EN 2532

ROBOT DESIGN AND COMPETITION

2021

Department of Electronic and Telecommunication Engineering

University of Moratuwa

Everyone knows that **Leonardo da Vinci** was an extraordinary artist, sculptor and inventor, swordsman, and intrepid adventurer. Leonardo managed to get the attention of Lorenzo Medici, an Italian statesman, the ruler of the Florentine Republic, and started to improve war machines like airplanes, automatic load cannons, and tanks. In the meantime, Leonardo da Vinci was testing his newest invention, a flying glider, with his friends Nico, and Vanessa.

One day Da Vinci went to the local tavern, to help himself think, where he first encountered the Turk, who was being bullied by the Florentine Guards. He managed to rescue the Turk but was later captured by the Guard. Leonardo visited the Turk, **who told him about a secret order**, the Sons of Mithras, the Book of Leaves, and his mother, whom he barely remembered. **The Turk tasked Leonardo with finding the Book of Leaves.**

"I am the son of Earth and Starry Heaven. " - The Turk said to Leonardo Da Vinci.

Day after that a Jew man was hanged and he recited the same for his last breath. Intrigued by this, Da Vinci decided to solve the riddle behind it. Nico and Vanessa were exhuming the Jew's body, whilst Leonardo had a vision in which he spoke to the Jew. After they brought the body back to the workshop, Leonardo began his autopsy. He found out that the Jew was missing a fingernail on the right hand, after dissecting the body. He found out **the Jew had swallowed an odd parchment that mentioned the same book mentioned**.

With the use of various information he could gather, **his search took him to faraway lands and forced him to re-evaluate everything he knew about the world and his own history.** Without maps, Da Vinci struggled to navigate across the Atlantic. At one point, Leonardo reunited with Riario (the captain-general of the Holy Roman Church and nephew of PopeSixtus IV) and Nico in the New World. The end goal was to conquer **the Vault of Heaven**, the guardian chamber that would lead them to the Book of Leaves. Leonardo and his allies faced challenges from the moment they entered the vault. They were threatened by death at every turn in this quest for the Book of Leaves. Every painful moment was part of God's plan.

The first challenge was **one of those labyrinths which would change its configuration every quarter moon**. An Incan Priestess who offered to help, sent a llama to demonstrate the trap.

"You must pay tribute according to the legend, you must navigate through the blind labyrinth at stern pace, you will only get to the mosaic dome if you avoid the blind walls" she said.

Da Vinci **created the first self-propelled cart, "scorpion"** to go through blind labyrinth and successfully entered the **mosaic dome**. The Priestess followed Da Vinci and companies and **acquired the key solids** in order to activate the vault and **to activate a suspension bridge over a bottomless cavern**, on the way to the book chamber. Da Vinci would have stuck the keys in the wrong keyholes, it's a quick trip south. Math allowed Da Vinci to save the day. This daring escape separated Da Vinci and company from the Priestess who wished Da Vinci good fortune with his quest. Even Riario's faith in Da Vinci was growing as the master now had escaped two convoluted death traps.

Upon the activation of the bridge, Leonardo could safely cross the bottomless cavern and arrive at the Janus junction **where a path had to be selected to reach the final gateway** that would grant him the ability to open the book chamber by using the other key. After brilliantly using his quick wit to transform the "scorpion" into doing his bidding Leonardo and his allies could enter the key to the chamber, finally making the Book of Leaves one of his precious possessions.

