LAUNCH A MODULE

1. Introduction

November 5th 2013 marks an important date in the history of space exploration for India. On this date, the Mars Orbiter Mission (MOM) or Mangalyaan was launched into space, which entered the Mars Orbit on 24th September 2014. Launching satellites or rockets into space involves highly complex maneuvers that take multiple stages of preparation and planning. e-Yantra Robotics Competition (eYRC-2016) introduces a theme **Launch a Module** which is geared towards helping students appreciate some of the complexity involved in the space missions. Consider the following scenario: In a galaxy far away a solitary planet with promises of water and atmosphere similar to Earth has been discovered and an unmanned preliminary mission has been planned.

Launching a rocket usually consists of multiple stages where each stage contains its own engine and propellant. Typically, after completing certain functions the first stage of the rocket is discarded and the second stage takes over. In this theme, we are simulating the situation inside the rocket where the second stage is to be launched. The critical functions that need to be completed before launching Stage 2 are represented as a puzzle. Teams receive a camera view of the control room that contains **Objects** that constitute the puzzle and **Obstacles** that need to be avoided. Images received from the camera have to be processed and commands need to be sent to the robot to move it around the control room area. The robot has to solve a puzzle by placing appropriate Objects in designated **Door Area,** in order to open a set of locks that will launch the second stage of the rocket.

The image processing part of this theme consists of challenges such as shape and color detection to distinguish between Objects and Obstacles. The robot has to identify and pick up the Objects placed randomly in the control room area and place them in their correct Door area in order to solve the puzzle.

The challenge is to complete this task in the shortest time possible and solve the puzzle. The robots that perform the task best in accordance with the rules set for this task will be declared the **WINNER**.

2. Theme Description

The arena for the theme is shown in Figure 1. Arena is a simplified abstraction of a floor space inside the control room, consisting of a **Door Area** and a **Working Area**. As shown in Figure 1, arena is divided into 9x6 **Cells**. Centre of each cell is marked by a square. Rows are referenced using English alphabets A through F and Columns are referenced using numerical digits 1 through 9. The area spanning Cells A1-F1 (marked in red in Figure 1) constitutes the **Door Area**. The rest of the area (marked in green in Figure 1) constitutes the **Working Area.**

