VERSION 2

SRI LANKAN ROBOTICS CHALLENGE 2022

UNIVERSITY CATEGORY

TECHNICAL SPECIFICATIONS

SLRC 2022 | EC | ENTC Electronic and Telecommunication Engineering

PARAQUM Platinum Partner | SYNERGEN Technology Labs Gold Partner | AZENDTECH Silver Partner

UNIVERSITY CATEGORY

Robotics has grabbed the critical interest of the local and international community for the past two decades with its innovative concepts. The Electronic club of University of Moratuwa, alongside the Department of Electronic and Telecommunication Engineering, has launched the Sri Lankan Robotics Challenge (SLRC) for nine consecutive times as the longest and pioneering robotics festival in Sri Lanka.

To celebrate its glorious tenth anniversary, the Sri Lankan Robotics Challenge 2022 will bring together robotics enthusiasts from all across the country to one location.

The University Category Competition aims to give robotics enthusiasts from the undergraduate community a platform to learn, engage, and show their passion for robotics. All the winners will be entitled to valuable cash prizes and certificates from the University of Moratuwa.

Your task is to make a robot that can successfully conquer the given challenge.

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"Boring! Boring! Boring! Give me something interesting, Watson."

It has been two weeks since Sherlock had a case, and now, not even a theft alarm. But, unfortunately, the situation at 221B, Baker's Street is worse as Sherlock is bored and shooting at Mrs. Hudson's wall. But, then comes the Napoleon of crime into the scene, Professor James Moriarty. Although he said, "Every fairy tale needs a good old-fashioned villain," this time, Professor Moriarty has come up with a puzzle that can only be solved using a robot.

There is a bomb that will go off on a day next month, which targets the Parliament of England. Sherlock is asked to stop this mass destruction by finding the exact date the bomb will go off. But Sherlock and Watson are both amateurs in robotics.

So, are you ready to help the great consulting detective and his trustworthy partner to save England again?

"All right, John, the game is on. But this time, we have support." They were thrilled. At that very moment, Sherlock and Dr. Watson started solving the puzzle.

"Oh my, Moriarty has become more and more unpredictable," said Dr. Watson while showing a piece of paper to sherlock which says:

"Simulation is for the computer geek, and the physical task is Sherlocked. Succeed the simulation, easier the physical task be."

"Okay, Watson. You are a blogger who is good at computers. Not me. Go, finish the simulation and make my work easy."

"You better build a robot that will work for real, Sherlock," Dr.Watson was mocking Sherlock while moving for the simulation task.....

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CONTENT

1. TASK

1.1. Day 1

Day 1 of the Sri Lankan Robotics challenge consists of 4 main regions.

1. Region A - Towers of Hanoi Arena
2. Region B - Line Maze Following Arena
3. Region C - Cave Arena
4. Region D - Elevated Arena

Proceedings of day 1 start from region A, where the robot needs to solve the Towers of Hanoi problem. Each team can select either one of the following methods to complete region A.

1. By simulating the robot in Webots
2. By physical implementation

Please note that only this task has the luxury of selecting the method of completing by a simulation, and all the remaining tasks should be completed physically.

After completing the Towers of Hanoi problem, then comes region B, where the robot needs to traverse a line maze. The starting position of this task for each team will differ based on the method of completing the region A.

After region B, the robot moves into the region C, where it enters a cave and needs to avoid the obstacles placed inside the cave.

Finally, region D has a ramp leading to the elevated area. Here, the robot should follow some arrows to locate the path to find its way out of the elevated region.

A sample arena that shows the layout of the above four regions can be found in figure 1.1.

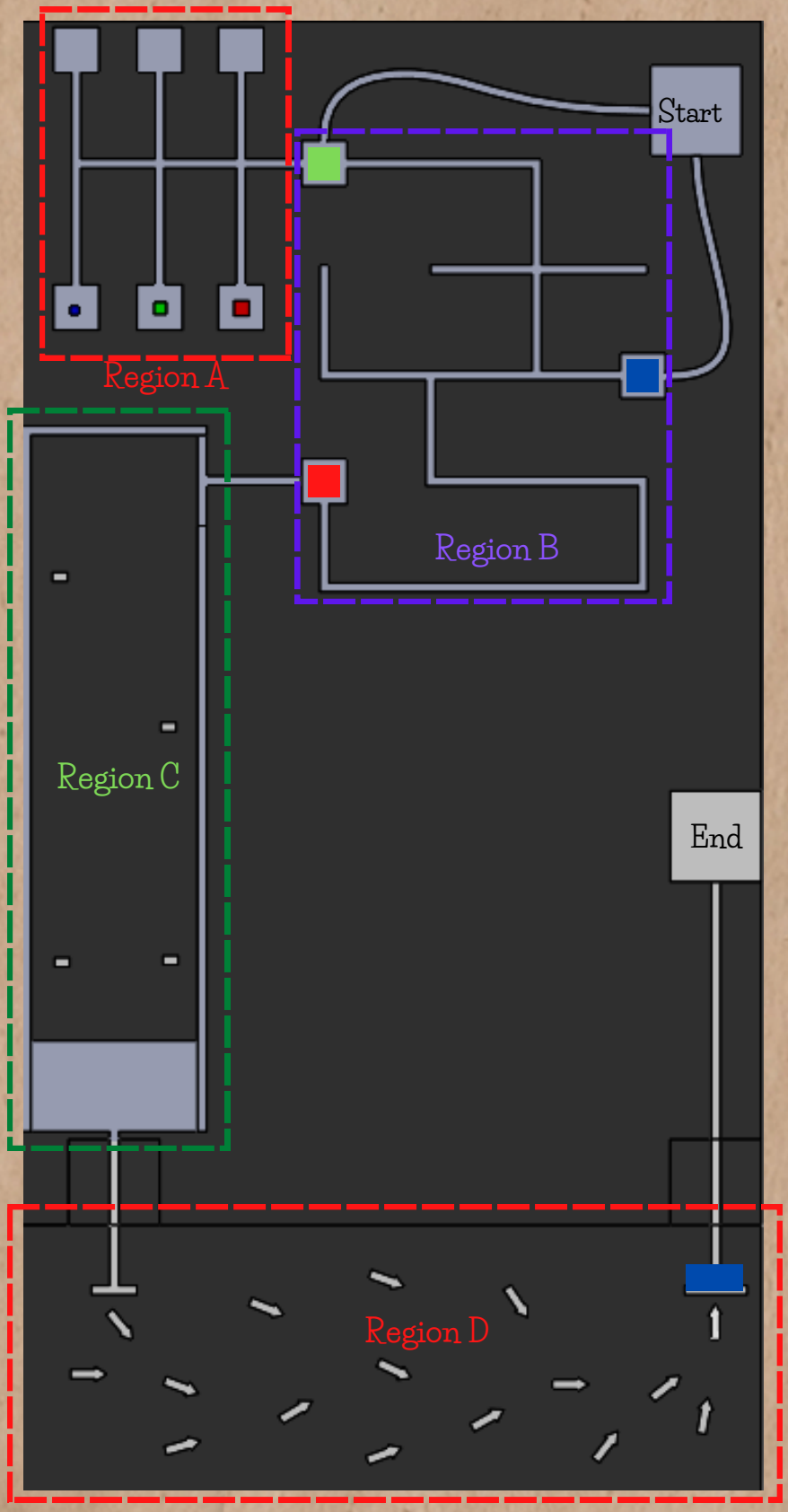


Figure 1.1 - Sample arena

1.1.1 Region A - Towers of Hanoi Arena

As mentioned above, this task can be completed using either one of the below-mentioned methods.

1.1.1.1 By simulating the robot

- The task can be completed by simulating the robot in the Webots Open-Source Simulator (https://cyberbotics.com/).
- We recommend using the newest version of Webots (Webots 2022b or Webots 2023a) to complete the simulation task.
- You can use any programming language (e.g. C++, Python, etc...) compatible with Webots to simulate the task.
- Each team is expected to design a virtual robot within limits specified to complete the simulation task.