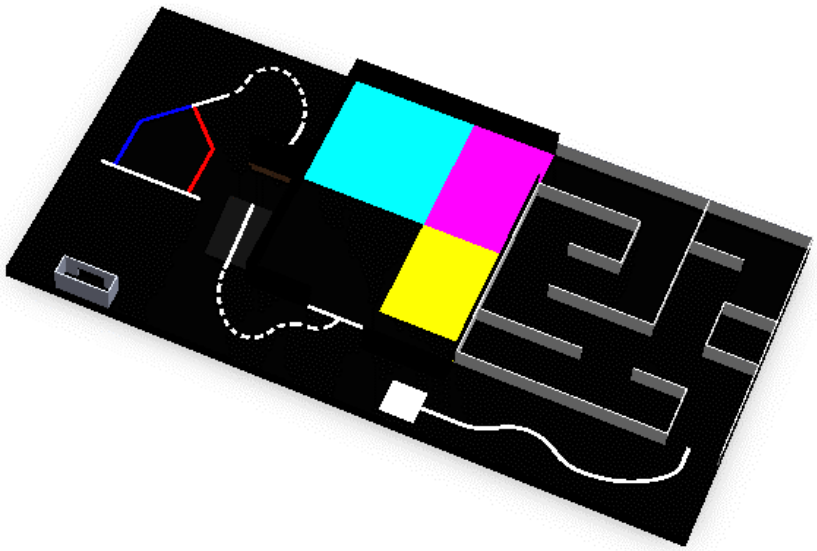
After 542 years, now it's your turn to enter the Vault of Heaven. This time, the prize will be one that you would not expect.

Task

The task consists of several subtasks.

- Line following
    - the robot must follow a white line on a black surface. These paths may contain straight lines, curved lines, or dotted line segments.
- Wall maze
    - After a line following section, the robot will have to navigate through a wall maze section. This maze will not contain any looping paths. (A single possible path from start to end is guaranteed.)
- Mosaic Floor Area
    - The robot exiting the wall maze should immediately enter the mosaic floor area and proceed to complete the following subtasks. Inserting the key solids to respective keyholes to close the bridge. Collecting the ball of the color assigned to your team at the start of the competition.
- Bridge
    - The robot should cross the closed bridge and exit the area to a dotted line segment.
- Shooting area
    - The robot must choose the correct path at the Y junction area according to the color assigned. While staying in the restricted space, the robot will have to shoot the collected ball through the goal.

Game Field



1. Overview

- All measurements are in millimeters.
- White lines, wall maze and positions of objects might change in final arena.
- Size of the arena is 4900 x 2450. The dimensions of the arena will be accurate within 5% or 20 mm, whichever is less.
- Paths are white lines with a width of 30 on a black background.

- Latter part of the task contains red and blue lines with the same dimensions.
- The minimum length of a continuous line is 250.

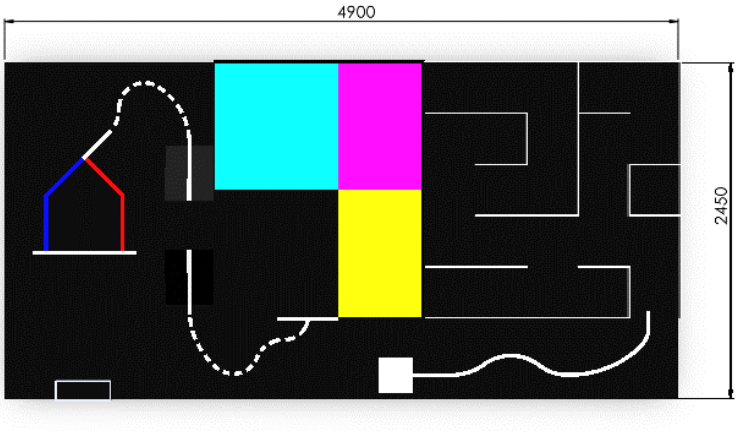


Figure 2 The colour blue is applied for clarity. It will not be applied to the actual arena.

2. Starting Square

- This is a white square with dimensions of 250 x 250. (see Figure 3.)

Figure 3

3. Wall Maze

- The maze consists of 25 cells (5 x 5) where a cell dimension is 370 x 370, including walls.
- The outer dimensions are 1860 x 1860 (see Figure 5)
- Wall height is 150 and thickness is 10.

