2022 IEEE R5 Conference
Student Robotics Competition Rules

Houston, Texas

Version 1.4

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1. Introduction

This document contains the rules of the 2022 R5 Robotics Competition. The competition is open to teams of no more than 5 and no less than 2 undergraduate students who are enrolled in a College or University within the IEEE Region 5 boundaries. Each R5 IEEE Student Branch may have up to 2 teams. The competition will be limited to a total of 16 registered teams on a first come, first served basis. The competition encourages a multidisciplinary approach to robot development and recognizes the participation of students who may already be members of SAE, ASME, EEGS, etc. Therefore, only one team member will be required to be a current IEEE Student Member.

2. Competition Motivation

The objective of the competition is to demonstrate the use of a tethered underwater robot to collect 'trash' from the ocean floor, midwater, and surface. The robot then will deposit the trash in a proper receptacle. The game field simulates an underwater environment containing objects such as industrial infrastructure and underwater debris. Underwater and surface obstacles and anomalies represent typical operational challenges.

3. Game Field

The Game Field is an area in the pool that is 23 ft. 6 in. x 11 ft. 6 in. The water depth is three to four feet, depending on the location in the pool. Figure 1 shows an overall view of the field elements and Figure 2 gives the relative positions of the elements and their dimensions. These elements will be placed in each Game Field area:

3.1. **Tunnel Rings** – two metal or plastic rings will be used to simulate an underwater tunnel that the robot will traverse. As shown in Figure 2, the distance between the rings is three feet.
- Large tunnel ring – the ring diameter will be 32” and will be mounted on a support beam that will be standing on the floor of the pool. The center of the large ring will be 30” above the floor.
- Small tunnel ring – the ring diameter will be 28” and will be mounted on a support beam that will be standing on the floor of the pool. The center of the small ring will be 24” above the floor.

3.2. **Open-Ended Box** – The open-ended box will have an open face towards the tunnel rings that measures 12” x 12”. The depth of the box will be eight inches. The bottom of the box will be placed on a support beam 12” above the pool floor. It will hold a small non-buoyant trash block (~ 6” x 6” x 6”) placed inside at the rear of the box.

3.3. **Hinged-Lid Box** – The hinged-lid box measures 8” x 8” x 18” that is constructed from a mesh material (metal or plastic) with a hinged lid that is secured with a pushbutton (at least 1” diameter) release. The box holds a number of tennis balls with the lid secured. Pushing the button allows the lid to open and releases the tennis balls. The bottom of the box will be 12” from the pool floor and is mounted on a support beam that will be standing on the bottom of the pool.

3.4. **Trash Receptacle Box** - The trash receptacle will be an open top mesh box (plastic or metal) with one of the vertical sides cut lower to allow the robot to deposit trash into the box. The box will be 18” x 18” area with 3 vertical sides of height 8 inches and one vertical side at 2 inches. The top of the lower vertical side will be placed at the surface level of the water to allow the robot to deposit trash into the receptacle. This side will have a ramp the length of the opening that will extend outward by 6” at a slight decline of approximately 30 degrees. The trash receptacle will be mounted on a support beam that will be standing on the bottom of the pool.

3.5. **Trash Receptacle Shelf** – The trash receptacle shelf will be attached to the side of the trash receptacle box, as shown in Figure 2. The shelf will measure 8” x 18” with a thickness of ¾”. The shelf will be located approximately 6 inches below the surface of the water and is intended to only hold the trash cube when placed from the robot.

3.6. **Trash Block** – The trash block is a 6” x 6” x 6” box with a simple eye-bolt attached to the top of the box. The inside diameter of the eye-bolt is approximately 1”. The Trash Block weighs approximately 3 pounds.