This task consists of the following sub-tasks.

- ·Traverse through a maze with walls
  - Your robot should traverse through and solve the maze to collect the required boxes. The path that the robot should move will be straight. However, penalties will be given if your robot collides with the maze's wall.

- ·Detect and collect the boxes
  - While your robot traverses through the maze without colliding, it should pick boxes of different sizes. Your robot can collect the boxes in any order.

- ·Solve the Towers of Hanoi
  - You need to solve the Hanoi Tower of 3 blocks.
  - Patches to place the boxes and construct the Hanoi tower are placed in the middle of the arena.
  - The robot will be placed at the start position in the beginning.
  - The starting square of the arena will be fixed as in the figure 1.2

- At the start of the simulation, the judges will give you two numbers out of 1,2 and 3 to enter as inputs through the terminal. You should write your code to take the two numbers as inputs from the terminal at the start of the simulation, accordingly.

  Details regarding the numbers manually given:
  - First number: This is the patch on which the robot should first make the tower after collecting the boxes (the robot can use all three patches to exchange the boxes while making the first tower)
  - Second number: This is the patch to which the robot should transfer the Hanoi Tower

And, you should consider that the entrance to the middle area is fixed, whereas the other wall locations can be changed in the final task.

Once your robot finishes solving the Towers of Hanoi, it can be navigated to exit the maze and continue to the next stage of the task which should have a physical implementation.

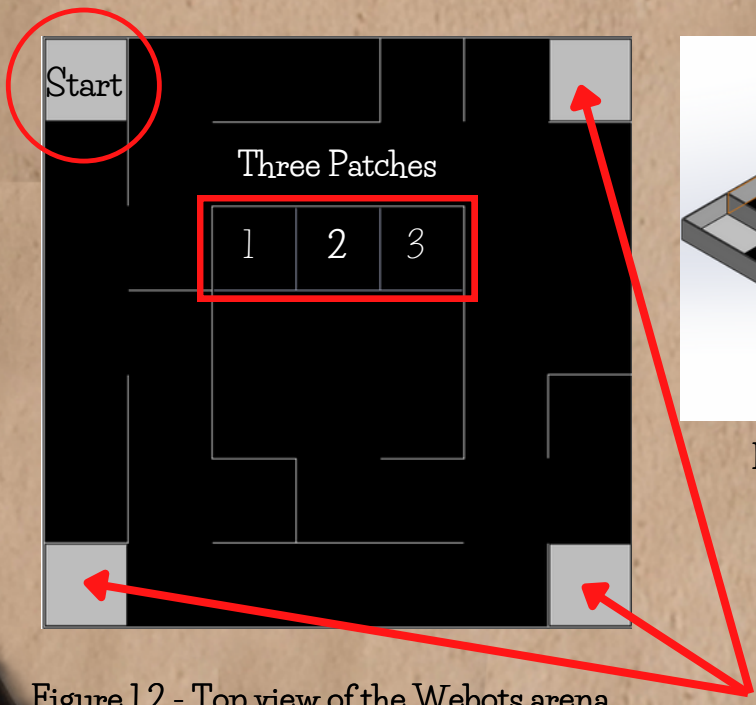


Figure 1.2 - Top view of the Webots arena

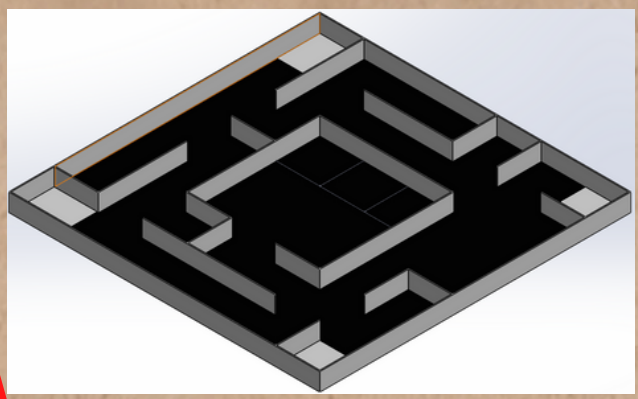


Figure 1.3 - Perspective view of the Webots arena

Specifications of the Webots Arena

The layout of the Webots arena is depicted in figure 1.2 and figure 1.3.
The dimensions and arena specifications are as follows:

- Grid size - 7 x 7
- Grid square size - 36 cm x 36cm
- Wall width - 1 cm
- Wall height - 15 cm
- Box sizes: all are with a height of 3 cm
  - Small (Blue color) - 3 cm x 3 cm
  - Medium (Green color) - 4 cm x 4 cm
  - Large (Red color) - 5 cm x 5 cm

- The width of the white lines that separate the middle squares: 1 cm
- Boxes are placed in the middle of the white patches.

We will release a Webots sample arena file on or before 5th of March with the above specifications. Please note that the arena in the competition day may slightly vary in layout but will obey the above specifications.

1.1.1.2 By physical implementation

- Three boxes of the same height but different base areas are placed on the white squares labeled from A to C as in figure 1.5.

(Please note that those squares will not have a label as A, B, or C on them during the competition. The relative positions of A, B, C squares will be the same.)

- The robot should pick each box and make a tower on the square labeled as number 1 in the descending order of their sizes (the biggest box at the bottom, the second biggest in the middle, and the smallest one at the top).
- Then it should transfer that tower to the square labeled as number 2.
- Only a box smaller than the ones below it can be placed on top of any box.
- If the robot fails to build the Hanoi Tower, it is allowed to continue with a penalty off the marks allocated for the task in region A, but the robot should have at least picked and placed one box.
- Dimensions of different elements of region A, as depicted in figure 1.4, will be as follows:
  - Size of a white square - 15 x 15 cm
  - Width of every white line - 3 cm
  - Maximum weight of a box - 150 g
  - Dimensions of the boxes
    - Height - 3 cm
      - Base
        - Small (Blue color) - 3 cm x 3 cm
        - Medium (Green color) - 4 cm x 4 cm
        - Large (Red color) - 5 cm x 5 cm

