



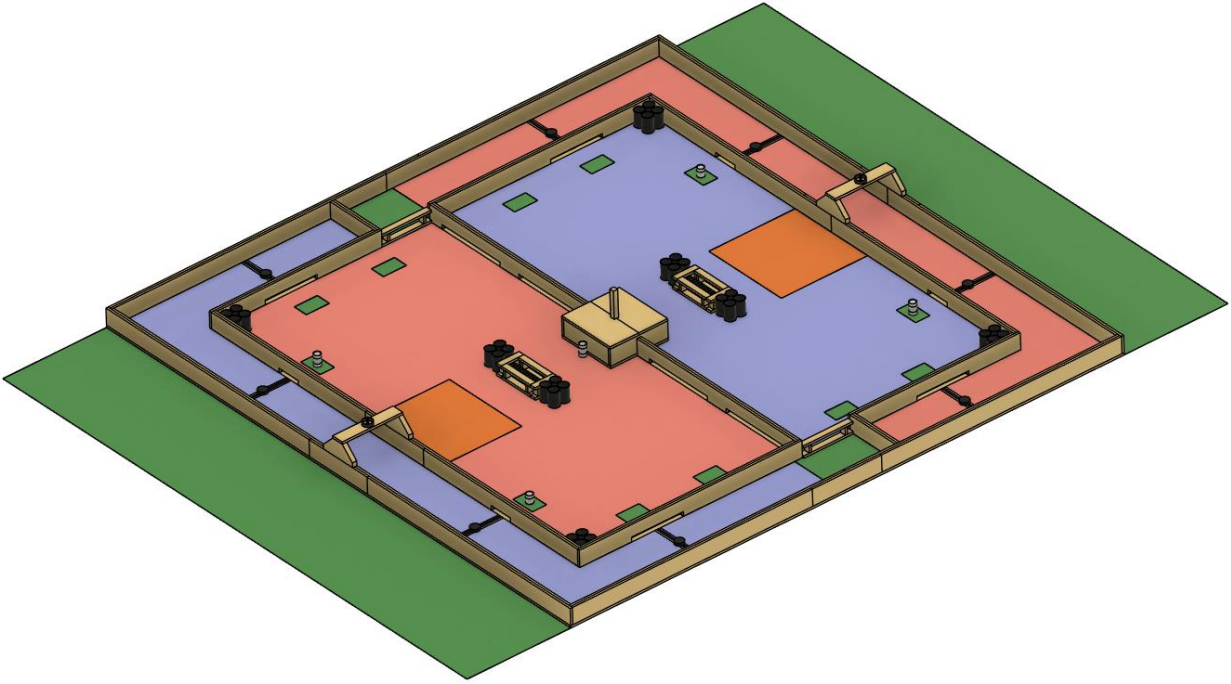
Project

Skill #23 – Mobile Robotics

SECONDARY

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Barrel of Laughs



Project Document
23 - Mobile Robotics
Secondary Level

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1. Terms

- 1.1. Tele-Operated Robots are defined as elements under the direct/active control of competitors during game play using one or two radio/game controller held by the courtside competitors.
- 1.2. Autonomous Robots are defined as independent elements not under the direct control of competitors throughout gameplay.
 - 1.2.1. Autonomous Robots are elements that operate without direct input from competitors during game play.
 - 1.2.1.1. These robots perform pre-programmed tasks using on-robot sensors (such as motor encoders, ultrasonic sensors, line follower sensors, etc.) and logic systems (including the microcontroller/programmable control unit and program).
 - 1.2.1.2. Autonomous robots must contain and utilize a programmable control unit, electrical components, and battery.
 - 1.2.1.2.1. Independent elements not containing these components will not be permitted.
 - 1.2.2. The only permitted direct competitor interaction with these robots is initiation of the autonomous robot at the beginning of the game.
 - 1.2.3. Once the expiration of the time has been complete, these devices must be turned off safely. This may be done by the NTC/Judges.
 - 1.2.4. Mobile Independent Autonomous Robots are considered any autonomous element that moves about the court.
 - 1.2.5. Stationary Independent Autonomous Robots are considered any autonomous element that does not move about the court.
 - 1.2.6. Independent Autonomous Robots may interact with the team's tele-operated mobile robot.
 - 1.2.6.1. Tele-operated Mobile Robot(s) may initiate an active response by the Independent Autonomous Robot which may be managed by a mechanical based system or a pre-programmed system internal to the Independent Autonomous Robot.

2. Safety

- 2.1. Safety is of paramount importance in all aspects of the competition.
 - 2.1.1. All individuals on site are expected to be mindful of their surroundings and ensure they act safely at all times.
- 2.2. Specific expectations with regards to the Robotics competition are as follows:
 - 2.2.1. All individuals are expected to wear eye protection at all times when they are in the competition area.
 - 2.2.2. Teams are expected to ensure their pit area is tidy.
 - 2.2.3. Teams are expected to have appropriate storage for their batteries when they are not on the robot.
 - 2.2.3.1. For Lithium based batteries, teams are required to have a properly rated Lithium storage bag/container.
 - 2.2.3.1.1. For other battery types, it is recommended to have a proper storage container for them when they are not in use.
 - 2.2.4. All fabrication work involving material removal processes (grinding / cutting) must be completed in the designated “Grinding Booth” area.
 - 2.2.5. All competitors must ensure they are not wearing any jewelry that could be caught in something.
 - 2.2.5.1. This includes competitor name tags. They are to be removed and placed on the competitor pit area table while within the competition area.
 - 2.2.6. All competitors must ensure their hair is tied back/not in their eyes, and not able to be caught in anything.
 - 2.2.7. All individuals are expected to ensure all trip hazards are reduced as much as possible.
 - 2.2.7.1. In situations where trip hazards cannot be eliminated, appropriate signage and notification must be made to everyone in the area.
 - 2.2.8. All individuals are expected to ensure they are wearing appropriate footwear.
 - 2.2.8.1. All footwear must be closed-toe shoes.
 - 2.2.8.2. All laces must be tied.
 - 2.2.9. All Robots must pass a safety inspection (details in Section 9).
 - 2.2.10. Batteries must be disconnected from all robots and charging devices during the overnight periods.
- 2.3. Safety Scoring criteria details are available in Appendix E.

3. Overview, Game Description, and Play

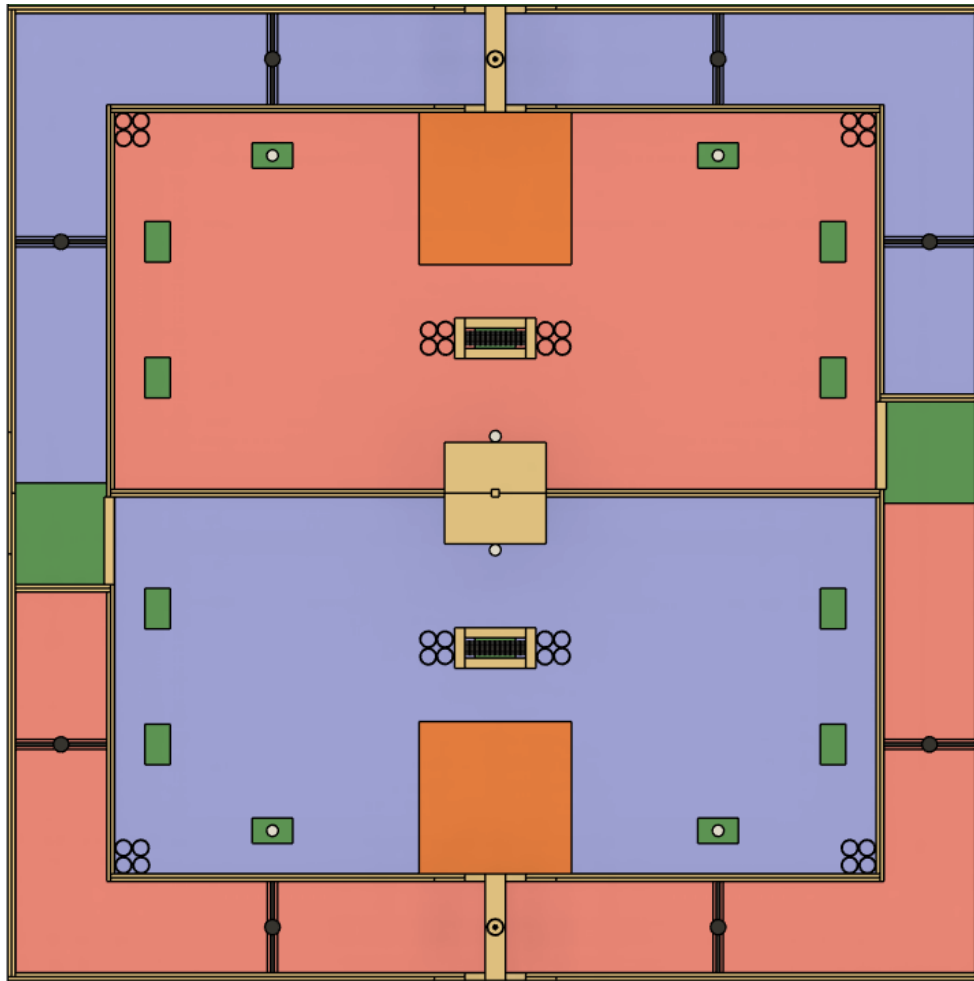


Figure 1: Top-Down Court View

3.1. General Overview

- 3.1.1. This section is intended as a brief overview of the general concepts. It does not override any later sections in this document where the full details of the game play are described.
- 3.1.2. Scenario: A chaotic scene has unfolded at a rodeo arena just before a major event. Bulls have broken free from their enclosures, scattering across the grounds and disrupting preparations. Rodeo clowns have taken cover, but many are stranded and need to be secured safely. Teams must act quickly to restore order, handle the bulls, and prepare the arena—all while disrupting the opponents' preparations before time runs out.

