Hazardous Waste Disposal

1. INTRODUCTION

Waste is generated in every manufacturing activity. Some of the products manufactured use chemicals that are hazardous as raw materials and require careful handling. Hence the waste generated also is hazardous in nature and may be toxic to the environment if not handled with care. Such waste should be disposed in a manner that is least harmful to living beings and the environment.

e-Yantra Robotics Competition 2015 aims to flag such real life urban problems and find solutions to these in creating smart cities. One such urban problem identified is the Hazardous Waste disposal. Typically, Hazardous Waste generated is treated on-site and requires transportation to a disposal site far away from the city in order to safeguard the health of all living beings.

In this theme, we have attempted to automate a system to transport Hazardous Waste and to place the waste in designated locations. The arena for this theme represents two areas: one **City Area** (**CA**) where the waste is generated and another **Isolated Area** (**IA**) where the waste has to be disposed. A water body separates CA and IA, which are connected by a bridge over the water. Different types of Hazardous Wastes are placed in random order stacked in CA. The robot should transfer these wastes to IA travelling across the bridge.

The challenge is to complete this task in the shortest time possible. The robot that performs the task in the best way as per the set rules will be declared the WINNER.

2. THEME DESCRIPTION

Description of the arena: The arena represents a **City Area (**CA) and an **Isolated Area** (IA) separated by a water body. A **Bridge** connects the two areas.

With reference to Figure 1:

- The arena is divided into two parts **CA** and **IA** respectively. CA is separated from IA by a water body (Blue colored portion in Figure 1). A Bridge connects these two parts.
    - The Bridge is a seesaw kind of mechanical system which is operated by placing weights on either end of the bridge.
    - As indicated in Figure1, two **Weight Deposition Zones** DZ1 and DZ2 are marked on the arena where **Container**s are placed to add Weights. The **Weight Block Locations** contain the required **Weight Blocks** to operate the Bridge. Construction and operation of the bridge are explained in Section 3.3.
- Blocks of dimension 6cm x 6cm x 6cm are used to represent **Hazardous Wastes**. Three types of Hazardous Wastes are represented by three different colors – Red, Green and Blue.
- There are two types of **Chemical Concentration Level (CCL)** associated with each type of Hazardous Waste – **High** and **Low**.
    - A block covered on all the sides with Red represents Hazardous Waste of that type with High CCL. A block covered with only one side with Red represents Hazardous Waste of that type with Low CCL. Similar terminology is used for Green and Blue blocks.
- Three types of Hazardous Wastes -- blocks one each of R, G, B -- are stacked at **Initial Position** (**IP**) in CA, such that the High CCL types are on top of the stack and Low CCL type is at the bottom. (Details are explained in Section 3.2)
- This Theme involves picking up the Hazardous Wastes from IP and taking them across the Bridge to IA.
- Two **Sorting zones** as shown in Figure 1 can be used as temporary holding zones for the Hazardous Wastes.
- In IA there are three **Deposition Zones** (indicated by A, B and C as shown in Figure 1). Each of these three Deposition Zones has an associated color indicated by a **Flag --** to designate the Type of Hazardous Waste that can be deposited there.

The robot starts from **START** position in CA of the arena (Refer to Figure 1) and performs the following tasks:

i. Identifies the type of the Hazardous Waste stacked at IP.
ii. Picks up the Hazardous Waste from IP.
iii. Travels from CA to IA across the water body using the Bridge – Note that the Bridge needs to be in "Down" position for the robot to traverse across it.
iv. Using the Flags identifies and deposits the Hazardous Waste at the appropriate Deposition Zone. (Sorting Zones may be used as temporary placeholders).

Once the robot deposits all the Hazardous Wastes in the appropriate Deposition Zones, it will stop and sound a continuous buzzer. The sound of the buzzer indicates the task has been completed.