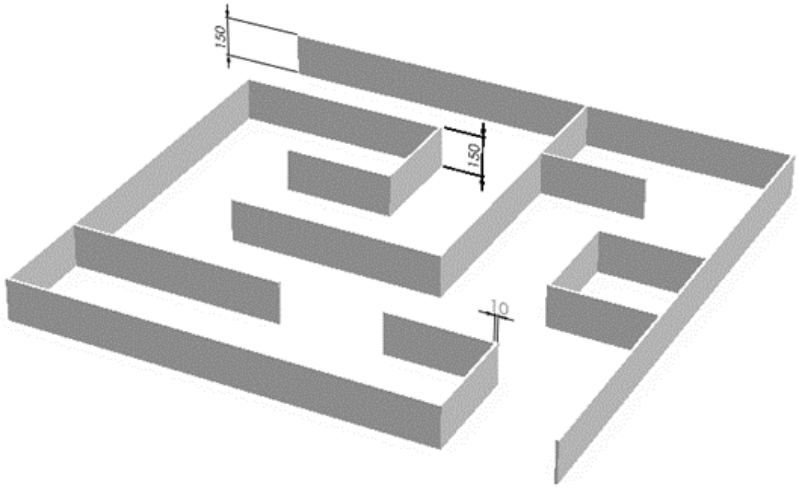


Figure 6

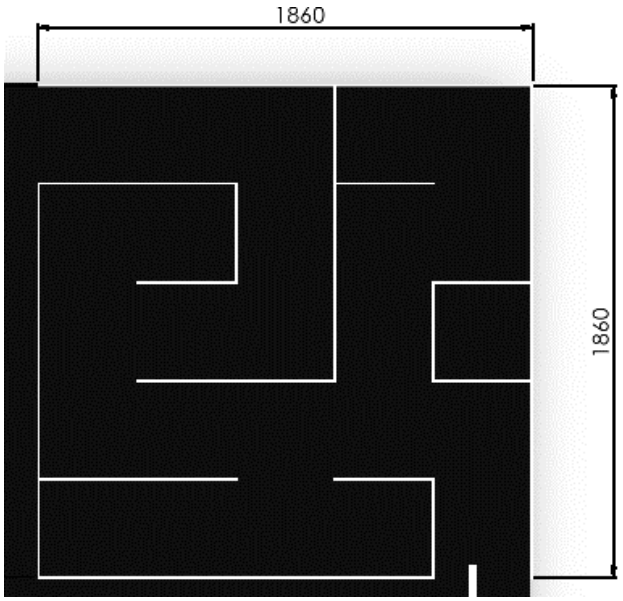


Figure 5

4. Mosaic Floor Area

- This area has four color segments, surrounded by black-colored walls with height of 250 and thickness of 10. Its dimensions including walls is 1520 x 1860. (see Figure 7)
- Dimensions of color patches will be as follows. (Figure 6)
    - Magenta : 600 x 920
    - Cyan : 900 x 920
    - Black : 900 x 920
    - Yellow : 600 x 920

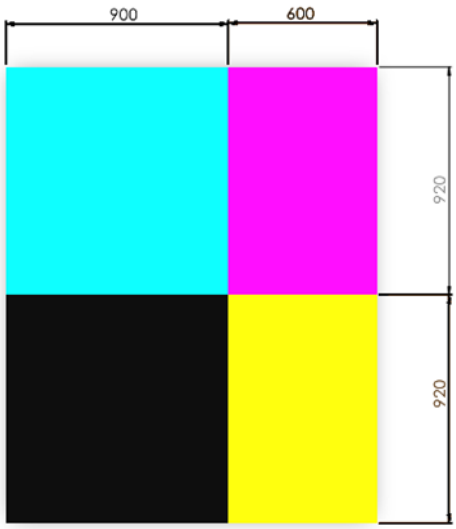


Figure 6

- The widths of entrance and exit will be 360 and 450 respectively.
- The exit is indicated by a 450 long and 30 wide white strip.