- 3.1.3. Objective: Teams must use a combination of tele-operated and autonomous robots to manage the chaos within their arena, and herd the bulls to cause more chaos for their opponents. Points are earned by herding bulls through the wall slots, placing barrels in designated zones, securing clowns safely inside barrels, and successfully lassoing the central post. Autonomous robots also play a key role by navigating the field, herding bulls, and completing a calf roping task. The team with the highest total score at the end of the match will be declared the winner.
- 3.1.4. Restrictions:
 - 3.1.4.1. Teams can use up to 2 tele-operated robot(s) and 1 independent autonomous robot.
 - 3.1.4.1.1. The autonomous robot will be used in both the “Barrel of Laughs” game and the On-Site Autonomous Challenge.
 - 3.1.4.2. A team’s full entry will start the “Barrel of Laughs” game match in there respective starting areas.
 - 3.1.4.2.1. The Tele-Op Robot(s) will start in the Starting Zone located in the Corral.
 - 3.1.4.2.2. The Autonomous Robot will start in the Transfer Zone, indicated by the green squares in Figure 1.
 - 3.1.4.3. Matches are 4 minutes long.
 - 3.1.4.4. Tele-Operated robots cannot operate in the autonomous zone.
 - 3.1.4.5. Autonomous robots can only operate in a team’s autonomous zone.
 - 3.1.4.6. Robots must remain in compliance with the full robot restrictions, as per [Section 8](#).
- 3.1.5. Scoring Overview
 - 3.1.5.1. Note: See [Section 6](#) for detailed scoring information.
 - 3.1.5.2. All scoring will take place at the end of the match using the final state of the game
 - 3.1.5.3. Teams will receive points for:
 - 3.1.5.3.1. Bulls in their opponents zones
 - 3.1.5.3.2. Having the Calf rope on the Calf Roping
 - 3.1.5.3.3. Barrels located in the barrel zones
 - 3.1.5.3.4. Clowns in the barrels
 - 3.1.5.3.5. Lasso on the center post

3.1.6. Appendices Overview

3.1.6.1. See [Appendix A](#) for:

- 3.1.6.1.1. Detailed court layout.
- 3.1.6.1.2. Starting positions for all game pieces.
- 3.1.6.1.3. Links to vendors and supplies of game pieces.
- 3.1.6.1.4. Cutlist for court construction.

3.1.6.2. See [Appendix B](#) for:

- 3.1.6.2.1. “Barrel of Laughs” score sheet.

3.1.6.3. See [Appendix C](#) for:

- 3.1.6.3.1. Sample wiring diagrams.

3.1.6.4. See [Appendix D](#) for:

- 3.1.6.4.1. Interview questions and rubric.

3.1.6.5. See [Appendix E](#) for:

- 3.1.6.5.1. Safety criteria.
- 3.1.6.5.2. Scoresheet for safety used by Judges/NTC.

3.1.6.6. See [Appendix F](#) for:

- 3.1.6.6.1. Inspection Sheet.

3.1.6.7. See [Appendix G](#) for:

- 3.1.6.7.1. List of Safety Data Sheets (SDS) the NTC have and will have on site.

3.2. Game Description

- 3.2.1. Games will involve two teams at a time.
- 3.2.2. Competitors must remain in their designated competitor zone on their side of the court.
- 3.2.3. Teams can utilize a maximum of TWO tele-operated robots.
- 3.2.4. Teams may also use a maximum of ONE autonomous robot.
- 3.2.5. Teams are not permitted to intentionally remove game pieces from the court area.

- 3.2.6. At no point is a team permitted to intentionally drop pieces off of their robot. Note: This includes the lasso.
 - 3.2.6.1. A dropped piece is one that is not in continuous physical connection with a single robot.
 - 3.2.6.2. A robot piece may not be transferred from one robot to another, to include the Lasso.
- 3.2.7. At no time shall a team's robots (Tele-operated or Autonomous) interact or interfere with their opponents, or their opponents' robots, to include the opponent's lassoes.
 - 3.2.7.1. Intentional violations of this may result in disqualification.
- 3.2.8. Robots may NOT be in possession of any game components at the Start of a game, with the exception of the Lasso on one of the team's Tele-Op Robot, and the Calf Rope on team's autonomous robot.
- 3.2.9. Teams and their robots are not permitted to intentionally reach over or under the exterior walls or zone barriers.
 - 3.2.9.1. Reaching over is defined as breaking the vertical plane extending from the wall surfaces nearest the robots.
- 3.2.10. NOTE: Competitors will participate in BOTH the "Barrel of Laughs" game and the "On-site Autonomous Robot" challenge during BOTH competition days.
- 3.2.11. All reasonable efforts will be made to have the courts set up to the same standard at the beginning of each match of the "Barrel of Laughs" game or run of the "On-Site" challenge.
 - 3.2.11.1. Teams are responsible for completing a final pre-check of the court.
 - 3.2.11.1.1. This includes the court surface, game pieces, and all game components.
 - 3.2.11.1.2. Should any issues be noted, competitors should notify the judges immediately.
 - 3.2.11.2. By starting the match, teams agree that the court is in an acceptable state as laid out in this document.

3.3. Game Play

3.3.1. Games will be played between 2 teams.

3.3.1.1. Games will last a maximum of 4 minutes.

3.3.1.1.1. The amount of time between matches will depend on the number of teams participating. This information will be provided to teams at the start of the competition.

3.3.1.1.2. Games will start on time.

3.3.1.1.2.1. Teams are responsible to know when their games are scheduled.

3.3.1.1.2.2. Teams arriving late will be allowed to use the remainder of the time in the game.

3.3.1.1.2.2.1. Team's arriving late will be at the discretion of the NTC/Judge's as to when they can place their robots into their respective start zones so as to not affect the other team's robots.

3.3.1.1.2.3. NTC/Judges may adjust the scheduled games as necessary for the purposes of ensuring fair game play.

3.3.1.1.3. Between games, battery changes and repairs to robots may be completed at the team's assigned "Pit Area Worktable," with appropriate PPE and Safety.

3.3.1.2. It is a team decision what roles team members will fill.

3.3.1.2.1. Drivers are the competitors holding the robot controller(s) and asserting direct control over a Tele-Operated robot.

3.3.1.2.2. The Spotter is the competitor providing navigational guidance to the driver.

3.3.1.2.3. Competitors must remain in their designated competitor zones at all times during a match.

3.3.1.2.4. Competitors may change roles while a game is in progress.

3.3.1.2.5. Competitors cannot enter onto the court surface or adjust their robot during a game.

- 3.3.2. Robots must start in their designated starting area, and in their designated starting position.
 - 3.3.2.1.1. The designated starting position is the same configuration used during the volume calculation.
 - 3.3.2.2. Damaging the court area is prohibited. If a robot's design causes damage to the court elements, then it will not be allowed to compete until it can operate without causing damage.
 - 3.3.2.2.1. Games missed due to this situation will be forfeited.
 - 3.3.2.2.2. Damage will be defined as any action that causes the court or components to no longer be able to function as intended.
 - 3.3.2.2.3. It is expected that all court components will be fixed firmly in place so that the court is a Neutral Factor in the competition.
 - 3.3.2.3. If a robot is mal-functioning and represents a hazard to participants, the court, other robots or itself, in the opinion of the NTC/Judge, then the NTC/Judge may authorize shutting off the robot during a game.
 - 3.3.2.3.1. Disabled robots or parts of robots not generating any safety concerns will be left on the court until the game time expires.
 - 3.3.2.4. Robots must not leave the court area at any time during a game.
 - 3.3.2.5. No aerial (flying) robots are permitted.

- 3.3.3. During game play, NTC/Judges will have ultimate authority over game rulings, and will have full authority over team conduct in the court area.
 - 3.3.3.1. It will be an NTC/Judge's ruling that decides if an 'End of the Game Component Placement' took place before or after the game-ending buzzer sounded.
 - 3.3.3.2. It will be an NTC/Judge's ruling that decides if the robot is in violation of the rules of the game.
 - 3.3.3.2.1. If any rule violations are noted during the competition, the following escalation pathway will be followed:
 - 3.3.3.2.1.1. During a match:
 - 1) 1st in-match Warning. In-match warning when noticed.
 - 2) 2nd in-match Warning. In-match warning when noticed, with the team clearly told the next occurrence is disqualification.
 - 3) Disqualification of the match. The team will then be subjected to a discussion with the judges. The team will have to prove the violation is addressed before they are allowed to proceed in another match.
 - 3.3.3.2.1.2. Not during a match (Practice time, inspection, or other):
 - 1) Discussion with the team about the violation noticed with the NTC/Judges.
 - 2) Teams will not be permitted to proceed until the NTC/Judges are convinced the violation is addressed.
 - 3.3.3.2.1.3. Note: Depending on the severity of the violation, warnings may be skipped.
- 3.3.4. All scoring will take place at the end of each match.
 - 3.3.4.1. All scores will be based on the location of all game components at the end of each match.
- 3.3.5. If a piece falls out of the court, it may not be retrieved and will be considered out of the game for the remainder of the game time.