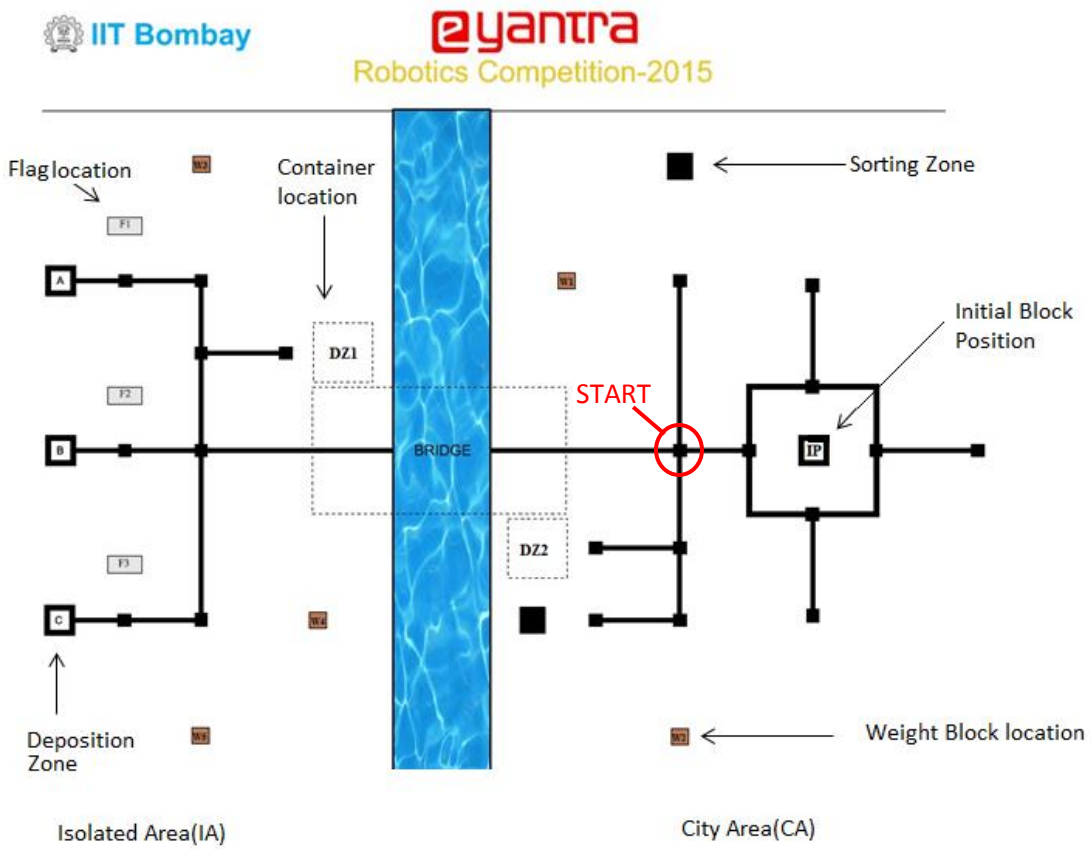


Figure 1: Arena

3. ARENA

The arena for this theme is a simplified abstraction of Hazardous Waste management system. Each team has to prepare the arena. Preparing the arena consists of three major steps:
1. Printing the arena design on flex sheet.
2. Preparing the Hazardous Wastes and Flags.
3. Construction and Placement of the Bridge.

NOTE: The Tutorial for preparation of Bridge and Weight blocks are provided along with this document. Teams are not allowed to make any changes in the arena design. Any team making unauthorized modifications will be disqualified from the competition.

3.1. Printing the arena design on the flex sheet

The Arena design to be printed on a flex sheet is as shown in Figure 2. A Corel Draw (.cdr) file containing the arena design will be provided to the teams. Each team prints the flex design according to the direction given in the .cdr file.

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**.

Details of arena design: (Refer to Figure 2)

- Dimension of the flex sheet is 243cm x 183 cm.
- The arena consists of a grid 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.
- The size of each Deposition Zone is 7 cm x 7 cm.
- Teams are not allowed to make any changes in the arena design. Any team making any modification whatsoever will be disqualified from the competition.