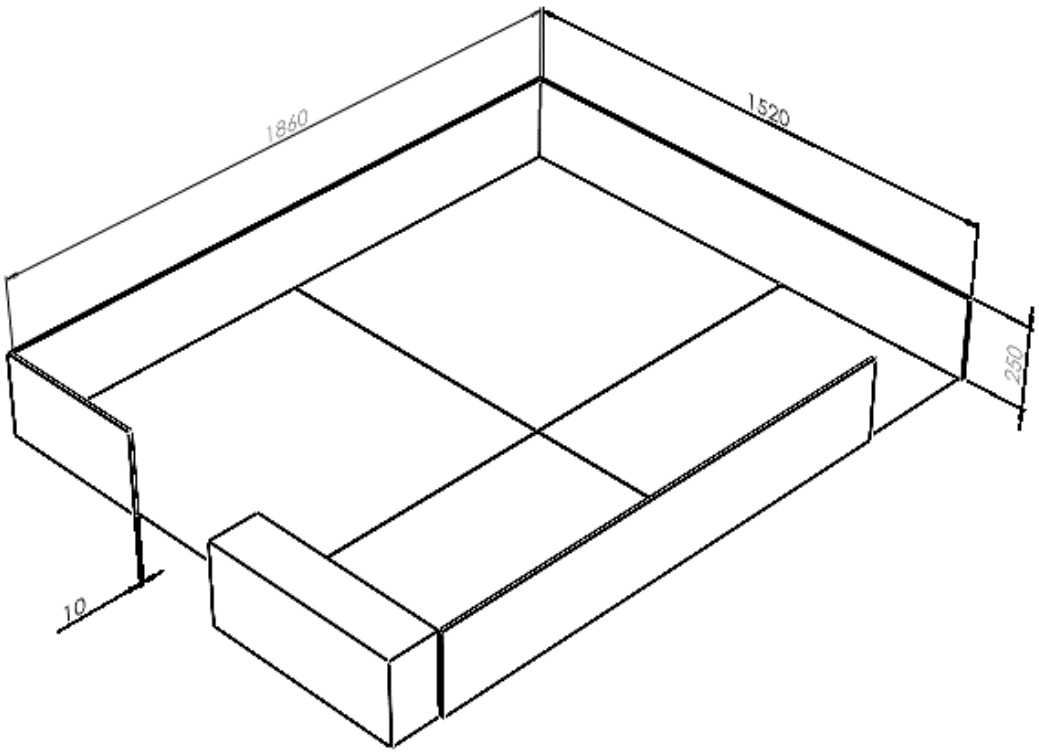


Figure 7

a) Objects

- Two objects, a box, and a cylinder, will be placed on the cyan colored region. These will be of following specifications.

Box		Cylinder		Ping Pong Balls	
Height	50	Height	50	Radius	40

Width	50	Radius	25		
Length	50				
Color		Color		Color	Red or Blue

- The two ping pong balls will be placed on the black color patch arbitrarily.
- The cylinder's curved surface will be touching the floor.

b) Keyhole Area

- Box hole is 60 x 60 x 51 (see Figure 9)
- Dimensions for the cylinder-shaped hole is mentioned in the Figure 8.
- Two holes are marked with borders having thickness of 10.

