



# NATIONAL ENGINEERING ROBOTICS CONTEST 2024



## THEME: LEGO UNIVERSITY

National Engineering Robotics Contest

A joint venture of NUST and STEM Careers Programme (HEC) Organized

by:

Department of Mechatronics Engineering,

College of Electrical and Mechanical Engineering (CEME),

National University of Sciences and Technology (NUST), Islamabad, Pakistan &

National Centre of Robotics and Automation (NCRA)



## CHANGE LOG

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The table below will list the pages on which changes have been made to the theme.

Revision Date	
18-March 2024	Table 6.1 section 7.3
20 March 2024	Section 2.2 eligibility criteria added
20 March 2024	Section 4 point 8

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### NOTE:

1. Any correspondence with the NERC officials via e-mail, telephone, or any other means will not be considered as part of the rules (unless uploaded as an FAQ on official NERC website).
2. In all matters of interpreting the rules before and during the Contest and in any issues not covered by these rules, the decisions of the Contest Judging Committee will be considered final.

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# 1 INTRODUCTION

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The National Engineering Robotics Contest (NERC) is a joint project of the National University of Sciences and Technology (NUST) and Science, Technology, Engineering, and Mathematics STEM Careers Program HEC to promote research in the field of robotics and its related fields in Pakistan. We, from the Department of Mechatronics Engineering, welcome you all to participate in 20<sup>th</sup> National Engineering Robotics Contest (NERC 2024). This competition will provide a common platform for the integration and evaluation of various electromechanical designs, control and path planning algorithms, and agent architectures.

Over the years, NERC has grown increasingly popular among students as well as engineering departments across the country. The Engineering students from all over Pakistan participate in this competition. Many students participate in this contest in their final years of undergraduate degree and take the contest theme as their Final Year Project thus becoming part of human resource required in field of robotics and automation. This not only adds value to the competition but also resolves our pledge to bring exciting new challenges every year for the advancement of robotics community at an increasingly wider scale. Robotics is a buzz word at today's technology forefronts. Due to exponential advancements in fields like high performance computing, computer vision, computer networks, material sciences and power electronics, the growth experienced by robotics in past few years is unprecedented. Robotics is the only field which can add precision while replacing the slow manual labor in the contemporary industrial world. Thus, this field faces enormous pressure from industry to produce all-purpose mobile manipulator robots which can perform simple tasks like grab, navigate and place objects at desired locations autonomously.

The future of Pakistan relies heavily on advancement in the fields of engineering and science and events of this nature will encourage and motivate students to improve their technical skills in leaps and bounds. The focus of NERC 2024 Modular Category is to create an autonomous robot that can simulate Fruit Harvesting tasks. In this theme, there will be a robot that is acting as the harvester robot. Its job is to pluck and collect the fruits (ping pong balls) from the trees. After collecting all the fruits, the robot shall reach a parking spot. The first team to successfully collect all the fruits and reach the parking spot will be declared winner.

## 2 CATEGORIES

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There are two categories of the contest:

- Indigenous Robot category
- Modular Robot category

The purpose of this contest is to develop a sense of problem-solving, project- based learning, team-based learning, technical design, and ingenuity among the contestants.

### 2.1 INDIGENOUS ROBOT CATEGORY

Indigenous category includes robots that are constructed from scratch. Their mechanical structure, controls etc. are designed by the teams themselves. The electronic control modules including all electronic boards and motor drivers (unless specified otherwise) etc. should be designed and manufactured by the students.

This category is only for university students.