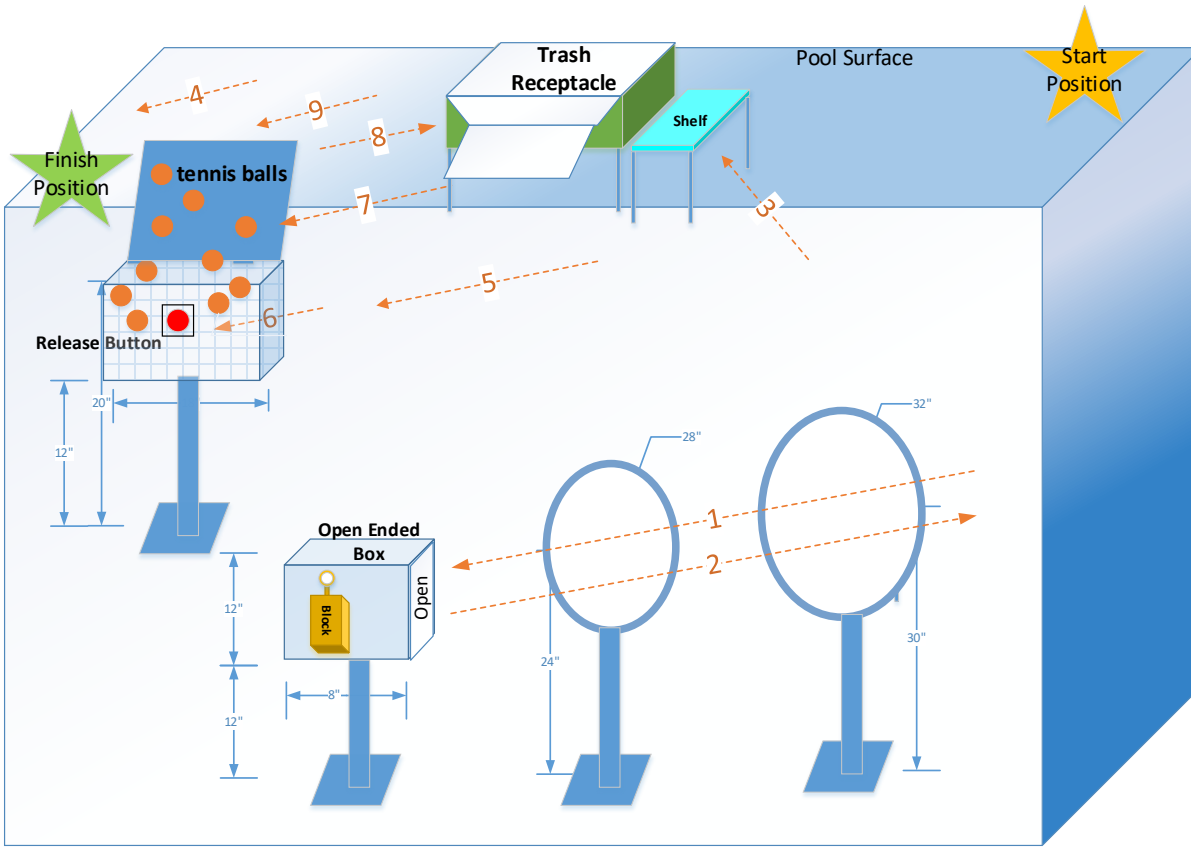

Figure 1 Game Field - Basic Layout and Task Sequence (Not to Scale)