- 3.3.6. Should any game pieces enter the opponent's court area, those pieces shall remain in play and usable by the opposing team.
 - 3.3.6.1. This applies to all game pieces which may count for points.
 - 3.3.6.2. Should a larger game piece enter the opposing team's court, it may be removed at the NTC/Judge's discretion.
- 3.4. Teams will participate in a "Round Robin" followed by a "Seeded Double Elimination Playoff Tournament".
- 3.5. Teams will play an equal number of "Round Robin" games.
 - 3.5.1. Round Robin games will be played between 2 teams.
 - 3.5.2. Overall final placement of teams in the Round Robin will be determined using the total win/loses by a team in all of their matches.
 - 3.5.2.1. If there exists a tie in the round robin ranking, the following Tie Breaker Protocol will be used in the final ranking.
 - 3.5.2.1.1. First Tie Breaker: Points scored in matches between tied teams.
 - 3.5.2.1.2. Second Tie Breaker: Total autonomous points scored by a team in all of their round robin matches.
 - 3.5.2.1.3. Third Tie Breaker: Rematch between tied teams.
- 3.6. All teams will qualify for the "Seeded Double Elimination Playoff Tournament".
 - 3.6.1. "Seeded Double Elimination Tournament" is defined as a competition format where participants are ranked by skill (seeded) and are eliminated only after losing two matches.
 - 3.6.1.1. It features two separate brackets: the winners bracket for undefeated players and the losers bracket for those with one loss.
 - 3.6.1.2. Teams must lose twice to be eliminated from the tournament bracket.
 - 3.6.2. Playoff Tournament seeding will be based on the results of the Round Robin ranking.
 - 3.6.3. The Tournament matches will occur between two teams.
 - 3.6.4. The winner of each match will be determined by the total points scored in the match.

- 3.6.5. Should a match in a playoff tournament result in “Tie”, the following Tie Breaker Protocols will be used to determine the match winner.
 - 3.6.5.1. First Tie Breaker: Clown points scored in the match.
 - 3.6.5.2. Second Tie Breaker: Lasso points scored in the match.
 - 3.6.5.3. Third Tie Breaker: Barrel points scored in the match.
 - 3.6.5.4. Fourth Tie Breaker: Bull points scored in the match.
 - 3.6.5.5. Final Tie Breaker: Instant rematch between the tied teams.
 - 3.6.5.5.1. Competitors are not permitted to modify the end-state of their robots from the tied match for use in the rematch. The robots must compete in the rematch in their end-state from the tied game, even if not functioning.

4. Team's Area and Court Areas

4.1. The overall court playing surface will be a 16' by 16' square.

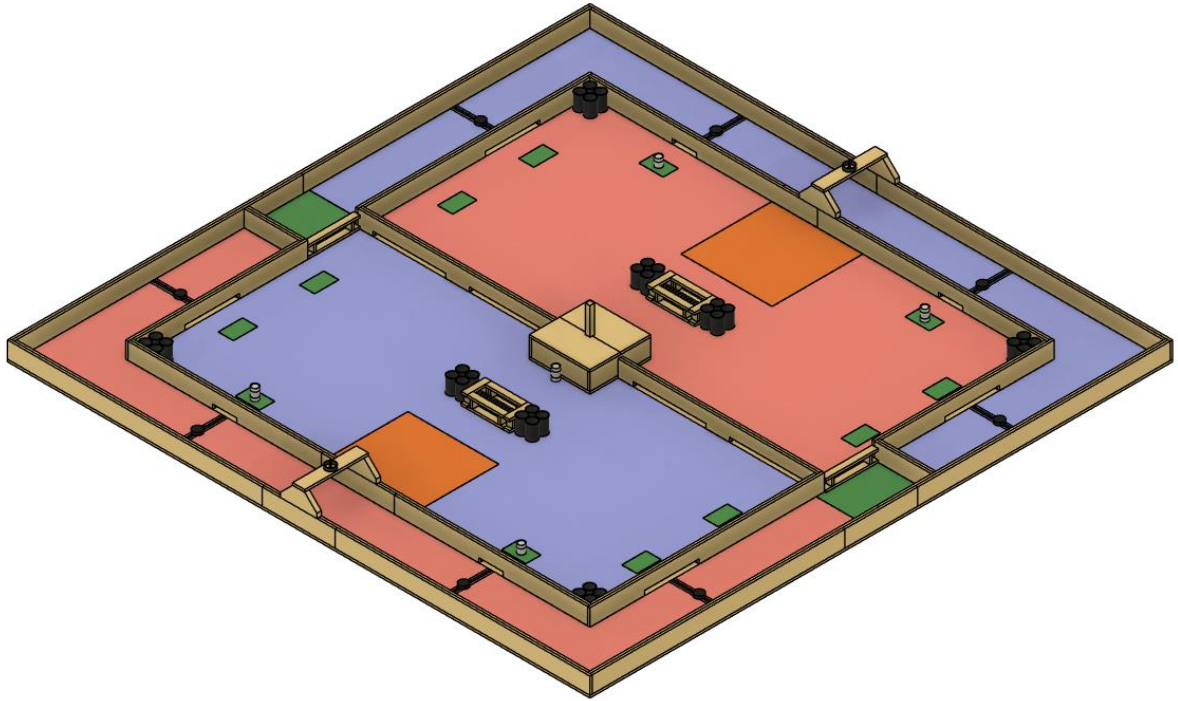


Figure 2: Overall Court

4.1.1. Exclusive-use team spaces are split between both sides of the court.

4.1.1.1. The tele-op area being the larger area on the same side as the team's driver zone.

4.1.1.2. The autonomous area is wrapped around the opponent's tele-op area. The autonomous area runs directly between the opponent's driver area and the opponent's tele-operated zone.

4.1.1.3. As shown in Figure 2 above, the red area is one team's exclusive play area, and the blue area is the exclusive play area for the second team.

4.1.2. Perimeter court walls will be made using $\frac{3}{4}$ " plywood doubled up, resulting in a 5.5" tall by 1.5" thick wall.

4.1.3. The court surface may vary between melamine, concrete, hardboard, plywood, painted plywood, or the facility floor.

4.1.4. All detailed court information is included in Appendix A.

4.1.4.1. Although great pains will be made to keep the court in compliance with the drawings, some inaccuracies in construction may occur. Please make your robot designs allowing for a possible ½ inch tolerance.

4.2. Court Overview - “Barrel of Laughs” Game

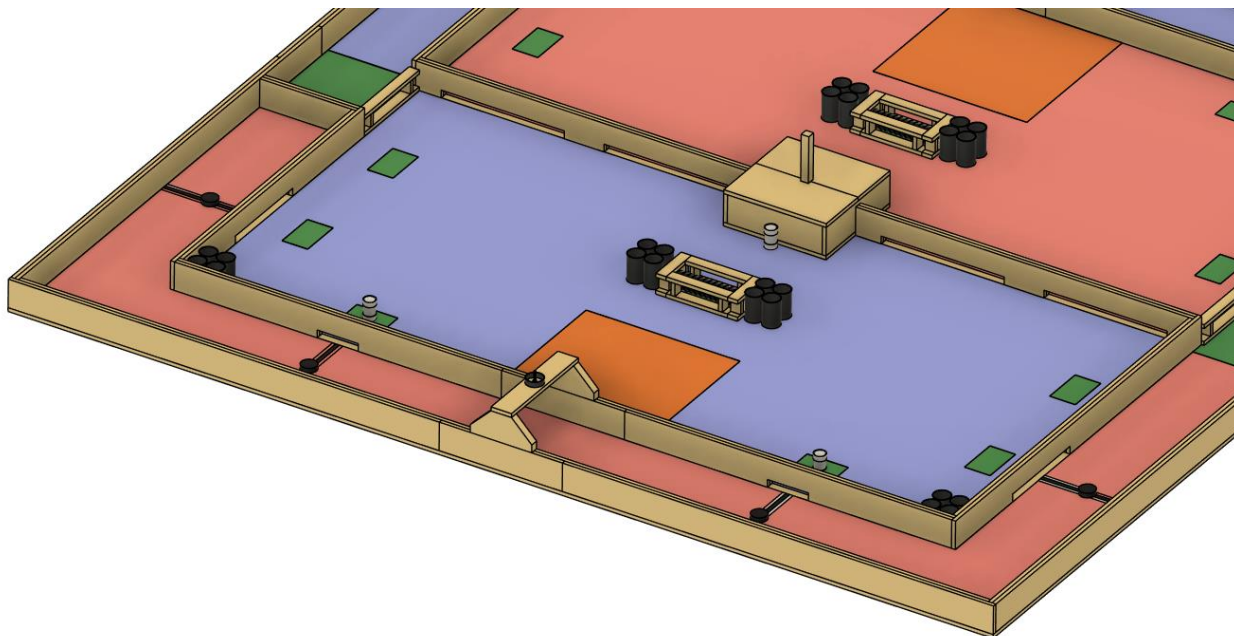


Figure 3: Half Court Overview

The court contains the following areas:

4.2.1. The Corral

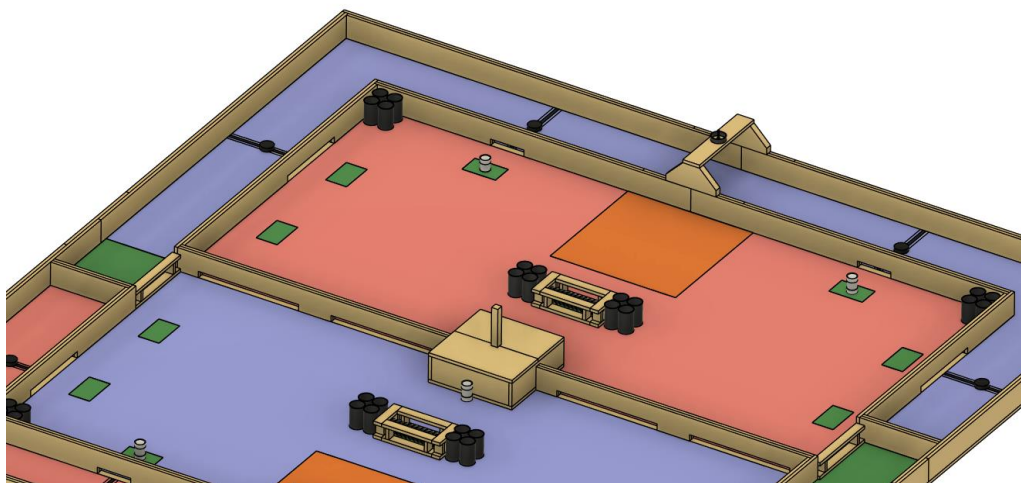


Figure 4: The Corral

- 4.2.1.1. The corral contains the starting zone, barrel zones, fences and some bulls, barrels, and clowns.