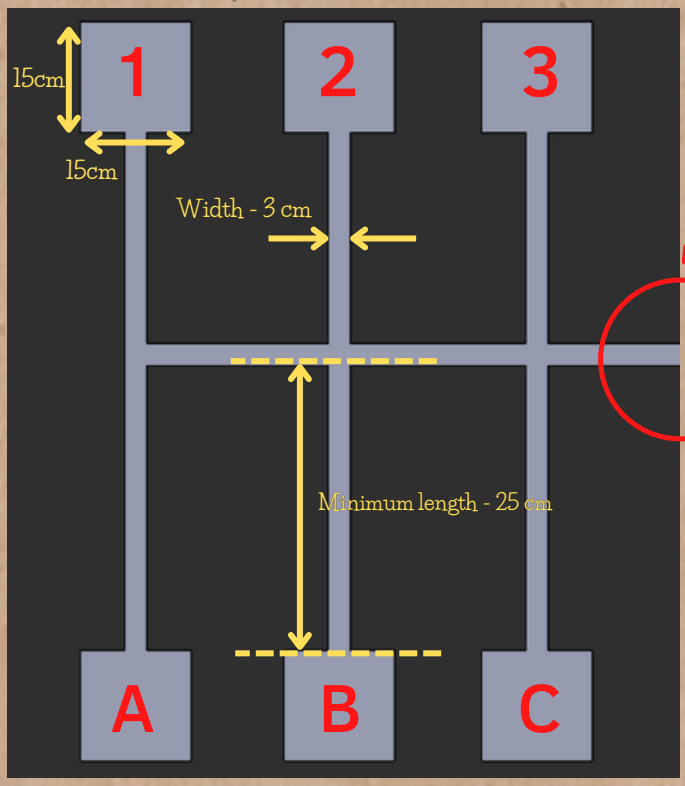


Figure 1.4 - Dimensions of the region A physical task

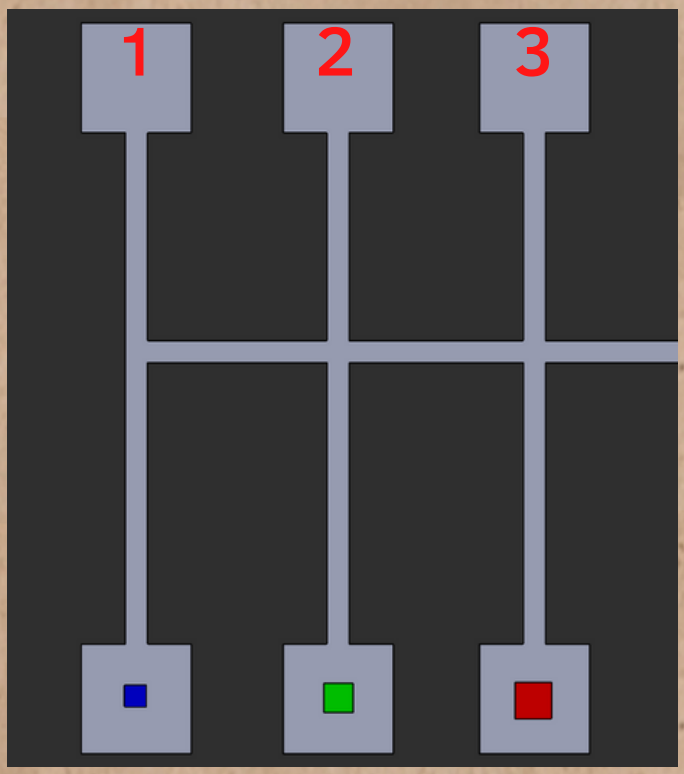


Figure 1.5 - Layout of the region A physical task

Special Note - There can be an error of ±1 cm from the center of the square and the center of a box inside a white square

1.1.2 Region B - Line Maze Arena

- A sample line maze is shown in figure 1.7. The maze during the competition can be different from the sample.
- However, all the entrances and exit color patches will be fixed as in figure 1.7.

1.1.2.1. For the teams who attempted region A task using the simulation

- Starting position is the white patch (labeled as Start),
- The entrance for the line maze will be the blue square.
- The robot should solve the line maze and come to the red square, which is the endpoint of the line maze region.
- Penalty marks will be given if the robot moves beyond the green square but returns back to the line maze. If the robot exits the line maze by moving beyond the green square, that attempt is terminated.

1.1.2.2. For the teams attempted region A task physically

- Starting position is the white patch (labeled as Start in figure 1.7).
- The entrance for the line maze will be the green square.
- The robot should solve the line maze and come to the red square, which is the endpoint of the line maze region.
- Penalty marks will be given if the robot moves beyond the blue square but returns back to the line maze. If the robot exits the line maze by moving beyond the blue square, that attempt is terminated.

Dimensions of the line maze region, as depicted in figure 1.6 and figure 1.7, will be as follows:

Grid - 4 x 3
Size of a square in the grid - 35 cm x 35 cm

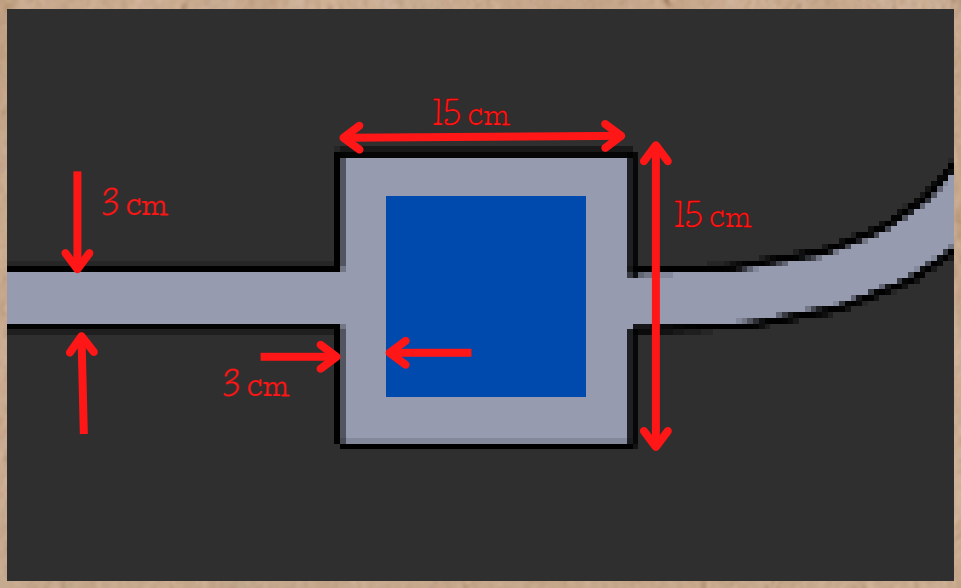


Figure 1.6- Dimensions of squares and line segments

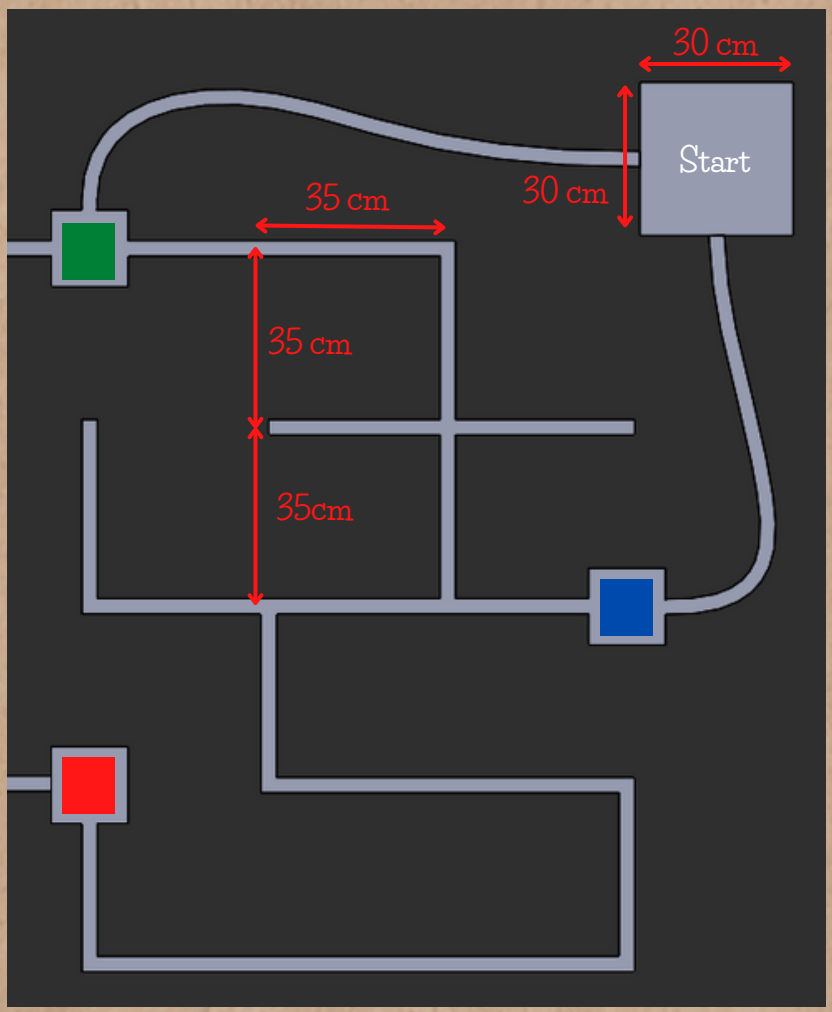


Figure 1.7 - Sample line maze with dimensions

1.1.3 Region C - Cave Arena

- The robot should avoid obstacles and move in the cave.
- Obstacles are randomly placed. The orientation of the objects will be perpendicular to the side walls.
- You can assume that there are gaps between the obstacles, which will allows enough space for the robot to go through.
- At the exit, there is a white patch.
- Penalties will be given each time the robot hits any of the two walls or obstacles.
- Dimensions of different elements of region C, as depicted in figure 1.8 and figure 1.9, will be as follows:
  - Wall height - 15 cm
  - Width of the entry point - 30 cm
  - Distance between inner walls - 55 cm
  - Width of an obstacle - 5 cm
  - Thickness of an obstacle - 3 cm
  - Height of an obstacle - 10 cm
  - Minimum distance between obstacle locations (vertically) - 40 cm
  - Minimum space between obstacles horizontally , - 35 cm
  - Length of last obstacle-free area (white patch) - 30 cm