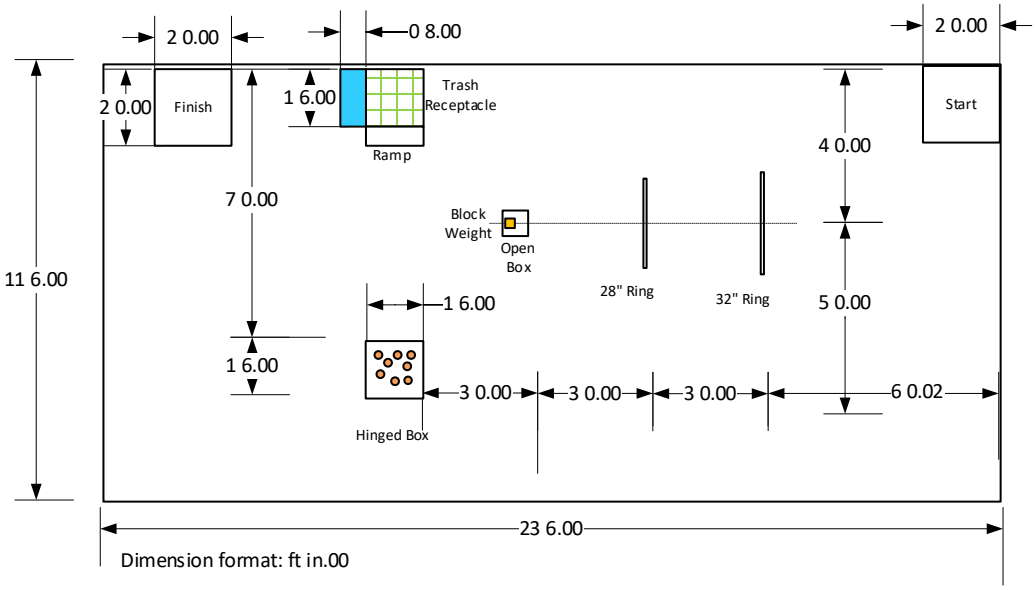

Figure 2 Pool gameplay layout section (top view)

4. Robot Requirements

- **Construction** - Robots should be built by the student teams and not be purchased as a complete unit.
- **Autonomous Operation** – Not required. Robots may be tethered with manual surface control by the team.
- **Size** – While occupying the START and FINISH location, the robot must fit inside a 20” x 20” x 20” cube.
- **Weight** – Must weigh 30.0 pounds or less, including the tether. The competition scale used for judging will be available at the Head Judge table during practice and competition. The Head Judge may disqualify robots that weigh over 30.0 pounds at their discretion without appeal.
- **Chemicals or explosives** – Explosives and volatile liquids are not permitted. Chemical batteries are allowed but only if used correctly and with appropriate safety and handling.
- **Power** – The robot may be powered internal or external to the robot:
    - No AC power is allowed to the robot.
    - Each team shall supply its own DC power source of no more than 48 VDC for the robot.
    - Voltage may not be increased above the nominal 48 volts anywhere in the robot system.
    - If the robot is powered externally, there must be an in-line fuse within 12 inches of the robot.
    - Fuses must not exceed 30 Amps.
    - ROV systems are allowed one replacement fuse during the competition. In the event that the robot system blows the second fuse during the round, the round will be over, and no additional points will be earned. Teams should have adequate replacement fuses on hand,
- **Capabilities** – Pneumatics, hydraulics, lasers and cameras are permitted.
- **Emissions** – No emissions of any kind are allowed into the pool.
- **Additional Devices** – Multiple vehicles are not allowed, but additional devices to help the robot perform its mission are allowed. However, any additions must be included in the size and weight limits when attached.
- **Bill of Materials** – A Bill of Materials for the robot system, including itemized and total cost, including tether, spare parts, and any attachments to the robot used during the competition, is to be submitted by each team by March 31, 2022.

5. General Rules

- Only team members are allowed to work on the vehicle not mentors or supervisors
- In the pool during the Underwater Missions, only four members are allowed to be in the station (a pilot, two co-pilots and a tether-person)
- Direct communication during the underwater tasks is only allowed between the pilot and the co-pilots in the team.
- The time given per round is 5 minutes for setup, 30 minutes for the underwater tasks to be done and 5 minutes to leave the station.
- The tether-person is not allowed to pull the vehicle from its tether, and the vehicle must come back to the surface under its own power
- The tether-person can communicate with one of the co-pilots to know what task to do, to attach the required devices to the vehicle
- The robot must carry any connected device on its own; the team can add nothing once the robot is in the water.
- Any debris should be returned to the surface before the mission time ends.

6. Gameplay and Order of Operations

6.1. Pre-Game Procedure

1. **T-20 minutes** - Twenty (20) minutes prior to the start of a Round, teams will have 5 minutes to deliver their robot to the Quarantine Area.
2. **T-15 minutes** – Fifteen (15) minutes prior to the start of a Round, all robots are required to be in the Quarantine Area. The Quarantine Area will be closed. A Judge will have an opportunity to assess the robot field for rule infractions.
3. **T-15 minutes** – Configuration of the game fields by Judges and assistants will begin.
4. **T-0 minutes** – The fields are ready to begin the Round.
5. The A/V Screen at the Head Judge table will display the order of competition for each game field.
6. The public address system will call the next robot team to their competition game field.
7. Upon entry to the Game Field Area (defined as inside the area surrounded by stanchions), the student designated as the Team Lead will be announced to the Scoring and Timing Judges.
8. Team Lead will place their robot fully within the START location in the pool.
9. After the robot has been fully placed in the START location and 60 seconds has elapsed, the Timing Judge will begin a countdown from 5 to GO. The countdown will be 5-4-3-2-1-GO.
10. Upon saying GO – the Timing Judge will start the Field Clock and the Team Lead is expected to begin directing the robot to perform the specified tasks.