### 2.2 MODULAR ROBOT CATEGORY

Modular/Lego category includes robots that are developed using ready-made kits for example Lego, EV3 kits, EDVON kits or NCRA robotic kit. The Modular category is further divided into two subcategories:

#### 2.2.1 Modular School

##### **2.2.1.1** *Lego School*

##### **2.2.1.2** *Ready to Race School*

#### 2.2.2 Modular University

##### **2.2.2.1** *Lego University*

##### **2.2.2.2** *Ready to Race University*

*This document describes the theme for **Lego University Category**. This category is for students from Engineering Universities/Institutions and Polytechnic Institutions.*

## 3 CONTEST STRUCTURE

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The contest will consist of two stages:

1. Heats/Qualifying Rounds
2. Head to head matches

### 3.1 QUALIFYING ROUNDS

Each robot will participate in the qualifying rounds (heats). For qualifying rounds following rules will be observed:

- 3.1.1 There will be NO head-to-head matches. Each team will individually run their robots.
- 3.1.2 Seeding chart will be based on points scored by teams. If the points of both teams are equal, decision will be made based on time taken by both teams. The team with less time will be placed on higher seed position. If time of both teams is also same, the decision of the higher seed will be based on the shortest distance from the next objective from the current position (as per discretion of judges). If all the above criteria are same, coin toss by judges will decide higher seed position.
- 3.1.3 Each team will be provided with maximum of 3 minutes to run their robot. A timer will be displayed for the audience, however, accurate time through the stopwatch will be recorded by jury.
- 3.1.4 A team can take as many retries as desired within 3 minutes without any penalty but only the total time taken, and final score will be recorded. (Refer to the section 7.9, **Retry** for further details)
- 3.1.5 When a team takes a retry, the score is reset to zero and the entire arena will be reset.
- 3.1.6 When the team is ready, and the whistle is blown, then the time will start.
- 3.1.7 If a robot is not able to successfully complete the task in time, then the time when team's flag bearer will call it off (By saying "STOP") will be recorded as the finish time.
- 3.1.8 Only the **flag bearer** has the right to say **Retry/Stop**. Other members of the group must refrain from saying Retry/Stop other than the flag bearer to avoid confusing the referee, If referee makes a call due to the confusion caused by other team members, the referee's call will be considered final.
- 3.1.9 Judges reserve the right to give a re-run to any team with zero score with justifiable reason (if required). This clause will only be applicable if the Judges, Jury and Referee agree to the re-run. This clause does not apply to the team's request but to reasons which are justifiable and acceptable to the judging committee.
- 3.1.10 If the robot completes all tasks successfully and crosses the finish line (scoring maximum point), the stop called by the flag bearer will be of no importance/significance.

## 3.2 HEAD-TO-HEAD MATCHES

After qualifying rounds, the top 32 teams (with non-zero score) from the qualifying rounds will go on into the final rounds for head-to-head matches. The judges reserve the right to change the number of head-to-head matches. The winners will be decided through a final match. The Runner-up will be decided based on the outcomes of the semifinals. (Subject to award of runner-up category only).

## 4 CONTEST THEME

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The NERC 2024 theme is continuation of 2023 based on precision agriculture with focus on autonomous robots that can simulate Fruit Harvesting tasks. In this theme, there will be a robot that is acting as the harvester robot, its job is to pluck fruits from the tree. Fruits are represented with orange colored ping pong balls respectively. The first team to successfully collect all the desired fruits and reach the parking spot will be declared the winner. The Contest arena is shown in Figure 1. Details are as follow:

1. Laminated wooden sheets (lasani) are used for the construction of the arena. The floor of arena will be of white color as shown in the map (Fig. 1). All the boundary walls and separation walls have a height of 5 inches throughout the arena. The solid line made with black tape of 3cm width (Dotted Line in Fig 1) present on the floor of arena can be used for line tracking. The entire arena is divided into 12x12 inch grids.
2. The starting position and orientation of the robots are fixed. The robot must be placed behind the starting line shown in Fig. 1 with red color. The complete robot should be behind the line. The red colored line is only for reference in Fig. 1, it will be a solid black colored line on actual arena.
3. The Robot may follow the black line (Reflective Tape) or wall of the arena to locate the Trees.
4. The fruits are considered to be ping pong balls of orange colors.
5. The fruits are hung from the branches of trees, with trees T1 and T2 having 1 fruit each (total 2 fruits), as shown in Annex B.
6. The placement of fruits is fixed.
7. The robot (R1) will reach the location of the trees and collect the fruit from the trees.
8. The robot must avoid yellow-colored boxes that represent obstacles present in arena. The dimension of obstacles are  $3 \times 3 \times 4$  inches. The robot cannot go between the obstacles.
9. Red-outlined boxes are made of red tape of 1 inch width. The dimension of the complete red square region will be 5x5 inches (including the dimension of tape).
10. After successful collection of fruits, the robot(R1) will move towards the Parking spot as marked in the arena shown in Figure 1. However, after collecting fruit the robot must cross the highlighted region/red line on row 4 (labelled as A for reference only). The red line labelled as A in row 4 is only present in Fig 1 for reference, it will not be present on actual arena.

11. The team to successfully complete all tasks and reach the parking spot will be declared as the winner. A successful “reach” means all the parts of the robots have crossed the parking entrance line (represented with red color in Fig.1) and no part is on and above the line. The red colored line is only for reference in Fig. 1, it will be a solid black colored line on actual arena.
12. The two sides are mirror images of each other.
13. After the start of the match, the team cannot touch the robot.
14. Each team must bring their own robot.
15. In case of a retry, the teams can reset their robots.
16. The maximum dimension of the robot is 12x12 inches (LxW).
17. The programming of the robot is allowed only in the setup time of around 1 minute, it is not allowed once a match has started.