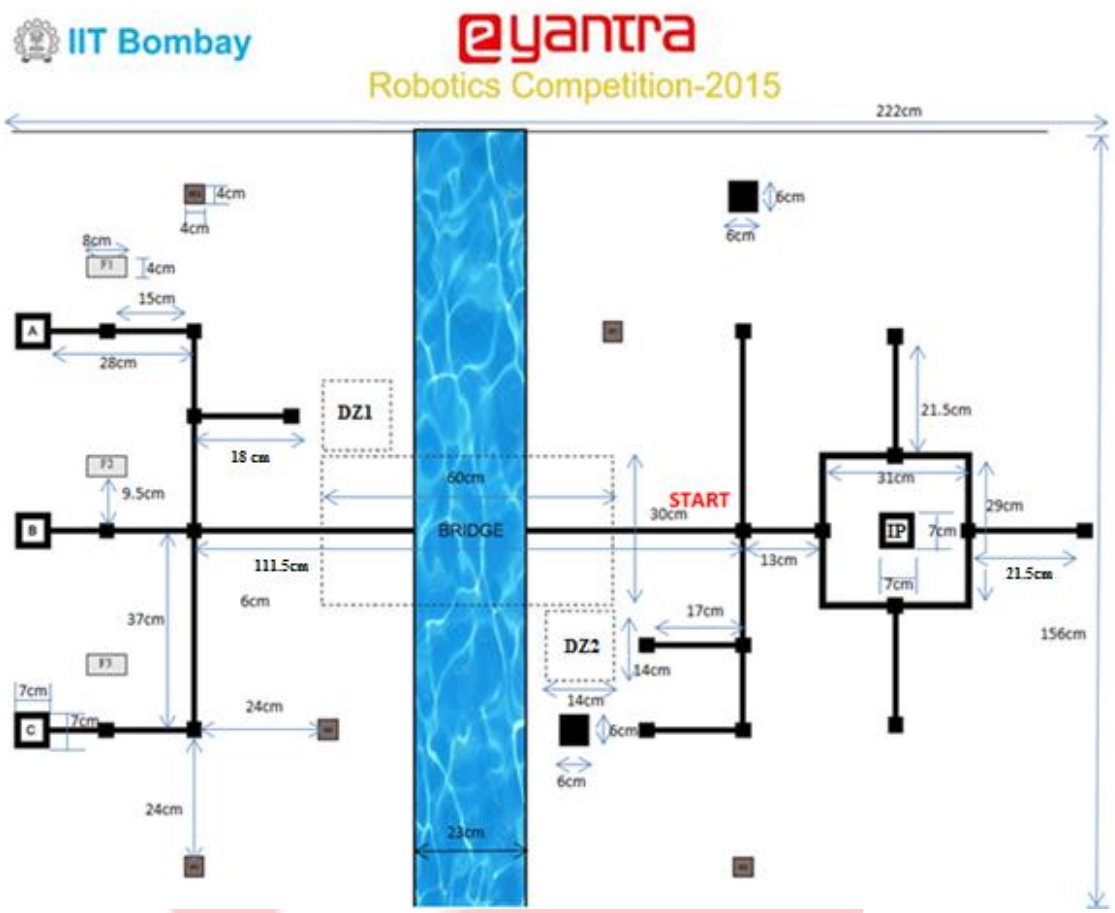


Figure 2: Arena Design

3.2. Preparing the Hazardous Wastes and Flags

There are two types of blocks that teams prepare: (i) Blocks of 3 colors (Red, Blue and Green) to represent three types of Hazardous Wastes and (ii) Flags of 3 different colors to distinguish the Deposition Zones.

Materials required for preparing the blocks and flags are:

- Thermocol sheet for making the blocks and flags.
- Red, Blue, Green and Black color chart paper for covering the blocks.
- Sample chart papers of all these colors are provided in your kit. Teams may need to purchase additional chart paper for preparing the blocks. Variation in the shades of chart paper may cause error in detection of these colors. Hence, we recommend that you take the sample chart paper and try to 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 similar chart paper as in the samples will be used in the Finals of the competition.

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.