6.2. ROUND 1: Trash Retrieval from Open-ended Box

See the step numbers below that correspond to those shown in Figure 1.

1. Place the robot into the START position and propel the robot sequentially through two rings to an open-ended box
2. Grab any part of the block inside the box and bring it back out through the two rings
3. Transport the cube to the underwater shelf and deposit it there
4. Return the robot to the FINISH location of the Game Field

6.3. End of ROUND 1 Conditions

The round is ended for a robot if **any** of the following conditions occur:

1. The robot enters the FINISH location of the Game Field.
2. A team member touches the robot while in the Game Field.
3. The robot is still in the Game Field when the allocated task time expires.

6.4. ROUND 2: Plastic Trash Release and Collection

1. Place the robot into the START position and propel the robot to the hinged lid box.
2. Position the robot to push the release button on the front of the box located midwater. Successfully pushing the button will release the trapped trash (tennis balls).
3. Collect the floating trash (balls) from the water with the robot
4. Place as much trash (balls) as possible in the trash receptacle in the time available.
5. Return the robot to the FINISH location of the Game Field

6.5. End of ROUND 2 Conditions

1. The robot enters the FINISH location of the Game Field.
2. A team member touches the robot while in the Game Field.
3. The robot is still in the Game Field when the allocated task time expires.

7. Primary Scoring

7.1. ROUND 1 Trash Retrieval from Open-ended Box

Activity	Points
Successfully navigating forward through the two tunnel rings to get to the open-ended box	+10
Grabbing and holding the cube located in the box and removing it from the box	+5
Successfully navigating backward through the two tunnel rings to come back from the open-ended box while holding the cube	+20
Successfully navigating backward through the two tunnel rings to come back from the open-ended box without holding the cube	+5
Depositing the cube completely on the underwater shelf	+10
Return to place robot completely in FINISH area	+5

7.2. ROUND 2: Plastic Trash Release and Collection

Activity	Points
Pushing the button successfully on the hinged-lid box to open the lid.	+10
Putting all (10) released tennis balls completely into the trash receptacle	+5 for each ball
Return to place robot completely in FINISH area	+5

Total possible primary score points: 110

8. Bonus Scoring

8.1. **Time** – If all tasks are fully completed in less than the allotted time, then bonus points will be awarded as follows:
- 6 points for each full minute less than the allotted time
- 0.1 point for each second in a partial minute less than the allotted time

8.2. **Weight** – Bonus points will be awarded based on the weight of the robot and any attachments used during the competition, including the tether.

Weight Range	Points
24 lbs. to 28 lbs.	+2 points
20 lbs. to 23.99 lbs.	+5 points
15 lbs. to 19.99 lbs.	+10 points
Less than 15 lbs.	+15 points

8.3. **Cost** – Based on submitted Bill of Materials total, including tether and any attachments used during the competition, bonus points will be awarded as follows:

Cost Range	Points
$1500 to $2000	+5 points
$1000 to $1999.99	+10 points
$500 to $999.99	+15 points
Less than $500	+20 points

9. Scoring Penalties

- **Game Field Damage** - A robot will be disqualified from the round if a robot or team member damages any part of a Game Field. Any Game Field component that requires replacement to continue the competition is considered damage. The Head Judge will make this determination.
- **Obstacle Movement**: Thirty (30) Points will be subtracted from the team score if a robot or team member moves any of the Game Field stationary elements.

10. Final Scoring, Placing and Tie Conditions

- The teams with the four highest scores from Round 1 will advance to Round 2.
- The final competition score is the total sum of all points, bonuses and penalties from the competition tasks on a per robot basis.
- No competition score will be less than zero (0).
- The highest robot point total from the task competition will be awarded First Place.
- The second highest robot point total from the task competition will be awarded Second Place.
- The third highest robot point total from the task competition will be awarded Third Place.
- The fourth highest robot point total from the task competition will be awarded Fourth Place.
- A tie will be decided by the Tie Breakers:
  - First Tie Breaker – The robot with the lowest weight.
  - Second Tie Breaker – The robot with the lower cost per the Bill of Materials.