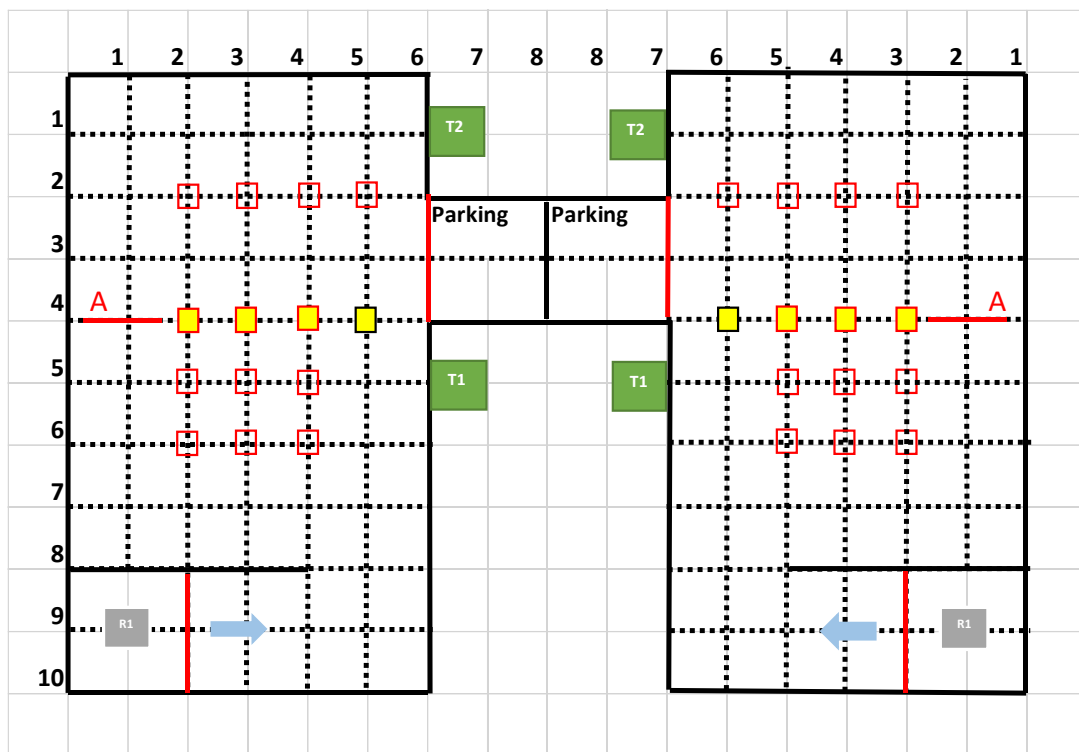


Figure 1: Contest Arena top view

- Each grid is 12x12 inches.
- Both sides are mirrored images, the trees are represented with green boxes.
- Yellow-colored boxes display the position of obstacles present in arena only. These are centered, 3x3x4 inches.
- Solid Black lines show the height of 5 inches wall and dotted lines shows the black tape of 3cm width on arena.
- The red-outlined boxes are made of red tape of 1 inch width. The dimension of the complete red square region will be 5x5 inches (including the dimension of tape).
- Robot must cross the region/red line labelled as A (label and red line are made in Fig 1 for reference only).



## 5 ROBOT OPERATION

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The qualifying teams (those which qualify for the final rounds) will compete with each other in a knockout format. In each match, two teams will be pitted against each other, running their robots side by side in the contest arena. Teams will be declared as Team A or Team B based on the coin toss before every match. The winner of coin toss will decide which arena to choose i.e. Left Arena or Right Arena. The left arena will be given a Blue flag while the right arena will be given a Red flag, hence the arena may be referred to as the Red or Blue arena. Once turned on, the robot must be self-controlled without any human intervention and contestants are NOT allowed to touch their robots. After the blow of a whistle, the robot will have 3 minutes to complete the task.

During a retry, the layout of the arena shall remain SAME and shall be reset, however the point-scoring will restart from zero. The robot may navigate through the arena using any suitable technique. The robot must not displace any item/obstacle in the arena. Displacing any item inside the arena will result in a forced retry or disqualification as per discretion of judges (Judges decision on declaring a displacement will be final). If the participating team sees that their robot has lost track of its location and is facing trouble localizing itself, the team can ask for a retry by raising their flag. During its motion, the robot may touch the walls of the arena without damaging them, but it is not allowed to use any sort of tactile sensor to sense the walls. This will result in forced retry or disqualification (as per discretion of judges).

In case of a tie, the contestant may be required to run a rematch, or the winner may be decided on a coin toss as per the discretion of the judges.

For a particular match, both teams will face the same layout of the arena.

## 6 POINTS

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The point scoring is shown below in Table 1 Point Scoring.

*Table 1 Point Scoring*

<b>Point Scoring:</b>	<b>Score</b>
*Reaching T1 position	<b>20</b>
Successful plucking and carrying of ball from tree 1 to the parking spot	<b>20</b>
*Reaching T2 position	<b>20</b>
Successful plucking and carrying of ball from tree 2 to the parking spot	<b>20</b>
**Entering the Parking	<b>20</b>
<b>Total</b>	<b>100</b>

\*Reaching means the front tyres of the robot must be within one grid position of the tree.

\*\* Entering means all the parts of the robots have crossed the parking entrance line and no part is on and above the line.

### 6.1 DEDUCTION OF POINTS

The deduction of points is shown below in Table 2. Deduction of Points

*Table 2. Deduction of Points*

<b>Deduction/Penalty</b>	
The robot fits in an area of 12x 12-inch square	No Penalty
Oversize Robot (14x14 inch square)	5 Points
Oversize Robot (exceeding 14 x 14-inch square)	Disqualification
Robots weighs less than 12 kg*	No Penalty
Overweight Robots (Weight between 12 and 14 kg)	5 Points
Overweight Robots (Weight exceeding 14 kg)	Disqualification
Damaging the arena/wall/sites/Tape/Objects	Disqualification

\*This is the individual weight of each robot

The penalty handicap shall be applicable in heats and head to head matches.

## 7 RULES

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The following are the rules governing the contest.