- Team prepares 6 blocks of dimension 6cm x 6cm x 6cm. (If the thermocol sheets of required dimensions are not available then the teams may cut or join the available sheets on their own).
- Since in each type of Hazardous Waste, two blocks – 1 of Low CCL and 1 of High CCL will be required, team covers the 6 blocks with colored chart paper in the following manner:
    i. One block with Red color on one face and Black color on all other faces.
    ii. One block with Green color on one face and Black color on all other faces.
    iii. One block with Blue color on one face and Black color on all other faces.
    iv. One block with Red color on all faces.
    v. One block with Green color on all faces.
    vi. One block with Blue color on all faces.
- Low CCL and High CCL Red blocks are shown as an example in Figures 3a and 3b.
- Team has to prepare three Flags of Red, Green and Blue. Dimension of each Flag is 4cm x 8cm x 8cm shown in Figure 3c.

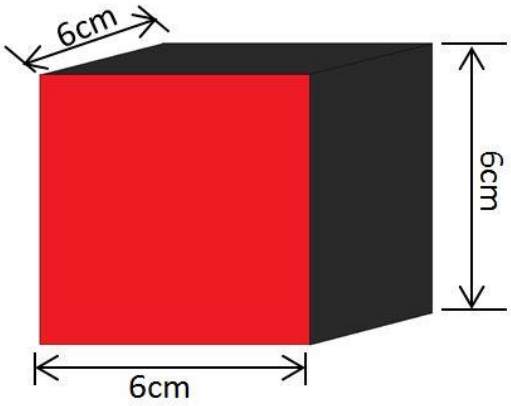


Figure 3a: A Block coloRed Red in single face.

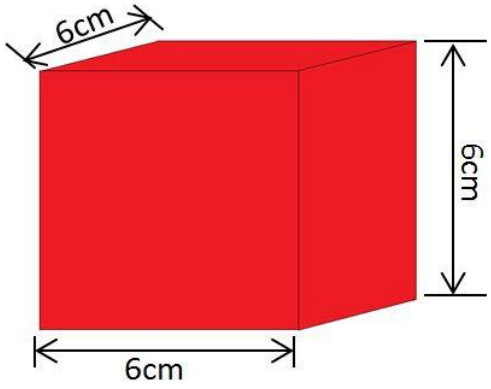


Figure 3b: A Block colored in all the faces.

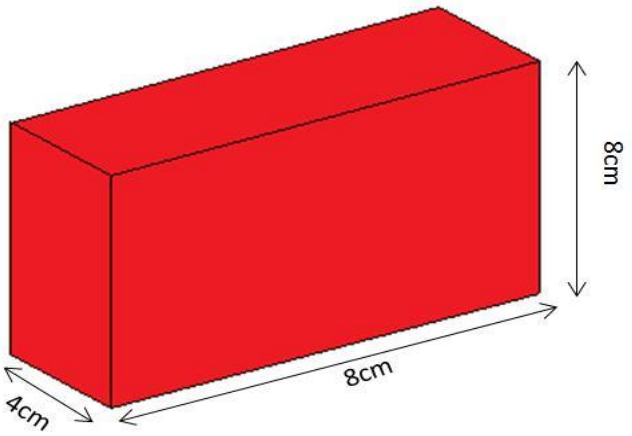


Figure 3c: A Red colored flag

3.3. Construction and Placement of the Bridge

- Materials required for constructing the Bridge is given in Table 1.

Table 1: Material List

Sl. No.	Material	Quantity
1.	T- Joints	2
2.	PVC Pipe	1
3.	Wooden Ply	1
4.	U- clamps	2
5.	Nuts and Bolts	4 each
6.	Araldite – Super Glue	1
7.	Decolam Sheet	1
8.	White cardboard sheet	2
9.	Marker- Black color	1
10.	Thermocol sheet	2 (Big)

- A video tutorial "Constructing of the Bridge" provided as Appendix A in the Resources tab in the Portal explains the process in a step-by-step manner. Please follow instructions and construct the Bridge.

- The Bridge is placed on the arena using the following steps:
    - Align the Bridge along the dotted markings on the flex sheet making sure that the containers are aligned with Weight Deposition Zones DZ1 and DZ2.The images before and after placing the finished Bridge in the flex sheet will look like Figure 4a and Figure 4b respectively
    - Stick the fulcrum strongly in the arena using Double-Side Sticky tape.