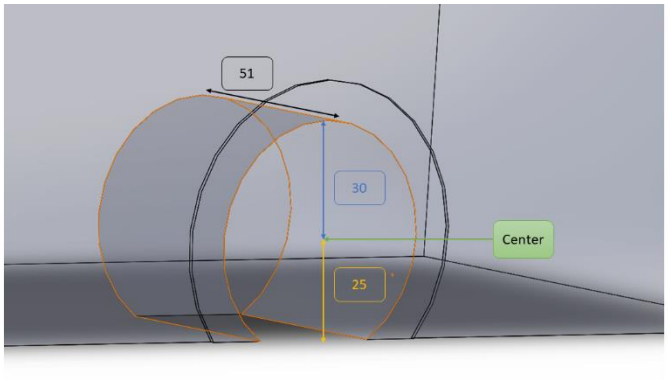


Figure 8

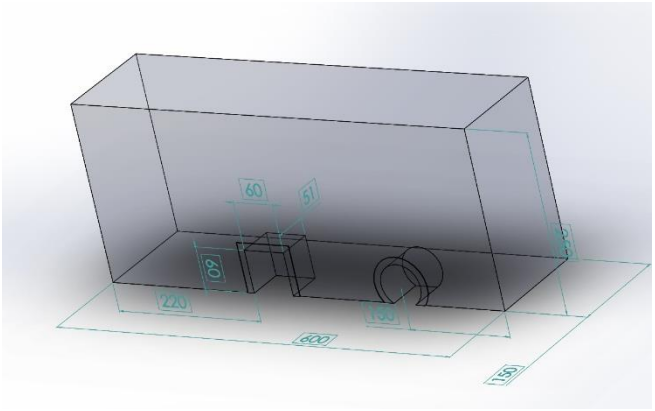


Figure 97

5. Dash-Line Follow Area

- Starting point of the dash lines will be placed as shown in Figure 10.
- The length of a dotted line segment can be in the range of 50 – 250 and the maximum distance between two dotted line segments is 30 - 50. (Figure 11)

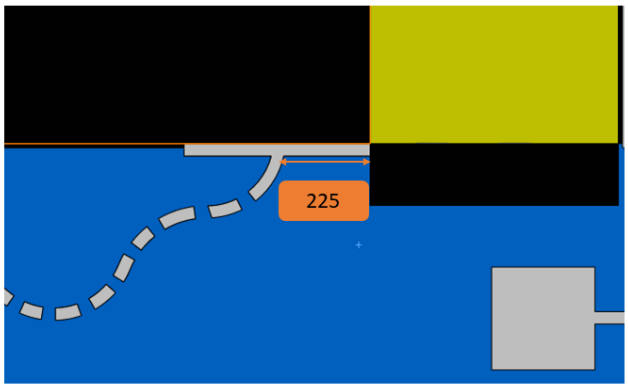


Figure 108

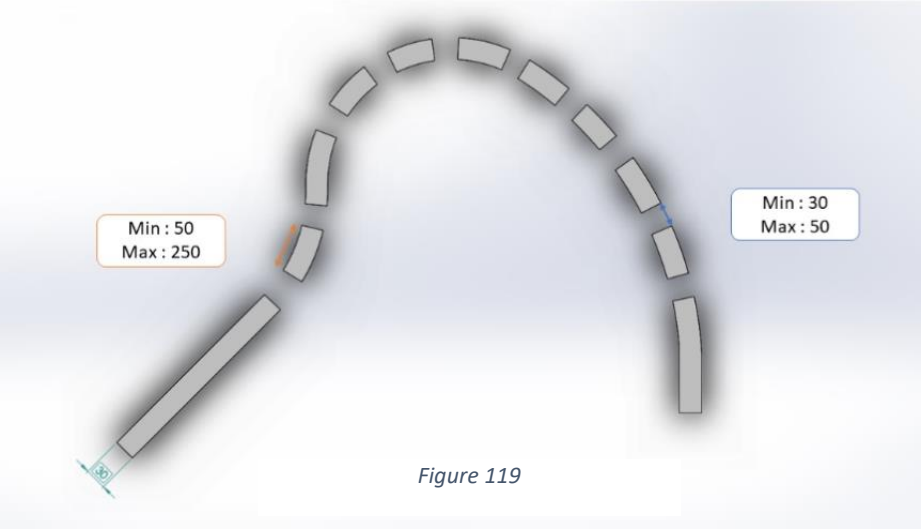


Figure 119

6. Bridge

- Ramp inclination is 20 degrees and consists of 2 inclined segments and one top area which can be opened and closed.
- Each inclined block is 350 wide and 412 long as shown in Figure 12.
- The movable segment is attached to the bridge using a simple hinge mechanism and its dimensions are 350 x 350.
- Continuous white line is placed on top of its surface for line following as showed in figure.
- There is no gap between the bridge and adjacent wall of mosaic area.