4.2.1.2. The starting zone is the orange square area in Figure 4, located in the center of the court, against the wall separating the corral and the opponent's Autonomous Zone.

4.2.1.2.1. The starting zone is where the tele-operated robot(s) entry starts and also serves as a measurement tool for the in-game size restrictions.

4.2.1.3. There are seven (7) barrel zones, two located on the right side of the court with respect to the respective team, and two located on the left side. Two are located on both sides of the starting area. One is under the starting bulls and fences.

4.2.1.4. There are 4 fences, 2 short ones and 2 long ones.

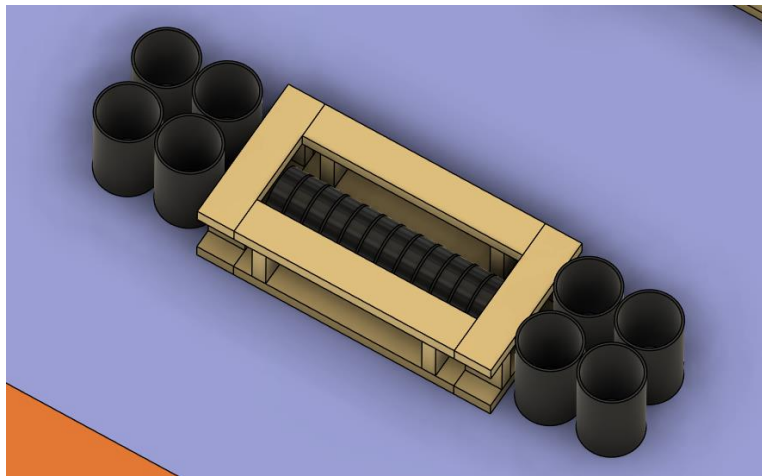


Figure 5: Fences, Bulls, and Barrels Starting Location

4.2.1.5. There are twelve (12) bulls surrounded by the fences located between the starting zone and the lasso platform, as shown in Figure 5.

4.2.1.6. The three clowns are located within the corral and are located in the following places at the start of the match:

4.2.1.6.1. Clown one will be located in front of the center platform

4.2.1.6.2. Clown two and three will be located in the barrel zones located left and right of the starting zone, closest to the competitor's area.

4.2.1.7. The wall along the perimeter of the Corral includes several cutouts sections designated as “bull chutes” which the bulls may be herded through and into the opponents’ exclusive-use area.

4.2.1.7.1. These are along the shared walls, both with the corrals and with the autonomous zones.

4.2.1.7.2. These cutout areas are along the court floor.

4.2.1.7.3. Bulls are permitted to pass between opponent's zones using these "Bull Chutes".

4.2.1.7.3.1. Bulls must travel through the "Bull Chutes".

4.2.1.7.3.2. Bulls are not permitted to move between zones by going over walls.

4.2.1.7.3.3. Only bulls are permitted to break the vertical plane of the walls through these “Bull Chutes”

4.2.2. Steer Head Platform

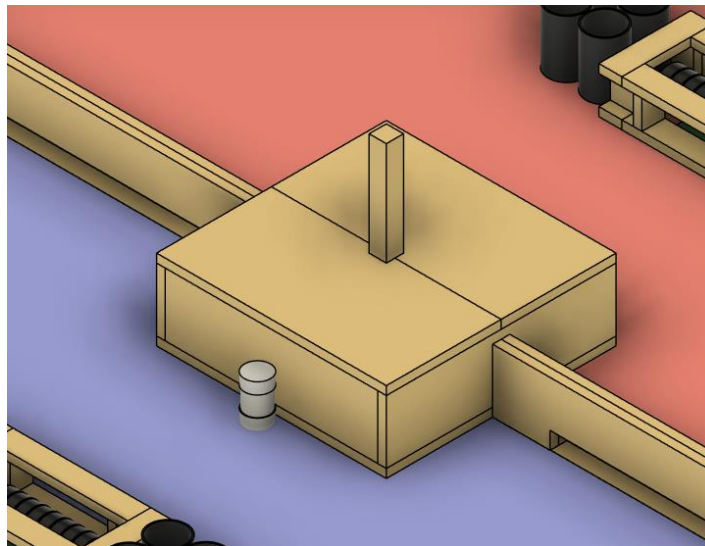


Figure 6: Steer Head Platform

4.2.2.1. This raised platform is located in the center of the court. A wooden pole extends vertically from the centre of the platform.

4.2.2.2. Each team will be trying to lasso the steer head (pole in the middle of the court).

4.2.2.3. No part of the robot will be allowed to cross the vertical plane of the outer edges of this platform, with the exception of the lasso.

4.2.3. Autonomous Zone

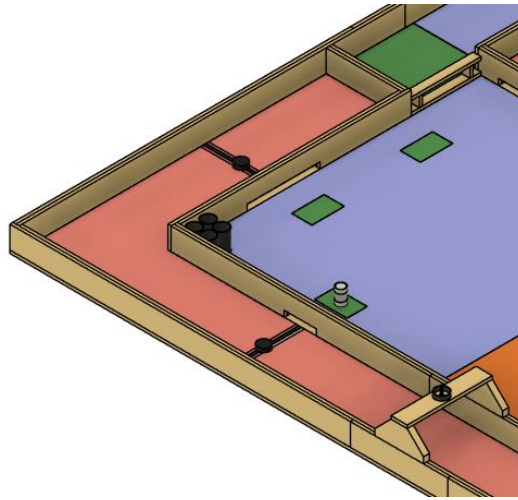


Figure 7: Autonomous Zone

- 4.2.3.1. The Autonomous Zone makes up the outer section of the court area.
- 4.2.3.2. The Autonomous Zone is accessible to the autonomous robot of the respective team in order to clear this zone of bulls and send them into the opponent's zone.
- 4.2.3.3. Four (4) of the bulls can be found in the Autonomous Zone, located in line with the bull chutes.

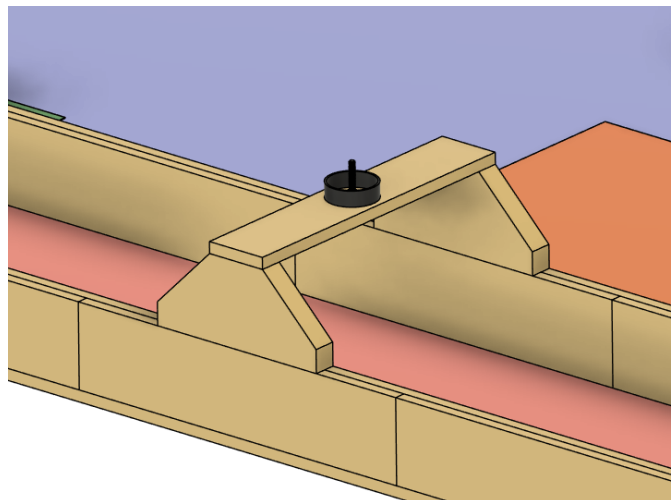


Figure 8: Calf

- 4.2.3.4. Aligned with the center of the court is a calf, represented by a carriage bolt, onto which the autonomous robot can place the calf rope to score points (see Figure 8).
- 4.2.3.5. There will be strips of white duct tape with black electrical tape on the ground to assist with autonomous navigation.

4.2.4. Transfer Zone

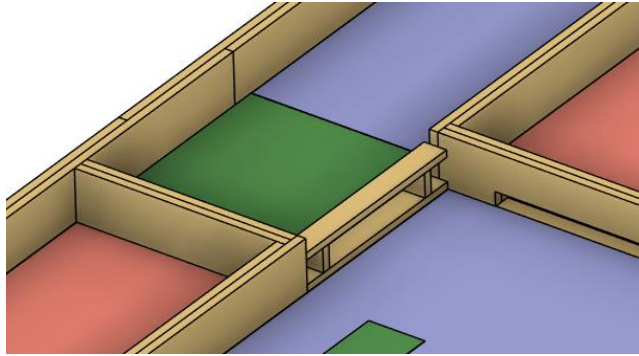


Figure 9: Transfer Zone

- 4.2.4.1. The transfer zone is located on the left hand side of each team's corral.
- 4.2.4.2. The transfer zone is where the autonomous robot entry starts
- 4.2.4.3. This is the area where the autonomous robot and the tele-op robots can interact by passing bulls over or through the fence.

4.3. Competitor Zones

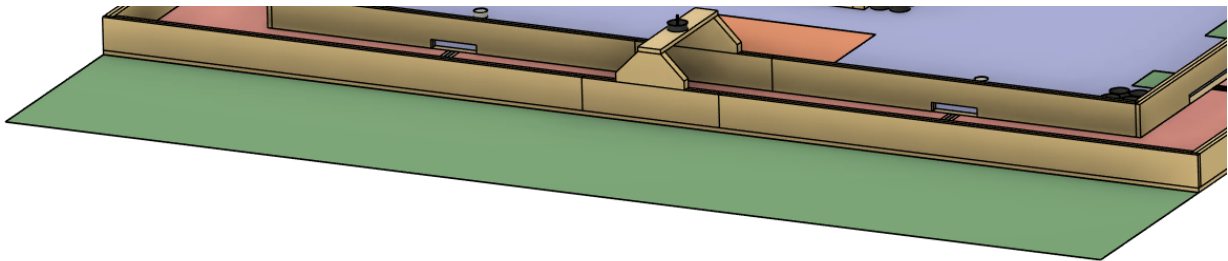


Figure 10: Competitor Zone

- 4.3.1. Each driver or spotter must remain in their designated competitor zone.
 - 4.3.1.1. Competitors shall at no point during a match break the vertical plane of the exterior wall
 - 4.3.1.2. A maximum of 2 competitors from each team may fill these roles.
 - 4.3.1.2.1. This means a team could have 2 drivers OR 1 driver and 1 spotter.
- 4.3.2. Both competitors may occupy any space within the competitor zone.
- 4.3.3. Competitor zones are located on the exterior ends of the court.
- 4.3.4. Each team has 1 designated competitor zone.
- 4.3.5. No other competitors are permitted within 6 feet of the court.
 - 4.3.5.1. This includes bystander competitors from other teams.