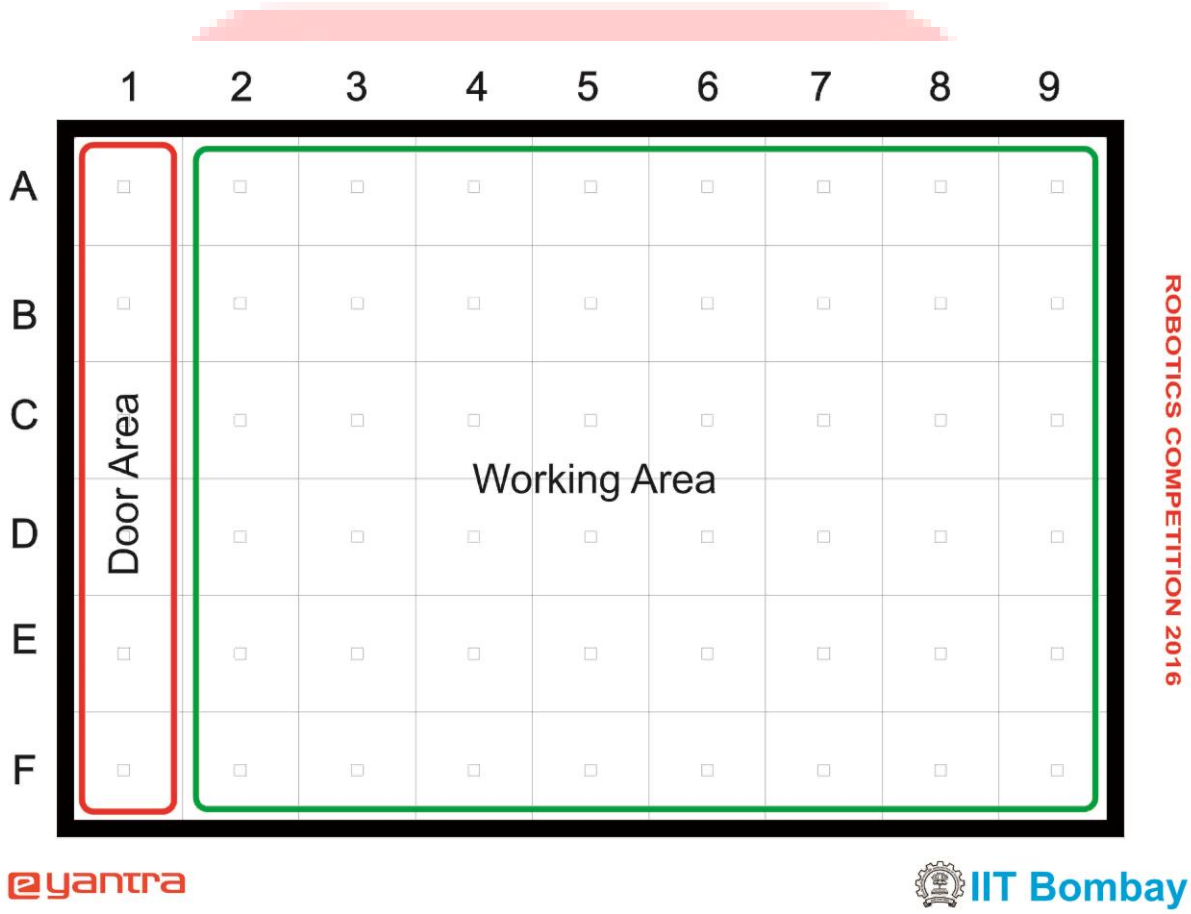

Figure 1: Arena with Areas Marked

Working Area contains:

1. Blocks depicting different **Objects**.
    a. Each **Object** is characterized by three properties, viz. **Colour**, **Shape** and **Size**. There are three possible colours – **Blue (B), Green (G) and Red (R)**. Shapes of object have three variations – **Circle (C), Square (S) and Triangle (T).** Objects can be of two sizes – **Large (L) and Medium (M).** Objects can be of **18 different Types** depending on these properties. Some possible combinations are shown in Table 1.

Object	Properties
1	B,C,L
2	B,C,M
3	B,S,L
4	B,S,M
5	B,T,L
6	B,T,M
7	G,C,L
8	G,C,M
...	..

Table 1: Some Possibilities for Objects

b. **Colour Markers,** having different shapes, sizes and colours can be printed from the ***LM_colour_markers.pdf*** provided in Task-3. Note that while all blocks are of same size, different **Types** of Objects are created by pasting the Colour Markers on the top of blocks. Construction of blocks is explained in Section 3.2.1.

2. Blocks depicting **Obstacles**. These blocks are larger than **Objects** and are in red colour. Construction of **Obstacle** is explained in Section 3.2.2.

In the Door Area, Colour Markers are placed. Instructions for setting up the Door Area are given in Section 3.3.

The objective of the Theme is to:

a) Detect the **Color markers** in the **Door Area.**

b) Find the matching Objects in the **Working Area.**

c) Use the provided robot to pick the matching Object from the Working Area and deposit it in the Door Area, without touching/displacing any Obstacle in the Working Area. This has to be repeated till all the matching Objects are deposited in the appropriate Cells in the Door Area.

The task is to design a robot considering the following:

1. Robot **starts** from the Cell location **C5** in the **Working Area.**
2. An overhead camera, mounted above the center of the arena, captures the entire arena. Instructions for mounting the camera are provided in Section 3.4.
3. The overhead camera is connected to a computer that uses Python and OpenCV to analyze the image obtained by the camera to detect the locations of the Objects, Obstacles and the robot.

4. Based on information obtained from the camera, path is computed and this information is communicated to the robot by using a pair of Zigbee modules, one connected to the robot, and the other connected to the computer.
5. The robot has to deposit **all the Objects correctly** in the **Door Area,** in order to open the locks that launch the second stage of the rocket.

3. Arena

Preparing the arena:

Each team has to prepare the arena. Preparing the arena consists of five major steps:

1) Printing the arena design on flex sheet
2) Object and Obstacle construction
3) Setting up the Door Area
4) Setting up the overhead camera
5) Final Arena Setup

3.1 Printing the arena design on flex sheet:

Flex design is shown in Figure 2. A Portable Document Format (.pdf) file containing the flex design is provided to the teams. Each team prints the flex design according to the direction given in the Readme 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.

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

Dimension of arena is shown in Figure 2.

- Outer dimension of arena is 7 x 5 feet (marked by red border in Figure 2).
- Inner dimension of arena is 6 x 4 feet (marked by blue lines in Figure 2).
- Dimension of each Cell is 8 x 8 inch (marked by green lines in Figure 2).