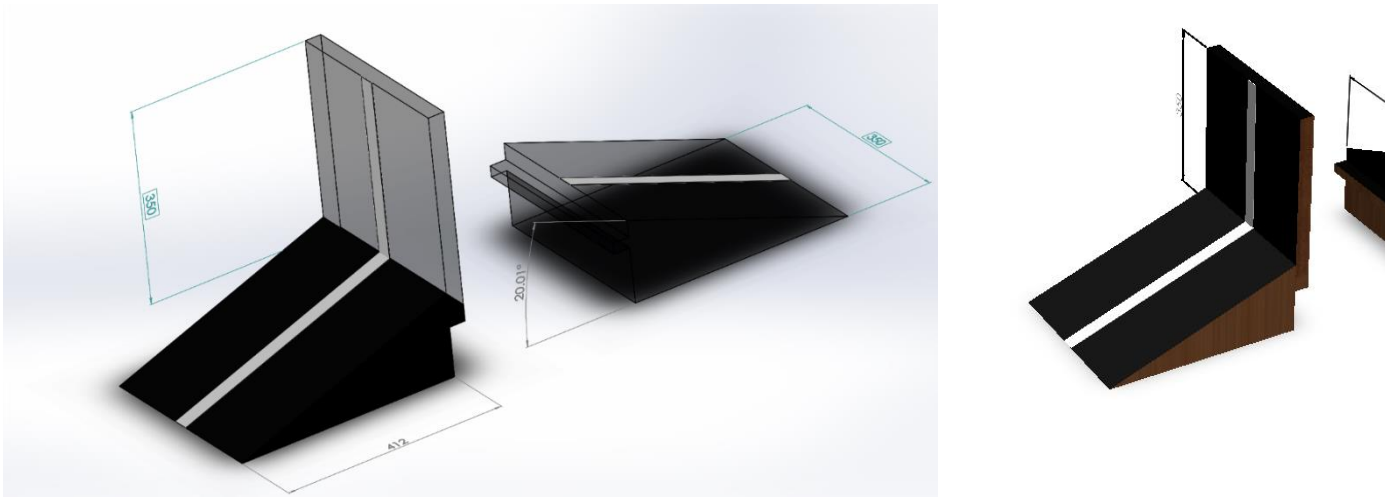


Figure 1210

7. Shooting area

- Bridge and the shooting area will be connected via a dash line path.

- At the junction where dash line meets color line paths, red line is on the left-hand side while Blue is on the front side.
- Distance between white line and the goal post is 900.
- Other relevant dimensions are mentioned in the figure 13.

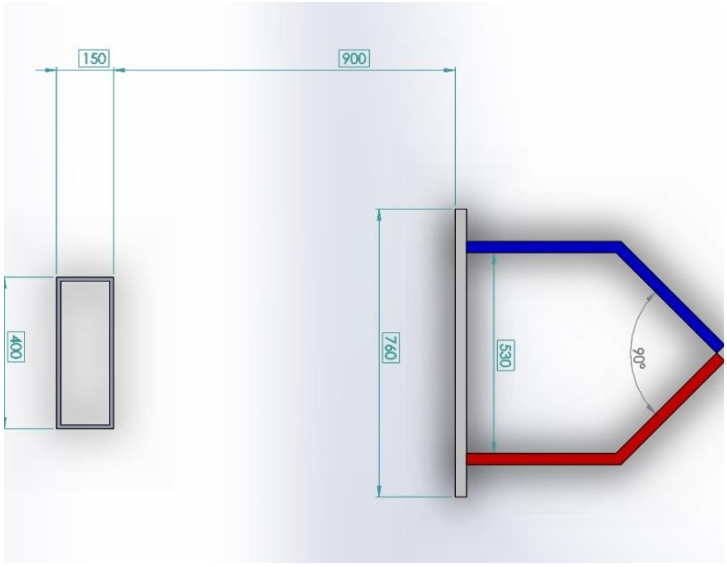


Figure 1311

8. Goal Post

- Dimensions related to the goal post are included in the Figure 14.