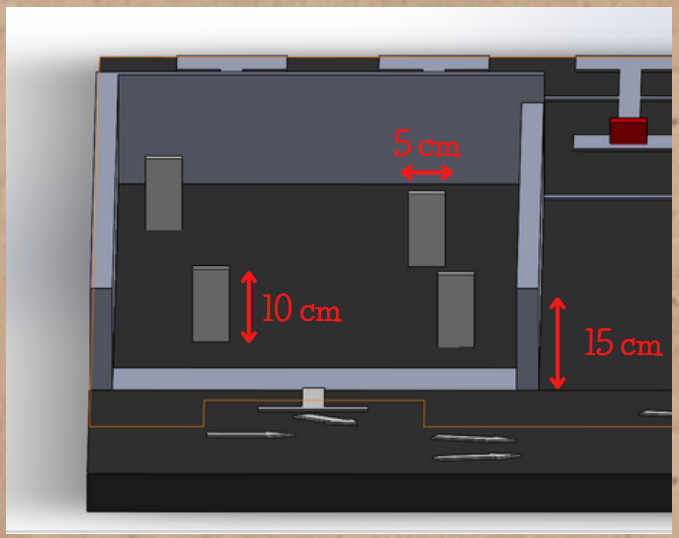


Figure 1.8- Sample placement of obstacles (3D view)

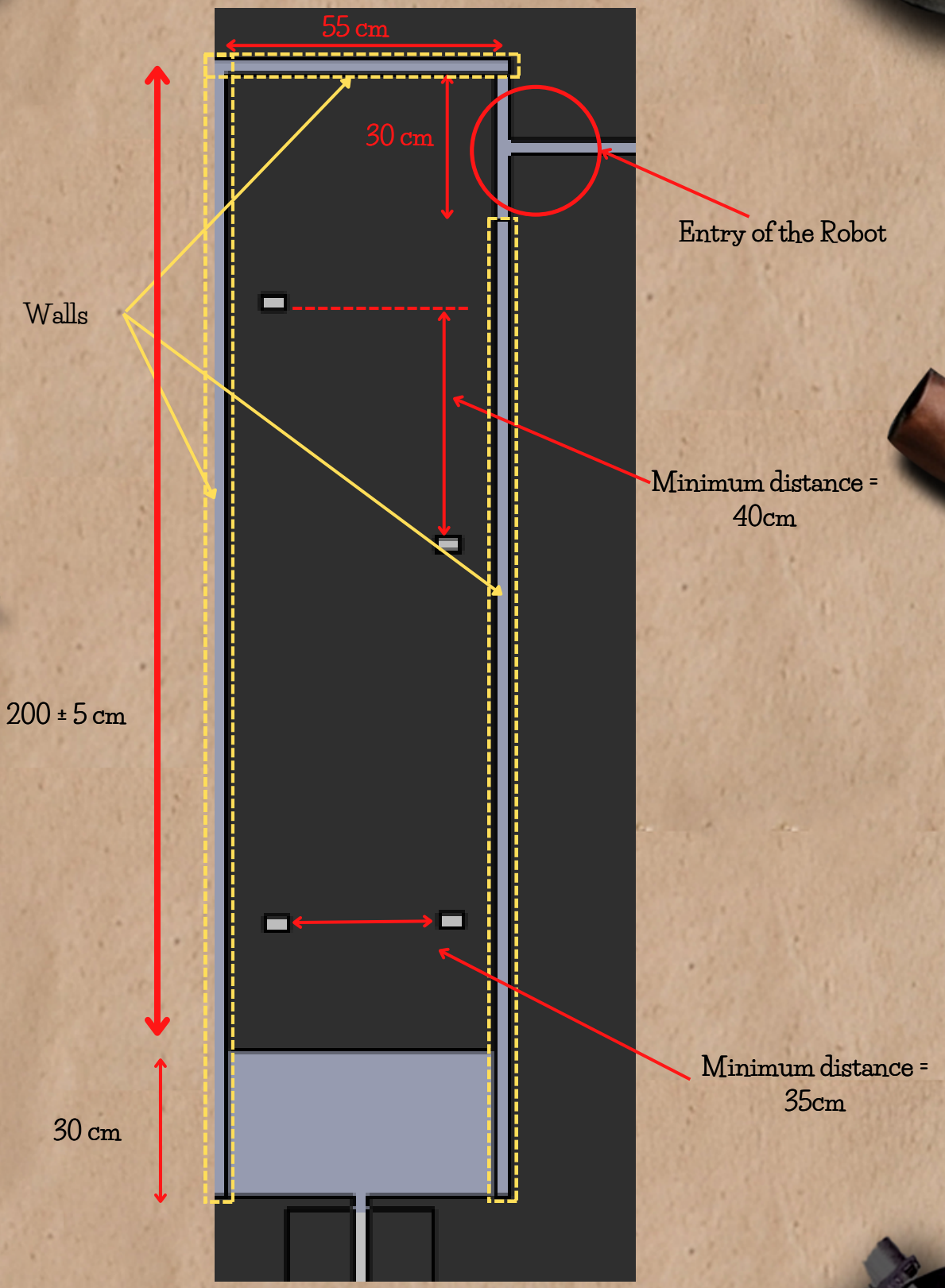


Figure 1.9 - Sample cave area with dimensions

1.1.4 Region D - Elevated Arena

- First, the robot should reach the top of the elevated region without falling.
- The elevated region is positioned 5 cm above the common arena level.
- Dimensions of the ramp, as depicted in figure 1.11, are as follows:
  - Width of the ramp - 30 cm
  - Angle of the ramp - 10 Degrees
  - Height of the ramp - 5 cm
- The robot should follow the arrows displayed in the arena.
- The distance between two arrows is not fixed, but the minimum space between 2 arrows will be 30 cm.
- The robot cannot follow the corners or go along a predefined path.
- If the robot deviates from the arrow path, to help the robot get to the correct path, arrows are present along the edge of the platform.
- One arrow always points toward the next arrow.

To identify the exit, there is a blue color patch of 5 cm in length at the end of the arrow following the region (as shown in figure 1.12).

- Dimensions of the arrows of region D, as depicted in figure 1.10, will be as follows:
  - Length of an arrow - 12 cm
  - Arrowhead - 4 cm
  - Maximum width of an arrowhead - 5 cm
  - Length of the body of an arrow - 8 cm
  - Width of the body of an arrow - 3 cm
  - Minimum distance between two arrows - 30 cm