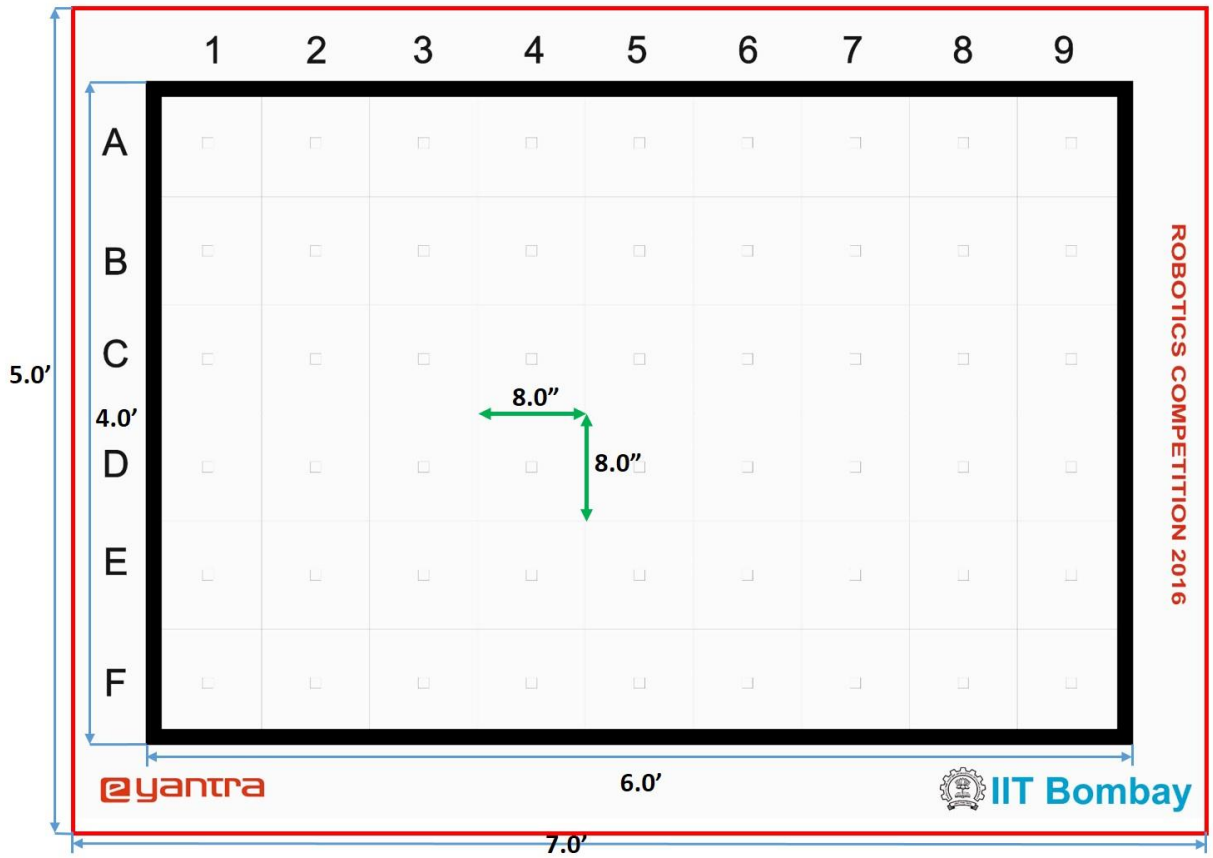

Figure 2: Arena with Dimensions

3.2 Object and Obstacle construction:

Material required for making Objects and Obstacles:

1. Thermocol Sheets
2. Printout of Colour Marker on sticker/A4 paper

3.2.1 Constructing the Objects:

Cut out blocks of 6cm x 6cm x 6cm from a thermocol sheet. Figure 3 shows a block.