### 7.1 GENERAL

- 7.1.1 The Contest judges may stop any robot at any time if they feel that it is performing, or is about to perform any action that is dangerous or hazardous to people or equipment.
- 7.1.2 Additional information regarding the contest rules and regulations may be found in the Tab of FAQs(<https://nerc.ceme.nust.edu.pk>) and will be considered as part of the theme and rules. New FAQs are uploaded frequently so keep watching the FAQ corner for new information.
- 7.1.3 Any correspondence with the NERC officials via e-mail, telephone or any other means will not be considered as part of the rules (unless uploaded as an FAQ on official NERC (website). It is the responsibility of each contestant to be familiar with all the rules.
- 7.1.4 If both the teams have scored the same points but are not able to complete the task in allocated time slot, decision of the winner will be on judges' discretion who will determine which robot is closer to finish the task first.
- 7.1.5 If both teams have scored the same points, have the same time and are at the same distance from the finish point, a coin toss will be used to decide the winner.
- 7.1.6 If any team wants to launch a protest (of any kind), they must do so within 15 minutes after the end of their match. The procedure and payment is outlined in Annex A.
- 7.1.7 Attempting to damage the game field or performing an act that fails to comply with the spirit of Fair Play will lead to the disqualification of the team.
- 7.1.8 In all matters of interpreting the rules before and during the Contest and for any issues not covered by these rules, the decisions of the Contest Judging Committee will be final.
- 7.1.9 Wireless Control of the Robot for operation is not allowed.

## 7.2 TEAMS

7.2.1 The Robots can be built by teams of currently registered students from Engineering Institutions and Polytechnic Institutions. Each team can comprise of a ***maximum of 6 members***.

7.2.2 If the students from two different Institutes/Universities join hands and form a team in collaboration, then the name of the Institute/University with maximum number of students in such a team would be registered or official consent from both institutions will be required at the time of registration before the contest start date.

7.2.3 A person can't participate in more than two teams.

## 7.3 ROBOT SIZE AND WEIGHT

The robot fits within 12x 12-inch square at the time of measurement. If the area of the robot base is more than 12x 12-inch square but less than 14 X 14- Inch square, then points will be deducted. There is no restriction on the maximum permissible height of the robot. Any robot which does not fit in 14 X 14-Inch square will be disqualified. All robots will be carefully measured. All sensors mounted on the robot will be counted as part of the robot's total dimensions. If contestants want to add a flag, hat or other purely decorative, non-functional items to the robot, they may do so. The decorations may be removed for measurement purposes. The weight of each robot excluding decorations must not exceed 12 kg. Penalties, as detailed in 6.1. Deduction of Points, will be levied if the robot does not fulfill the size and/or weight criteria.

## 7.4 ROBOT OPERATION

7.4.1 Any team that damages the arena will be disqualified.

7.4.2 The robot must not use any harmful substances such as oil, petrol etc. in its operation that can damage the arena.

7.4.3 The Robot CANNOT split after the start of the game, only one Robot is allowed to compete at a time.

7.4.4 The robot must not use any destructive or dangerous methods to displace any obstacle or box.

## 7.5 SENSORS

7.5.1 Robot is not allowed to use tactile sensor of any type for sensing the walls.

## 7.6 POWER SUPPLY

- 7.6.1 The robot must be battery-powered.
- 7.6.2 The robot must not have any wired connections with its surroundings.
- 7.6.3 Voltage of the machine's electrical power source must not exceed 48-volt DC. **Power banks may be used.**
- 7.6.4 Power sources that are considered dangerous or unsuitable by the contest officials shall not be permitted.