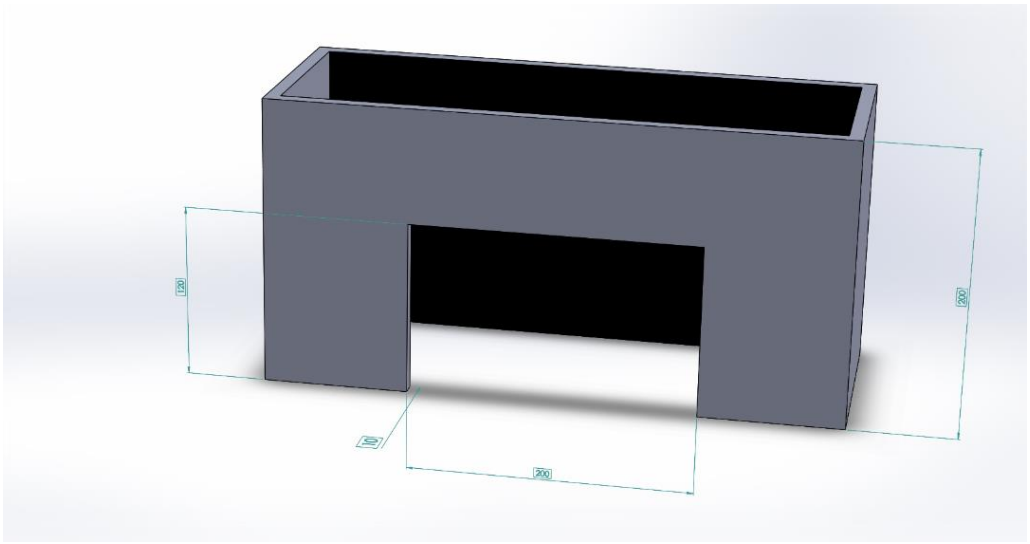


Figure 1412

Game Play

- Prior to every attempt the contestant will receive color. It will be either Red or Blue and the selection will happen in a randomized manner.
- Robot should start the task from inside the starting square with the line that leaves the starting square centered on the robot.
- Robot should follow the white line till the wall maze.
- Then the robot should follow the walls and find its way out of the maze.

- Once the robot completes the maze it will be entered to magenta color patch in the Mosaic floor.
- Next it should identify the objects and their positions in the cyan patch using a camera.
- Then the robot should move those objects and insert them to the respective key holes which are positioned in the yellow patch.
- When the key insertion is complete bridge will close automatically.
- Next the robot should pick a Ping Pong ball according to the color assigned.
- The robot is then expected to exit the Mosaic floor and follow the dash line path until it reaches the bridge.
- Once it reaches the ramp it can follow the continuous line to cross the bridge.
- Again, the robot must follow a dash line and enter the shooting area. Here, the robot should turn left and follow red line if it carries a red ball or move forward and follow blue line if it carries a blue ball.
- Then the robot should stop once it reaches to the white line, place the ball on it and shoot it into the goal.

Robot Specifications

- Dimensions of the robot should not exceed 250 x 250 (width x length). The robot should be completely autonomous. Any sort of remote control would lead to the disqualification of robots.
- The robot should be supplied with an internal power supply with a supply voltage not exceeding 24V and the final unit including the power source should be within the dimensions specified above.
- The robot must be completely built by the team members. No off-the-shelf kits are allowed except the processing boards, sensor modules, and drive gears.
- The robot should not cause any damage to the platform (arena). Any kind of damage to the platform leads to disqualification.
- The robot should be activated using a single start switch which is placed on the robot itself.
- The robot should be able to operate under provided lighting conditions.
- If robot consist of a camera module it should be placed below a height of 150 from the ground.
- The use of mecanum and omni wheels are not allowed.