11. Events and Prizes

- Team registration is required for area game field entry and badges.
- The competition will conclude with an awards banquet on Saturday evening.
- Cash prizes and certificates will be awarded at the banquet.
- Specific award details will be provided on the Robotics Competition page of the Region 5 website.
- The general public may view the competition; however, guests must register and pay to attend the banquet.

12. Field Design Data

Field Design Data will be provided to Teams on the Robot Competition page of the IEEE R5 website:

- Game Field Bill of Materials
- Game Field Assembly Instructions
- Game Field CAD Files and Drawings (various file formats)

13. Venue

- The 2021 Region 5 Robotics Competition will be held at the Hilton Houston North Hotel located at 12400 Greenspoint Dr, Houston, TX 77060.
- Four (4) game fields will be available starting Friday, April 1, 2022.
- The competition will be held on Saturday, April 1, 2022..
- Detailed schedule information will be posted on the Robotics Competition page of the Region 5 website.
- Wireless internet will be available for teams in the Hotel on Friday and Saturday.
- Each team station will have 2 adjoining tables, 6 chairs and a single 120 VAC 15 amp outlet.
- Four (4) competition fields, as shown in Figure 3, will be available for practice on Friday and for the competition on Saturday. They will be placed in each quadrant of the pool.

14. Glossary of Key Terms

- **A/V Screen** – Audio Visual display system
- **BOM** – Bill of Materials required to build a Game Field
- **CAD** – Computer Aided Design. A set of drawings required to build a Game Field
- **Elapsed Time** – The time interval between the Timing Judge saying “GO” and the moment when any End of Round Condition occurs.
- **Field Clock** – The timing device controlled by the Timing Judge
- **Game Area** – The entire area marked in the pool around the Game Field
- **Game Field** – all of the components situated in and including the 23 ft. 6 in. by 11 ft. 6 in pool area.
- **Head Judge** – An IEEE Houston Section Member who makes all final rule decisions and award determination
- **Quarantine Area** – Numbered grid location where robots are placed prior to entering the Start location in the pool
- **Scoring Judge** – Records and reports all points and penalties
- **START/FINISH** – The marked pool locations contained within the designated Game Field area
- **Team Lead** – A student designated at the start of the competition round to handle the Team robot
- **Timing Judge** – Controls and reports elapsed time