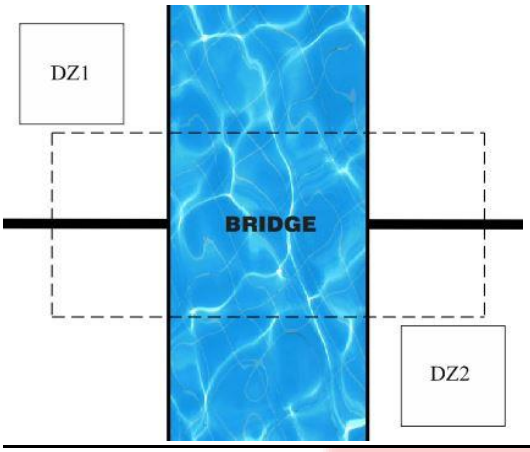


Figure 4a: Markings on the flex sheet

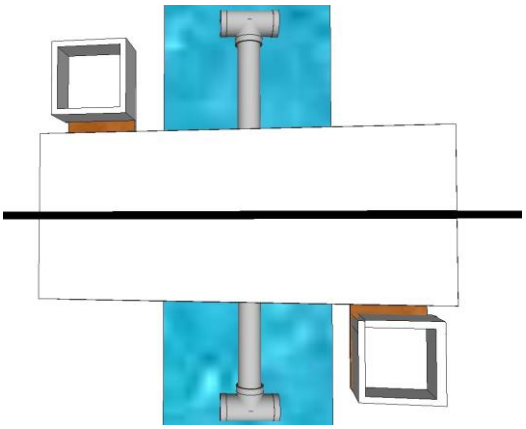


Figure 4b: Aligning of Bridge on the flex sheet

3.4. Operating the Bridge

- Note that the Containers are positioned at the two opposite ends of the plank.
- These two Containers will hold **Weight blocks** (Preparation of Weight Blocks are explained in the Appendix B: "Preparation of Weight Blocks" In the Resources section of the portal.)
- **Initially Weight blocks are placed in CA and IA at different Weight block locations, and denoted as w1, w2, w3, w4 and w5.**
- Weight blocks when added to a Container will tilt the seesaw bridge to the respective side. Note that **Orientation** of the bridge can be either "tilted toward CA" as shown in Figure 5a or "tilted toward IA" as shown in Figure 5b.

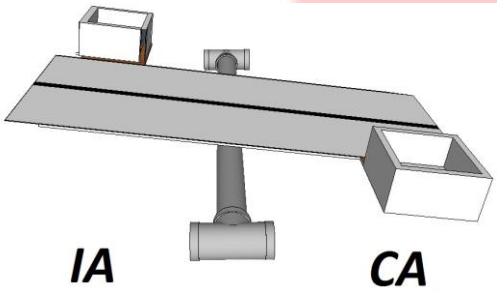


Figure 5a: Bridge tilted towards CA

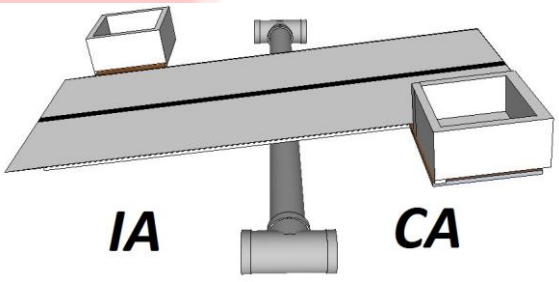


Figure 5b: Bridge tilted towards IA

3.4. Setting up the Arena

The Weights are placed in a stack of two at locations w1, w2, w3, w4 and w5.

The following set-up parameters will be provided just before video submission.

1. Placing the Hazardous Wastes

Placement of the Hazardous Waste 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 Hazardous wastes with the following constraints:

- One Low CCL Block of any color will be at the bottom of the stack. . Orientation of this block is inferred from the image .Two different colored High CCL blocks are stacked on the bottom block. The colors of the three blocks are mutually exclusive. We illustrate these with an example in Figure 7.
- D1, D2, D3 and D4 in Figure 6 represent direction in which Red/ Blue/Green colored face faces in a Low CCL Block.