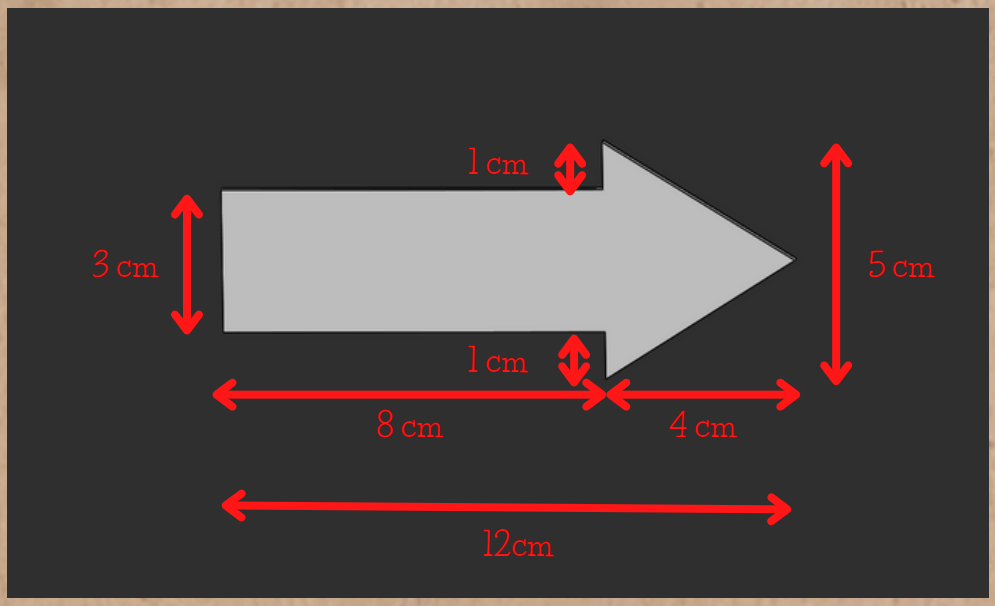


Figure 1.10 - Dimensions of an arrow

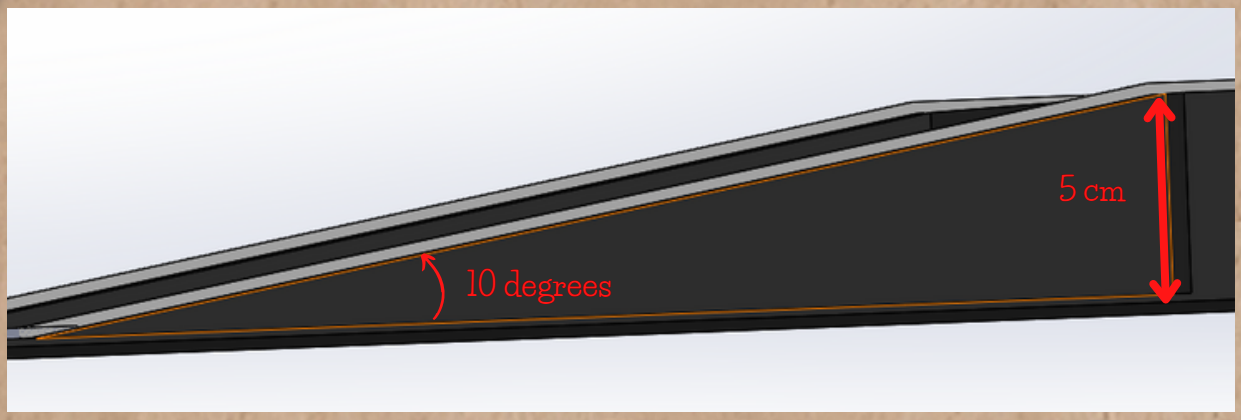


Figure 1.11 - Dimensions of the slope

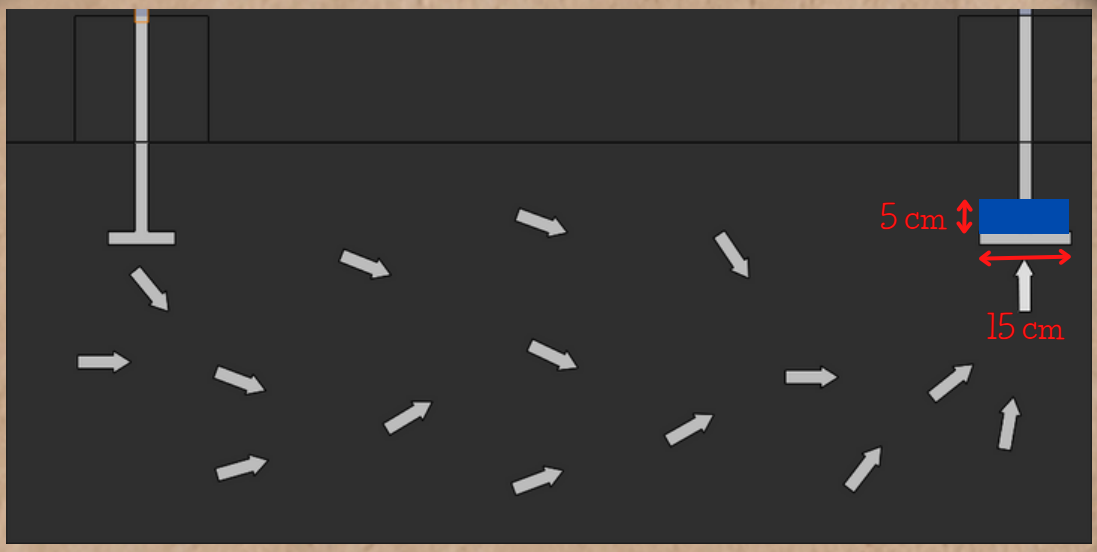


Figure 1.12 - Top view of the sample elevated area

- The robot should stop at the end square, which is labeled as in figure 1.13. It will be the indication which is considered as the completion of day one.

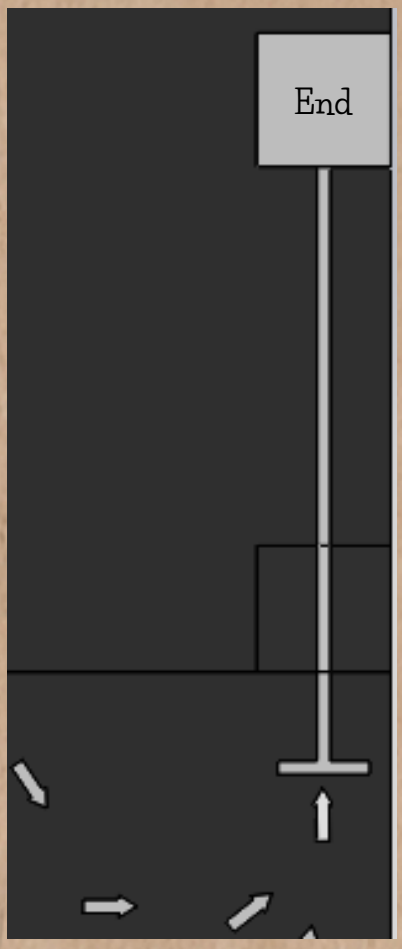


Figure 1.13 - Position of the end square on day 1

1.2. Day 2

The teams who complete stage 1 in day 1 are eligible to compete in the 2nd (final) stage.

The region of play will be almost similar to stage 1, but the Hanoi Tower area is eliminated, and a new region is added to the end of the task, as in figure 1.14.

1. Region A - Line Maze Following Arena
2. Region B - Cave Arena
3. Region C - Elevated Arena
4. Region D - 7 Segment Number Construction Arena