15. Appendices

15.1. Hotel Pool Game Fields Layout

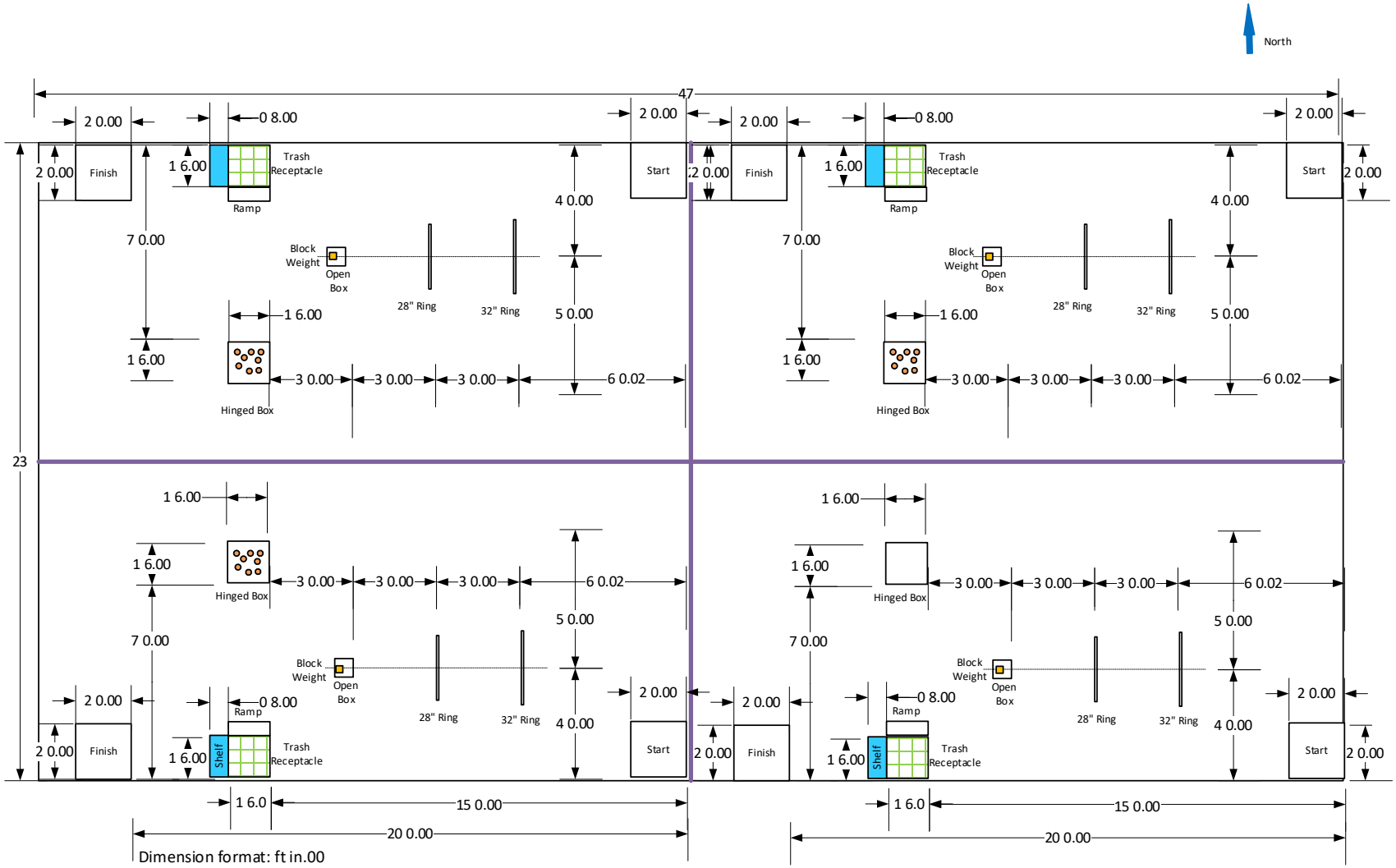

Figure 3 Hilton Houston North hotel pool Game Field layout

15.2. Change Record

Change Number	Date of Change	Location in Rules	Reason	From	To
01	9/9/2021	3.Robot Requirements	Size limit correction	24” x 24” x 24”	20” x 20” x 20”
02	10/2/2021	1.Introduction	Clarification	Not specified.	Each R5 IEEE Student Branch may have up to 2 teams.
03	10/2/2021	6. Gameplay and Order of Operations	Explicitly note conditions for end of round	Not explicitly specified.	The round is ended for a robot if **any** of the following conditions occur:
04	10/02/2021	4.Robot Requirements	Explicitly state requirements to ensure safety of participants.	Not explicitly specified.	No AC power is allowed to the robot. Each team shall supply it’s own DC power source of no more than 48 VDC for the robot. Voltage may not be increased above the nominal 48 volts anywhere in the robot system. If the robot is powered externally, there must be an in-line fuse within 12 inches of the robot. Fuses must not exceed 30 Amps. ROV systems are allowed one replacement fuse during the competition. In the event that the robot system blows the second fuse during the round, the round will be over, and no additional points will be earned. Companies should have adequate replacement fuses on hand,
05	10/2/2021	4.Robot Requirements	Prevent pool contamination.	Not explicitly specified.	No emissions of any kind are allowed into the pool.
06	10/02/2021	4.Robot Requirements	Ensure consistency with Bonus Scoring section	Not explicitly specified.	A Bill of Materials for the robot system, including itemized and total cost , including tether, spare parts, and any attachments to the robot used during the competition, is to be submitted by each team.
07	10/21/2021	1. Introduction	Clarify number of teams	Not explicitly specified.	The competition will be limited to a total of 16 registered teams on a first come, first served basis.

08	11/01/2021	7.1 Round One	Clarify grab and hold cube, navigate back through rings with or without cube. Point distribution.	Grabbing and holding the cube located in the box. Successfully navigating backward through the two tunnel rings to come back from the open-ended box.	Grabbing and holding the cube located in the box and removing it from the box Successfully navigating backward through the two tunnel rings to come back from the open-ended box while holding the cube Successfully navigating backward through the two tunnel rings to come back from the open-ended box without holding the cube