5. Detailed Game Components

5.1. All game piece dimensions and starting locations will be detailed in [Appendix A](#).

5.2. Barrels

5.2.1. Throughout the court area, there are 32 barrels, 16 within each corral.

5.2.2. Barrels will be made of 3" ID ABS pipe.

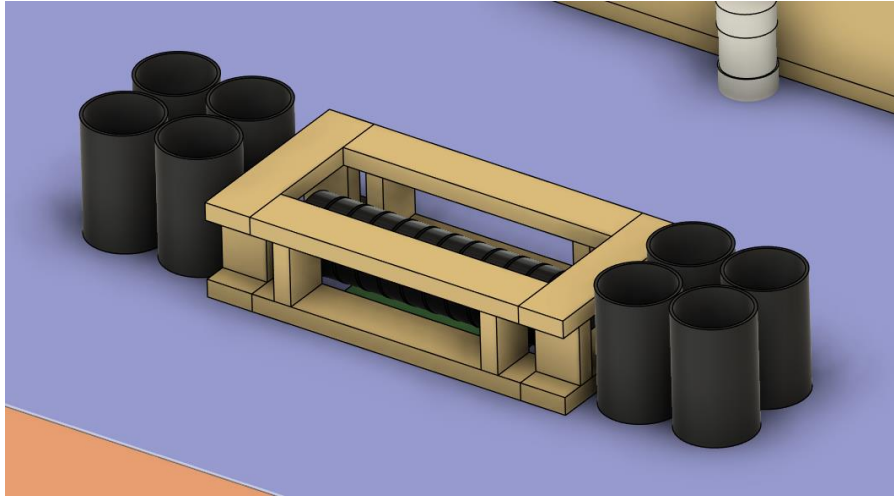


Figure 11: Barrel

5.2.3. Barrel pieces are to be collected and moved into the barrel zones for points.

5.2.3.1. Barrels may be stacked.

5.2.3.1.1. A maximum of 3 barrels per barrel zone may receive barrel points.

5.2.3.2. A barrel counts for barrel points if it is fully supported by the floor and all points of contact with the floor are completely within a barrel zone OR is fully supported by a barrel that counts for barrel points.

5.2.3.2.1. Barrels can overhang the barrel zone to count for barrel points, but will not count for barrel points if they are touching the floor outside of a barrel zone

5.2.3.3. Barrels in contact with a robot do not count for barrel points.

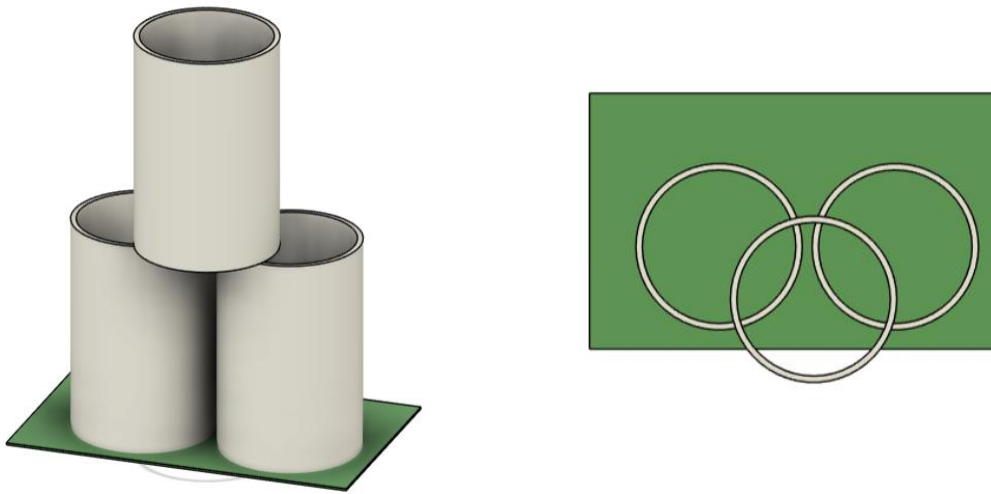


Figure 12: Example of Stacked Barrels

5.3. Bulls

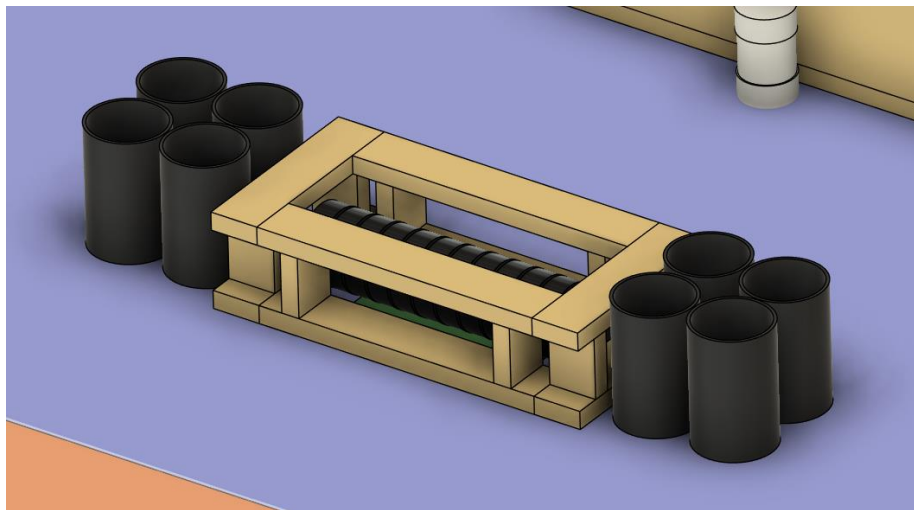


Figure 13: Bull

- 5.3.1. The bulls will be commercial, off the shelf 3" diameter foam floor hockey pucks, as per the material list at the end of [Appendix A](#).
- 5.3.2. There are 32 bulls in designated locations throughout the court at the beginning of the match.
 - 5.3.2.1. Twelve (12) bulls will be located in each corral and surrounded by the fences as per Figure 13.
 - 5.3.2.2. Four (4) bulls will be located in each Autonomous Zone.
- 5.3.3. Bulls may traverse to other zones, either through the bull chutes between the corral and the autonomous zones, or to the transfer zone over or through the fence.

5.4. Clowns

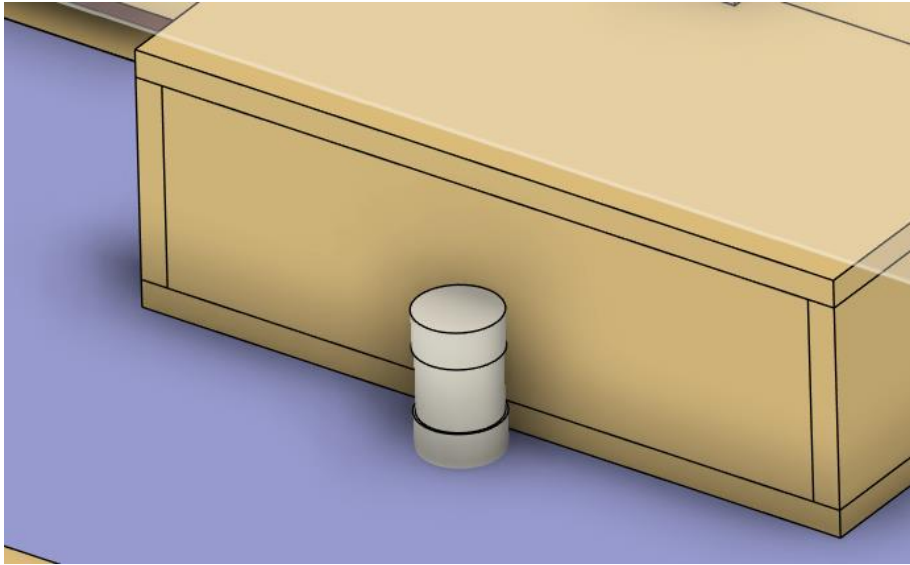


Figure 14: Clown

- 5.4.1. There are six (6) Clowns in the game, three (3) located in each corral.
- 5.4.2. Clowns will be made of 2" ID vacuum pipe with End Caps.
- 5.4.3. Teams should move the clowns completely inside the barrels by the end of the match.

5.5. Lasso

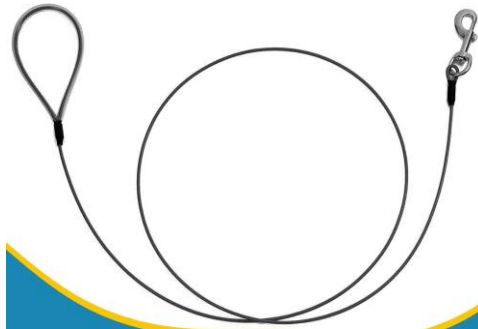


Figure 15: Lasso

- 5.5.1. Teams must affix the commercial, off the shelf pet leash to one of their tele-operated robots prior to the match. During the match, this leash is to be secured onto the steer head in the center of the playfield.

- 5.5.2. The lasso is not considered part of the robot, but the parts connecting the lasso to the robot are considered part of the robot.
 - 5.5.2.1. Each team will have one tele-operated robot with a point for the lasso to remain firmly attached robot for the duration of the match.
 - 5.5.2.1.1. The leash must be attached to the robot from the plastic eye loop.
 - 5.5.2.2. The lasso will be formed by the leash clip being clipped back onto the leash.