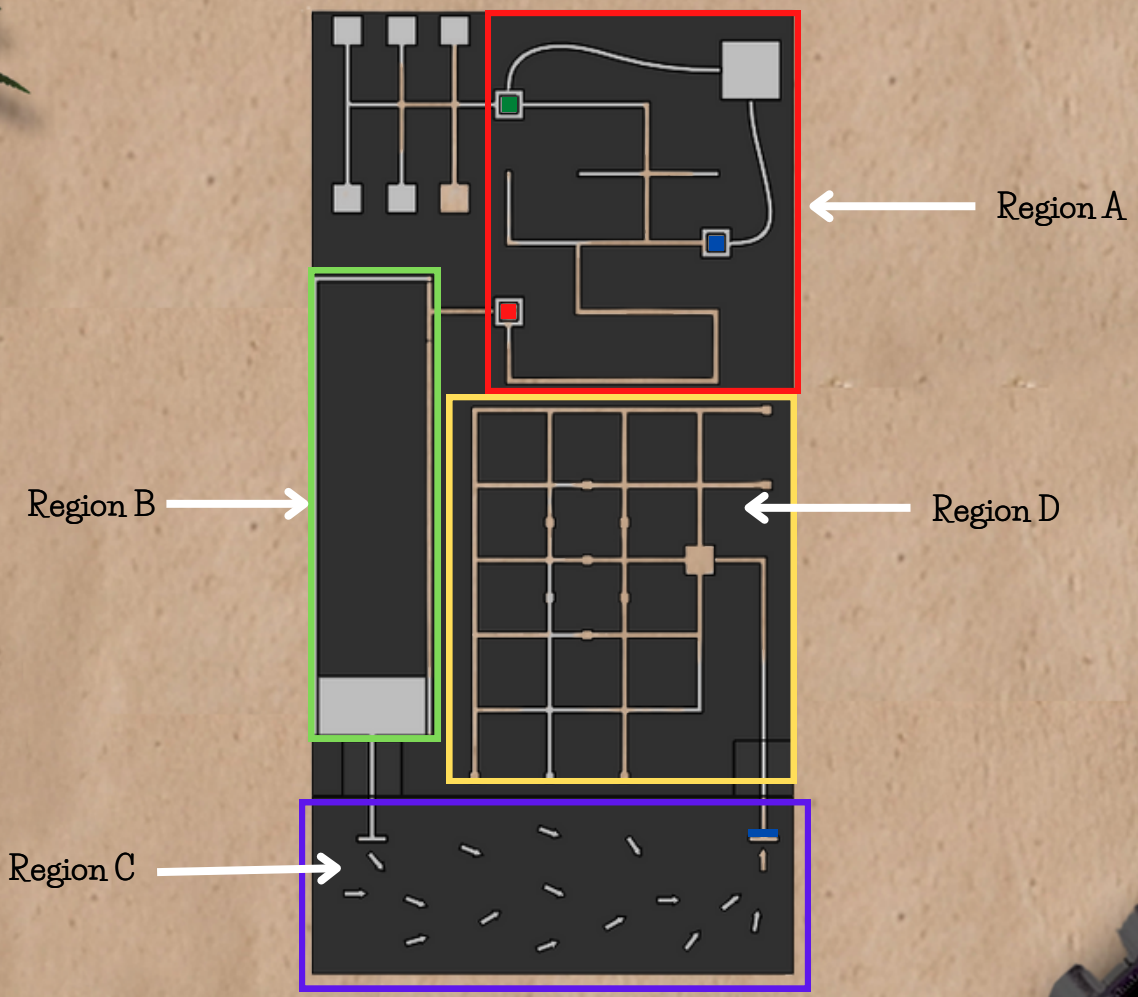


Figure 1.14 - Sample arena of day 2

1.2.1 Region A - Line Maze Following Arena

- The entrance for the line maze will be the blue color square.
- The robot should solve the line maze and arrive at the red color square, which is the endpoint of the line maze region. Note that the line maze in Day 2 may be different from the line maze in Day 1.
- A certain number of boxes will be kept near the robot's traversal path as in figure 1.15.
- The boxes will be 5cm x 5cm x 5cm and white in color.
- The robot must count the number of boxes inside the maze and store it in its memory.
- This count is essential to complete the final stage of the task.
- The layout of a sample line maze is depicted in figure 1.15.

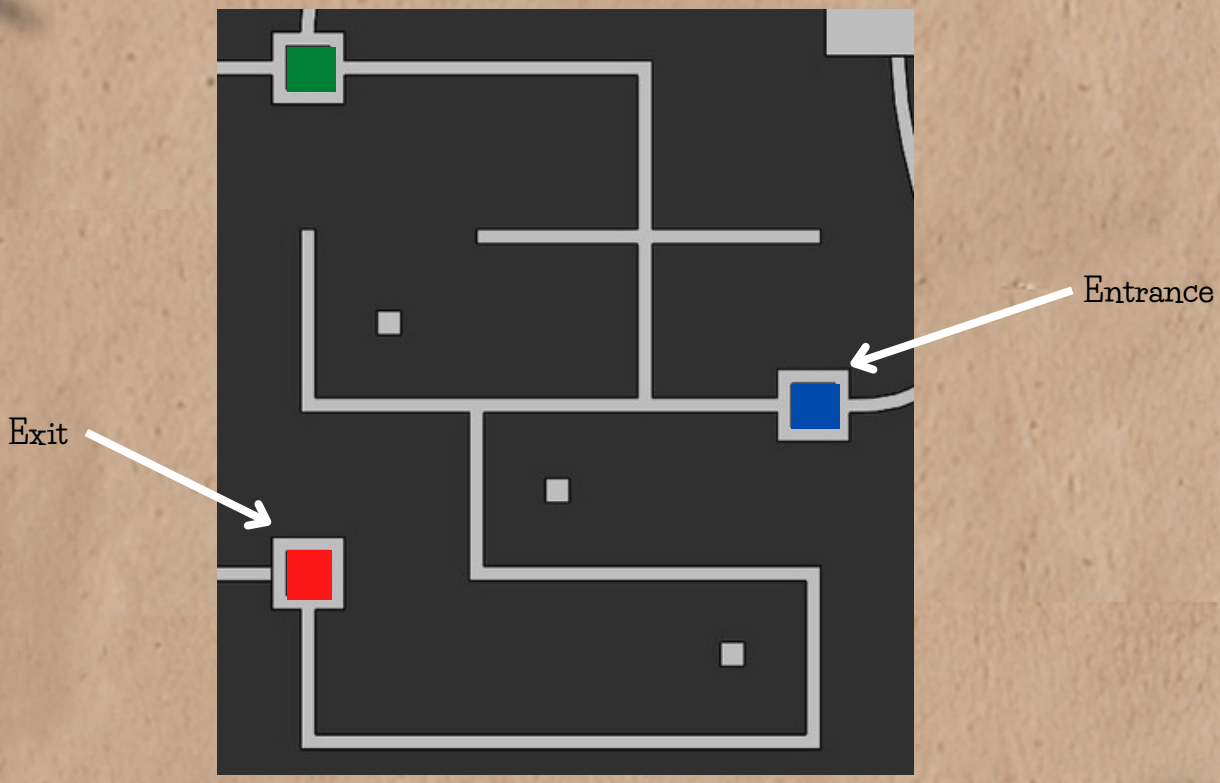


Figure 1.15 - Sample line maze arena

More about the grid and maze

- Note that the base of this maze is a 4x3 grid of squares.
- The yellow-colored dotted lines in the figure 1.16 depict the 4x3 grid. They will not be present in the arena but shown in the figure for visualization purposes only.
- The traversal path is constructed by connecting some selected edges of the squares in the grid.
- The white color lines depict the line maze.
- The size of a unit square in the grid is 35cm x 35cm
- The 5cm x 5cm x 5cm sized white color boxes to be counted will be kept in the middle of such unit squares. Sample positions of boxes is shown in figure 1.16.
- The robot can map the grid along the line maze and count the number of boxes without directly traveling from the blue color square to the red color square.
- The task will terminate when the robot arrives at the red color square.

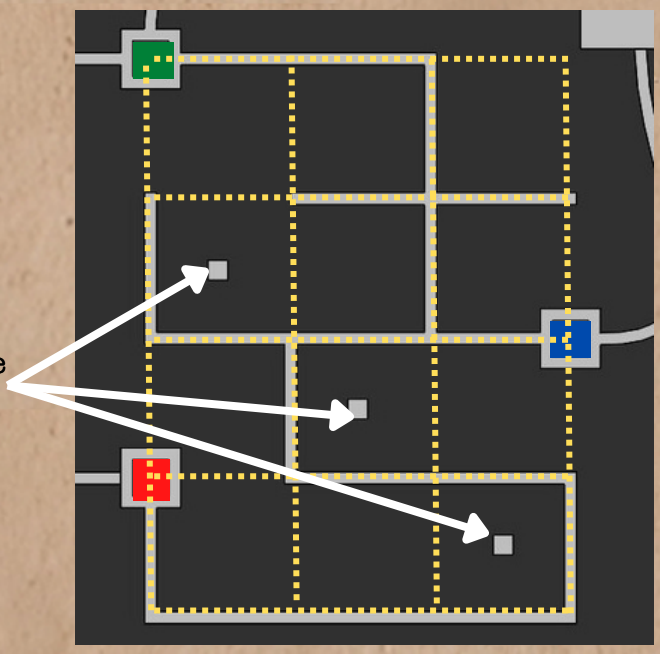


Figure 1.16 - Sample placement of boxes in the sample line maze

The tasks to be completed in region B and region C on Day 2 are similar to those in region C and region D respectively on Day 1. But, the placement of obstacles in region C and the layout of arrows in region D in day 1 may be different in the regions C and D respectively in Day 2.