Game Rules

- All the teams must submit their robots to the organizers 15 minutes before the start of the competition.
- Each team member will be questioned about the functionality of the robot prior to the start of the contest to prove their own design. A team may be disqualified depending on the answers given.

- At the start of their run, a team should place the robot inside the starting area with the line that leaves the starting area centered on the robot. When the judges give the signal, they can switch on the robot. From then on, the robot should navigate autonomously.
- Program modifications of the robot are not allowed. A maximum of 3 attempts is given in a single round and the fastest run will be counted. A maximum time of 15 minutes is allocated per team. All the attempts and modifications are reserved for this time period only. If the robot exceeds the time limit of 15 minutes, your robot will be removed from the arena.
- If the robot drifts out of the line to the extent that no part of it is on top of the line (except while the wall-following), the judges will consider it as jumping out of line. However, if the robot manages to find its way back onto the line automatically, it can be allowed to continue provided that the distance skipped by the robot along the line is less than 30cm. The judges may deduct points in this case.
- No timing bonus will be given unless the robot completes the task.
- The task is considered complete when the robot arrives inside the destination square. The clock will be stopped when the robot reaches the relevant endpoint.

Webots Specifications

- Contestants should complete all Webots programming in C/C++ languages.
- Note: C/C++ are the most used languages for embedded systems programming. If the physical competition was to be held, programming ability in C/C++ would have been required (e.g. Arduino).
- You have the freedom to use Cameras (in Webots) as color sensors.
- All sensors, actuators, and other components (e.g., batteries etc.) used in the robot should correspond to a real-world element (model number and datasheet should be available). All parameters of the simulated sensor/actuator should be configured to be very close to the real-world element.
- Note: The specifications for the motors provided by ENTC can be found via the link, https://www.pololu.com/product/3216/specs.
- The number of sensors/actuators/components should not exceed the input-output capacity of a chosen microcontroller platform or Raspberry Pi that can be used for creating a physical robot for a similar task.
- Webots platform does not require you to define a virtual processing unit (microcontroller/ Raspberry pie). However, you are expected to pick a suitable processing unit and evolve the design of you robot while considering the inherent limitations of that processing unit. For instance, Arduino Uno facilitates 6 Analog Read pins, and therefore, the number of analog sensors you can interface directly with it will also be 6.

- You are expected to draw a reference wiring diagram, emphasizing the interfacing of sensors, actuators, power converters and power sources with the microcontroller. You can color code the wires at your discretion (Figure 15).
- The robot simulated in Webots should correspond to a CAD design. CAD design should include all the components required to run the robot in a real-world environment. For the purpose of simulation on Webots, you are allowed to simplify the design of the robot body. However, the total weight and the center of gravity of the robot should be preserved.

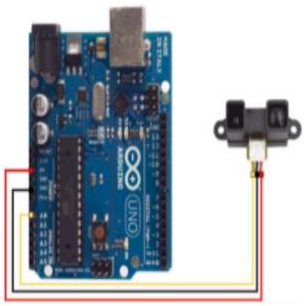


Figure 15

- For evaluation purposes the basicTimeStep field of the WorldInfo node will be set to 16ms. Note:https://cyberbotics.com/doc/guide/tutorial-5-compound-solid-and-physics-attributes#basictimestep-erp-and-cfm recommends values between 8 and 16 for regular use of Webots.
- The lighting of the arena (e.g., using Directional Light nodes) will be defined in the sample testing arena that will be provided and will not be changed during evaluation.
- Windows operating system is preferred for your Webots simulation

Evaluation Criteria

- Contestants will be evaluated on the following criteria.

  1. Task completion

  2. Engineering approach

  3. Total approximate cost/part utilization

- Percentages will be notified to you in due time