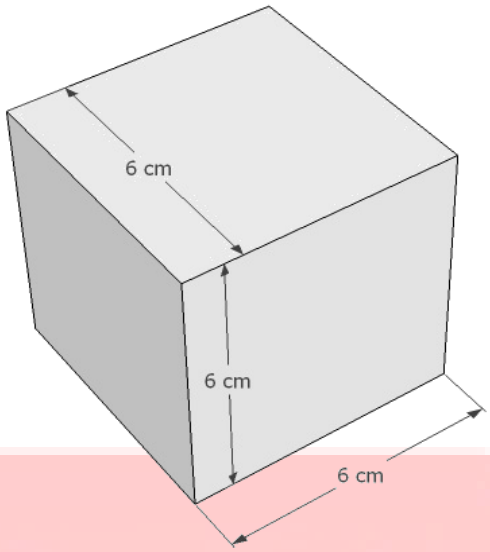

Figure 3: Block for constructing Objects

Team is provided *LM_colour_markers.pdf* which has markers of varying Color, Shape and Size. Team should take a printout of *LM_colour_markers.pdf* either on A4 paper or on sticker paper. Cut each marker and paste it on any one side of the thermocol block. The side with marker pasted on it is referred to as **Top side.** A {Blue, Square, Medium} Object is shown in Figure 4.

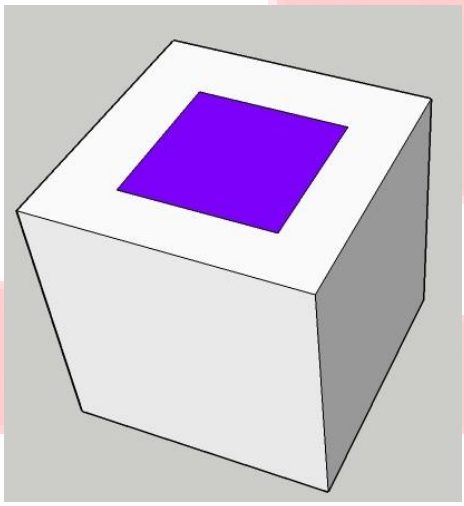

Figure 4: {Blue, Square, Medium} Object

In the Finals of the competition, e-Yantra may choose to place Objects from any of the 18 different Types. A maximum of 2 Objects of a given Type will be placed in the arena. Team can create any number of Objects, for practice.

3.2.2 Constructing the Obstacles:

Obstacles are created by joining 4 thermocol blocks, each of dimensions 6cm x 6cm x 6cm. In order to join the thermocol blocks, teams can use adhesives such as Fevicol. Figure 5 shows an Obstacle.

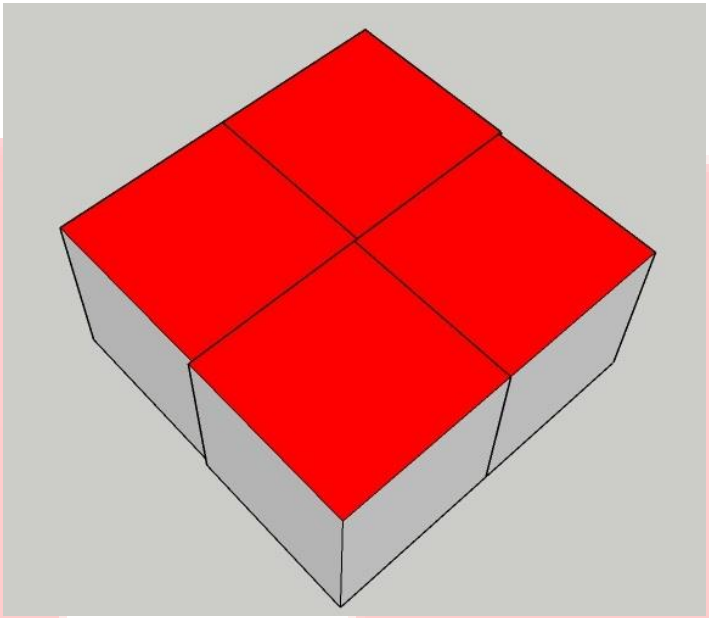

Figure 5: Obstacle

Team is provided *LM_colour_markers.pdf* which has Obstacle marker of **Red color.** Print, **c**ut the marker of **Red** color and paste it on any one side of the Obstacle. The side with marker pasted on it is referred to as **Top side.** Teams may construct a maximum of 5 Obstacles.

In the arena, both Objects and Obstacles are kept with their Top sides facing the ceiling.

3.3 Setting up the Door Area:

Door Area consists of 6 empty cells. Team has to use *LM_colour_markers.pdf* which has markers of varying Color, Shape and Size (as specified in 3.2.1). Team has to cut the Colour Markers and temporarily paste them in the empty cells. Note that different combinations can be used for practice. Figure 6 shows an example configuration used in the Door Area.