1.2.2 Region B - Cave Arena

- This task is the same as the region C in day 1. Refer to section 1.1.3 for more details.

1.2.3 Region C - Elevated Arena

- This task is the same as the region D in day 1. Refer to section 1.1.4 for more details.

1.2.4 Region D - 7 Segment Number Construction Arena

- The robot must leave the elevated region and enter the region of number construction through the 'Entrance' shown in figure 1.2.4.1.
- The task is to form a number using a seven-segment integer representation.
- First, the robot must traverse through the grid and identify the number already present in the arena without touching the boxes used to form the number.
- In the instance of a collision, the robot will be allowed to continue at the expense of a penalty.
- The robot must stay in the grid, and leaving the grid will be considered an elimination.
- Once the robot reads the number in the arena, it must reform a new number in the grid with the help of a small calculation, as explained below.

Suppose the number identified in Region A is "a" and that identified in Region D is "b", and the number to be constructed is "x".

$$x = (a^2+b^2) \bmod 10$$

In other words, "x" is the remainder when the summation of squares of "a" and "b" is divided by 10.

Ex :- Suppose a = 3 and b = 7 (according to figures 1.16 and 1.17)

$x = (3^2+7^2) \bmod 10$

$= (9 + 49) \bmod 10$

$= 58 \bmod 10$

$= 8$

- There are seven boxes of size 5cm x 5cm x 5cm inside the grid.
- The sides of those cubes will be white, whereas the upper and lower sides will be red.
- A certain number will be present in the arena when the robot enters this region. (denoted as "b" in the above expression)

- The boxes not used to form that number (additional boxes) will be kept in the area denoted in the figure 1.2.4.1. The total number of boxes in the arena is 7. The additional boxes will be placed randomly in the 5 sqaures in blue in figure 1.17.
- The new number must be reformed by either removing or reordering the existing boxes or using additional boxes kept in the corner of the grid.
- For example, when the number 3 is constructed, five boxes should be placed within the grid in the correct positions, and the remaining two boxes should be removed.
- Moving the additional boxes to the region allocated to keep the other boxes is not mandatory when removing them.
- They can also be kept somewhere inside the grid, where it will not affect the number formation. (The final number should be visible on the arena)
- The task is terminated once the number formation is correctly done.
- Dimensions of the grid will be as follows.
  - Grid - 4 x 3
  - Size of a square - 35 cm x 35 cm

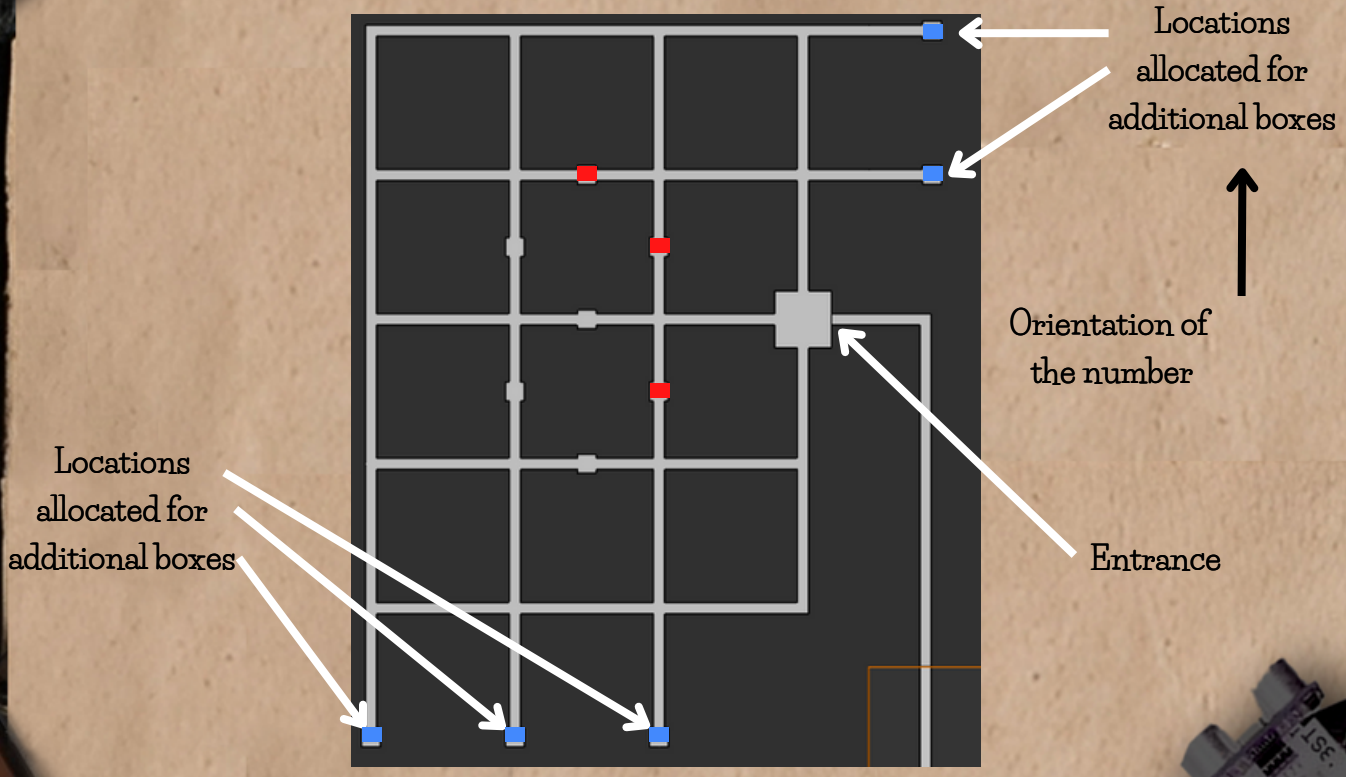
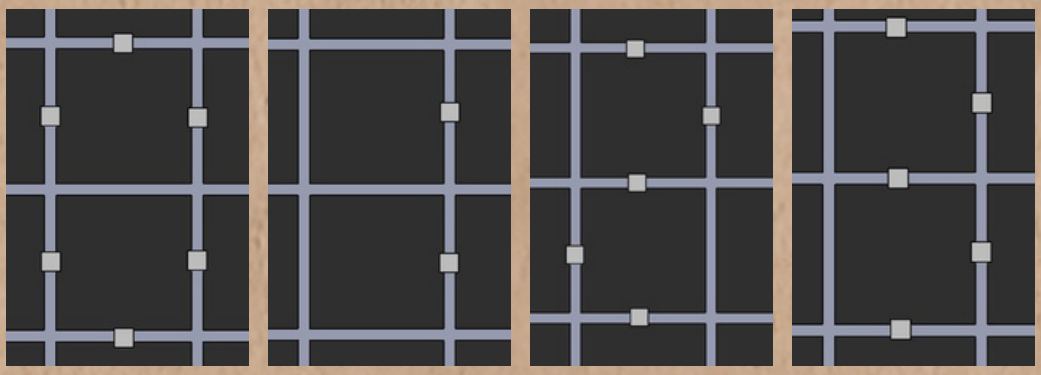
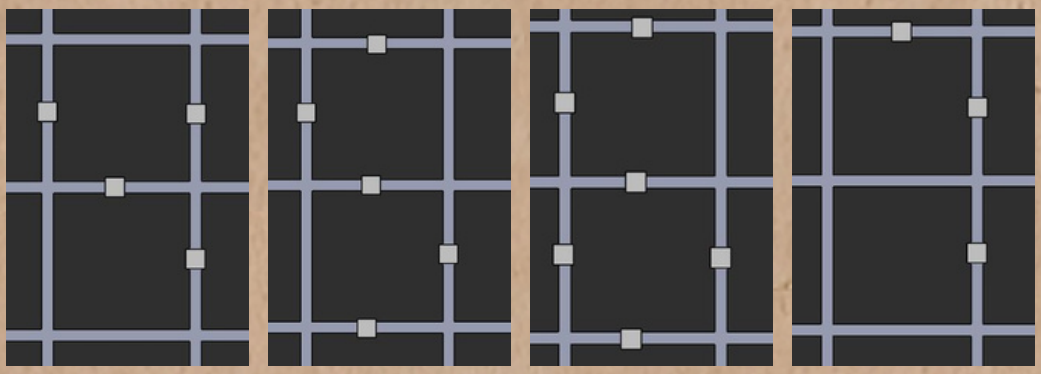