## 7.7 DURATION OF MATCH

- 7.7.1 Each match will be of maximum 3 minutes.
- 7.7.2 Teams will be given around 1 minute for setting up the Robot at the start.
- 7.7.3 Robots can start at the instant when the start signal is given, and a whistle is blown. The Robot should be constructed so that it can start in minimum possible steps.
- 7.7.4 Once the Robot moves, team members will not be allowed to touch the Robot or enter the Contest Arena. If any team member enters, forced retry shall be imposed.
- 7.7.5 Timing shall start once the start signal is given and the whistle is blown.
- 7.7.6 Time would be stopped as soon as robot reaches completely into the parking spot. If a robot is not able to successfully complete the task then the time when team will call it off (by the flag bearer saying "STOP") will be recorded as the finish time. The team must leave their robots as it is on their current locations when time stop is called by them. They must NOT pick their robots up till the referee announces the end of the match. The team is not allowed to take a retry after the time has stopped or STOP has been called.
- 7.7.7 The team which picks all fruits and then reaches the parking spot first will be declared the winner of the match.
- 7.7.8 If both teams fail to complete the task within time limit, the team scoring more points will be declared the winner of the match.
- 7.7.9 If both the teams have scored the same points but are not able to complete the task in allocated time slot, then winner will be decided on time. If both teams call stop at same time, then decision of the winner will be on judges' discretion, who will determine which robot is closer to finish the task first. The distance of the robot's current location from the Finish Point (Parking Spot) will be measured.
- 7.7.10 The Complete robot is required to cross the parking line for the run to terminate.

## 7.8 **RETRY**

If the robot is strayed due to some reason, retries are allowed.

- 7.8.1 There is no limitation on the number of retries and a team can take as many retries within the 3 minutes duration of the match. No Points will be deducted for retries but total score will reset to zero.
- 7.8.2 Each team would be provided a flag of their respective team. If a team wants to take a retry, the flag bearer must raise the flag and say clearly “retry”. Once the referee announces a retry, the team shall place its robots at their starting location.
- 7.8.3 If a team wants to stop their robot during the match, the flag bearer must raise the flag and say “stop”. The team can then turn off their robot, but they must not move it. The time at which the robot is stopped would be recorded as the final time. The team must not enter the arena until referee has acknowledged the “STOP”.
- 7.8.4 For each retry, robots must be started again from the start point. Points will reset to zero.
- 7.8.5 Arena Management team is responsible to reset the arena, any team member is not allowed to interfere or do the resetting of arena themselves. If such an act is done, referee will call retry.
- 7.8.6 Separate time for individual retries will NOT be recorded or maintained. When a team takes a retry, it is only allowed to restart the robot.
- 7.8.7 Once the start whistle is blown, the team can't reprogram their robot.
- 7.8.8 If the contestants enter the arena during the match, it will automatically be counted as a retry.
- 7.8.9 Once the stop has been called by the flag bearer or the task has been completed (obtained full marks), retry will not be allowed.
- 7.8.10 Only the **flag bearer** has the right to say **Retry/Stop**. Other members of the group must refrain from saying Retry/Stop other than the flag bearer to avoid confusing the referee, If referee makes a call due to the confusion caused by other team members, the referee's call will be considered final.

## 7.9 **DISQUALIFICATION**

The following behavior shall be considered for disqualification by the referee and the team could possibly be disqualified:

- 7.9.1 Attempting to damage the game field.
- 7.9.2 Performing any act that fails to comply with the spirit of Fair Play.

## 7.10 PROTEST PROCEDURE

The protest procedure is as follows:

- 7.10.1 The team must launch a protest (submit a complete protest form to the head jury) within 15 minutes after the end of their match.
- 7.10.2 The team must collect the protest form from the head jury on request or use a hard copy of the form in Annex A.
- 7.10.3 The team must submit a non-refundable protest fee of Rs. 5000/- along with the protest form.
- 7.10.4 A complete protest form includes submission of the protest fee.
- 7.10.5 The head jury will forward the case to the judges.
- 7.10.6 The judges will decide on the protest's validity and render their decision.
- 7.10.7 In case of noncompliance of above mentioned points the protest will not be considered valid.
- 7.10.8 The judges' decision will be final.