2. Orientation of the Bridge

The orientation of the bridge will be given as " tilted toward CA" or "titled toward IA".

3. Placing the Flags

The placement of flags will be given as an image. An example of Flag placement in the arena is shown in Figure 8.

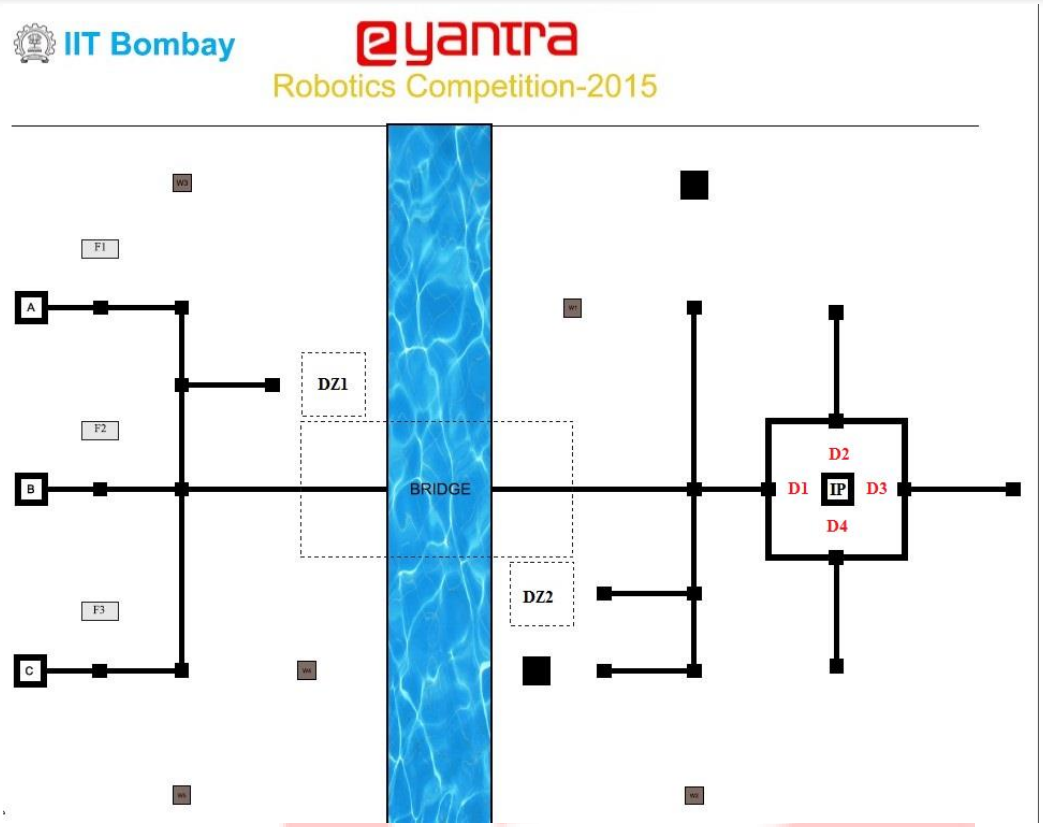


Figure 6: Arena indicating direction for stack position-1.

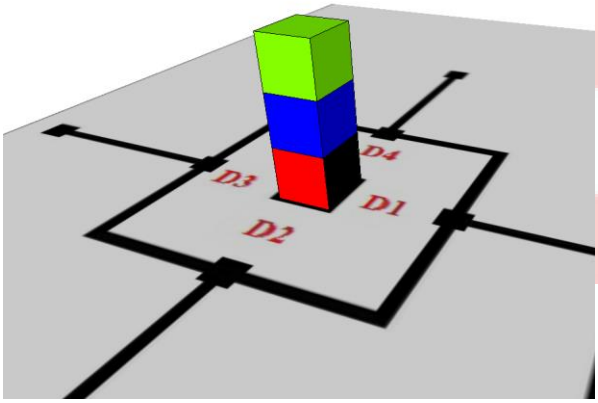


Figure 7: A combination of blocks in stack.