Figure 1.17 - Region of number construction

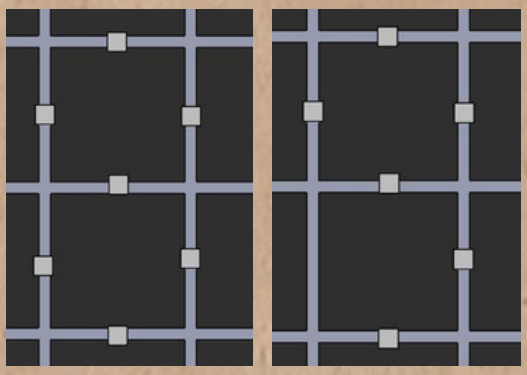
For your convenience, a guide for the number construction in this region is given in figure 1.2.4.2.



Number 0 Number 1 Number 2 Number 3



Number 4 Number 5 Number 6 Number 7



Number 8 Number 9

Figure 1.18 -Number formation using 7-segment

2. Arena Specifications

- The arena consists of four 8 ft x 4 ft (240 cm x 120 cm) boards such that the final arena size is 16 ft x 8 ft (480 cm x 240 cm).
- The surface can be slightly uneven at the places where two boards are connected
- The arena will be black, and the lines will be white.
- The width of all the line following lines will be 3 cm.
- The minimum length of any straight-line segment will be 25 cm.
- The surfaces of the lines and the walls will be matte-finished. The type of sticker used will be "buffel" stickers.

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3. Robot Specifications

1. Dimensions of the robot should not exceed 25 cm x 25 cm (width x length). It will be tested before the start of the first round by placing the robot inside a 25 cm x 25 cm box.
2. The robot should be completely autonomous. Any remote control would lead to disqualification of the robot.
3. The robot should be powered with an internal power supply with a supply voltage not exceeding 24V. The final unit, including the power source, should be within the dimensions specified above.
4. The robot must be built entirely by the team members. Therefore, no off-the-shelf Lego kits or assemblies are allowed except for the ready-made processing boards, sensor modules, drive gears, and other electronic modules.
5. The robot should not cause any damage to the platform (arena). Any damage to the arena leads to disqualification. If the judges feel that a robot has a high risk of damaging the arena, they can deny the attempt.
6. A team can use any preferred method for wall sensing; however, the robot must not exert a force on a wall, likely to cause damage. For example, the robot must not jump over, climb, scratch, damage or destroy the walls in the arena.
7. The robot should be activated using a single start switch placed on the robot itself. Therefore, the robot should have a simple starting procedure.
8. The starting procedure of the robot should not involve giving the robot any manual force or impulse in any direction.
9. The robot should be able to operate under provided lighting conditions.
10. The robot cannot transform into two robots during gameplay.
11. There should be a way to indicate that the robot has completed its task. This will be considered to measure the time.
12. The minimum distance between the middle of the lines and the edges of the arena will be 15 cm. The robot should be designed such that it won't fall out of the arena.
13. The robot should not leave any components behind in the rest of the arena.

4. Team Composition & Eligibility

1. A team can have a maximum of 5 members and a minimum of 1 member.
2. Undergraduates from different state or private universities can form a team, but the team should register under one university name.
3. Each team member should be under 28 years of age at the time of their participation to be eligible to compete, and one undergraduate can only represent one team.
4. All team members should be registered or selected to register as undergraduates of any state or private university in Sri Lanka at the time of their participation in the competition.
5. All the team members should have a valid document to prove their eligibility to participate in the competition.
6. Multiple teams could compete, representing the same university, but one team can only submit one robot.
7. Violation of the above conditions would lead to disqualification.

5. Rules and Regulations

5.1 General

1. There won't be any arena changes once the round has started. All teams will have the same arena.
2. All the teams must submit their robots to the organizers 15 minutes before the start of the first round. After that, the robot will be given to the relevant team only for its attempts at the round.
3. The contestants must be prepared to start within 5 minutes after the call; if not, the attempt is lost.
4. A team should place the robot entirely inside the starting square at the start of their run. When the judges give the signal, the robot can be switched on. From then on, the robot should navigate autonomously. The contestants should not manually alter the orientation of the robot during the gameplay. In addition, the contestants should not communicate with or control the robot during an attempt.
5. A maximum of 3 attempts are given in a single round, and the overall time (the total time of all attempts taken) will be counted.
6. A maximum time of 15 minutes (period of gameplay) is allocated per team. Therefore, all the attempts are reserved for this period only. If the robot exceeds the time limit of 15 minutes, your robot will be removed from the arena.
7. Program or hardware modifications of the robot are not allowed within this 15 minutes.
8. The time taken to travel from the start square to the end square is called the total run time. The clock will start when the judges give the signal to start. Then, the clock will stop when the robot reaches the end square on day 1, and the robot should give a proper indication that it has completed the task on day 2.
9. The clock will not be paused during attempts.

10. If the robot drifts out of the line to the extent that no part is on top of the line in line following segments, the judges will consider it as jumping out of line. However, if the robot finds its way back to the line on itself, it can continue, provided that the distance skipped by the robot along the line is less than 30 cm. The judges may deduct points in this case. If the robot does not find its way back to the line within a skipped distance of 30 cm, that would be considered the end of that attempt, and you will be allowed to remove the robot from the arena.

5.2 Calibration

1. Two additional minutes before the gameplay period of 15 minutes is given for the calibration of the robot.
2. The robot can only use the arena from the starting square until the end of line segment 1 for calibration.
3. Calibrations can only be done through external adjustments of the robot. Therefore, program changes nor hardware part replacements are not allowed.
4. The team can request the start of their first attempt before the calibration period ends. The gameplay period of 15 minutes will start at that moment. (The remaining calibration time will not be added to the 15 minutes given for three attempts)
5. If a team fails to finish calibrating within these 2 minutes, the extra time taken will be deducted from the period of gameplay of 15 minutes.

6. Judging

1. Each team member may be questioned about their robot; every member should clearly understand and be able to explain the robot's working principles and mechanisms. There would be an immediate disqualification of defaulters of any kind.
2. The robot's code will be checked for hard coding upon judges' request.
3. No timing bonus will be given unless the robot completes the task.
4. Penalties will be mainly given to but not limited to;
    - Touching the walls of the arena
    - Deviation of less than 30 cm in length without covering any part of the line in line following segments
5. The final judging criteria will be given in a later version of this task document, which we will release before the competition.
6. If the robot is not performing well, the judges may ask to stop the current attempt. However, the team will still be given all three attempts. If this happens in all three attempts, the total run time of 15 minutes may not be allowed.
7. The decision of the panel of judges will be the final decision.

7. Contact Information

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Special Note

Please don't assume anything about the task or the arena if it is not specified in this document. Contact us if you need any clarification.

This is version 2 of the task document. Please be updated on the WhatsApp group and the SLRC website for further updates.

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