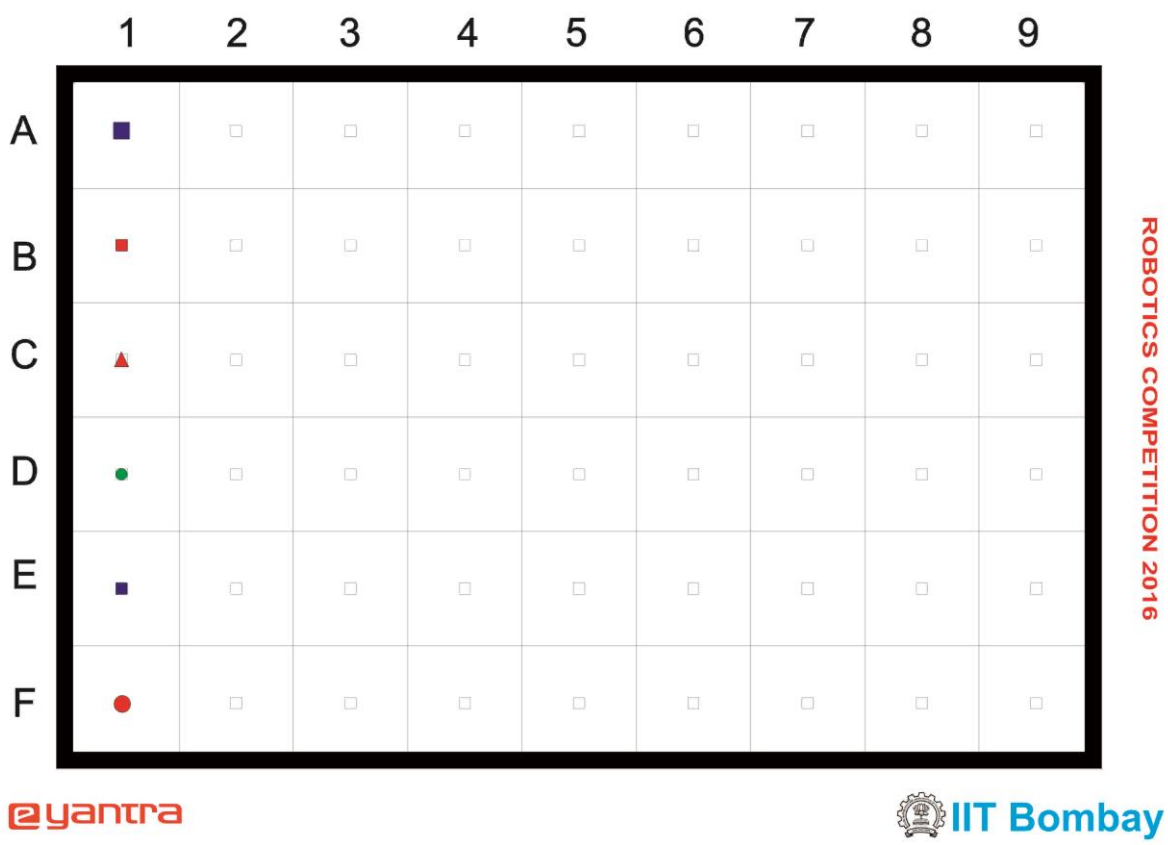

Figure 6: Example Configuration of Door Area

In the Final competition, e-Yantra can choose to place any Colour Markers in the Door Area. In order to practice, teams can temporarily paste the markers using clear tapes/fevistick. This will make swapping markers very easy.

3.4 Setting up overhead camera:

- Team is provided with a USB camera and USB-to-USB extension cable.
- The provided camera must be mounted such that it has a complete top view of the arena. Camera should be mounted above the center of the arena at an approximate height of **7' 7"**.
- Teams are expected to use their creativity to design an arrangement to mount the camera, for example, hang it from a ceiling, construct a frame, etc.
- USB-to-USB extension cable will be useful to connect the USB camera to the PC/Laptop.

Figure 7 shows an example setup for overhead camera.