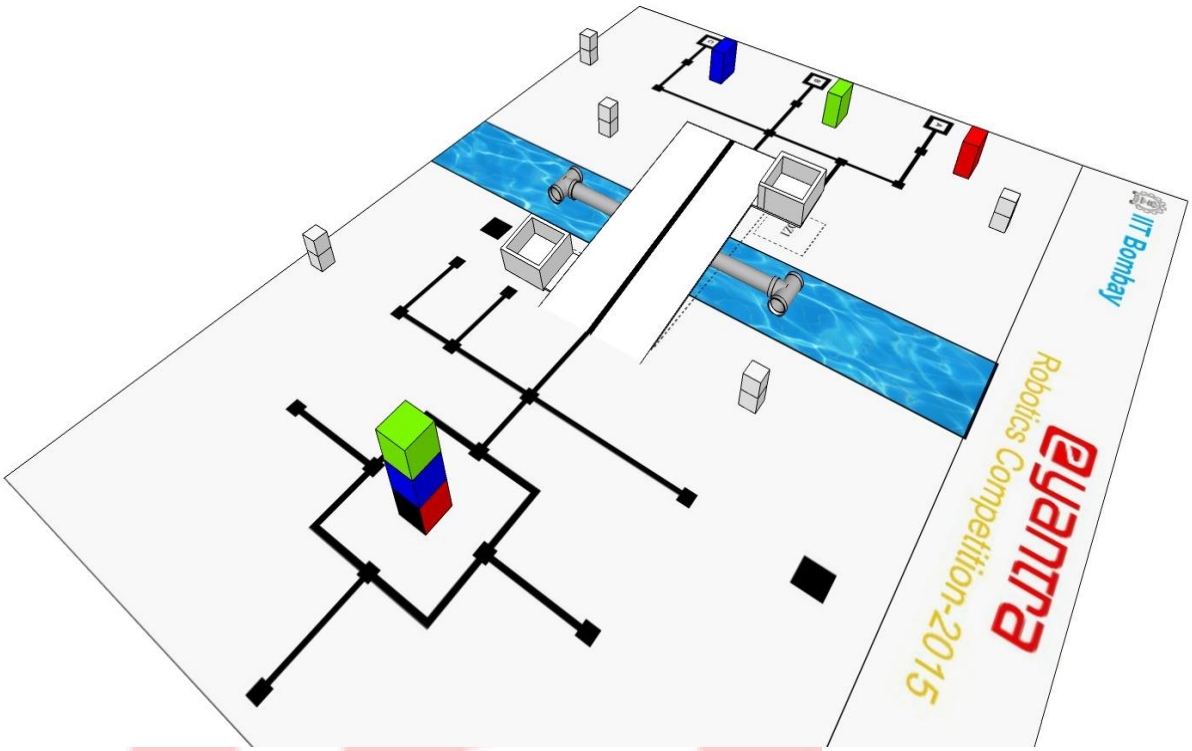


Figure 8: An example of placement of blocks on the arena.

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 10 minutes. 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 must place only Weight blocks at Containers to change the position of bridge.
- The robot has to take reference of the Flags in the Flag locations to determine the designated color of each Deposition zone. Note that the Flags placed at the Flag locations should not be displaced as they are used only to determine the designated color for each Deposition zone.
- The robot may use the Sorting zones for sorting of Hazardous wastes.
- The run ends when all the Hazardous wastes are deposited in respective Deposition Zones.
- The end of run is indicated by the continuous buzzer.