## 8 TEST RUN

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Contestants will be given time for trial run one day before the contest to calibrate their robot/sensors on the actual arena/game field. However, considering the huge numbers of participants, practice time may be limited. Scheduling shall be done by the organizers.

Annex A PROTEST FORM

# Protest Form

Team Name:	
Team ID:	
Team University:	
Team Members:	
Match finish time (to be filled by Head Jury)	
Launch time of Protest (to be filled by the head jury)	
Protest fee Payment (to be filled by head jury)	

**Reason of Protest:** \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

\_\_\_\_\_  
 Signature of Team Leader

\_\_\_\_\_  
 Signature of Head Jury

**Decision of Judges:** \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

\_\_\_\_\_  
 Signature of Head Judge



# Annex B TREE DIMENSIONS

The ball is attached with a magnet to the tree. Specifications of the magnet are given in the link below:  
[\\*https://www.evselectro.com/strong-n50-rare-earth-neodymium-ring-magnets-3mm-hole-10x3mm-7111?search=Magnet&page=2](https://www.evselectro.com/strong-n50-rare-earth-neodymium-ring-magnets-3mm-hole-10x3mm-7111?search=Magnet&page=2)

## Characteristics of the Ball

Color: Orange  
 Double Circle (Brand of DHS) Classic 40mm Table Tennis Balls –  
 Standard Plastic Balls  
 Diameter = 40 mm  
 Weight of each ball = 2 – 3 grams each  
 Manufacturer [www.dhs-sports.com](http://www.dhs-sports.com)

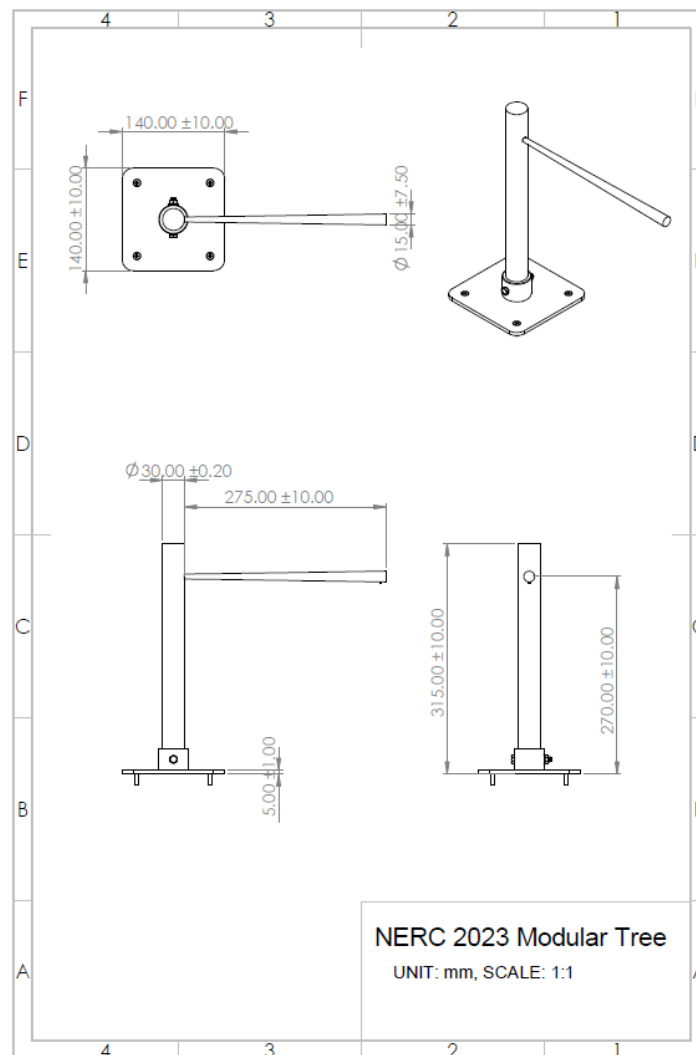


Fig. 2. Tree Dimension