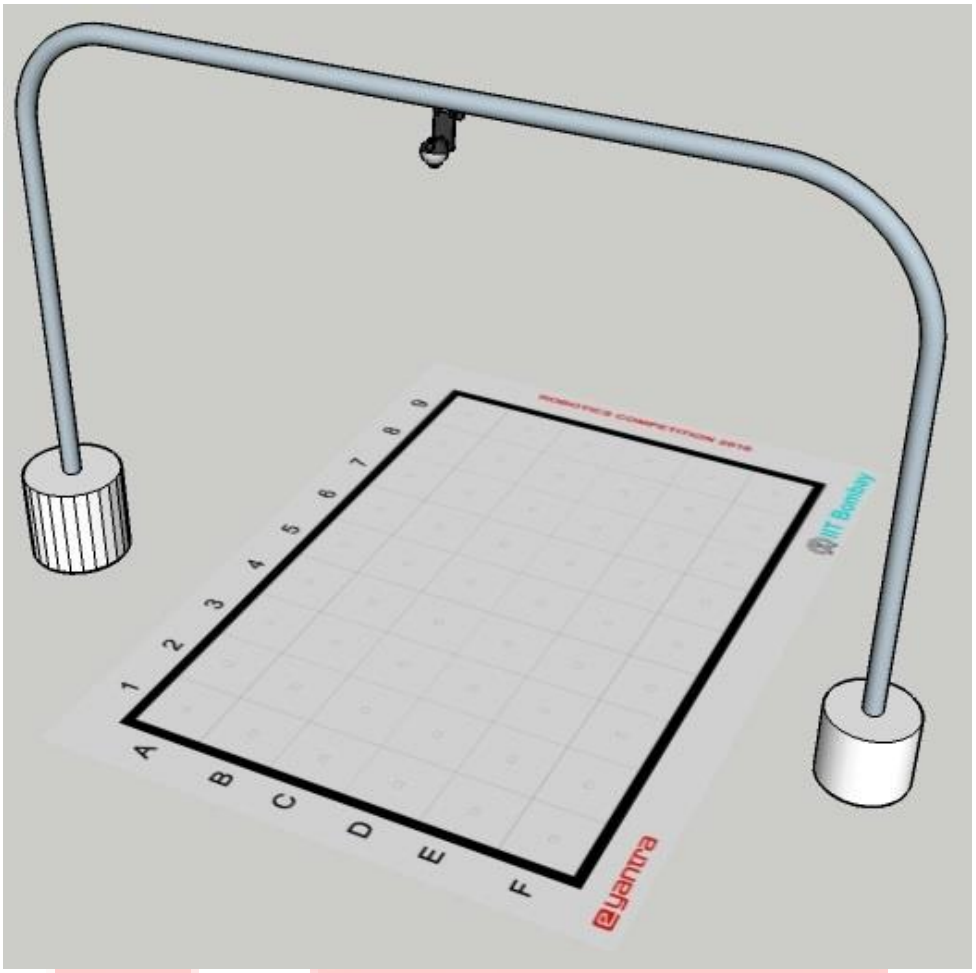

Figure 7: Overhead Camera Setup

3.5 Final Arena Setup

The final arena configuration is subject to the following rules:

1. Placement of Color Markers in Door Area:
    i. There are total 6 Cells in Door Area.
    ii. Cells in Door Area can either be vacant or have color marker.
    iii. There can be a minimum of 2 and maximum of 6 Colour markers that can be present in the Door Area.
    iv. Colour Markers should be placed on the square marked at the centre of an individual Cell in the Door Area.
2. Only one Object or Obstacle can be placed in a Cell.
3. Object or Obstacle should be placed on the square marked at the center of the Cell.

Figure 8 shows an example arena setup.