Figure 16: Lasso formed by having Leash clipped back onto itself

- 5.5.2.3. Lassos are permitted to go to the farther edge of the steer head platform, however at no point should the lasso go into the opponent's exclusive area.
 - 5.5.2.3.1. Teams will be expected to be controlling the lasso and will be tested during the inspection of the robots.
- 5.5.2.4. Teams are expected to bring their own lasso.
 - 5.5.2.4.1. The specific lasso to be used can be found at this link:
https://www.amazon.ca/dp/B0B6F6BPCW?ref=fed_asin_title&th=1
 - 5.5.2.4.2. No other “lassos” will be permitted.

5.6. Fences

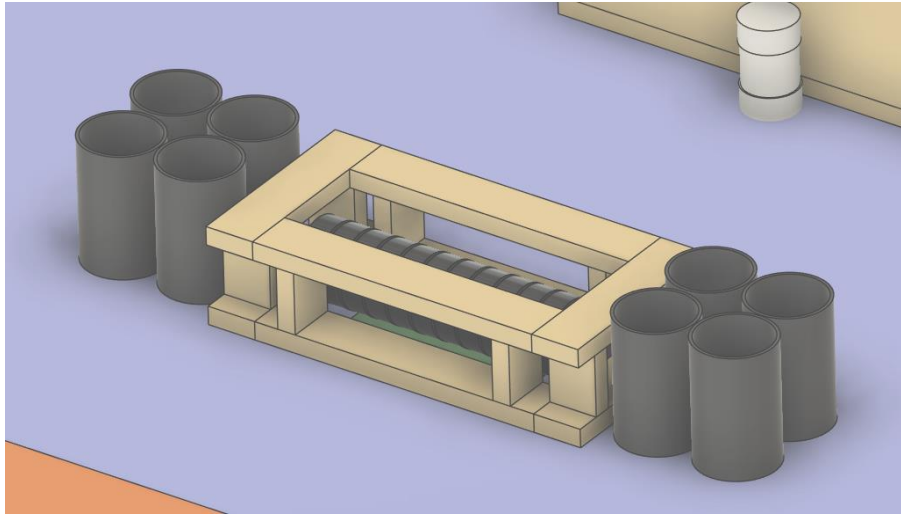


Figure 17: Fence

- 5.6.1. There are four (4) fences in each corral; they surround the bulls at the start of the game.
- 5.6.2. The fences are made of four (4) pieces of $\frac{3}{4}$ " plywood, two longer pieces with two shorter pieces attached within.
- 5.6.3. The fences may be repositioned by the team's tele-operated robots within their exclusive use areas during gameplay.
- 5.6.4. There are no points associated with fences.

5.7. Calf Rope

- 5.7.1. Each team's autonomous robot will be in possession of one calf rope at the start of the game to be placed on the calf in the Autonomous Zone.
- 5.7.2. The calf rope will be made of 3" ID ABS pipe.

6. “Barrel of Laughs” Game Scoring Summary

- 6.1. Reference [Appendix B](#) for the Game Score Sheet
- 6.2. All scoring will take place at the end of each match.
 - 6.2.1. All scores will be based on the location of game pieces at the end of each match.
 - 6.2.2. A match will last 4 minutes.
- 6.3. Bull Points
 - 6.3.1. One (1) point will be given for each bull in the opponent’s Tele-Op Zone.
 - 6.3.2. One (1) point will be given for each bull in the opponent’s Autonomous Zone, to a maximum of 8.
 - 6.3.3. A bull will be considered in the opponent’s zone if the majority of the visible bull is in the opponent’s zone.
 - 6.3.4. A maximum of 32 bull points can be awarded between both teams.
- 6.4. Barrel Points
 - 6.4.1. Two (2) points will be given for each freestanding barrel within a barrel zone, to a maximum of 6 points per barrel zone.
 - 6.4.1.1. A freestanding barrel is defined as being fully supported by the court floor within the barrel zone or by barrels that are also freestanding.
 - 6.4.1.2. Barrels in contact with a robot or other game piece will not be considered freestanding.
 - 6.4.1.2.1. The only exception to this is the clowns within the barrels.
 - 6.4.2. A maximum of 32 barrel points can be awarded for each team.

6.5. Clown Points

6.5.1. Clowns placed in a single barrel will receive points.

6.5.1.1. Clowns partially in a barrel will be worth one (1) point.

6.5.1.1.1. Clowns partially in 2 barrels will qualify for only one (1) point.

6.5.1.2. Clowns fully in a single barrel will be worth three (3) points.

6.5.1.3. A clown is considered to be fully in the barrel if the clown is inside the barrel and no part of the clown is breaking the plane of either end of the barrel.

6.5.1.4. A clown is considered to be partially in the barrel if at least some part of the clown is inside the barrel and the clown is breaking the plane of one end of the barrel.



Figure 18: Left/Center: Clown Fully In Barrel, Right: Clown Partially In Barrel

6.5.2. A maximum of nine (9) clown points can be awarded for each team.

6.6. Lasso Points

6.6.1. Lasso points will be awarded based on the order the lasso's have been delivered and kept on the steer head in the centre.

6.6.2. The points will be awarded as follows: eight (8) Points for the first lasso and four (4) points for the second.

6.6.3. The lasso will be considered on the steer head when the loop created by the leash being clipped back onto itself, as seen in Figure 16, is around the central wooden pole.

6.7. Calf Roping Points

- 6.7.1. Having the autonomous robot successfully place the loop onto the calf in the autonomous zone will be worth five (5) points.
- 6.7.2. The bolt must be completely through the ring in order to qualify for calf points.

6.8. Return to Start Points

- 6.8.1. Up to four (4) points will be awarded for robots returning to their respective starting zones.
- 6.8.2. Two (2) points will be awarded for the Tele-Operated robot(s) returning to the start zone
 - 6.8.2.1. Note: all tele-operated robots must return and be fully within this zone to be awarded the points.
- 6.8.3. Two (2) points will be awarded for the autonomous robot returning to the autonomous starting zone (the transfer zone on the court).
- 6.8.4. Robots must have fully left their respective starting zones to be eligible for Return to Start Points.

7. Pit Area and Court Access

- 7.1. Competitors MUST wear safety glasses at all times when in the competition area.
- 7.2. Competitors MUST wear appropriate safety equipment when doing fabrication work involving material removal or adding processes (grinding, cutting, soldering, etc.).
- 7.3. Only registered competitors are permitted in the competition area.
- 7.4. Designated teacher/industry team advisors are not permitted in the competition area during the competition.
- 7.5. Teachers and industry advisors are not permitted to handle tools or robot parts.
- 7.6. Students must affect all repairs and modifications on their robot.

- 7.7. A pit area is provided so that students may make repairs and improvements to their robots between games.
 - 7.7.1. Teams will be provided with a pit area workspace on a standard project table. Depending on the number of teams and availability of space, teams may have to share a 60 by 30-inch table.
 - 7.7.2. Teams must have a purpose-built tabletop robot stand, designed to keep the robot wheels off the ground/tabletop surface regardless of orientation.
 - 7.7.2.1. This stand or these stands should hold the robot(s) securely and be capable of preventing the robot(s) from driving on or off the table in the case of either deliberate motor testing during repairs or due to random, unexpected motor activity.
 - 7.7.3. A team's pit area must be kept safe at all times.
 - 7.7.3.1. This specifically means:
 - 7.7.3.1.1. Robots must be on the stand at all times when a battery is installed and connected to the robot.
 - 7.7.3.1.2. Pit areas must be kept clean, tidy and free of all tripping hazards. Extension cords and power bars must all be taped, ziptied or velcro tied to the satisfaction of on-site NTC safety representatives.
- 7.8. Teams MUST bring their robots, tools, and supplies into the skill area at Orientation. Teams are NOT allowed to remove their robots (or any part of their robots) from the skill area during the overnight periods between Orientation Day, Competition Day 1, and Competition Day 2 of the contest.
 - 7.8.1. Batteries must be disconnected from all robots and charging devices during the overnight periods.
- 7.9. Laptops may be removed overnight by competitors.
- 7.10. Competitors are not permitted to be in the competition area during times which are not scheduled as competition times.
 - 7.10.1. This includes before the competition day begins, after the competition day ends, and during lunch.
 - 7.10.2. At no time is a competitor permitted to be in the competition area if NTC members are not present.
- 7.11. Robots may be operated only in designated areas as specified during the competition.

8. Robot Restrictions

- 8.1. Robots must remain in compliance with the following rules throughout the competition. If teams fall out of compliance with these rules, then they will not be permitted to compete and will forfeit all their scheduled games until they have corrected the problem.
- 8.2. Teams are permitted to enter 2 tele-operated robots and 1 autonomous robot in total for the competition.
 - 8.2.1. This includes the “Barrel of Laughs” game entries, and the “On-Site Autonomous Challenge” described in [Section 11](#).
 - 8.2.2. This requires the same autonomous robot to be used in both the “Barrel of Laughs” game and the “On-Site Autonomous Challenge”.
- 8.3. Start of Game Status - “Barrel of Laughs” Game
 - 8.3.1. A team’s tele-operated entry must not exceed 4 cubic feet (6912 cubic inches) and a team’s independent autonomous robot must not exceed 1 cubic foot (1728 cubic inches) at the start of each game.
 - 8.3.1.1. The total combined volume of the tele-operated robots will be measured in their starting position.
 - 8.3.1.2. Team entries may expand to a larger size once a game has started.
 - 8.3.1.3. The in-game size restriction for any tele-operated robot entry shall not expand beyond the area of the starting zone.
 - 8.3.1.4. The in-game size restriction for Independent autonomous robots shall not expand beyond the autonomous starting zone.
 - 8.3.1.5. The in-game height of any robot shall not exceed 24”.
 - 8.3.1.6. Total volume will include the mechanism holding the lasso and **WILL NOT** include the lasso.
 - 8.3.1.6.1. This holds true for both start of game volume and in-game size restrictions.
 - 8.3.2. Tele-operated robots must start the “Barrel of Laughs” game completely within the starting zone described in [Section 4.2.1.2](#).
 - 8.3.3. Independent Autonomous robots must start the “Barrel of Laughs” game completely within the “Transfer Zone” described in Section 4.2.4
 - 8.3.4. Teams will be permitted to start the Autonomous robot 10 seconds prior to the match beginning, but it must remain stationary until the beginning of the match.
 - 8.3.5. All details for starting locations for components can be found in [Appendix A](#).