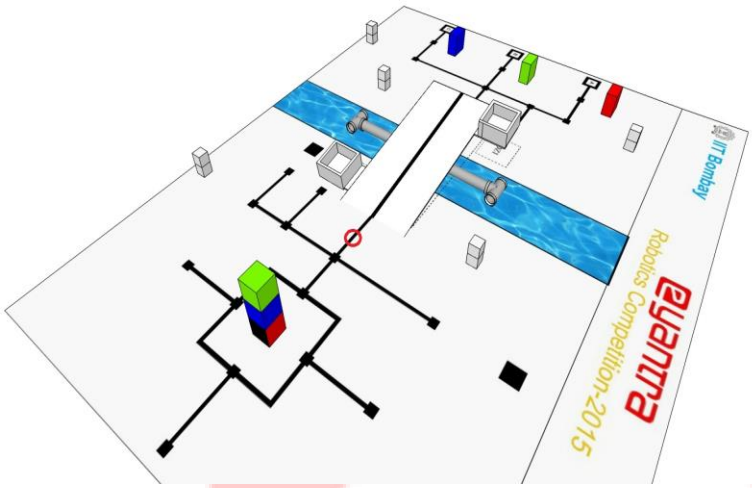
Note:

- Team can pick and sort a Hazardous waste in any order.
- Initially, all Hazardous wastes will be kept at the center of Initial Block Position. Later, when robot places the Hazardous waste in the appropriate Deposition Zone, it can place the Hazardous waste anywhere inside the Deposition Zone. Even if a part of the Hazardous waste is inside the Deposition Zone, it will be considered correct for scoring.
- Teams are not allowed to use any other mechanism except addition of Weight blocks onto the Containers to balance the Bridge.
- Each Deposition Zone will be flagged with only one designated color.
- Each Deposition Zone can only take one Hazardous waste.
- The team has to use same colors as given in the kit.
- The robot must be started with power switch. The starting procedure of the robot should be simple and should not involve giving robot any manual force or impulse in any direction.
- The robot should be kept at the START line with the castor wheel of the robot positioned on the line.
- When the robot malfunctions such as deviating from the Black line, during a run it can be repositioned. In this case the robot will be kept ahead of the **PREVIOUS** node it passed.
- 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.

7. Repositioning of Robot

1. Robot repositioning can be requested under following circumstances:
   - If robot is found to be displacing any block or damaging the arena or the bridge 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. The reposition is allowed in following two cases:
     Case A: When the robot malfunctions such as deviating from the Black line, during a run it can be repositioned. In this case the robot will be kept ahead of the **PREVIOUS** node.
     Case B: When the robot misses the path on the Bridge or when it tries to climb the Bridge and fails, in either of the cases, the robot will be kept ahead from the node **PREVIOUS** to the Bridge. Refer Figure 8.

- For repositioning, the reviewer will drag the robot to the previous node and not pick up the robot.



NOTE: **The red circle in the figure shows the area in which the castor wheel of the robot must be placed during repositioning for Case A while robot travels from CA and IA.**

Figure 8: An Example of Reposition

2. For reposition, the robot should NOT be turned OFF. The reviewer will reposition the robot by merely dragging the robot to the previous node and keep it ahead of the node. 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. 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. Placement of Hazardous Wastes, Flags and Orientation of Bridge will be random .The robot must use only sensors to identify the same.**
- **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.**

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) + (CS x 50) - (ISx50) + (CPx50) - (IPx50) + (BC x 100) - P+B

- **T(Total time):**

  It is the total time in seconds to complete the task.

- **CS (Correct Sorting):**

  It is the number of Hazardous Wastes picked and placed in Deposition Zone or Sorting Zone correctly from IP.

- **IS (Incorrect Sorting):**

  It is the number of colored blocks picked and placed in Deposition Zone or Sorting Zone incorrectly from IP.

- **CP (Correct Placement) :**

  It is the number of blocks correctly placed in the Deposition Zones.

- **IP (Incorrect Placement) :**

  It is the number of blocks that are placed improperly.

- **BC (Bridge Crossing):**

  BC=1, if the robot crosses the bridge every time successfully.

- **P (Penalty) :**

  Penalty where 40(forty) points are deduced for each block or section of bridge that robot dashes against or displaces during the run.

- **B (Bonus) :**

  It is the bonus of 100 points awarded, if the robot completes all the tasks below

- Correct sorting of Hazardous Wastes.
- Correct placement of blocks in the specific Deposition Zones.
- Crosses bridge without penalty.

ALL THE BEST!!!!!!!