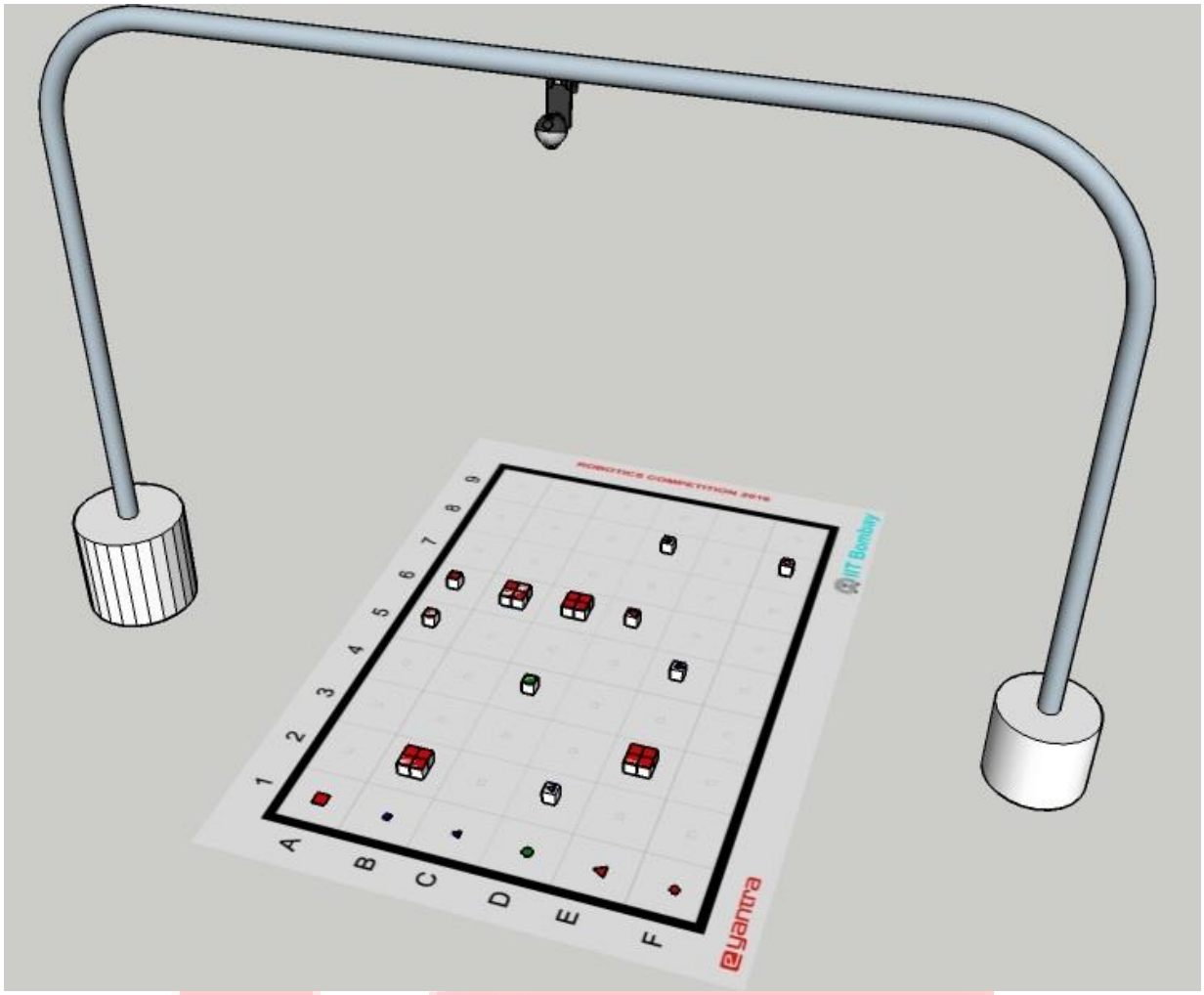

Figure 8: Example Arena Setup

Note: The arena shown in Figure 8 is just for illustration. Placement of Objects, Obstacles and Colour Markers will be random and revealed at the time of the competition.

Please maintain the arena in a 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 e-Yantra.**

4. Hardware Specifications

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, other than those provided in the kit.

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.
- The teams must use a computer capable of running OpenCV and Python.
- Teams are not allowed to use ready-made gripper mechanism for picking/placing objects in the arena.

4.3 Power Supply:

- The robot can be charged through battery or auxiliary power supply. These are shipped 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 the battery powered 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.
- The teams must use OpenCV and Python to write their code.
- Use of any non-open source libraries/external python modules is not allowed and will result in disqualification.
- As per e-Yantra policy, all your code and documents are open-source and maybe published on the e-Yantra website.

6. Theme Rules

1. 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 re-positions** (explained below) will be allowed in each run.
2. The team must use only OpenCV and Python for the task.
3. The team must detect the position and orientation of the robot using the overhead camera.
4. The teams must use the Zigbee modules to communicate between Computer and the robot.
5. At start of a run, robot should be switched ON and placed in the **Cell C5** facing the **Door Area.**
6. The team should start the execution of code when told to do so by the reviewer. This is the **start of a run**. The timer will start at the same time.
7. Once the robot is switched on, human intervention is **NOT allowed**. Any human intervention is considered as re-position.
8. A run ends and the timer is stopped when:
   a) The robot completes the task and sounds a continuous buzzer.
   b) If the maximum time limit for completing the task is reached or
   c) If the team needs re-positioning but has used both re-positioning options of that run.

9. Task will be considered incomplete and time will be considered maximum (600 seconds) if:

    a) The robot deposits **less than two Objects** in the Door Area.
    b) The robot needs re-positioning after using both its re-positions.