- 8.3.6. When a robot's main power is turned on prior to the start of a game, the robot must be in an overall "Idle State", and the following conditions must exist:
 - 8.3.6.1. It must be stationary.
 - 8.3.6.2. It must not be in possession of any game pieces, with the exception of the calf rope and the lasso.
- 8.3.7. All systems may be turned ON.
- 8.3.8. Air System Circuits may be fully charged to 100 PSI, and their compressors can be ON.
- 8.4. During Game Status - "Barrel of Laughs" Game
 - 8.4.1. Robots may expand beyond the starting volume once the game begins.
 - 8.4.1.1. All Robots must remain in their own team's court.
 - 8.4.1.2. All Tele-operated Robots are permitted to access any area within the team's exclusive-use area, except the "Autonomous Zone".
 - 8.4.1.3. The team's autonomous robot is restricted to the team's autonomous zone and transfer zone.
 - 8.4.2. Strategies aimed at preventing the opponent from playing the game are not permitted, as they violate the spirit of fair play.
- 8.5. Each team's autonomous robot must not have any direct interaction with the competitors.
- 8.6. All Robots must conform to all of the following safety requirements.
 - 8.6.1. All Robots (Tele-operated and Autonomous) must be able to be shut off with a single motion. The single motion mechanism is considered the "kill switch" for the purposes of this document.
 - 8.6.1.1. The "Kill Switch" must be easily accessible.
 - 8.6.1.2. The "Kill Switch" must be securely mounted.
 - 8.6.1.3. Robot controller receivers may be in an independent circuit.

8.6.2. Robot power sources and circuits must meet the following requirements:

8.6.2.1. The maximum continuous power rating allowed in any circuit branch is 256 Watts, which will be limited by voltage and fuse selection.

8.6.2.1.1. To calculate power in any given circuit, use the following formula: $\text{Power (Watts)} = \text{Voltage (Volts)} \times \text{Current (Amps)}$.

8.6.2.2. The total voltage in any individual circuit cannot exceed 24 Volts.

8.6.2.3. Each current branch path from the battery must include either an in-line fuse, resettable fuse, circuit breaker, or be connected to a dedicated fuse in a rack.

8.6.2.3.1. Systems which utilize a built-in fuse will be considered to have this requirement met, as long as:

8.6.2.3.1.1. It is a known and documented system. If the system is unknown to the NTC, teams may be required to produce this documentation.

8.6.2.3.1.2. There are no modifications made to the system.

8.6.2.3.1.3. There are no external circuits which do not contain a fused circuit. Proper fuses are required for modified circuits.

8.6.2.4. Batteries must meet the following requirements:

8.6.2.4.1. All batteries must be a complete, sealed commercial battery pack.

8.6.2.4.2. All batteries must be securely mounted to the robot.

8.6.2.4.3. Batteries wired in series should be the same amp hour rating (ex. both 1500 mAh) and batteries in parallel must be the same voltage (ex. both 12 volts).

8.6.3. Robots utilizing non-electrical energy sources must meet the following requirements:

8.6.3.1. Pneumatic systems are permitted, with the following restrictions:

8.6.3.1.1. Pneumatic based energy sources may be pre-charged to a maximum of 100-PSI pressure in their reservoirs (cylinders) at the start of each game.

8.6.3.1.2. Pneumatic systems using Competitor-made or modified air pressure hardware are NOT permitted.

8.6.3.1.3. All pressurized tanks on robots must have a pressure gauge to indicate the stored pressure and a form of automatic overpressure safety relief system.

8.6.3.1.4. The pressure tanks and related gauges / controls must be shielded from damage due to collisions or flying target objects.

8.6.3.1.5. The stored pressure in the tank must not exceed a maximum of 100 PSI at any time.

8.6.3.2. Tension-based energy sources (elastics, springs or other) may be in either a relaxed at rest state or in a tense / compressed state at the start of each game.

8.6.4. The following devices are not permitted:

8.6.4.1. No explosive materials of any kind may be used (ether, gunpowder, acetylene etc.).

8.6.4.2. Laser devices are permitted so long as the competitors have documentation stating they are a Class one laser. Lasers of a higher classification shall not be used.

8.6.4.3. Hydraulic fluid systems are not permitted.

8.7. Teams must use an appropriate Robot Controller.

8.7.1. Teams are allowed the use of an unlimited number of channels, but only two separate tele-operated robots.

8.7.1.1. Teams assume full responsibility if any interference is to occur with their respective communication systems that could render the robot(s) useless.

8.7.1.2. Robots may not transmit audio/visual information off the robot to devices, including anything directly observable by the driver(s) or spotter(s). (Ex: Having a camera transmit images real time to a computer near the driver, etc.).

9. Inspection

- 9.1. All Robots must pass a pre-competition inspection for compliance with the safety and design rules before they will be allowed to participate in games.
 - 9.1.1. If any modifications are made on a Robot during the competition, the Robot may be subjected to an additional inspection for compliance before being permitted to participate in games.
 - 9.1.2. All Robots must be inspected, including the Tele-operated robots and Autonomous robots in a team's entry.
- 9.2. It is the purpose of the inspection to ensure teams and all Robots are in compliance with the rules and restrictions described in this document.
- 9.3. Team entries will be measured for total combined volume.
 - 9.3.1. All Robots will be measured in their starting positions in their starting configuration.
 - 9.3.2. Volume of the Robots will be calculated using the maximum length, width, and height of the entry, using the formula $V = LWH$.

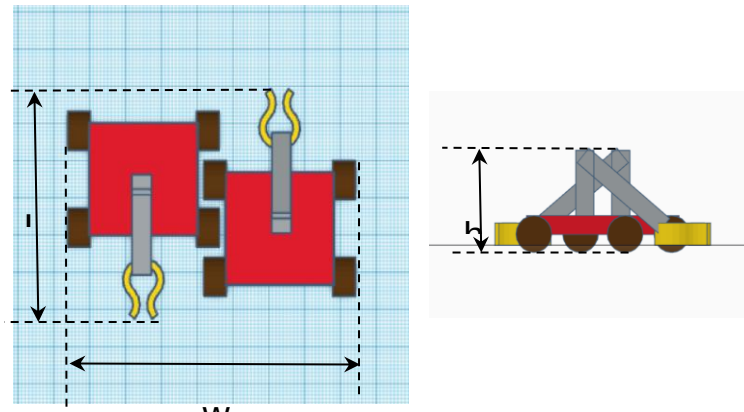


Figure 19: Volume Measurement

- 9.4. Teams will be required to demonstrate the operation of their robots as part of the inspection.
 - 9.4.1. A demonstration of a team's Robot entry (or entries) must show the functionality of the robot to play the game.
 - 9.4.1.1. A demonstration of the team's lasso mechanism will be required to ensure that it does not go into the opponent's zone or potentially interfere with the opponent's robots during operation.
 - 9.4.2. All Robots must be shown to be in full compliance with the rules of the game, as described in this document.
 - 9.4.2.1. Should any clarification document be made, it will also be considered as part of this document.

- 9.5. All teams and Robots must abide by all safety requirements.
 - 9.5.1. All robots must have a wiring diagram.
 - 9.5.1.1. Acceptable examples of wiring diagrams are available in the [Appendix C](#).
 - 9.5.2. All Robots must have a method of shutting the robot with a single motion. For the purposes of this document, this will be called a “kill switch”.
 - 9.5.2.1. The “kill switch” must be easily accessible.
 - 9.5.2.2. The Robots must be able to be safely turned off, without risk to anyone.
 - 9.5.3. All teams must ensure the appropriate SDS is available and on-site for all chemical-based components.
 - 9.5.3.1. This includes all batteries, as well as any other component that may be chemical based.
 - 9.5.3.2. The NTC has SDS for a range of batteries, as listed in [Appendix C](#). If your battery is on that list, you do not need to provide one.
 - 9.5.3.2.1. If your battery is not on that list, you will need to provide the NTC with the appropriate SDS.
 - 9.5.3.2.2. If you are unsure if your battery matches one on the list, please reach out to your NTC representative.
 - 9.5.4. All batteries must be in good working condition.
 - 9.5.4.1. Batteries must be complete sealed commercial battery packs.
 - 9.5.4.2. Batteries must be securely mounted.
 - 9.5.4.2.1. Securely mounted is defined as not able to be knocked off of the robot in any manner of regular gameplay.
 - 9.5.4.2.2. If a battery is knocked off, or shows signs of shifting, the robots may be turned off by the NTC/Judges at their discretion.
 - 9.5.4.3. Batteries wired in series should be the same amp hour rating.
 - 9.5.4.4. Batteries wired in parallel should be the same voltage.
 - 9.5.5. All teams must have a tabletop robot stand for their robots.
 - 9.5.5.1. This stand or these stands should hold the robot(s) securely and be capable of preventing the robot(s) from driving on or off the table in the case of either deliberate motor testing during repairs or due to random, unexpected motor activity.

