
- The run ends when all the packages are sorted.
- The end of run is indicated by the continuous buzzer.

Note:

- Team can pick up and sort a block in any order.
- Initially, all blocks will be kept at the center of each deposition zone. Later, when robot places the block in the appropriate deposition zone, it can place the block anywhere inside the deposition zone. Even if a part of the block is inside the deposition zone, it will be considered correct for scoring.
- Each terminal will have only one designated color.
- Each deposition zone can only take one block.
- The team has to use same colors given in the kit.
- 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.
- When the robot malfunctions during a run it can be repositioned. In this case the robot is kept at the START position without resetting the timer.
- A maximum of two repositions 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 the task is reached or
    - If the team needs repositioning but has used both options.
- Buzzer sound for more than 5 seconds will be considered as 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.

- Participants 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 participant by any other means is not acceptable for scoring.
- Once the robot starts moving on the arena, participants 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.

Repositioning of Robot

1. Robot repositioning is done under following circumstances:
   - If robot is found to be displacing any block or damaging the arena then it will be kept at the **START** position.
   - If the robot gets stuck in the arena or goes off the arena, teams can ask for the reposition.
2. For a reposition, the robot should be in Power Off mode, and turned on again at the **START** position, upon signal from the reviewer. **During a reposition, the timer will not be set back to zero.**
3. Each team is allowed a maximum of two repositions in each run. All repositions require the approval of the reviewer; the team will be disqualified if the robot is handled within the arena without approval.
4. During repositions, a participant must not feed any information to the robot. A participant may not alter a robot in a manner that alters its weight. The reviewer's decision is final.
5. Note that during reposition, any block that is not deposited at the appropriate deposition zone, (any block dropped during traversal) will be placed back in its original position on the appropriate node.
6. After reposition the robot has to complete the remaining task; the blocks that are previously deposited correctly will be counted in the score.

Note:

- **You will be given an image depicting the arena just before the submission of Task 3: Video submission along with instructions for completing this task.**
- **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 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 competition for a team starts from the moment the robot is switched ON. The timer will stop as soon as the robot finishes the task.
- The better score of the two runs for a team will be considered as the final score of the team.
- The total score will be calculated by the following formula:

Total Score = (600 - T) + (C * 50) – (W * 20) + B – P

- ❖ T is total time taken to complete task in seconds.
- ❖ C is the total number of blocks placed correctly in the deposition zones after run ends. A block is deposited correctly when it is placed in the appropriate deposition zone as designated by the indicator blocks placed on the indicator spots.
- ❖ W is the number of blocks deposited incorrectly. Deposition of a block is considered incorrect when a block of a different color is deposited in a terminal designated for a given color; for example, if T1 is designated for Red, and a green block is deposited in it.

- Bonus Points (B)

Forty (40) Bonus points will be awarded, if the robot:

- ✓ Places all the packages correctly.
- ✓ Completes the task within 10 minutes.
- ✓ Does not damage the arena.

- Penalty(P)

- ✓ Twenty (20) points will be deducted for damaging arena.
- ✓ Twenty (20) points will be deducted for each block left in the sort zone.
- ✓ Twenty (20) points will be deducted for each displaced indicator block.

ALL THE BEST .....!!!!!!!!!