10. Buzzer sound of more than **5 seconds** will be considered as continuous buzzer.

11. FINISH line is NOT marked on the arena; the robot stops and sounds a continuous buzzer as an indication to show that it has finished the task.

12. Second run starts once again whilst resetting the score, timer and arena. The score of both runs is recorded and best of two runs is considered the team's score.

13. For second run, teams are not allowed to make any software changes. Hardware changes are allowed.

14. Participants are not allowed to keep anything inside the arena other than the robot and the Blocks.

15. The time measured by the reviewer is final and will be used for scoring the Teams.

16. Time measured by any participant by any other means is not acceptable for scoring.

17. The robot is not allowed to make any marks while traversing the arena. Any robot found damaging the arena will be immediately stopped; re-positioning will be allowed as per the rules. **The final decision is at the discretion of the e-Yantra team.**

18. Object is said to be deposited correctly if:

    a) The Object with a given Colour Marker is deposited in the Door Area Cell having the same Colour Marker.

    b) The deposited Object should be completely inside the Cell. Figure 9 shows some correct and incorrect Object depositions.

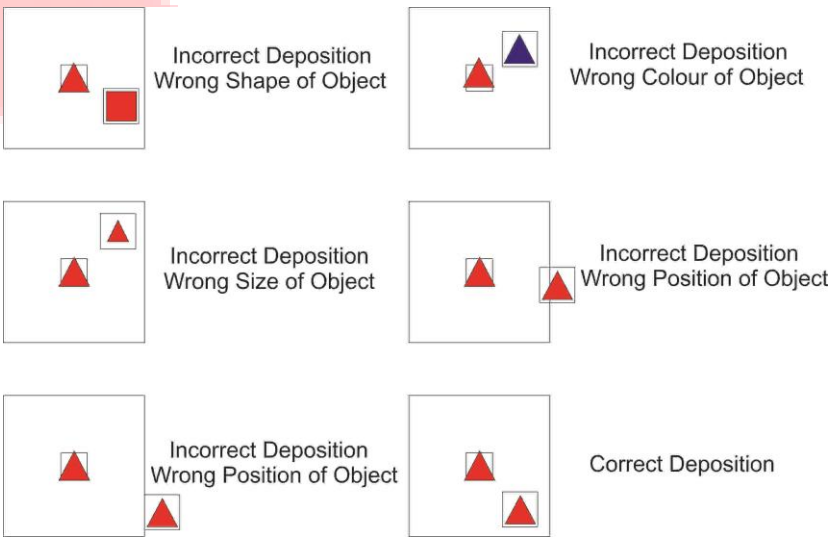

Figure 9: Examples - Correct and Incorrect Depositions

Re-position of Robot:

1. Teams can ask for a re-position if the robot gets stuck in the arena or goes off the arena.
2. Each team is allowed a maximum of **two re-positions in each run**. All re-positions require the approval from e-Yantra; the team stands disqualified if the robot is handled within the arena without approval.
3. During re-position, Robot is placed back in **Cell C5**.
4. If Obstacles/Objects in Working Area are displaced, they are placed back in the original locations. Any Objects already deposited in the Door Area remain untouched.
5. Any arena setup during re-position is done by members of e-Yantra team.
6. For a re-position, a team can choose either to keep the robot powered ON or restart it.
7. During a re-position, the timer keeps running.
8. Team cannot make any changes in robot code during a re-position.
9. Team is allowed to restart the execution of Python program. However team is not allowed to make any changes in the code.

10. Judging and Scoring System

- The competition time for a team starts from the moment the team starts the execution of code. The timer will start at the same time.
- 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 the final score of the team. (Refer to Section 6 - Theme Rules for details).
- The team's total score is calculated by the following formula:

Total Score = (600 - T) + CDT*50 + CD*100 – P*40 + B

Where:

T – Time taken to complete task (in sec)

CDT – Correct Detection and Traversal. If the robot traverses to an Object, picks it up (or attempts to pick it up) then traverses to the corresponding Colour Marker in the Door Area to deposit it.

CD – Correct Deposition. It is incurred when the robot correctly deposits the Object as per rules explained in Section 6.18. Correct depositions will be counted at the end of the run.

P – Penalty is incurred when the robot touches/displaces an Obstacle OR it touches/displaces an Object other than those whose matching Colour Markers are present in the Door Area.

B – Bonus (100 points awarded if the robot displays a perfect run i.e. no penalties, all correct depositions, no re-position of robot)

All the Best !!