- 9.5.6. All Robots will be inspected to ensure all parts are permitted parts.
 - 9.5.6.1. Should any non-permitted part be detected, teams will be required to remove them before being allowed to compete.
- 9.5.7. The maximum continuous power rating allowed in any circuit branch is 256 Watts, which will be limited by voltage and fuse selection.
 - 9.5.7.1. Power will be calculated using the formula $\text{Power} = \text{Voltage} \times \text{Current}$.
 - 9.5.7.2. The total voltage in any circuit cannot exceed 24 Volts.
 - 9.5.7.3. Each current branch path from the battery must include either an in-line fuse, resettable fuse, circuit breaker, or be connected to a dedicated fuse in a rack.
 - 9.5.7.3.1. It is the purpose of a fuse/breaker to protect competitors and the equipment in their circuits.
 - 9.5.7.3.2. Systems which utilize a built-in fuse will be considered to have this requirement met, as long as:
 - 9.5.7.3.2.1. It is a known and documented system. If the system is unknown to the NTC, teams may be required to produce this documentation.
 - 9.5.7.3.2.2. There are no modifications made to the system.
 - 9.5.7.3.2.3. There are no external circuits which do not contain a fused circuit.
- 9.5.8. Teams are expected to have appropriate storage for their batteries when they are not on the robot.
 - 9.5.8.1. For Lithium based batteries, teams are to have a properly rated Lithium storage bag/container.
- 9.5.9. Any teams using pressure-based systems must ensure:
 - 9.5.9.1. No Competitor-made or modified air pressure hardware is being used.
 - 9.5.9.2. Only commercially manufactured pressure tanks (cylinders) can be used.
 - 9.5.9.3. Pressure in tanks does not exceed 100 PSI.
 - 9.5.9.4. Systems have an over-pressure safety valve.
 - 9.5.9.5. Pressure tanks and related gauges and controls are shielded from damage due to collisions.
 - 9.5.9.6. Pressure system circuit diagram is provided.

- 9.5.10. All teams must have eye protection available.
- 9.5.11. All teams must wear eye protection while in the competition area.
- 9.5.12. All teams' pit areas must be kept tidy and free from safety concerns.

10. Team Interview

- 10.1. Competitors will be required to answer questions about their robot(s) specifications and functioning, game play strategy, transferable competencies, and logical reasoning.
 - 10.1.1. Competitors will be able to complete the Interview in either English or French, based on their preference.
- 10.2. Each interview will be judged by a team of 2 bilingual judges.
 - 10.2.1. If there are not enough bilingual judges available, an NTC will act as a translator. This NTC will not also act as a judge.
 - 10.2.2. NTC members cannot judge a team from their province/territory. The chair or co-chair will take the place of a judge in this situation.
- 10.3. Interviews will start on time.
 - 10.3.1. Teams are responsible for knowing when their interview is scheduled.
 - 10.3.2. Teams arriving late will be allowed to use the remainder of the time in the interview.
 - 10.3.3. NTC judges may adjust the scheduled interviews as necessary for the purposes of ensuring fair game play.
- 10.4. A maximum of 15 minutes is allocated for the interview (question/answer).
 - 10.4.1. Participants must answer questions as concisely/efficiently as possible to ensure all questions get asked/answered.
 - 10.4.2. Additional time will be allocated to accommodate translation (If a translator is required).
 - 10.4.3. Additional time will be allocated to accommodate for exceptionalities (if requested prior to the interview process).
 - 10.4.4. Participants are expected to evenly contribute to the answering of questions.
 - 10.4.4.1. NTC judges reserve the right to direct a question to either participant on a team should it appear that one participant is not contributing.
 - 10.4.5. Questions not asked/answered will be assessed.
 - 10.4.6. Only participants, judges, and translators can be present during the interview (Exceptions can be made for accommodations)

- 10.5. The interview will be assessed using the “Interview Questions and Rubric” document, located in [Appendix D](#).
- 10.5.1. Details about the interview questions are provided in appendix D
- 10.6. Competitors may use photos, diagrams, and/or code to help them respond to the interview questions.
 - 10.6.1. The documentation and/or computer use is for illustrative purposes only (e.g., images, diagrams, computer code).
 - 10.6.2. Text containing answers to interview questions is not permitted on the documents nor computer programs.
 - 10.6.3. The software/files used for the interview must be run from the competitor's computer.
 - 10.6.4. An external screen with an HDMI connector will be available for competitor use during the interview.

11. On-Site Autonomous Challenge Overview

- 11.1. The on-site autonomous challenge must be completed using the same autonomous robot as the “Barrel of Laughs” game challenge.
 - 11.1.1. The “same robot” refers to a single, identifiable robot that maintains its core structure and functionality across both the “Barrel of Laughs” game and the autonomous challenge. While minor adjustments (such as adding a sensor, sensor repositioning or reprogramming) are permitted, teams may not swap out the robot, or replace it with a second build.
 - 11.1.2. It will be the responsibility of the competitors to provide all their own parts for this Autonomous Robot.
 - 11.1.3. The microcontroller and programming language used will be the choice of the competitors.
 - 11.1.4. Competitors may use compatible components for their chosen microcontroller/programmable control unit.
- 11.2. The Autonomous robot must meet the same restrictions as the “Barrel of Laughs” game challenge.
 - 11.2.1. It must be able to pass the inspection for the “Barrel of Laughs” game and remain in compliance throughout the competition.
 - 11.2.2. This may cause the robot entries to be reinspected if any physical changes are made to the autonomous robot.
- 11.3. Competitors will demonstrate their robot’s performance in a court to be defined at the Skill area.

- 11.4. At the orientation meeting, Competitors will be told the specific Robot tasks their autonomous robots need to complete for the On-Site Autonomous Challenge.
 - 11.4.1. During this time, teams will also be informed of the On-Site Autonomous Challenge marking system.
- 11.5. Autonomous robots will need to complete the same type of tasks in the on-site challenge as they do in the “Barrel of Laughs” game. These include:
 - 11.5.1. Navigate throughout a defined area, potentially with multiple turns.
 - 11.5.2. Locate the various game pieces.
 - 11.5.3. Manipulate game pieces.
 - 11.5.4. Place game pieces.
 - 11.5.5. Note: All tasks will be designed to be completed with a robot that can complete the tasks in the “Barrel of Laughs” game.
 - 11.5.6. Note: All or some of the listed tasks will be a part of the On-Site Autonomous task.
- 11.6. Game pieces used in the On-Site Autonomous Challenge will match the game pieces used in the “Barrel of Laughs” Game.
- 11.7. Competitors need to be prepared to complete several steps for full marks in this challenge.
- 11.8. Competitors are only permitted to interact with the autonomous robot to initiate the robot.
 - 11.8.1. No competitor interaction with the robot after pressing the initiation switch/button.
- 11.9. On-Site Autonomous Challenge Equipment:
 - 11.9.1. Competitors will be required to build their autonomous robot solutions using their own parts.

- 11.9.2. In addition to robot parts, teams may use the following to help with this challenge:
 - 11.9.2.1. Laptop/Computer, mouse, and keyboard, power cord, usb cable, software drivers.
 - 11.9.2.2. Sample code, Arduino IDE or similar program.
 - 11.9.2.3. Measuring tape, allen keys, small wrench or pliers.
 - 11.9.2.4. Paper, pen, pencil, calculator to record measurement.
 - 11.9.2.5. Replacement parts for the originals (eg: Cable ties.)
 - 11.9.2.6. Large and/or small storage containers.
 - 11.9.2.7. Tele-op controllers and /or modules are not permitted to be used at any time on the autonomous robot.
 - 11.9.2.7.1. This includes during marked attempts and practice.
- 11.10. Teams will have time periods where they have shared access to the various On-site Performance Court Environments to conduct their Task Solution / Preparation Activities.
- 11.11. Teams will have a select number of Marked Attempts at each of the Autonomous Performance Tasks as time permits. The number of attempts will be predetermined at the start of the competition.
- 11.12. Teams may request a Marked Attempt when they are ready to do so. Teams must complete all On-site Task Preparations by a predetermined time (as announced at the start of the competition.) For example: All On-site activities must be completed by 3:45 PM on Competition Day 2.

12. Medal Awarding System

12.1. Medals will be awarded based on Tele-operated game (Round Robin and Playoff Tournament), Autonomous task, and Safety.

12.2. The overall score will be determined by combining the points awarded in each section of the competition.

12.2.1. “Barrel of Laughs” Game Round Robin points will be awarded based on overall standing during the Round Robin.

12.2.1.1. Round Robin points will be awarded in the following manner:

Place	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th
Points	30	28	26	24	22	20	18	16	14	12	10	8	6

12.2.2. “Barrel of Laughs” Game Playoff Tournament points will be awarded based on final tournament placement.

12.2.2.1. Tele-operated Playoff Tournament points will be awarded in the following manner:

Place	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th
Points	35	32	29	26	23	21	18	15	12	10	7	4	1

12.2.3. Autonomous task points will be awarded based on the Autonomous task.

12.2.4. Safety points will be awarded based on the safety criteria listed in the [Appendix E](#).

12.3. Overall score will be 65% “Barrel of Laughs” Game performance, 20% On-site Autonomous task performance, 5% Safety score, and 10% Interview score.

12.4. Medals will be awarded based on the overall team scores. The Gold Medal will go to the team with the highest overall score, the Silver to the next highest overall score, and the Bronze to the next highest after that.

12.4.1. In the case that a tie occurs in the Overall Team Scores, the medal will go to the team with the higher On-Site Autonomous Challenge Score.

Appendix A: Court Dimensions and Details

See Attached.

Appendix B: “Barrel of Laughs” Game Score Sheet

See Attached.

Appendix C: Sample Wiring Diagrams

See Attached.

Appendix D: Interview Questions and Rubric

See Attached.

Appendix E: Safety Criteria and Scoresheet for Judging

See Attached.

Appendix F: Inspection Sheet

See Attached.

Appendix G: SDS List

See Attached.